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SYSTEMATIC REVIEW

The physical and psychological health effects of pet ownership among children in China: A systematic review

Xiaoshan Yin*, Paul Graham Morris, Fangqing Liu and Joanne M. Williams

Abstract

Research to date in Western contexts has indicated various physical and psychological health effects of pet ownership among children, but less is known about the role pets play in the health of children in China. The aim of this systematic review was to evaluate the evidence on the effects of pet ownership on physical and psychological health among children in China. A literature search was performed in eight databases for studies that investigated the health and psychological effects of pet exposure on children (operationalized as birth to 20 years) in China, and a quality assessment and a narrative synthesis of results were conducted. Fifty-nine studies published between 2002 and 2021 were included in this review, of which 57 focused on children's physical health issues including asthma and allergy symptoms, *Toxoplasma gondii* infection, animal induced injuries, low birth weight and hypertension, while only two studies focused on children's psychological health. Overall, pet exposure was most often studied as a risk factor for respiratory health, injuries, and *T. gondii* infection among children in China but was also seen as a protective factor for cardiovascular health and for the association between environmental pollution and children's respiratory function. In addition to physical health effects, two studies focused on psychological factors: post-traumatic stress following animal-induced injuries and benefits of reading following a canine-assisted activity. Findings underscore the need for further research examining the effects of pet ownership on children's development and psychological health in China.

Keywords: pets, children, adolescent, physical health, psychological health, systematic review

Introduction

Since interactions between humans and other animals are pervasive in everyday life across time, culture, and history, Human-Animal Interaction (HAI) has gained increasing research attention (Beck *et al*., 2018). A systematic review (Purewal *et al*., 2017) found that companion animal ownership has a positive impact on children's and adolescents' emotional development in terms of lower levels of loneliness and higher self-esteem (e.g. Van Houtte and Jarvis, 1995; Rew, 2000; Rhoades *et al*., 2015); as well as increased cognitive development such as perspective-talking abilities and problem-solving skills (e.g. Maruyama, 2010). Evidence indicates that pet ownership can be a protective factor for children's and adolescents' development, though most research has been carried out in Western contexts and less research has been conducted in China (Melson, 2003; Su and Martens, 2017). Recently, there has been a rapid increase of pet ownership in China, so the influence of companion animals on Chinese children's and adolescents' physical and psychological health is worthy of investigation (Headey *et al*., 2008).

Pet ownership has the potential to promote children's physical health in various ways (Matchock, 2015). Both adults and children owning pets, especially dogs, are more likely to be physically active than those without pets (Parslow and Jorm, 2003; Timperio *et al*., 2008). In a study with healthy workers and homemakers aged 18–59 years, there was a positive association between dog ownership and walking duration, with dog owners walking an additional 180 min per week on average (Giles-Corti and Donovan, 2003). However, the actual benefits of pet ownership were also influenced by how much time and how much effort a person spends caring for or playing with pets in the family (Mathers *et al*., 2010). Additional benefits of pet ownership for adults include lower systolic blood pressure (Friedmann *et al*., 2013), higher levels of oxytocin (Curry *et al*., 2015), higher sleep quality, less risk for heart disease (McHarg *et al*., 1995), and better survival rates among patients with coronary artery disease (Friedmann and Thomas, 1995).

Despite the potential health benefits, there are health risks to interactions between children and companion animals. Previous

Affiliation: Clinical and Health Psychology, School of Health in Social Science, University of Edinburgh, Teviot Place, Edinburgh, UK, EH8 9AG

*Corresponding author: Xiaoshan Yin. Email: s1716195@sms.ed.ac.uk

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studies have shown mixed findings on associations between childhood pet exposure and asthma and allergic symptoms (Apelberg *et al*., 2001; Almqvist *et al*., 2003; Carlsen *et al*., 2012). A meta-analysis of 32 studies found that cat exposure had a slight preventative effect on asthma whereas exposure to dogs increased risk of asthma (Takkouche *et al*., 2008). A large-scale UK study reported that childhood pet ownership reduced risks of childhood aeroallergen sensitization and atopic asthma among children at 7 years old and increased risks of non-atopic asthma (Collin *et al*., 2015). However, another study of 22,000 children aged 6–10 found pet ownership in early life was neither related to increased nor reduced risk of asthma or allergic rhinitis (Carlsen *et al*., 2012).

Another common risk of pet companionship is childhood physical injuries induced by pets. Compared with adults, there is a higher incidence of dog-bite injuries in the paediatric populations (Shen *et al*., 2017). In 2013, there were an estimated >133,000 cases of dog-bite injuries among children under 18 years in the USA (Centers for Disease Control and Prevention, 2015). Studies also report higher incidences of dog-bite injuries among children and adults in some countries (Georges and Adesiyun, 2008; Si *et al*., 2008). There are multiple reasons why children are at a greater risk of such injuries than adults. First, due to physical development (including weak strength and short stature), children are more likely to become injured and are especially at high risk of facial injuries when playing with dogs (Bernardo *et al*., 2002; Hon *et al*., 2007). Furthermore, children's lack of safety knowledge may lead to impulsive behaviour when interacting with dogs, which may heighten the risk of injury (Shen *et al*., 2013). More dog bites occur between 4 PM and 8 PM when children could be hurt by others' dogs on their way back from school or interacting with their family dogs alone at home (Bernardo *et al*., 2002). Even though evidence highlights the risk of injuries children face from some pet animals, there is a lack of effective practices to reduce paediatric dog-bite injuries, especially in low- and middle-income countries (Shen *et al*., 2017).

Countering some of the evidence of risks, there has been a growing focus on the psychological impact of companion animals, especially on potential benefits (Bennett, 2011; McConnell *et al*., 2011). For instance, interacting with animals is beneficial to adults' and children's emotional and behavioural development (O'Haire, 2010; Purewal *et al*., 2017). Companion animals can have a positive effect on human mental, social, and physiological health (Friedmann and Son, 2009; Wells, 2009). Pets can facilitate positive social engagement and can also be calming and non-judgemental (Kruger and Serpell, 2010). It is plausible that companionship from animals creates a positive environment through the activation of the oxytocin system, which explains the reduction of negative emotions including stress and anxiety, as well as the promotion of social interaction and empathy (Beetz *et al*., 2012). Pets, especially the emotional attachments children form with their pets, create a positive impact on their development and wellbeing (Purewal *et al*., 2017; Muldoon *et al*., 2019). Companion animals have also been found to influence children's social and cognitive development (Poresky, 1996), form a social buffer for children with autism in socially stressful situations (O'Haire *et al*., 2015), and enhance communication between children and their families and friends (Marsa-Sambola *et al*., 2017).

Research to date, Western literature has indicated various physical and psychological health effects of pet ownership among children, but less is known about the role of companion animals play in the health and development of children in China. As pet ownership increases in China (Chan, 2018), it is time to systematically review and synthesize existing evidence and identify research gaps. The aim of this systematic review was to examine the health (including psychological health) effects of pet ownership among children in China for the first time. The review questions are:

1. What are the effects of interacting with companion animals on Chinese children's physical health?
2. What are the effects of interacting with companion animals on Chinese children's psychological health?

Methods

PROTOCOLS AND SEARCH STRATEGY

The systematic review was developed following The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page *et al*., 2021). Literature search of journal articles covering all dates up to 27th October 2021 was conducted in the following eight databases: Ovid EMBASE, MEDLINE, PsycINFO, Global Health (CABI), CAB Abstracts, Scopus, Web of Science, and China Academic Journals (CNKI). The search terms for all listed databases are provided in Table 1. Search terms for this systematic review were formulated through a comprehensive analysis of commonly used key terms in other systematic reviews pertaining to health and wellbeing impacts of HAI (Davis *et al*., 2015; Purewal *et al*., 2017; Gee and Mueller, 2019). Reference lists of reviewed studies were screened to identify further potentially eligible studies.

STUDY ELIGIBILITY CRITERIA

The following inclusion criteria were adopted to select relevant articles for review: (a) publication in either English or Chinese in a peer-reviewed journal, (b) original and empirical research topically focused on human-animal interaction among children in China. The Youth Population in China (2018) defines childhood as including adolescence (ages 10–19), while people in China usually use age one year older than their actual age. The current review included children as individuals up to 20 years old (see also Norbäck *et al*., 2007), (c) measuring relations between pet exposure and children's physical and/or psychological health, (d) sufficient information about the study could be accessed to enable quality appraisal. Studies focusing on children's interactions with wild animals were excluded in this review. Other review studies, grey literature, and duplicates were also excluded.

STUDY SELECTION

Data manager software (Rayyan QCRI) was used to collate articles and remove duplicates. Initial screening of titles and abstracts was

Table 1. Search terms used to identify the literature.

Category	Search terms
Age	"preteen*" OR "pre adolescen*" OR "infan" OR "minor*" OR "subteen*" OR "child*" OR "youth" OR "young*" "schoolchild" OR "juven*" OR "adol*"
Pet ownership/interactions	"pet" OR "pets" OR "dog" OR "dogs" OR "cat*" OR "cats" OR "canine*" OR "feline*" OR "equine*" OR "horse*" OR "bird*" OR "fragrant pig*" OR "pet pig" OR "aquarium*" OR "dolphin*" OR "goldfish*" OR "rabbit*" OR "hamster*" OR "corn snake*" OR "tortoise*" OR "animal assisted activit*" OR "animal assisted intervention*" OR "animal assisted therap*" OR "companion animal*" OR "service animal*" OR "interspecies interaction" OR "pet* ownership" OR "human-animal bond*" OR "human-animal interaction" OR "human-animal relationship"
China	"China" OR "Chinese" OR "Hongkong" OR "Macau"

completed by one reviewer (XY). Full-text papers were obtained and then assessed for eligibility by two reviewers (XY and JW), with conflicts being discussed and resolved or further discussed with PGM. The initial literature search resulted in 9731 papers from eight databases. First, the listed inclusion and exclusion criteria were used to assess the titles and abstracts. The health outcomes were not listed as search terms in the review process because we decided to include all kinds of effects of pet ownership on children's physical and psychological health. However, the reviewers applied the process of checking inclusion criteria of health outcomes in all the studies. Epidemiological studies on bacterial diseases from animals were excluded if the animals were wild animals or livestock animals rather than pets. After the primary eligibility assessment, 81 papers were included.

In the screening of full-text articles, the inclusion criteria were further checked, and disagreements were discussed by two reviewers (XY and JW). In this process, nine review studies, four studies involving wild animals, eight studies with the wrong population group, and one single case study were excluded. After discussion, we included studies on children's health primarily reported by their parents. Fifty-six studies met the eligibility criteria after the full-text screening and their reference lists were checked for further potentially relevant studies, which led to a further three studies being included. These 59 studies were selected for detailed data extraction. The process of study selection is listed in Fig. 1.

DATA EXTRACTION AND EVALUATION

Data was extracted with a purpose-developed data extraction form. The following data was extracted and summarized in Table 2: research topics, types of animals involved in the study, participant information (sample size, age, gender), study design, measurement of outcomes, and key findings of animal impacts on children's health.

Of all the selected studies, the risk of bias was assessed by two reviewers (XY and FL). The 14-item Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (NIH) (National

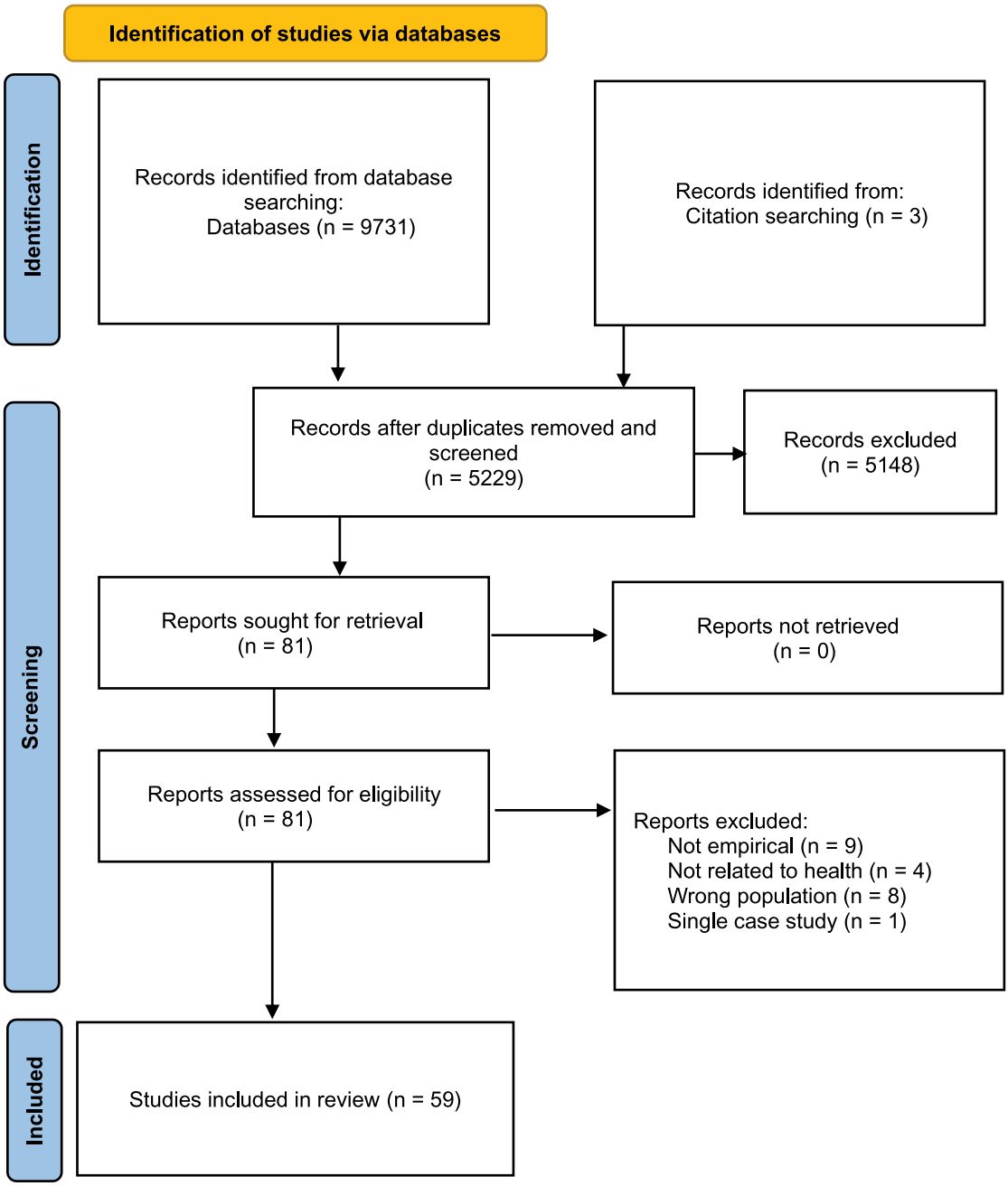

Fig. 1. PRISMA flow diagram of studies for inclusion in the systematic review to assess the psychological and health effects of pet ownership among children in China.

Heart, Lung, and Blood Institute, 2021) was used to assess the quality of the studies, with studies rated as good (over 60%), fair (being 50–60%), and poor (under 50%). The initial consistency rate of quality assessment from the two reviewers was 76.37%, with disagreements then discussed and agreed by those two reviewers (XY and FL). The results of the quality assessment are outlined in Tables 2 and 3.

Results

DESCRIPTIVE INFORMATION

The initial search identified 9731 publications (Fig. 1). After duplicates were removed, there were 5229 studies for screening and 5148 of them were removed during title and abstract screening. At full-text screening, 22 studies were excluded. Reference lists of the remaining studies were searched, and three additional studies were added. Full-text articles were available for 59 studies.

Articles included in this review were published between 2002 and 2021 (Fig. 2). Age of participants across all included studies ranged from 0 to 20 years. All the studies included both male and female participants (Table 2). In this review, 57 of 59 studies were devoted to children's physical health including asthma and allergic symptoms, *Toxoplasma gondii* infection, animal induced injuries, low birth weight and hypertension, and only two studies focused on children's psychological health. Findings are synthesized below in terms of different health outcomes.

PHYSICAL HEALTH OUTCOMES

Respiratory and allergic symptoms

Forty-seven publications investigated the impact of pet exposure on children's respiratory and allergy health, and the most frequently reported clinical health outcomes were asthma, wheezing, persistent cough or phlegm, rhinitis, eczema, common cold, fever, and allergens (Table 2). Six of these studies were unable to undergo quality appraisal because of their descriptive design and low quality of data analysis (Yang and Tan, 2006; Duan *et al*., 2011; Dong *et al*., 2012a; Lao and Pan, 2013; Qi *et al*., 2015; Xu *et al*., 2016). For study design, the remaining 41 included 35 cross-sectional studies, 4 case-control studies, 1 cohort study and 1 random controlled trial (RCT) study.

For the primary outcomes, 3 of 41 studies (Wang *et al*., 2016b; Cai *et al*., 2017; Fan *et al*., 2017) did not observe any association between pet keeping and respiratory symptoms and infections, allergic rhinitis, and eczema respectively. Twenty-six studies reported companion animals as potential risk factors for children because pet exposure increased the prevalence of respiratory and allergy symptoms including asthma, wheezing, phlegm, coughing, rhinitis, and allergens, as well as the common cold (Norbäck *et al*., 2017). In contrast, another three studies found pet exposure decreased the prevalence of allergic asthma cough, and even acted as a protective factor between environmental pollution and children's respiratory functions (Guo, 2013; Qian *et al*., 2014; Hu *et al*., 2020). Hu *et al*. (2020) reported in a cohort study with a strong methodology that although a child's parents owning a pet while the child was in utero increased the effect of environmental tobacco smoke (ETS) exposure on children's lung function impairment (e.g. with pets: OR=3.13; without pets: OR=1.07), current pet exposure reduced the lung function impairment induced by ETS exposure (e.g. with pets: OR=1.02; without pets: OR=1.10).

The reported associations between pet exposure and the prevalence of respiratory health and allergic diseases were not consistent across studies. The remaining nine studies, with more complex research designs examining pet effects on children's respiratory health at different stages of exposure (such as utero exposure, children's first-year exposure, early exposure, and current exposure), reported mixed outcomes. Two studies reported that there was no association between children's utero exposure to pets and lung function impairment, while current pet exposure was found to worsen children's lung function impairment (Hu *et al*., 2017; Yang *et al*., 2017). Hu *et al*. (2017) also reported that having more than one pet was associated with severe lung function impairment. Three studies agreed that long-term pet keeping decreased the prevalence of allergic rhinitis (Liu *et al*., 2013; Zhang *et al*., 2013; Lu *et al*., 2020a). It was reported that children's pet exposure at birth acted as a risk factor for wheezing and coughing, but early and current pet exposure acted as a protective factor doctor-diagnosed asthma (Luo *et al*., 2018) and diagnosed hay fever (Huang *et al*., 2013). However, one study reported that current exposure to furry pets was a protective factor for wheezing, and a risk factor for asthma (Huang *et al*., 2020), while another study reported that both current pet exposure and pet exposure in children's first year was associated with increased childhood eczema (Shi *et al*., 2021).

Animal induced injury

There were five studies exploring animal-induced injuries. Of the four cross-sectional studies investigating the impact of pet-induced injuries among Chinese children, two of them were at high risk of bias due to their unclear data recruitment strategies and descriptive study design (Liu *et al*., 2010; Song *et al*., 2014b). The other two studies were rated 'high quality' and consistently reported that pet exposure was associated with a higher risk of animal-induced injury, with dogs and cats being the main risk factors for children's pet-induced injuries in China (Shen *et al*., 2014; Chen *et al*., 2016). One study reported that exposure to cats was a risk for scratches on hands, while bite injuries were commonly caused by dogs (Chen *et al*., 2016). Chen *et al*. (2016) also reported that dog bites were usually caused by others' dogs, while cat-related injuries were caused by the victim-owned cat. Two studies found that most animal-induced injuries happened in spring and summer, especially from June to August (Liu *et al*., 2010; Shen *et al*., 2014). Shen's research team (Shen *et al*., 2014) also mentioned that children's dog bites tended to occur in the daytime, especially during the period when children travelled to or from school, and at times when children were unsupervised by adults.

One high-quality case-control study compared children with disabilities and those without and found that for children with pet cats and/or pet dogs, those with disabilities were more likely to be injured than children without impairments (Zhu *et al*., 2012). Along with the finding that companion animal-induced injuries are a health risk for children, a potential negative psychological health outcome is that children who had experienced dog bite injuries were subsequently less willing to approach dogs and were more fearful of dogs (Shen *et al*., 2014).

Toxoplasma gondii *infection*

Two studies focused on *T. gondii* infection-related factors including pet ownership. Results showed that contact with cats was a risk factor for increasing the prevalence of *T. gondii* infection among children (Duan *et al*., 2019; Wang *et al*., 2020). One high-quality study reported that although cats were risk factors for *T. gondii* infection among children, no association was found between *T. gondii* infection and contact with dogs (Duan *et al*., 2019).

Environmental health indicators

One cohort study reported that pet (dog) exposure during pregnancy was not associated with children's low birth weight (Lu *et al*., 2020).

Two cohort studies assessed the effects of pet ownership on blood pressure and hypertension of children in China. One study examined the interactive effects of pet exposure and air pollutants on hypertension and found that children exposed to pets during both utero and postnatal periods had lower blood pressure and lower prevalence of hypertension (Lawrence *et al*., 2018). However, this protective effect of pet exposure is more obvious among younger children (Lawrence *et al*., 2018). The other study observed that pet ownership was a protective factor for children

Table 2. Evidence for the psychological and health effects of pet ownership among children.

First Author (Year)	Research topic	Types of animals (% ownership)	Participants			Study design	Outcome measure	Outcome	Quality assessment
			Sample size	Age	Gender (% female)				
Zheng (2002)	Physical health (asthma)	Dog, cat, and others	806	6–10	41.0%	Case-control study	Questionnaire (The International Study of Asthma and Allergies in Childhood Questionnaires) (ISAAC)	Having both a dog and a cat at home was associated with a higher risk of childhood asthma (OR = 1.5; 95% CI, 1.0–2.3).	Good
Salo *et al.* (2004)	Physical health (indoor allergens and asthma)	Dog, cat, farm animals, and other animals (chicken, duck, cow, and pig)	4145	13–15	48.4%	Cross-sectional study	Questionnaire (American Thoracic Society questionnaire) (ATS)	Current pet exposure was associated with increased prevalence of cough (OR = 1.54; 95% CI, 1.12–2.11) and wheeze (OR = 1.41; 95% CI, 1.03–1.94), but not with ever-diagnosis of asthma (OR = 1.10; 95% CI, 0.76–1.58). Exposure to pets before the age of 6 was associated with increased cough (OR = 1.42; 95% CI, 1.04–1.94), wheeze (OR = 1.85; 95% CI, 1.34–2.55), and doctor-diagnosed asthma (OR = 1.61; 95% CI, 1.00–2.58). Associations of cough/wheeze and pet exposure were stronger among children who allowed animals to enter bedrooms.	Good
Yang and Tan (2006)	Physical health (asthma)	Dog (20.7%), cat (20.7%)	98	2–14	44.9%	Cross-sectional study	Insertion test on skin	20.7% of children reported dog as an allergen and 20.7% children reported cat as allergen.	Poor
Zhao *et al.* (2006)	Physical health (asthma and allergy)	Cat, dog, and furry pets	1993	11–15	49.3%	Cross-sectional study	Questionnaire (ISAAC)	In Chinese junior high school students, 1.2% reported cat allergy and 1.3% reported dog allergy. Compared with boys, girls reported higher prevalence of cat allergy (OR = 1.34; 95% CI, 0.61–2.79) and dog allergy (OR = 1.29; 95% CI, 0.87–2.41).	Good
Norbäck *et al.* (2007)	Physical health (asthma, eczema, and cat allergy)	Cat and dog	2116	9–20	50.0%	Cross-sectional study	Questionnaire (The European Community Respiratory Health Survey) (ECRHS)	1.7% reported cat allergy, and none reported dog allergy.	Good
Dong *et al.* (2008a)	Physical health (asthma)	Dog (10.1%), cat (3.2%), birds (6.8%), farm animals (4.7%), Other animals (5.1%)	16789	2–13	49.5%	Cross-sectional study	Questionnaire (ATS)	Exposure to pets was associated with increased risk of doctor diagnosed asthma (adjusted OR = 1.49; 95% 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).	Good
Dong *et al.* (2008b)	Physical health (respiratory health)	Dog, cat, and farm animals (bird, chicken, duck, and goose)	14729	1–13	50.4%	Cross-sectional study	Questionnaire (ATS)	Pet exposure was associated with increased prevalence of persistent cough, persistent phlegm, doctor-diagnosed asthma and current wheeze among both boys and girls, while exposure to cat was more associated with the asthma-related symptoms among girls.	Good

Continued

Table 1.2. Continued.

First Author (Year)	Research topic	Types of animals (% ownership)	Participants			Study design	Outcome measure	Outcome	Quality assessment
			Sample size	Age	Gender (% female)				
Dong *et al*. (2008c)	Physical health (respiratory health)	Dog, cat, and farm animals (bird, chicken, duck and goose)	3945	1–6	49.9%	Cross-sectional study	Questionnaire (ATS)	Pet exposure was associated with increased prevalence of persistent cough (OR = 1.93; 95% CI, 1.46–2.54), persistent phlegm (OR = 2.82; 95% CI, 1.9–4.02), and doctor-diagnosed asthma (OR = 1.45; 95% CI, 1.03–2.06). Exposure to dogs was strongly related to doctor-diagnosed asthma (OR = 2.57; 95% CI, 1.31–5.02).	Good
Dong *et al*. (2009)	Physical health (asthma)	Dog (10.9%), cat (4.9%), birds (5.8), farm animals (4.6%), other animals (5.0%)	12910	7–13	50.3%	Cross-sectional study	Questionnaire (ATS)	Pet exposure during mothers' pregnancy was associated with higher prevalence of doctor-diagnosed asthma (OR = 1.86; 95% CI, 1.35–2.57), current asthma (OR = 3.06; 95% CI, 1.95–4.81), wheeze (OR = 2.91; 95% CI, 2.10–4.03), and persistent phlegm (OR = 1.50; 95% CI, 1.01–2.26). Exposure to animals in the first year of life was associated with increased prevalence of current asthma (OR = 2.50; 95% CI, 1.69–3.70) and wheeze (OR = 2.29; 95% CI, 1.73–3.04). Current pet exposure was associated with increased prevalence of persistent cough (OR = 2.01; 95% CI, 1.72–2.33), persistent phlegm (OR = 2.59; 95% CI, 2.13–3.14), and doctor-diagnosed asthma (OR = 1.53; 95% CI, 1.28–1.84). Associations between the respiratory symptoms and animal exposure were stronger among children who allow pets to enter bedrooms.	Good
Xie *et al*. (2010)	Physical health (asthma)	Dog, cat, bird, chicken, duck, goose, and others	3244	8.15–11.73	50.5%	Cross-sectional study	Questionnaire (ATS)	Pet exposure was associated with increased prevalence of persistent cough (OR = 1.89; 95% CI, 1.30–2.76) and persistent phlegm (OR = 2.01; 95% CI, 1.22–3.33).	Fair
Dong *et al*. (2011)	Physical health (respiratory health)	Dog (5.5%), cat (4.9%), bird (4.6%), farm animal (3.5%) others (5.0%)	8819	2.2–6.7	49.3%	Cross-sectional study	Questionnaire (ATS)	Pet exposure during mothers' pregnancy was associated with increased current wheeze (OR = 1.80; 95% CI 1.17–2.77) and allergic rhinitis (OR = 2.52; 95% CI, 1.43–4.44). Exposure to animals in the first year of life was associated with increased prevalence of doctor-diagnosed asthma (OR = 1.80; 95% CI, 1.19–2.73), current asthma (OR = 2.39; 95% CI, 1.41–4.08), and asthma-related symptoms. Current animal exposure was associated with increased persistent cough. Children with two or more animals were more likely to report persistent phlegm than were those who had only one animal.	Good
Duan *et al*. (2011)	Physical health (asthma)	Dog and cat	180	5–13	28.9%	Cross-sectional study	Skin prick test (SPT)	For children with asthma, 47.1% reported dog as allergens and 32.8% reported cat as allergens.	Poor
Leung *et al*. (2011)	Physical health (asthma)	Dog and cat	115	5–18	41.0%	Cross-sectional study	SPT test	Cat and/or dog exposure was associated with increased prevalence of asthma and asthma-related symptoms (P<0.001).	Good

Dong *et al*. (2012a)	Physical health (allergens and asthma)	Dog and cat	402	4–10	49.3%	Case-control study	SPT test	Cat allergy was associated with increased prevalence of asthma (P=0.030).	Poor
Dong *et al*. (2012b)	Physical health (respiratory disease)	Dog (6.0%), cat (5.0%), birds (3.1%), farm animals (2.1%), other pets (3.4%)	31049	2.2–13.4	49.5%	Cross-sectional study	Questionnaire (ATS)	For children without allergic predisposition, pet exposure during pregnancy was associated with increased prevalence of persistent phlegm (OR = 1.53; 95% CI, 1.04–2.26), doctor-diagnosed asthma (OR = 1.58; 95% CI, 1.12–2.24), current asthma (OR = 2.27; 95% CI, 1.04–2.26), and current wheeze (OR = 2.27; 95% CI, 1.62–3.17). Moreover, pet exposure in the first year was associated with increased doctor-diagnosed asthma (OR = 1.59; 95% CI, 1.19–2.13), current asthma (OR = 3.05; 95% CI, 2.05–4.53) and current wheeze (OR = 2.31; 95% CI, 1.74–3.07). Current pet exposure was associated with increased persistent cough (OR = 1.60; 95% CI, 1.43–1.78), persistent phlegm (OR = 1.89; 95% CI, 1.64–2.19), doctor-diagnosed asthma (OR = 1.46; 95% CI, 1.27–1.67), and current wheeze (OR = 1.29; 95% CI, 1.12–1.50). For children with allergic predisposition, pet exposure during pregnancy was associated with increased current wheeze (OR = 2.03; 95% CI, 1.16–3.53). Pet exposure in the first year was associated with increased persistent phlegm (OR = 1.82; 95% CI, 1.06–3.53) and current wheeze (OR = 1.62; 95% CI, 1.02–2.57). Current pet exposure was associated with increased persistent cough (OR = 1.44; 95% CI, 1.17–1.78) and persistent phlegm (OR = 1.96; 95% CI, 1.52–2.53).	Good
Huang (2012)	Physical health (chronic cough)	Pets	245	3–14	43.3%	Random controlled trial (RCT)	Clinical diagnoses	Pet exposure was associated with increased prevalence of chronic cough (P=0.012).	Good
Liu *et al*. (2012)	Physical health (asthma)	Pets	6278	2–14	40.2%	Cross-sectional study	Questionnaire (ATS)	Pet exposure was associated with increased prevalence of persistent cough, persistent phlegm, and allergic rhinitis, but presented no association with childhood asthma and doctor-diagnosed asthma. Sleeping with pets was associated with increased prevalence of asthma (P<0.05). Pet exposure at mothers' pregnancy and at before 2 was associated with increased prevalence of allergic rhinitis and wheeze.	Good
Wang *et al*. (2012)	Physical health (allergic rhinitis)	Dog and cat	626	4–14	49.0%	Cross-sectional study	SPT test	In children with allergic rhinitis, 7.03% of all reported cat allergy and 11.98% of all reported dog allergy.	Fair
Guo (2013)	Physical health (allergic asthma)	Dog and cat	225	2–5	43.5% allergic group, 42.9% control group	Case-control study	Questions asking	Pet ownership was associated with decreased allergic asthma cough (OR = 0.391; 95% CI, 0.223–0.688).	Fair

Continued

Table 1.2. Continued.

First Author (Year)	Research topic	Types of animals (% ownership)	Participants			Study design	Outcome measure	Outcome	Quality assessment
			Sample size	Age	Gender (% female)				
Huang *et al*. (2013)	Physical health (asthma and allergies)	Dog, cat, rodent, rodent, fish, and others	13335	4–6	49.1%	Cross-sectional study	Questionnaire (ISAAC)	Persistent furry pet keeping (pet keeping at birth and currently) was associated with decreased rhinitis (OR = 0.91; 95% CI, 0.77–1.10) and eczema (OR =0.85; 95% CI, 0.67–1.07). Current furry pet keeping was associated with decreased doctor-diagnosed asthma (OR = 0.64; 95% CI, 0.47–0.88), and diagnosed hay fever doctor-diagnosed asthma (OR = 0.71; 95% CI, 0.54–0.93). Early pet exposure at birth was associated with increased wheeze (OR = 1.40; 95% CI, 1.16–1.69) and cough during night (OR = 1.32; 95% CI, 1.07–1.62). Fish keeping was significantly associated with increasing all symptoms.	Good
Lao and Pan (2013)	Physical health (respiratory symptoms)	Pets	250	0–7	47.2%	Case-control study	Clinical diagnoses	Pet exposure was associated with increased prevalence of respiratory infection (P=0.01).	Poor
Liu *et al*. (2013)	Physical health (respiratory health)	Dog, cat, bird, chicken, duck, or goose	6730	3–7	46.6%	Cross-sectional study	Questionnaire (ATS)	Pet exposure was a protective factor for persistent cough (OR = 0.85), asthma symptoms (OR = 0.97), current asthma (OR = 0.81), wheeze (OR = 0.89), and allergic rhinitis (OR = 0.90), but risk factor for persistent phlegm (OR = 1.08).	Good
Ma *et al*. (2013)	Physical health (asthma)	Furry pets	8733	0–12	49.4%	Cross-sectional study	Questionnaire (ATS)	For children susceptible to asthma, keeping pets was associated with increased prevalence of persistent cough (OR = 1.6; 95% CI, 1.2–2.1) and persistent phlegm (OR = 2.2; 95% CI, 1.6–3.1). For non-susceptible children, keeping pets was associated with increased prevalence of asthma (OR = 1.6; 95% CI, 1.1–2.3), persistent cough (OR = 1.6; 95% CI, 1.2–2.0), persistent phlegm (OR = 2.1; 95% CI, 1.5–2.9), and wheeze (OR = 1.4; 95% CI, 1.1–1.7).	Good
Zhang *et al*. (2013)	Physical health (asthma and rhinitis)	Pets	2193	1–8	47.3%	Cross-sectional study	Questionnaire with combined questions from ISAAC, Dampness in Buildings and Health (DBH) and Bulgarian ALLHOME study questions)	Pet exposure was not associated with doctor-diagnosed asthma (P=0.927), while pet exposure was associated with increased prevalence of doctor-diagnosed allergic rhinitis (adjusted OR = 1.60; 95% CI, 1.20–2.13).	Good
Zhao *et al*. (2013)	Physical health (respiratory disease and symptoms)	Furry pets	8798	5–11	49.4%	Cross-sectional study	Questionnaire (ATS)	Pet exposure during mothers' pregnancy was associated with an increased prevalence of allergic rhinitis (OR = 2.30; 95% CI, 1.54–3.44). Current pet exposure was associated with increased prevalence asthma (OR = 1.62; 95% CI, 1.30–2.02), persistent cough (OR = 1.85; 95% CI, 1.54–2.21), persistent phlegm (OR = 2.48; 95% CI, 1.96–3.14), and allergic rhinitis (OR = 1.34; 95% CI, 1.03–1.70).	Good
Zhou *et al*. (2013)	Physical health (asthma)	Pets	3473	8.06–11.44	49.5%	Cross-sectional study	Questionnaire (ATS)	Pet exposure was associated with increased prevalence of persistent cough (OR = 1.08; 95% CI, 0.73–1.61).	Fair

Liu *et al*. (2014)	Physical health (asthma)	Dog, cat, bird, chicken, duck, and goose	23326	6–13	49.7%	Cross-sectional study	Questionnaire (ATS)	Exposure to pet in home was associated with increased prevalence of persistent cough (OR = 1.73; 95% CI, 1.55–1.93), persistent phlegm (OR = 2.04; 95% CI, 1.77–2.35), diagnosed asthma (OR = 2.04; 95% CI, 1.77–2.35), current asthma (OR = 1.44; 95% CI, 1.26–1.64), and current wheeze (OR = 1.22; 95% CI, 1.05–1.41).	Good
Qian *et al*. (2014)	Physical health (respiratory health)	Dog (5.4%), cat (4.5%)	31049	2–12	55.9%	Cross-sectional study	Self-designed questionnaire	Dog ownership was associated with lower prevalence of childhood current asthma and wheeze among children under impacts of air pollution. There was no effect of cat ownership and air pollution interaction.	Good
Song *et al*. (2014a)	Physical health (asthma, rhinitis, and eczema)	Dog and cat	10338	6–18	50.7%	Cross-sectional study	Questionnaire (ISAAC)	Pet exposure was associated with increased wheezing with exercise (OR = 1.6; 95% CI, 1.2–2.0), rhinitis (OR = 1.6; 95% CI, 1.4–1.8), and chronic rash in the past year (OR = 1.4; 95% CI, 0.7–2.6).	Good
Huang *et al*. (2015)	Physical health (asthma)	Pets	122	2–13	46.7%	Case-control study	Clinical diagnoses	Pet exposure was associated with increased prevalence of childhood asthma (OR = 3.362).	Good
Qi *et al*. (2015)	Physical health (allergic rhinitis)	Dog and cat	412	3–14	42.0%	Cross-sectional study	SPT test	In children with allergic rhinitis, 62.31% of all reported cat allergy and 43.16% of all reported dog allergy.	Poor
Wang *et al*. (2016b)	Physical health (rhinitis)	Furry pets	13335	4–6	49.1%	Cross-sectional study	Questionnaire (ISAAC)	No association was found between current furry pet exposure and allergic rhinitis (OR = 1.04; 95% CI, 0.91–1.91) and rhinitis symptoms (OR = 1.08; 95% CI, 0.98–1.18).	Good
Wang *et al*. (2016a)	Physical health (asthma and related symptoms)	Pets	330	0–2	50.0%	Cross-sectional study	Clinical diagnoses	Pet exposure was reported as allergen (OR = 6.854; 95% CI, 1.065–44.110).	Good
Xu *et al*. (2016)	Physical health (asthma)	Dog, cat, bird, pig, horse, and cow	13877	0–14	36.7%	Cross-sectional study	Questionnaire with combined questions from ISAAC and National Epidemiology study of Asthma and Allergies in China (NEAAC)	Pet exposure was associated with increased the prevalence of asthma (P=0.013).	Poor
Cai *et al*. (2017)	Physical health (atopic eczema)	Furry pets	13335	4–6	49.2%	Cross-sectional study	Questionnaire (ISAAC)	No association was found between furry pet exposure and eczema in the past year before the survey or eczema in lifetime.	Good
Fan *et al*. (2017)	Physical health (asthma)	Dog and cat	2134	11–15	50.6%	Cross-sectional study	Questionnaire (not mentioned)	No association was found between keeping a cat (P=0.717) or a dog at home (P=0.848) and respiratory symptoms or respiratory infections.	Good

Continued

Table 1.2. Continued.

First Author (Year)	Research topic	Types of animals (% ownership)	Participants			Study design	Outcome measure	Outcome	Quality assessment
			Sample size	Age	Gender (% female)				
Hu *et al*. (2017)	Physical health (lung function)	Dog, cat, bird, farm animal, and others	6740	7–14	49.8%	Cross-sectional study	Electronic spirometers	No association was found between children's pet exposure in utero and lung function impairment. Current pet exposure was associated with increased lung function impairment (OR = 1.43; 95% CI, 1.18–1.74), especially exposure to dogs (OR = 1.72; 95% CI, 1.29–2.29) and birds (OR = 1.78; 95% CI, 1.31–2.41). Having more than 1 pet was associated with severe lung function impairment (OR = 1.78; 95% CI, 1.31–2.41). Girls had higher prevalence of lung function impairment with pet exposure.	Good
Norbäck *et al*. (2017)	Physical health (common cold)	Dog (4%) cat (2%)	39782	3–6	48.0%	Cross-sectional study	Self-designed questions	Perinatal dog keeping was associated with increased prevalence of common cold duration (OR = 1.22; 95% CI, 1.06–1.41), and perinatal cat keeping (OR = 1.39; 95% CI, 1.09–1.78) and current cat keeping (OR = 1.31; 95% CI, 1.02–1.68) were associated with more frequent common cold in southern China.	Good
Yang *et al*. (2017)	Physical health (lung function)	Dog, cat, bird, chicken, duck, goose, pig, lizard, and snake	6280	7–14	50.5%	Cross-sectional study	Questionnaire (ATS)	Utero exposure to pets was not related to children's lung function impairment (OR = 1.09), However, Pets ownership impaired lung function of children without asthma (OR = 1.32).	Good
Luo *et al*. (2018)	Physical health (asthma and allergy)	Dog (14.7%), cat (4.0%), rodent (2.0%), bird (2.5%), fish (3.2%)	7360	0–8	48.1%	Cross-sectional study	Questionnaire with combined questions from ISAAC and DBH	Pet keeping in early childhood was associated with increased prevalence of current wheeze (OR = 1.70; 95% CI, 0.77–1.10), current dry cough (OR = 1.32; 95% CI, 0.96–1.84), and diagnosed rhinitis (OR = 1.06; 95% CI, 0.71–1.57), but associated with decreased diagnosed asthma (OR = 0.85; 95% CI, 0.48–1.53).	Good
Hu *et al*. (2020)	Physical health (lung function)	Dog, cat, farm animals, and other animals	6740	7–14	48.8%	Cohort study	Electronic spirometers	Pet ownership in utero was associated with increased effect of environmental tobacco smoke (ETS) exposure on children's lung function impairment (e.g. with pets: OR=3.13; without pets: OR=1.07). Current pet exposure was associated with reduced lung function impairment induced by ETS exposure (e.g. with pets: OR=1.02; without pets: OR=1.10).	Fair
Huang *et al*. (2020)	Physical health (asthma, rhinitis, and wheeze)	Furry pets	2214	3–6	49.2%	Cross-sectional study	Questionnaire (DBH)	Furry pet exposure was a protective factor for wheeze (OR = 0.70; 95% CI, 0.44–1.12), and a risk factor for asthma (OR = 2.12; 95% CI, 1.15–3.9) and rhinitis (OR = 1.27; 95% CI, 0.74–2.20).	Good
Lu *et al*. (2020a)	Physical health (wheeze and rhinitis)	Cat and dog	39782	3–6	48%	Cross-sectional study	Questions on clinical diagnoses	Cat keeping (OR = 1.62; 95% CI, 1.12–2.37) and dog keeping (OR = 2.28; 95% CI, 1.79–2.89) were risk factors for furry pets related respiratory symptoms, while cat keeping (OR = 0.73; 95% CI, 0.50–1.05) and dog keeping (OR = 0.78; 95% CI, 0.62–1.00) were protective factors of other diagnosed rhinitis.	Good

Norbäck *et al*. (2021)	Physical health (wheeze, rhinitis & eczema symptoms)	Dog (7.5%) and cat (1.9%)	3606	3–6	48%	Cross-sectional study	Questionnaire (ISAAC)	Only dog keeping was associated with increased prevalence of wheeze (OR = 1.69 95% CI, 1.09–2.65) and eczema (OR = 2.14; 95% CI, 1.06–4.36).	Fair
Shi *et al*. (2021)	Physical health (eczema)	Pets	8153	2–8	48%	Cross-sectional study	Questionnaire with questions combined from DBH and previous study	Current pet exposure (OR = 1.23; 95% CI, 1.01–1.51), and pet exposure at children's first year was associated with increased childhood eczema (OR = 1.45; 95% CI, 1.14–1.85).	Good
Zhang *et al*. (2021a)	Physical health (allergic rhinitis)	Pets	284	3–6	Allergic rhinitis (40%), control group (36.36%)	Case-control study	Clinical diagnoses and SPT test	Pet exposure was associated with increased prevalence of allergic rhinitis (OR = 2.075; 95% CI, 1.029–4.109).	Fair
Zhang *et al*. (2021b)	Physical health (asthma and asthma-related symptoms)	Cat, dog, bird, and poultry (chickens, ducks, and geese)	11611	3–6	47.6%	Cross-sectional study	Questionnaire (ATS)	Cat keeping was associated with increased risk of persistent cough (OR = 1.77; 95% CI, 1.03–3.05). Sleeping with pets was associated with increased prevalence of persistent cough (OR = 3.32; 95% CI, 1.01–10.91), persistent phlegm (OR = 5.22; 95% CI, 1.24–21.99), doctor-diagnosed asthma (OR = 3.57; 95% CI, 1.47–8.65), and current asthma (OR = 4.27; 95% CI, 1.02–17.96). Exposure to pets before 2 was associated with increased prevalence of current asthma (OR = 1.84; 95% CI, 1.07–3.14)	Fair
Liu *et al*. (2010)	Physical health (animal induced injuries)	Dog and cat	2408	6–14	51.1%	Cross-sectional study	Questions	Children's inappropriate interactions with dogs and cats was associated with increased prevalence of rabies (9.22%). Boys presented higher prevalence on rabies than girls (P=0.0319).	Poor
Zhu *et al*. (2012)	Physical health (non-fatal injuries)	Dog and cat	2402	1–14	32.8%	Case control study (interview)	Questions	Children with disabilities whose family raised cat/dog(s) were more likely to be injured (OR = 1.76; 95% CI, 1.02–3.02). For children without disabilities, those whose family had cat/dog(s) were over three times more likely to having injuries comparing with those whose family did not have any cat/dog.	Good
Shen *et al*. (2014)	Physical health (dog-bite injuries)	Dog	101	2–17	34.7%	Cross-sectional study (interview)	Structured interview	Children's dog bites often occurred during daytime, especially in spring and summer, and occurred most often when children were alone with peers. Dog that bites children were often unleashed. Caregivers attributed the injury to children's behaviour (children were naughty or careless, had poor knowledge about safety interaction with dogs.	Good
Song *et al*. (2014b)	Physical health (rabies cases)	Dog, cat and others	5088	0–15	Not reported	Cross-sectional study	Questions	The rabies cases in children accounted for 21.3% of the total number of rabies cases in China, 97.0% of these cases occurred in rural areas, mainly caused by dogs (81.5%), and were primarily level III exposure (47.7%). Furthermore, 25.4% of cases adopted incorrect treatments such as extruding bleed and wound closure, cases vaccinated with 5 injections accounted for only 22.5%.	Poor

Continued

Table 1.2. Continued.

First Author (Year)	Research topic	Types of animals (% ownership)	Participants			Study design	Outcome measure	Outcome	Quality assessment
			Sample size	Age	Gender (% female)				
Chen *et al*. (2016)	Physical health (dog and cat induced injuries)	Dog (8.1%) and cat (7.4%)	9308	6–19	49.5%	Cross-sectional study	Questionnaire	Previous pet ownership was associated with higher risk of animal induced injuries (OR = 1.33; 95% CI, 1.10–1.61). Current cat exposure usually caused scratches on hand (OR = 3.32; 95% CI, 2.59–1.51), while bites were commonly caused by current dog exposure (*P*=0.505) (OR = 1.11; 95% CI, 0.82–1.51).	Good
Duan *et al*. (2019)	Physical health (*Toxoplasma gondii* infection) (*T. gondii*)	Dog and cat	628	0–14	63.3%	Case control study	The enzyme immunoassay kits (ELISA)	Cat was associated with increased prevalence of *T. gondii* infection both in children with lymphoma (OR = 2.5; 95% CI, 1.4–4.5) and children without lymphoma (OR = 2.5; 95% CI, 1.2–5.4).	Fair
Wang *et al*. (2020)	Physical health (*T. gondii*)	Cat	2451	6–11	47.4%	Cross-sectional study	ELISA kits	Cat was associated with increased prevalence of *T. gondii* infection (12.23% among children who contacted with cats and 7.66% among children who had not contacted with cats).	Poor
Lu *et al*. (2020b)	Physical health (Low birth weight)	Dog (5%)	3509	0–7	46.0%	Cohort study	Questionnaires	No association was found between lower birth weight and household pet exposure (dogs) during pregnancy (*P*=0.102).	Good
Lawrence *et al*. (2018)	Physical health (hypertension)	Pets	9354	5–17	48.7%	Cohort study	Blood pressure measure equipment	Pet ownership modified the association between air pollutants on elevated arterial blood pressure and hypertension in children and was acted as a protective factor on hypertension.	Good
Xu *et al*. (2020)	Physical health (hypertension)	Dog, cat, bird, farm animal and others	9354	5–17	49.0%	Cohort study	Blood pressure measure equipment	Pet exposure is a protective factor on the effects of environmental tobacco smoke on children potentially acts as a factor to protect against the development of hypertension in children.	Good
Ji *et al*. (2010)	Mental health (PTSD)	Dog (82.1%), cat (7.0%), rabbits (5.3%), guinea pig (3.4%), and rat (2.2%)	358	6.6–12.2	60.9%	Cohort study	Questionnaire	Pet induced injuries was risk factor for the development of post-traumatic stress disorder (PTSD).	Good
Fung (2019)	Mental health (reading ability and physiological response)	Dog	15		13.3%	Pre-test and post-test design	Different reading assessment	Pet companions increased reading speed and speeded reading accuracy and decreased stress level.	Good

Table 3. Evidence for the psychological and health effects of pet ownership among children.

	Research question	Study population (clearly specified)	Study population (participation rate)	Groups recruited from the same popula-tion and uniform	Sample size justification	Exposure assessed prior to outcome measure-ment	Sufficient timeframe to see an effect	Different levels of the expo-sure of interest	Exposure measures and assess-ment	Repeated exposure assess-ment	Outcome mea-sures	Blinding of outcome assessors	Follow up rate	Statisti-cal analyses	Overall
Zheng (2002)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	NR	Y	Good
Salo *et al*. (2004)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Yang and Tan (2006)	N	Y	Y	N	N	N	N	Y	Y	N	Y	N	N	N	Poor
Zhao *et al*. (2006)	Y	Y	Y	N	Y	N	N	Y	Y	N	Y	Y	NR	Y	Good
Norbäck *et al*. (2007)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Dong *et al*. (2008a)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Dong *et al*. (2008b)	Y	Y	Y	N	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Dong *et al*. (2008c)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Dong *et al*. (2009)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Xie *et al*. (2010)	Y	N	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Fair
Dong *et al*. (2011)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Duan *et al*. (2011)	Y	Y	Y	N	N	N	N	Y	Y	N	Y	N	N	N	Poor
Leung *et al*. (2011)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	NR	Y	Good
Dong *et al*. (2012a)	Y	Y	Y	N	N	N	N	Y	Y	N	Y	N	NR	N	Poor
Dong *et al*. (2012b)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Huang (2012)	Y	Y	Y	N	Y	N	N	Y	Y	N	Y	Y	NR	Y	Good
Liu *et al*. (2012)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Wang *et al*. (2012)	Y	Y	Y	Y	N	N	N	Y	Y	N	Y	N	NR	Y	Fair
Guo (2013)	Y	Y	Y	Y	Y	N	N	N	Y	N	Y	N	NR	Y	Fair
Huang *et al*. (2013)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Lao and Pan (2013)	Y	Y	Y	N	Y	N	N	Y	Y	N	Y	N	NR	Y	Poor
Liu *et al*. (2013)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good

Continued

Table 1.3 Continued.

	Research question	Study population (clearly specified)	Study population (participation rate)	Groups recruited from the same population and uniform	Sample size justification	Exposure assessed prior to outcome measurement	Sufficient timeframe to see an effect	Different levels of the exposure of interest	Exposure measures and assessment	Repeated exposure assessment	Outcome measures	Blinding of outcome assessors	Follow up rate	Statistical analyses	Overall
Ma *et al*. (2013)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Zhang *et al*. (2013)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Zhao *et al*. (2013)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Zhou *et al*. (2013)	Y	Y	Y	Y	Y	N	N	N	Y	N	Y	N	NR	Y	Fair
Liu *et al*. (2014)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Qian *et al*. (2014)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Song *et al*. (2014a)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Huang *et al*. (2015)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Qi *et al*. (2015)	Y	Y	Y	N	N	N	N	Y	Y	N	Y	N	N	N	Poor
Wang *et al*. (2016b)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Wang *et al*. (2016a)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Xu *et al*. (2016)	Y	Y	Y	Y	N	N	N	Y	Y	N	Y	N	NR	N	Poor
Cai *et al*. (2017)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Fan *et al*. (2017)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Hu *et al*. (2017)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Norbäck *et al*. (2017)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Yang *et al*. (2017)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Luo *et al*. (2018)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Hu *et al*. (2020)	Y	Y	Y	N	Y	N	N	Y	Y	N	Y	N	NR	Y	Fair
Huang *et al*. (2020)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Lu *et al*. (2020a)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	NR	Y	Good
Norbäck *et al*. (2021)	Y	Y	Y	NR	Y	N	N	Y	Y	N	Y	N	NR	Y	Fair
Shi *et al*. (2021)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	NR	Y	Good

Zhang *et al*. (2021a)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Fair
Zhang *et al*. (2021b)	Y	Y	Y	N	Y	N	N	Y	Y	N	Y	N	NR	Y	Fair
Liu *et al*. (2010)	Y	Y	Y	Y	N	N	N	Y	Y	N	Y	N	NR	N	Poor
Zhu *et al*. (2012)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Shen *et al*. (2014)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Song *et al*. (2014b)	Y	Y	N	N	N	N	N	Y	Y	N	Y	N	NR	N	Poor
Chen *et al*. (2016)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Duan *et al*. (2019)	Y	Y	Y	N	Y	N	N	Y	Y	N	Y	N	NR	Y	Fair
Wang *et al*. (2020)	Y	Y	Y	N	Y	N	N	Y	Y	N	Y	N	NR	N	Poor
Lu *et al*. (2020b)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Lawrence *et al*. (2018)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	NR	Y	Good
Xu *et al*. (2020)	Y	Y	Y	Y	Y	Y	NR	Y	Y	N	Y	Y	NR	Y	Good
Ji *et al*. (2010)	Y	Y	Y	Y	Y	Y	Y	Y	Y	NR	Y	N	NR	N	Good
Fung (2019)	Y	Y	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	N	Good

Note: Dark shading = Y(yes), Good; mid-shading = N(no), Fair; and light-shading=NR(not reported), Poor.

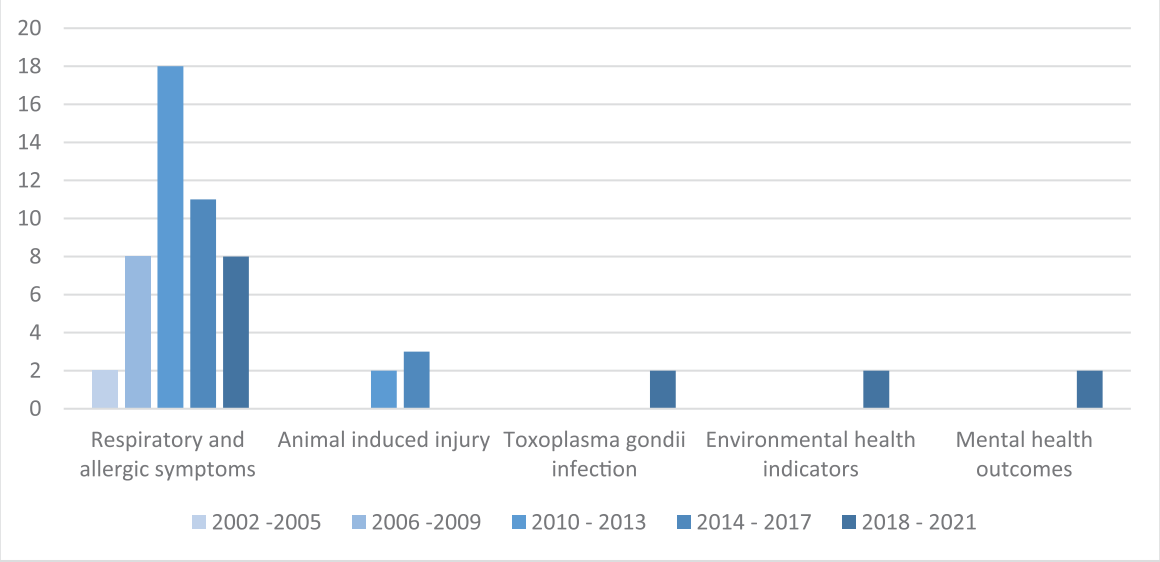

Fig. 2. Bar chart of studies published timeline: The change of studies amounts on different outcomes in each period.

experiencing strong effects of environmental tobacco smoke (Xu *et al*., 2020). To be more specific, the negative impacts of environmental tobacco smoke exposure on children in utero only happened in children without pets, and the modified impacts of pet ownership were more robust for girls than boys, for younger children than older ones (Xu *et al*., 2020).

Psychological health outcomes

Only two studies, which were both rated as high quality, reported the impacts of pet ownership on children's psychological health and development (Ji *et al*., 2010; Fung, 2019). One study investigated post-traumatic stress disorder in children who had experienced animal-induced injuries and found that children with autism spectrum disorder (ASD) were more likely to experience severe injuries compared to other children (Ji *et al*., 2010). It was also found that children were at risk of post-traumatic stress disorder after experiencing severe animal attacks and that psychological support for those with animal-induced injuries is needed (Ji *et al*., 2010). The other study was a pilot study designed to assess the effectiveness of a canine-assisted intervention on children's reading ability and other psychological outcomes in Hong Kong, China (Fung, 2019). The results showed that a canine-assisted read-aloud programme improved children's reading speed and speed-reading accuracy but had no effect on children's current reading accuracy (Fung, 2019).

RISK OF BIAS

Risk of bias was appraised using The Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (NIH), the results of which are listed in Table 2 and the risk of bias assessment has been listed in Table 3. Fifty-nine studies were all independently assessed by two reviewers. The consistency rate of independent quality assessment from two reviewers is 76.37%, and disagreements were discussed and reunified by two reviewers (XY and FL) with a total agreement of 100%.

Most studies were judged to be at high risk of bias in terms of blinding between outcome and exposure assessment due to their use of self-reported questionnaire measurements. Fourteen studies did not meet the criteria of groups recruited from the same population and uniform eligibility because their participants were not recruited during the same time period. Moreover, there was a high risk of bias in terms of exposure assessed prior to outcome measurement, sufficient timeframe to see an effect, repeated exposure assessment, and the follow-up rate for all cross-sectional studies and some of the cohort studies.

Nine studies were assessed to be of poor quality because they did not meet the quality criteria due to their descriptive study design and low-quality of data analysis. Nine studies were assessed as of fair quality. Forty-one studies were appraised to be of good quality. All these studies clearly stated and specified their research aim or research questions and study population. Most studies provided sample size justification, power description, or effect estimates. Moreover, the exposure and outcome measures are clear in most of the studies assessed as good quality.

Discussion

To the best of our knowledge, this is the first systematic review to synthesize published research on the effects of interactions with companion animals on children's physical and psychological health in China. Meta-analysis was not possible due to the heterogeneity of measures across a wide variety of health outcomes. To be more specific, outcome measures across these studies included different types of questionnaires, interviews, skin prick tests, clinical diagnoses which were not specified, electronic spirometers, and other biological testing tools, as shown in Table 2. Therefore, it was not feasible to conduct a meta-analysis in this study. Most current studies assessed the impact of pets on Chinese children's physical health, including respiratory and allergy symptoms, pet-induced injuries, and *T. gondii* affections, along with one study reporting no association between pet exposure and children's low birth weight. However, there was evidence of an emerging trend in Chinese studies to examine the potential psychological effects of pet exposure.

The potential risks of pet exposure to children were respiratory and allergy outcomes, animal-induced injuries, and *T. gondii* infection. However, the impact of companion animals on children's respiratory and allergy outcomes is complicated depending on the timing of exposure and types of pets. For respiratory symptoms, this review found that pet exposure could be a risk factor for wheezing and coughing, but a protective factor for doctor-diagnosed asthma (Luo *et al*., 2018) and hay fever (Huang *et al*., 2013). Bornehag *et al*. (2003) argued that this kind of protection comes along with one's avoidance behaviour after knowing the potential risks of contact with animals. For allergens, pet-induced allergies from children's direct and indirect contact with pets' fur and dander were found in this review (see also Apfelbacher *et al*., 2016). Even though it

was mentioned in one study that canine exposure during perinatal stages could support the development of infants' immune system tolerance due to exposure to mixed aeroallergens at early ages (Chen *et al*., 2010), most studies in this review reported that current pet exposure increased the prevalence of respiratory and allergy symptoms, as well as the common cold (Dong *et al*., 2012a, b; Norbäck *et al*., 2017).

It is important to note that although pet exposure was viewed as an environmental risk in most studies, in some studies, it was also reported as a protective factor between environmental pollution such as air pollution and environmental tobacco smoke, and children's respiratory function (Qian *et al*., 2014; Hu *et al*., 2020). In addition to exposure timing and pet type, potential behaviours such as having more than one pet, allowing pets into the bedroom, and sleeping with pets also increased the risks to respiratory health (Salo *et al*., 2004; Dong *et al*., 2009, 2011). Instead of limiting children's contact with companion animals, it is more important for children and parents to consider the timing of introducing pets into the family and the types of pets involved. Moreover, another suggestion of this review is to keep pets in communal living areas of homes and decrease instances of direct skin contact such as sleeping with pets, to minimize risks to respiratory health.

Children's interactions with animals and parental monitoring of these interactions can also impact the potential risks of pet-induced injuries. It was found in the review that pet exposure is a potential risk factor for animal-induced injuries in China, especially among younger children. One of the reasons that led children to become vulnerable to animal-induced injuries and rabies was inappropriate behaviour when playing with dogs and cats (Liu *et al*., 2010). It was also suggested that caregivers failure to recognize the importance of educating children on safety behaviours was a factor in animal-induced injuries, which was also mentioned in a Canadian study of parenting style and children's injuries (Morrongiello *et al*., 2006). Moreover, an increased risk of pet-induced injuries also occurs when children are alone or with peers and not supervised by caregivers (Shen *et al*., 2014). It was also noted in this review that boys had more instances of animal-induced injuries than girls (Chen *et al*., 2016), which might be because boys are more impulsive than girls with higher frequencies of sensation-seeking (Balan and Lingam, 2012). Another behaviour that increased the risk of bites among pet owners in China was dogs being unleashed, both at home and in public (Shen *et al*., 2014). In this case, more education for pet owners on dog care and canine behaviour management is needed to prevent potential injuries to children. A 36 min video-based intervention that displayed scripted testimonials of actual dog-bite experiences was found to be effective in reducing paediatric dog-bite injury risks in rural China (Shen *et al*., 2016). However, a gap may exist between videos of human-dog interactions and children's actual interactions with pets, so further research is needed to develop educational and therapeutic interventions to prevent and promote recovery from animal-induced injuries (Ji *et al*., 2010).

One of the most important findings in this review is that within HAI studies in China, there has been an emerging trend from focusing on children's physical health to considering children's psychological health. Two cohort studies focused on physical health reported that pet exposure was a protective factor against the effects of environmental pollutants on elevated arterial blood pressure and hypertension in children and decreased the prevalence of hypertension (Lawrence *et al*., 2018; Xu *et al*., 2020). Although blood pressure is a physiological indicator, a potential mechanism could be that pet companions act as an inhibitor of sympathetic nervous system activity and decrease psychological distress (Nagengast *et al*., 1997; Hansen *et al*., 1999). Future studies should focus on exploring the psychological mechanisms involved in associations between pets and cardiovascular health. Another pilot study in Hong Kong, China tested the effects of canine-assisted read-aloud programmes on children's reading abilities such as reading speed and speed-reading accuracy (Fung, 2019). Children's psychological factors were also examined in this study and stress reduction was found in the reading process (Fung, 2019). A systematic review on the effects of reading to dogs programmes found that they can improve children's reading confidence and reading performance (Hall *et al*., 2016).

This review had limitations including: (1) Only studies published in English and Chinese were included due to limited resources; (2) Studies with low quality were included and data extracted in order to be inclusive, however, the results of these studies were not emphasized in the narrative synthesis of findings due to the low quality of evidence; and (3) A meta-analysis was not possible due to the heterogeneity of included studies. The strengths of this review are: (1) This is the first systematic review to assess the impact of pets on Chinese children's and adolescents' physical and psychological health; (2) A research gap in studies on the impacts of pets on children's psychological health was identified; (3) Quality assessments were conducted in this review; and (4) The review and narrative synthesis included a wide range of health outcomes.

In conclusion, pet exposure in Chinese children was studied more as a potential risk factor for respiratory health and allergies, animal-induced injuries, *T. gondii* infection, and additionally as a protective factor between environmental pollution such as environmental tobacco smoke and children's respiratory function. Two studies focusing on cardiovascular health found pet ownership as a protective factor. Only two studies focused on children's psychological health: one focused on the negative psychological effects of animal-induced injuries; the second focused on the cognitive benefits of children reading to dogs. Further research is required to determine the potential impact of pet ownership on children's psychological health in China.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

The authors confirm that the research meets any required ethical guidelines, including adherence to the legal requirements of the study country.

AUTHOR CONTRIBUTIONS

All authors contributed equally in the development of this article.

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Reference

Almqvist, C., Egmar, A.C., Van Hage-Hamsten, M., Berglind, N., Pershagen, G. *et al.* (2003) Heredity, pet ownership, and confounding control in a population-based birth cohort. *The Journal of Allergy and Clinical Immunology* 111(4), 800–806. DOI: 10.1067/mai.2003.1334.

Apelberg, B.J., Aoki, Y. and Jaakkola, J.J. (2001) Systematic review: Exposure to pets and risk of asthma and asthma-like symptoms. *The Journal of Allergy and Clinical Immunology* 107(3), 455–460. DOI: 10.1067/mai.2001.113240.

Apfelbacher, C., Frew, E., Xiang, A., Apfel, A. and Smith, H. (2016) Assessment of pet exposure by self-report in epidemiological studies of allergy and asthma: A systematic review. *Journal of Asthma* 53(4), 363–373. DOI: 10.3109/02770903.2015.1099161.

Balan, B. and Lingam, L. (2012) Unintentional injuries among children in resource poor settings: Where do the fingers point? *Archives of Disease in Childhood* 97(1), 35–38. DOI: 10.1136/archdischild-2011-300589.

Beck, A.M., Barker, S., Gee, N.R., Griffin, J.A. and Johnson, R. (2018) The background to human-animal interaction (HAI) research. *Human-Animal Interaction Bulletin* 6, 47–62. DOI: 10.1079/hai.2018.0015.

Beetz, A., Uvnäs-Moberg, K., Julius, H. and Kotrschal, K. (2012) Psychosocial and psychophysiological effects of human-animal

interactions: The possible role of oxytocin. *Frontiers in Psychology* 4, 886. DOI: 10.3389/fpsyg.2012.00234.

Bennett, P.C. (2011) Animals in our lives: Human–animal interaction in family, community, & therapeutic settings. *Anthrozoös* 24(4), 432–435. DOI: 10.2752/175303711X13159027359863.

Bernardo, L.M., Gardner, M.J., Rosenfield, R.L., Cohen, B. and Pitetti, R. (2002) A comparison of dog bite injuries in younger and older children treated in a pediatric emergency department. *Pediatric Emergency Care* 18(3), 247–249. DOI: 10.1097/00006565-200206000-00024.

Bornehag, C.G., Sundell, J., Hagerhed, L., Janson, S. and DBH Study Group (2003) Pet-keeping in early childhood and airway, nose and skin symptoms later in life. *Allergy* 58(9), 939–944.

Cai, J., Liu, W., Hu, Y., Zou, Z., Shen, L. *et al*. (2017) Household environment, lifestyle behaviors, and dietary habits in relation to childhood atopic eczema in Shanghai, China. *International Archives of Occupational and Environmental Health* 90(1), 141–159. DOI: 10.1007/s00420-016-1177-8.

Carlsen, K.C.L., Roll, S., Carlsen, K.H., Mowinckel, P., Wijga, A.H. *et al*. (2012) 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* 7(8), e43214. DOI: 10.1371/journal.pone.0043214.

Centers for Disease Control and Prevention (2015) Web-based injury statistics query and reporting system (WISQARS) 2010. *National Center for Injury Prevention and Control, Centers for Disease Control and Prevention*. Available at: https://www.cdc.gov/injury/wisqars/index.html.

Chan, B. (2018) The China boom in pet markets, dog breeding and pet cremation, and the restaurants still serving dog meat (tasty but tough). *South China Morning Post.* Available at: https://www.scmp.com/lifestyle/article/2143707/china-boom-pet-markets-dog-breeding-and-pet-cremation-and-restaurants.

Chen, C.M., Tischer, C., Schnappinger, M. and Heinrich, J. (2010) The role of cats and dogs in asthma and allergy-a systematic review. *International Journal of Hygiene and Environmental Health* 213(1), 1–31. DOI: 10.1016/j.ijheh.2009.12.003.

Chen, Y., Gao, Y., Zhou, L., Tan, Y. and Li, L. (2016) A comparative study of dog- and cat-induced injury on incidence and risk factors among children. *International Journal of Environmental Research and Public Health* 13(11), 1079. DOI: 10.3390/ijerph13111079.

Collin, S.M., Granell, R., Westgarth, C., Murray, J., Paul, E. *et al*.. (2015) Pet ownership is associated with increased risk of non-atopic asthma and reduced risk of atopy in childhood: Findings from a UK birth cohort. *Clinical & Experimental Allergy* 45(1), 200–210. DOI: 10.1111/cea.12380.

Curry, B.A., Donaldson, B., Vercoe, M., Filippo, M. and Zak, P.J. (2015) Oxytocin responses after dog and cat interactions depend on pet ownership and may affect interpersonal trust. *Human-Animal Interaction Bulletin* 3(2), 56–71. DOI: 10.1079/hai.2015.0008.

Davis, T.N., Scalzo, R., Butler, E., Stauffer, M., Farah, Y.N. *et al*. (2015) Animal assisted interventions for children with autism spectrum disorder: A systematic review. *Education and Training in Autism and Developmental Disabilities* 50(3), 316–329.

Dong, G.H., Ding, H.L., Ma, Y.N., Jin, J., Cao, Y. *et al*. (2008a) Asthma and asthma-related symptoms in 16789 Chinese children in relation to pet keeping and parental atopy. *Journal of Investigational Allergology and Clinical Immunology* 18(3), 207–213.

Dong, G.H., Ding, H.L., Ma, Y.N., Jin, J., Cao, Y. *et al*. (2008b) Housing characteristics, home environmental factors and respiratory health in 14,729 Chinese children. *Revue d'Épidémiologie et de Santé Publique* 56(2), 97–107. DOI: 10.1016/j.respe.2007.12.002.

Dong, G.H., Ma, Y.N., Ding, H.L., Jin, J., Cao, Y. *et al*. (2008c) Housing characteristics, home environmental factors and respiratory health in 3945 pre-school children in China. *International Journal of Environmental Research* 18(4), 267–282. DOI: 10.1080/09603120701842864.

Dong, G.H., Ma, Y.N., Ding, H.L., Jin, J., Cao, Y. *et al*. (2009) Pets keeping in home, parental atopy, asthma, and asthma-related symptoms in 12,910 elementary school children from northeast China. *Indoor Air* 19(2), 166–173. DOI: 10.1111/j.1600-0668.2008.00576.x.

Dong, G.H., Ren, W.H., Wang, D., Yang, Z.H., Zhang, P.F. *et al*. (2011) Exposure to secondhand tobacco smoke enhances respiratory symptoms and responses to animals in 8,819 children in kindergarten: Results from 25 districts in northeast China. *Respiration* 81(3), 179–185. DOI: 10.1159/000321222.

Dong, W., Sheng, J., Gu, X.M., Yan, H.J., Zeng, C.Y. *et al*. (2012a) Allergens and their relationships to childhood bronchial asthma in the Jiading District of Shanghai [上海嘉定地区儿童过敏原调查及过敏原与支气管哮喘的相关性]. *Chinese Journal of Contemporary Pediatrics* 14(7), 521–523.

Dong, G.H., Wang, J., Liu, M.M., Wang, D., Lee, Y.L. *et al*. (2012b) Allergic predisposition modifies the effects of pet exposure on respiratory disease in boys and girls: The seven northeast cities of China (SNECC) study. *Environmental Health* 11, 50. DOI: 10.1186/1476-069X-11-50.

Duan, B., Ma, C.L. and Ren, X.M. (2011) Detection and analysis of common allergens in 180 children with asthma [儿童哮喘患者 180例常见变应原检测分析]. *Shaanxi Medical Journal* 40(11), 1501–1503.

Duan, Y., Zhi, Y., Liu, Y., Zhou, N., Li, F. *et al*. (2019) Toxoplasma gondii infection in children with lymphoma in Eastern China: Seroprevalence, risk factors and case-control studies. *Epidemiology & Infection* 147, E305. DOI: 10.1017/S0950268819001869.

Fan, X.J., Yang, C., Zhang, L., Fan, Q., Li, T. *et al*. (2017) Asthma symptoms among Chinese children: The role of ventilation and PM10 exposure at school and home. *The International Journal of Tuberculosis and Lung Disease* 21(11), 1187–1193. DOI: 10.5588/ijtld.17.0196.

Friedmann, E. and Son, H. (2009) The human–companion animal bond: How humans benefit. *Veterinary Clinics of North America: Small Animal Practice* 39(2), 293–326. DOI: 10.1016/j.cvsm.2008.10.015.

Friedmann, E. and Thomas, S.A. (1995) Pet ownership, social support, and one-year survival after acute myocardial infarction in the cardiac arrhythmia suppression trial (CAST). *The American Journal of Cardiology* 76(17), 1213–1217. DOI: 10.1016/s0002-9149(99)80343-9.

Friedmann, E., Thomas, S.A., Son, H., Chapa, D. and McCune, S. (2013) Pet's presence and owner's blood pressures during the daily lives of pet owners with pre to mild hypertension. *Anthrozoös* 26(4), 535–550. DOI: 10.2752/175303713x13795775536138.

Fung, S.C. (2019) Effect of a canine-assisted read aloud intervention on reading ability and physiological response: A pilot study. *Animals (Basel)* 9(8), 474. DOI: 10.3390/ani9080474.

Gee, N.R. and Mueller, M.K. (2019) A systematic review of research on pet ownership and animal interactions among older adults. *Anthrozoös* 32(2), 183–207. DOI: 10.1080/08927936.2019.1569903.

Georges, K. and Adesiyun, A. (2008) An investigation into the prevalence of dog bites to primary school children in Trinidad. *BMC Public Health* 8(1), 1–7. DOI: 10.1186/1471-2458-8-85.

Giles-Corti, B. and Donovan, R.J. (2003) Relative influences of individual, social environmental, and physical environmental correlates of walking. *American Journal of Public Health* 93(9), 1583–1589. DOI: 10.2105/ajph.93.9.1583.

Guo, W. (2013) Association of pet ownership and living conditions with allergic asthma in preschool children [宠物饲养及居住条件与学龄前儿童过敏性哮喘的关系]. *Chinese Journal of Healthy Birth & Child Care* 19(3), 166–168.

Hall, S.S., Gee, N.R. and Mills, D.S. (2016) Children reading to dogs: A systematic review of the literature. *Plos One* 11(2), e0149759. DOI: 10.1371/journal.pone.0149759.

Hansen, K.M., Messinger, C.J., Baun, M.M. and Megel, M. (1999) Companion animals alleviating distress in children. *Anthrozoös* 12(3), 142–148. DOI: 10.2752/089279399787000264.

Headey, B., Na, F. and Zheng, R. (2008) Pet dogs benefit owners' health: A 'Natural Experiment' in China. *Social Indicators Research* 87(3), 481–493. DOI: 10.1007/s11205-007-9142-2.

Hon, K.L.E., Fu, C.C.A., Chor, C.M., Tang, P.S.H., Leung, T.F. *et al*. (2007) Issues associated with dog bite injuries in children and adolescents assessed at the emergency department. *Pediatric Emergency Care* 23(7), 445–449. DOI: 10.1097/01.pec.0000280509.67795.a9.

Hu, L.W., Qian, Z., Dharmage, S.C., Liu, E., Howard, S.W. *et al*. (2017) Pre-natal and post-natal exposure to pet ownership and lung function in children: The seven northeastern cities study. *Indoor Air* 27(6), 1177–1189. DOI: 10.1111/ina.12401.

Hu, L.W., Yu, S., Marks, T., Zhang, Y.T., Lodge, C.C. *et al*. (2020) The time window of pet ownership exposure modifies the relationship of

environmental tobacco smoke with lung function: A large population-based cohort study. *Environmental Research* 183, 109197. DOI: 10.1016/j.envres.2020.109197.

Huang, S.R. (2012) Influence of environmental factors on chronic cough in children [环境因素对儿童慢性咳嗽的影响]. *Chinese Journal of Child Health Care* 20(6), 562–564.

Huang, C., Hu, Y., Liu, W., Zou, Z. and Sundell, J. (2013) Pet-keeping and its impact on asthma and allergies among preschool children in Shanghai, China. *Chinese Science Bulletin* 58(34), 4203–4210. DOI: 10.1007/s11434-013-5679-4.

Huang, Y., Yang, L. and Long, Z. (2015) Analysis on related factors of onset of childhood asthma. [儿童哮喘发病的相关因素分析]. *Maternal and Child Health Care of China* 30(4), 554–556.

Huang, S., Garshick, E., Weschler, L.B., Hong, C., Li, J. *et al*. (2020) Home environmental and lifestyle factors associated with asthma, rhinitis and wheeze in children in Beijing, China. *Environmental Pollution* 256, 113426. DOI: 10.1016/j.envpol.2019.113426.

Ji, L., Xiaowei, Z., Chuanlin, W. and Wei, L. (2010) Investigation of post-traumatic stress disorder in children after animal-induced injury in China. *Pediatrics* 126(2), e320–324. DOI: 10.1542/peds.2009-3530.

Kruger, K.A. and Serpell, J.A. (2010) Animal-assisted interventions in mental health: Definitions and theoretical foundations. In: *Handbook on Animal-Assisted Therapy*, 3rd edn. Elsevier Academic Press, Amsterdam, pp. 33–48. DOI: 10.1016/B978-0-12-381453-1.10003-0.

Lao, J. and Pan, Q. (2013) Analysis of factors of respiratory infection in preschool children [学龄前儿童反复呼吸道感染相关因素分析]. *Medical Innovation of China* 10(10), 125–126.

Lawrence, W.R., Yang, M., Lin, S., Wang, S.Q., Liu, Y. *et al*. (2018) Pet exposure in utero and postnatal decreases the effects of air pollutants on hypertension in children: A large population based cohort study. *Environmental Pollution* 238, 177–185. DOI: 10.1016/j.envpol.2018.03.030.

Leung, T.F., Wong, Y.S., Chan, I.H.S., Yung, E., Sy, H.Y. *et al*. (2011) Domestic exposure to aeroallergens in Hong Kong families with asthmatic children. *Pediatric Pulmonology* 46(7), 632–639. DOI: 10.1002/ppul.21391.

Liu, B., Li, Q., Zhang, D. and Xu, Z. (2010) A survey on exposure to rabies among the primary school student in the area with a high incidence of rabies in China [中国狂犬病高发地区小学生狂犬病暴露调查]. *Chinese Journal of Epidemiology* 31(8), 870–872.

Liu, M.M., Wang, D., Ren, W.H., Gao, F., He, Q.C. *et al*. (2012) Relationship between pet keeping and childhood asthma in Shenyang city [家养皮毛宠物与儿童哮喘关系]. *Chinese Journal of Public Health* 28(11), 1428–1430. DOI: 10.11847/zgggws2012-28-11-11.

Liu, M.M., Wang, D., Zhao, Y., Liu, Y.Q., Huang, M.M. *et al*. (2013) Effects of outdoor and indoor air pollution on respiratory health of Chinese children from 50 kindergartens. *Journal of Epidemiology* 23(4), 280–287. DOI: 10.2188/jea.je20120175.

Liu, F., Zhao, Y., Liu, Y.Q., Liu, Y., Sun, J. *et al*. (2014) Asthma and asthma related symptoms in 23,326 Chinese children in relation to indoor and outdoor environmental factors: The seven northeastern cities (SNEC) study. *Science of The Total Environment* 497–498, 10–17. DOI: 10.1016/j.scitotenv.2014.07.096.

Lu, C., Norbäck, D., Zhang, Y., Li, B., Zhao, Z. *et al*. (2020a) Furry pet-related wheeze and rhinitis in pre-school children across China: Associations with early life dampness and mould, furry pet keeping, outdoor temperature, PM10 and PM2.5. *Environment International* 144, 106033. DOI: 10.1016/j.envint.2020.106033.

Lu, C., Zhang, W., Zheng, X., Sun, J., Chen, L. *et al*. (2020b) Combined effects of ambient air pollution and home environmental factors on low birth weight. *Chemosphere* 240, 124836. DOI: 10.1016/j.chemosphere.2019.124836.

Luo, S.G., Sun, Y.X., Hou, J., Kong, X.R., Wang, P. *et al*. (2018) Pet keeping in childhood and asthma and allergy among children in Tianjin area, China. *Plos One* 13(5), e0197274. DOI: 10.1371/journal.pone.0197274.

Ma, Y.N., Zhao, Y., Liu, Y.Q., Liu, M.M., Wang, D. *et al*. (2013) Effects of indoor air pollution on asthma and asthma-related symptoms among children in Shenyang city [沈阳室内空气污染对儿童哮喘及相关症状的影响]. *Chinese Journal of Preventive Medicine* 47(1), 49–54.

Marsa-Sambola, F., Williams, J., Muldoon, J., Lawrence, A., Connor, M. *et al*. (2017) Quality of life and adolescents' communication with their significant others (mother, father, and best friend): The mediating effect of attachment to pets. *Attachment & Human Development* 19(3), 278–297. DOI: 10.1080/14616734.2017.1293702.

Maruyama, M. (2010) *The Effects of Animals on Children's Development of Perspective-Taking Abilities*. Available from ProQuest Dissertations & Theses Global. (851538012). Available at: https://www.proquest.com/dissertations-theses/effects-animals-on-childrens-development/docview/851538012/se-2

Matchock, R.L. (2015) Pet ownership and physical health. *Current Opinion in Psychiatry* 28(5), 386–392. DOI: 10.1097/YCO.0000000000000183.

Mathers, M., Canterford, L., Olds, T., Waters, E. and Wake, M. (2010) Pet ownership and adolescent health: Cross-sectional population study. *Journal of Paediatrics and Child Health* 46(12), 729–735. DOI: 10.1111/j.1440-1754.2010.01830.x.

McConnell, A.R., Brown, C.M., Shoda, T.M., Stayton, L.E. and Martin, C.E. (2011) Friends with benefits: On the positive consequences of pet ownership. *Journal of Personality and Social Psychology* 101(6), 1239–1252. DOI: 10.1037/a0024506.

McHarg, M., Baldock, C., Headey, B. and Robinson, A. (1995) *National People and Pets Survey*. Urban Animal Management Coalition, Sydney, Australia.

Melson, G.F. (2003) Child development and the human-companion animal bond. *American Behavioral Scientist* 47(1), 31–39. DOI: 10.1177/0002764203255210.

Morrongiello, B.A., Corbett, M., Lasenby, J., Johnston, N. and McCourt, M. (2006) Factors influencing young children's risk of unintentional injury: Parenting style and strategies for teaching about home safety. *Journal of Applied Developmental Psychology* 27(6), 560–570. DOI: 10.1016/j.appdev.2006.08.004.

Muldoon, J.C., Williams, J.M., Lawrence, A. and Currie, C. (2019) The nature and psychological impact of child/adolescent attachment to dogs compared with other companion animals. *Society and Animal* 27(1), 55–74. DOI: 10.1163/15685306-12341579.

Nagengast, S.L., Baun, M.M., Megel, M. and Leibowitz, J.M. (1997) The effects of the presence of a companion animal on physiological arousal and behavioral distress in children during a physical examination. *Journal of Pediatric Nursing* 12(6), 323–330. DOI: 10.1016/s0882-5963(97)80058-9.

National Heart, Lung, and Blood Institute (2021) *Study Quality Assessment Tools*. National Heart, Lung, and Blood Institute. Available at: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools.

Norbäck, D., Zhao, Z.H., Wang, Z.H., Wieslander, G., Mi, Y.H. *et al*. (2007) Asthma, eczema, and reports on pollen and cat allergy among pupils in Shanxi province, China. *International Archives of Occupational and Environmental Health* 80(3), 207–216. DOI: 10.1007/s00420-006-0123-6.

Norbäck, D., Lu, C., Zhang, Y., Li, B., Zhao, Z. *et al*. (2017) Common cold among pre-school children in China – associations with ambient PM and dampness, mould, cats, dogs, rats and cockroaches in the home environment. *Environment International* 103, 13–22. DOI: 10.1016/j.envint.2017.03.015.

Norbäck, D., Zhang, X., Tian, L., Zhang, Y., Zhang, Z. *et al*. (2021) Prenatal and perinatal home environment and reported onset of wheeze, rhinitis and eczema symptoms in preschool children in Northern China. *Science of the Total Environment* 774, 145700. DOI: 10.1016/j.scitotenv.2021.145700.

O'Haire, M. (2010) Companion animals and human health: Benefits, challenges, and the road ahead. *Journal of Veterinary Behavior* 5(5), 226–234. DOI: 10.1016/j.jveb.2010.02.002.

O'Haire, M.E., McKenzie, S.J., Beck, A.M. and Slaughter, V. (2015) Animals may act as social buffers: Skin conductance arousal in children with autism spectrum disorder in a social context. *Developmental Psychobiology* 57(5), 584–595. DOI: 10.1002/dev.21310.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C. *et al*. (2021) The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *International Journal of Surgery* 88, 105906. DOI: 10.1136/bmj.n71.

Parslow, R.A. and Jorm, A.F. (2003) Pet ownership and risk factors for cardiovascular disease: Another look. *Medical Journal of Australia* 179(9), 466–468. DOI: 10.5694/j.1326-5377.2003.tb05649.x.

Poresky, R.H. (1996) Companion animals and other factors affecting young children's development. *Anthrozoös* 9(4), 159–168. DOI: 10.2752/089279396787001437.

Purewal, R., Christley, R., Kordas, K., Joinson, C., Meints, K. *et al*. (2017) Companion animals and child/adolescent development: A systematic review of the evidence. *International Journal of Environmental Research and Public Health* 14(3), 234. DOI: 10.3390/ijerph14030234.

Qi, J.C., Zhao, Y.L., Li, W.U., Wang, J., Zhang, Y.J. *et al*. (2015) Analysis of allergens spectrum in children with allergic rhinitis in Zhengzhou district [郑州地区变应性鼻炎患儿变应原谱分析]. *Journal of Clinical Otorhinolaryngology Head and Neck Surgery* 29(5), 404–406.

Qian, Z.M., Dong, G.H., Ren, W.H., Simckes, M., Wang, J. *et al*. (2014) Effect of pet ownership on respiratory responses to air pollution in Chinese children: The seven northeastern cities (SNEC) study. *Atmospheric Environment* 87, 47–52. DOI: 10.1016/j.atmosenv.2014.01.010.

Rew, L. (2000) Friends and pets as companions: Strategies for coping with loneliness among homeless youth. *Journal of Child and Adolescent Psychiatric Nursing* 13(3), 125–132. DOI: 10.1111/j.1744-6171.2000.tb00089.x.

Rhoades, H., Winetrobe, H. and Rice, E. (2015) Pet ownership among homeless youth: Associations with mental health, service utilization and housing status. *Child Psychiatry & Human Development* 46(2), 237–244. DOI: 10.1007/s10578-014-0463-5.

Salo, P.M., Xia, J., Johnson, C.A., Li, Y., Avol, E.L. *et al*. (2004) Indoor allergens, asthma, and asthma-related symptoms among adolescents in Wuhan, China. *Annals of Epidemiology* 14(8), 543–550. DOI: 10.1016/j.annepidem.2003.09.015.

Shen, J.B., Li, S.H., Xiang, H.Y., Pang, S.L., Xu, G.Z. *et al*. (2013) A multi-site study on knowledge, attitudes, beliefs and practice of child-dog interactions in rural China. *International Journal of Environmental Research and Public Health* 10(3), 950–962. DOI: 10.3390/ijerph10030950.

Shen, J., Li, S., Xiang, H., Lu, S. and Schwebel, D.C. (2014) Antecedents and consequences of pediatric dog-bite injuries and their developmental trends: 101 cases in rural China. *Accident Analysis & Prevention* 63, 22–29. DOI: 10.1016/j.aap.2013.10.025.

Shen, J.B., Pang, S.L. and Schwebel, D.C. (2016) A randomized trial evaluating child dog-bite prevention in rural China through video-based testimonials. *Health Psychology* 35(5), 454–464. DOI: 10.1037/hea0000273.

Shen, J.B., Rouse, J., Godbole, M., Wells, H.L., Boppana, S. *et al*. (2017) Systematic review: Interventions to educate children about dog safety and prevent pediatric dog-bite injuries: A meta-analytic review. *Journal of Pediatric Psychology* 42(7), 779–791. DOI: 10.1093/jpepsy/jsv164.

Shi, H., Wan, G., Wang, T., Zhu, J., Jiang, L. *et al*. (2021) Prevalence and influencing risk factors of eczema among preschool children in Urumqi city: A cross-sectional survey. *BMC Pediatr* 21(1), 347. DOI: 10.1186/s12887-021-02819-5.

Si, H., Guo, Z.M., Hao, Y.T., Liu, Y.G., Zhang, D.M. *et al*. (2008) Rabies trend in China (1990–2007) and post-exposure prophylaxis in the Guangdong province. *BMC Infectious Diseases* 8(1), 1–10. DOI: 10.1186/1471-2334-8-113.

Song, N., Mohammed, S., Zhang, J., Wu, J.L., Fu, C.L. *et al*. (2014a) Prevalence, severity and risk factors of asthma, rhinitis and eczema in a large group of Chinese schoolchildren. *Journal of Asthma* 51(3), 232–242. DOI: 10.3109/02770903.2013.867973.

Song, M., Tang, Q., Rayner, S., Tao, X.Y., Shen, X.X. *et al*. (2014b) Factors influencing the number of rabies cases in children in China. *Biomedical and Environmental Sciences* 27(8), 627–632. DOI: 10.3967/bes2014.095.

Su, B. and Martens, P. (2017) Public attitudes toward animals and the influential factors in contemporary China. *Animal Welfare* 26(2), 239–247. DOI: 10.7120/09627286.26.2.239.

Takkouche, B., González-Barcala, F.J., Etminan, M. and FitzGerald, M. (2008) Exposure to furry pets and the risk of asthma and allergic rhinitis: A meta-analysis. *Allergy* 63(7), 857–864. DOI: 10.1111/j.1398-9995.2008.01732.x.

The Youth Population in China (2018) *The Youth Population in China: The Current Situation and Development Trends*. Available at: https://china.unfpa.org/sites/default/files/pub-pdf/The%20Youth%20Population%20in%20China%20%282018%29-EN.pdf.

Timperio, A., Salmon, J., Chu, B. and Andrianopoulos, N. (2008) Is dog ownership or dog walking associated with weight status in children and their parents? *Health Promotion Journal of Australia* 19(1), 60–63. DOI: 10.1071/he08060.

Van Houtte, B.A. and Jarvis, P.A. (1995) The role of pets in preadolescent psychosocial development. *Journal of Applied Developmental Psychology* 16(3), 463–479. DOI: 10.1016/0193-3973(95)90030-6.

Wang, J., Zhou, L., Chen, Y., Luo, R. and Tao, J. (2012) Analysis of inhaled allergen spectrum of children with allergic rhinitis in Guangzhou [广州地区儿童变应性鼻炎患者吸入变应原谱分析]. *Journal of Clinical Otorhinolaryngology Head and Neck Surgery* 26(22), 1026–1029.

Wang, X.X., Cui, Y.F., Wang, Q.L., Yan, H. and Xiao, X. (2016a) Study on the related risk factors of infant allergic disease [婴幼儿过敏性疾病相关危险因素的研究]. *Chinese Journal of Child Health Care* 24(5), 528–531.

Wang, X.Y., Liu, W., Hu, Y., Zou, Z., Shen, L. *et al*. (2016b) Home environment, lifestyles behaviors, and rhinitis in childhood. *International Journal of Hygiene and Environmental Health* 219(2), 220–231. DOI: 10.1016/j.ijheh.2015.11.007.

Wang, S., Yao, Z., Li, H., Li, P., Wang, D. *et al*. (2020) Seroprevalence and risk factors of Toxoplasma gondii infection in primary school children in Henan province, central China. *Parasite* 27, 23. DOI: 10.1051/parasite/2020018.

Wells, D.L. (2009) The effects of animals on human health and well-being. *Journal of Social Issues* 65(3), 523–543. DOI: 10.1111/j.1540-4560.2009.01612.x.

Xie, J.S., Deng, S.H., Li, H., Huang, H.L. and Dong, G.H. (2010) Epidemiological investigation of the effects of domestic furry pets on childhood asthma and asthma related symptoms [家养皮毛宠物对儿童哮喘及哮喘样症状影响的流行病学调查]. *Chinese Journal of Health Statistics* 27(2), 161–162.

Xu, D., Wang, Y., Chen, Z., Li, S., Cheng, Y. *et al*. (2016) Prevalence and risk factors for asthma among children aged 0–14 years in Hangzhou: A cross-sectional survey. *Respiratory Research* 17(1), 8. DOI: 10.1186/s12931-016-0439-z.

Xu, S.L., Liu, A.P., Wu, Q.Z., Marks, T., He, Z.Z. *et al*. (2020) Pet ownership in utero and in childhood decreases the effects of environmental tobacco smoke exposure on hypertension in children: A large population based cohort study. *Science of the Total Environment* 715, 136859. DOI: 10.1016/j.scitotenv.2020.136859.

Yang, B.Z. and Tan, Z.Y. (2006) An analysis of 98 cases of fast insertion tests on skin sensibiligen of children with asthma [儿童哮喘皮肤过敏原点刺试验 98 例分析]. *Journal of Pediatric Pharmacy* 12(2), 16–17.

Yang, J., Hu, L. and Dong, G. (2017) Pet ownership and lung function in children without asthma [家养宠物暴露对非哮喘儿童肺功能的影响]. *The Journal of Practical Medicine* 33(11), 1868–1872.

Zhang, M., Zhou, E., Ye, X., Sun, Y., Sundell, J. *et al*. (2013) Indoor environmental quality and the prevalence of childhood asthma and rhinitis in Wuhan area of China. *Chinese Science Bulletin* 58(34), 4223–4229. DOI: 10.1007/s11434-013-5687-4.

Zhang, Y., Tan, M., Qian, X., Li, C., Yue, L. *et al*. (2021a) Interaction between early-life pet exposure and methylation pattern of ADAM33 on allergic rhinitis among children aged 3–6 years in China. *Allergy, Asthma & Clinical Immunology* 17(1), 1–9. DOI: 10.1186/s13223-021-00526-5.

Zhang, H.L., Wang, B.Y., Luo, Y., Li, Y., Cai, C.S. *et al*. (2021b) Association of pet-keeping in home with self-reported asthma and asthma-related symptoms in 11611 school children from China. *Journal of Asthma* 58(12), 1555–1564. DOI: 10.1080/02770903.2020.1818772.

Zhao, Z.H., Elfman, L., Wang, Z.H., Zhang, Z. and Norbäck, D. (2006) A comparative study of asthma, pollen, cat and dog allergy among pupils and allergen levels in schools in Taiyuan city, China, and Uppsala, Sweden. *Indoor Air* 16(6), 404–413. DOI: 10.1111/j.1600-0668.2006.00433.x.

Zhao, Y., Liu, Y.Q., Liu, M.M., Wang, D., Ren, W.H. *et al*. (2013) Interactive effects of environmental tobacco smoke and pets ownership on respiratory diseases and symptoms in children [家养宠物与被动吸烟对儿童呼吸系统 疾病及症状影响的交互效应]. *Chinese Journal of Pediatrics* 51(2), 96–100.

Zheng, T. (2002) Childhood asthma in Beijing, China: A population-based case-control study. *American Journal of Epidemiology* 156(10), 977–983. DOI: 10.1093/aje/kwf127.

Zhou, L.D., Xie, J.S., Zhao, Y., Liu, Y., Huang, M.M. *et al*. (2013) Environmental tobacco smoke exposure enhances effects of pets ownership on asthma and asthma-related symptoms in children [被动吸烟与家养宠物对儿童哮喘及哮喘样症状影响]. *Chinese Journal of Public Health* 29(4), 559–561.

Zhu, H.P., Xia, X., Xiang, H.Y., Yu, C.H. and Du, Y.K. (2012) Disability, home physical environment and non-fatal injuries among young children in China. *Plos One* 7(5), e37766. DOI: 10.1371/journal.pone.0037766.