

Asthma, eczema, and reports on pollen and cat allergy among pupils in Shanxi province, China

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Abstract

Objectives To study self-reported asthma, eczema, and pollen and furry pet allergy among pupils (9–20 years) in Shanxi province, China, in relation to dietary and environmental factors.

Methods A standardised questionnaire was distributed to pupils in two primary and two secondary schools, one in Taiyuan city (3.0 milj. inhabitants), the others in Qingxu county, a rural area 30 km outside Taiyuan. Totally, 2,116 pupils (90%) participated.

Results Fifty percent were girls, 61% had been growing up on the countryside, 18% lived in Taiyuan now, 1.7% had ever had asthma, 0.8% had doctor's diagnosed asthma, 1.4% pollen allergy, 1.7% cat allergy, and 0% had dog allergy. Multiple logistic regression was applied, controlling for age, gender, diet, indoor exposures, rural childhood, and current urban residency. Girls had less eczema (OR = 0.51; 95% CI 0.28–0.92). Pupils in the city had more eczema (OR = 5.05; 95% CI 1.11–23.3). Those with a rural childhood had less asthma (OR = 0.17; 95% CI 0.05–0.60), eczema (OR = 0.15; 95% CI 0.13–0.66) and pollen/cat allergy (OR = 0.50; 95% CI 0.25–0.99). None of the indoor variables was related to asthma or allergy. Children with frequent fruit consumption had less asthma (OR = 0.40; 95% CI 0.19–0.82) and pollen/cat allergy (OR = 0.49; 95% CI 0.29–0.84). Those with frequent

fish consumption had less asthma (OR = 0.32; 95% CI 0.11–0.97). Those with frequent hamburgers consumption had more asthma (OR = 2.05; 95% CI 1.09–3.87) and eczema (OR = 1.85; 95% CI 1.12–3.04).

Conclusion Asthma, eczema, and pollen or pet allergy was uncommon, compared with western countries and other areas in China. Pupils with a rural childhood had less asthma and allergy, which is consistent with the “hygiene hypothesis”. Fruit and fish consumption may reduce, and fast food consumption may increase the risk for asthma. Finally, the higher prevalence of asthma and eczema among younger children, born in the 1990s, indicates a cohort effect similar to that observed in western countries.

Keywords Asthma · Atopy · China · Dietary factors · Rural childhood

Background

Two large international studies, the ISAAC (Asher et al. 1998) and the ECRHS (Janson et al. 2001), have demonstrated large global differences in asthma and allergies. Moreover, there has been an increase of asthma and atopic sensitisation in industrialised countries, particularly in urban areas (von Mutius 2000; Schneider and Freeman 2001). Growing up in a rural environment, particularly with animal contact, may protect against asthma and allergy (Braun-Fahlander 2001), possibly because of the beneficial effect of early-life microbial stimulation (“the hygiene hypothesis”) (von Mutius 2000; Holt et al. 1999). In addition, dietary factors can influence respiratory health, with beneficial effects of a high intake of antioxidants, fruits, vegetables,

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and omega-3-fatty acids from deep sea fish (Romieu and Trenga 2001). There are global changes of dietary habits, with increased consumption of fast food and soft drinks (Holmboe-Ottesen 2000), and frequent fast food consumption has been associated with a higher prevalence of childhood asthma in Saudi Arabia (Hijazi et al. 2000) and New Zealand (Wickens et al. 2005). Finally, air pollution may affect asthma and allergies in children (Schneider and Freeman 2001). In developing countries, both indoor (Bruce et al. 2000) and outdoor air pollution (Qian et al. 2000; Venners et al. 2004) is a major environmental and public health challenge.

Because China has the largest population in the world, an increase of asthma and allergies will affect a large number of individuals. Within China, asthma and allergy is most prevalent in the more developed areas (Asher et al. 1998; Chen 2004; Zhao et al. 2000). Environmental tobacco smoke (ETS) at home, coal heating at home, mould growth in the dwelling and furry pets keeping have been associated with childhood asthma (Zheng et al. 2002). Sensitisation to indoor allergens (cat and house dust mites) is associated with wheeze and bronchial hyperresponsiveness in Chinese children (Wong et al. 2002). China has some of the most polluted areas in the world (Qian et al. 2000; Richter et al. 2005; Venners et al. 2001), and Shanxi province, situated west of Beijing, is one of the most polluted areas in China (Richter et al. 2005), but here are few publications on asthma and allergies in this region.

The main aim was to study the prevalence of self-reported asthma, eczema, and allergy to pollen and furry pets among school children of different ages, and to relate these health effects to age, gender, current dietary factors, current urban residency, growing up in a rural environment (rural childhood), and selected environmental factors in the current dwelling: ETS, freshly painted indoor surfaces and new floor materials (proxy variables for chemical indoor emissions). The following hypotheses were tested: asthma, childhood eczema, and atopic sensitisation is related (positively or negatively) to birth year, gender, current urban residency in Taiyuan, growing up on the countryside, current domestic exposure to ETS and emissions from fresh paint and new floor material, and consumption of meat, fish, vegetables, fruit, fruit juice, hamburgers, and carbonated soft drinks (the two latter were proxy variables for fast food consumption).

Materials and methods

Taiyuan is the largest city in Shanxi province (3.0 million inhabitants), situated 500 km south-west of Beijing. Four

schools were selected for the study. One of the schools, with totally 18% of the children, was situated in the city of Taiyuan, in a relatively wealthy part of the city. The other pupils (82%) were recruited from three schools in the rural Qingxu county, situated 30 km outside Taiyuan. Qingxu county has 290,000 inhabitants, and is one of the ten most wealthy counties in Shanxi province, with agriculture (meat production, vegetables, and fruits), coal mining, and food industry. The county has two regional, and several local hospitals, and good communication to Taiyuan city. Endemic arsenic poisoning from the drinking water has been reported from different parts of China, including Nemeng in Shanxi province (Jin et al. 2003), but there are no such problems known from Taiyuan or Qingxu county. The schools were selected to get both urban and rural environments, and different ages of the pupils. None of the schools was selected because of any previous complaints or known allergy problems. The deans of the schools were contacted, all agreed to participate. A standardised questionnaire was distributed in the school to the pupils by the teachers, and collected within 1 h.

The questionnaire was translated from Swedish to Chinese, and back translated to Swedish by another person. It was a short questionnaire on asthma, different types of allergies, allergies, and childhood eczema. It also contained questions on age, gender, type of childhood environment (urban vs. rural childhood), and a few questions about the current indoor environment in dwellings. There were no questions on animal keeping, parental allergy, or parental education. The questions were standardised questions used in previous questionnaire studies in Swedish school pupils (Smedje et al. 1997). Finally, there was a food frequency questionnaire with eight simple questions about current consumption of meat, fish, fruit, fruit juice, raw vegetables, cooked vegetables, hamburgers, and carbonated soft drinks. The latter two served as indicators of fast food consumption. There were five alternatives given for each type of the food item, intended to measure the frequency of consumption. In the statistical calculations, a consumption score was used, scored as follows: 0 = never consumed, 1 = less than once a week, 2 = once a week, 3 = more than once a week, 4 = daily consumption. The food frequency questionnaire has been used in other studies among schoolchildren of similar age, for example, in Sweden (Kim et al. 2005).

Statistical methods

The chi-square test was used to analyse associations between binary dependent and independent variables. Student's *t* test was used to study mean differences between groups. Multiple logistic regression analysis

was applied. In one model, personal and environmental factors were included. This model contained age, gender, and five environmental variables including rural childhood, current urban residency, exposure to ETS at home, recent indoor painting, and recent redecoration with new floor materials at home. When studying effects of dietary factors, two other logistic regression models were used. First, a simple model was used, adjusting for age and gender only, introducing each of the eight dietary variables separately in the model. Finally, a complex model with 15 explanatory variables was used: including age, gender, the five environmental variables mentioned here, and eight dietary variables kept at the same time in the model. For age, odds ratio (OR) was calculated for a change of 1 year. Exposure to ETS was rated in four steps (never, less than weekly, weekly, daily exposure), coded 0, 1, 2, and 3. The OR was calculated for a change from 0 to 3, estimating the difference between those never exposed and those with daily exposure to ETS at home. Each dietary variables were rated in five steps (never, less than weekly, weekly, more than once a week, daily consumption), coded 0, 1, 2, 3, and 4. The OR was calculated for a change of two steps, for example, estimating the difference between those with weekly versus daily consumption. Statistical calculations were made by the SPIDA statistical package (Gebski et al. 1992), using collinearity diagnostics. For logistic regression, the program uses a method described by Belsley (1991) in which a condition index exceeding 20 indicates collinearity problems. Initially, some collinearity problems were detected, but they disappeared when the age of the subject was centred, by subtracting the mean age. In all statistical analysis, two-tailed tests and a 5% level of significance was applied.

Results

In total, 2,116 out of 2,360 pupils (90%) answered the questionnaire, 50% were girls. In total, 1.7% had ever

had asthma, 0.8% reported doctor's diagnosed asthma, 1.4% reported pollen allergy from tree or grass pollen, 1.7% reported cat allergy, and 0% reported allergy to dogs. The mean age was 15 years (SD = 3), ranging from 9–20 years. The majority (77%) were born before 1990 (age 13–20 years), and around one-fourth (23%) was born in the 1990s (Table 1). In the bivariate analysis, girls reported less eczema ($P = 0.02$), but there were no other gender differences. Mean age was lower among those who ever had asthma ($P < 0.001$), doctor's diagnosed asthma ($P = 0.004$), and eczema ($P < 0.01$). No significant age trend was observed for pollen allergy or cat allergy (Table 1).

A majority consumed cooked vegetables (91%), fruits (86%), and meat (63%) at least once a week, and daily consumption of cooked vegetables and fruits was common. Consumption of fish was uncommon, 34% had a weekly consumption, and only 1% had daily fish consumption. Daily consumption of cooked vegetables was common (81%), daily consumption of raw vegetables was less common (22%). Totally, 16% had a weekly consumption of hamburgers, 39% had a weekly consumption of carbonated soft drinks, and 38% had a weekly consumption of non-carbonated fruit juice (Table 2). The consumption of hamburgers, fruit juice, and soft drinks were the dietary factors most strongly related to each other. The strongest correlation was between consumption of fruit juice and carbonated soft drinks ($r = 0.52$; $P < 0.001$). Consumption of hamburgers was correlated to consumption of fruit juice ($r = 0.44$; $P < 0.001$) and carbonated soft drinks ($r = 0.36$; $P < 0.01$). There was a weak correlation between hamburger eating and meat consumption in general ($r = 0.22$; $P < 0.05$).

Only 7% of the children now living in Taiyuan had been growing up on the countryside, while 25% children now living in Qingxu county had been growing up in a city. Totally, 60% reported an urban childhood, 37% a rural childhood, and 3% did not answer the question (missing value). The mean age was 16 years

Table 1 Prevalence of asthma, eczema, and allergy in the total material of pupils, stratified with respect to gender and age group

Illness parameter	Gender		Age group			Total material
	Boys	Girls	9–12 years	13–16 years	17–20 years	
	(<i>N</i> = 1,063) (%)	(<i>N</i> = 1,051) (%)	(<i>N</i> = 479) (%)	(<i>N</i> = 735) (%)	(<i>N</i> = 891) (%)	
Ever had asthma	2.2	1.2	4.1	0.7	1.2	1.7
Doctors' diagnosed asthma	0.8	0.8	2.1	0.4	0.4	0.8
Eczema	3.5	1.8	6.5	1.0	1.9	2.6
Pollen allergy	1.2	1.5	1.9	1.6	0.8	1.4
Cat allergy	1.5	1.9	1.7	2.3	1.2	1.7
Pollen or cat allergy	2.4	3.0	2.9	3.5	1.9	2.7

Information about gender and age was lacking in 2 and 11 subjects, respectively

Table 2 Frequency of consumption of different types of food products, in the total material ($n = 2,116$)

Type of food products	Frequency of consumption				
	Never	Less than once a week	Once a week	More than a week	Every day
Meat	3	34	18	29	16
Fish	7	59	19	14	1
Fruits	1	13	12	20	54
Raw vegetables	19	40	9	10	22
Cooked vegetables	2	7	4	6	81
Hamburgers	47	37	9	6	1
Fruit juices	8	54	15	14	9
Carbonated soft drinks	6	55	15	16	8

(SD = 2) for those with a rural childhood, and 14 years (SD = 3) for those with an urban childhood. A rural childhood was associated with a lower cumulative incidence of asthma (ever asthma), less doctor's diagnosed asthma, less eczema, and less reports on atopy (pollen/cat allergy) (Table 3). A rural childhood was associated with current lifestyle factors, current diet, and current housing conditions. Those who had been growing up on the countryside now consumed more cooked vegetables, but less meat, less fish, less fruit, less hamburgers, less fruit juice, and less carbonated soft drinks. The consumption of raw vegetables did not differ between the two groups (Table 3). Those with a rural childhood lived more often on the countryside now, and had more often lived in the same house since birth. They lived more often in brick buildings, stone buildings, and wooden buildings, but less often in modern concrete buildings ($P = 0.002$). The mean area of the dwelling was 143 m^2 (SD = 118) among those with a rural childhood, and 85 m^2 (SD = 42) among those with an urban childhood ($P < 0.001$). In China, the area of a house or an apartment is measured outside the building, including the area of both inner and outer walls. As a rule of thumb, the Chinese way to measure housing area includes about 30% wall areas, and only about 70% of the measured area is internal floor area. The mean building age of the dwelling was 14 years among those with a rural childhood, and 9 years in those with an urban childhood ($P < 0.001$). ETS in the dwelling was very common. Totally, 51% reported a daily exposure to ETS at home. Current ETS exposure was more common among those with a rural childhood. Indoor painting of the home in the last 12 months was relatively common (14%), but not related to the type of childhood. Recent exchange of the floor material was less common among those with a rural childhood (Table 4).

Table 3 Current health parameters and diet among pupils who have grown up in a rural environment, as compared with those in an urban environment

Type of health outcome	Rural childhood	Urban childhood	Two-tailed
	($N = 1,281$) (%)	($N = 784$) (%)	P value ^a
Ever had asthma	0.5	3.4	$< 0.001^a$
Doctors' diagnosed asthma	0.2	1.8	$< 0.001^a$
Childhood eczema	1.0	5.5	$< 0.001^a$
Pollen or cat allergy	2.1	3.7	0.03^a
Dietary factors			
Weekly consumption of meat	53	77	$< 0.001^b$
Weekly consumption of fish	22	54	$< 0.001^b$
Daily consumption of fruit	48	65	$< 0.001^b$
Weekly consumption of raw vegetables	41	43	NS ^b
Daily consumption of cooked vegetables	84	77	0.002^b
Weekly consumption of hamburgers	5	32	$< 0.001^b$
Weekly consumption of fruit juice	28	55	$< 0.001^b$
Weekly consumption of carbonated soft drinks	32	52	$< 0.001^b$

^a Differences between rural and urban childhood, calculated by chi-square test for 2×2 contingency tables

^b For simplicity, the prevalence of daily consumption is presented for common food and weekly consumption for less common food. In the statistical calculations, a consumption score was used, scored as follows: 0 never consumed, 1 less than once a week, 2 once a week, 3 more than once a week, 4 daily consumption

As a next step, the associations between the health variables and both personal and environmental factors were investigated by multiple logistic regression analysis, keeping age, gender, rural childhood, current urban residency, ETS, indoor painting, and new floor materials at home simultaneously in the model (Table 5). Type of childhood environment was the strongest predictor. Those with a rural childhood had a lower cumulative incidence of asthma (OR = 0.17; 95% CI 0.05–0.60), less doctor's diagnosed asthma (OR = 0.15; 95% CI 0.03–0.81), eczema (OR = 0.29; 95% CI 0.13–0.66), and less pollen or cat allergy (OR = 0.50; 95% CI 0.25–0.99). Age was not significantly related to any health parameters, when controlling for the influences of other factors. Girls had less eczema (OR = 0.51; 95% CI 0.28–0.92), similar as in the bivariate analysis, but there were no significant gender differences for asthma or allergy. Subjects currently living in a large city (Taiyuan) had more childhood eczema (OR = 5.05; 95% CI 1.11–23.3). Indoor painting, new floor materials, or ETS at home

Table 4 Comparison of current home environment among pupils who had grown up in a rural versus an urban environment

Type of environmental factor	Rural childhood (<i>N</i> = 1,281) (%)	Urban childhood (<i>N</i> = 784) (%)	Two-tailed <i>P</i> value	Total material (<i>N</i> = 2,116) (%)
Has lived in the same dwelling since birth	53	23	< 0.001 ^a	40
Currently living in large city (Taiyuan)	2	54	< 0.001 ^a	19
Construction year of the building				
≤ 1980	14	7	< 0.001 ^b	11
1981–1990	40	23		34
1991–2001	46	70		55
Major construction materials of the building				
Stone materials	11	3.7	< 0.001 ^a	7.7
Concrete	22	28	0.002 ^a	23
Bricks	95	76	< 0.001 ^a	81
Wood	28	5.9	< 0.001 ^a	18
Interior redecoration in the last 12 months				
Newly painted interior surfaces	16	14	NS ^a	14
New floor materials	7.7	12	0.002 ^a	9.4
Environmental tobacco smoke (ETS) in the dwelling				
Never	13	18	0.002 ^c	15
Less than once a week	17	20		18
1–4 time per week	17	14		16
Every day	53	48		51

^a Tested by chi-square test for 2 × 2-fold contingency tables^b Tested by chi-square test for 2 × 3-fold contingency tables^c Tested by chi-square test for 2 × 4-fold contingency tables**Table 5** Associations between asthma, eczema and allergy, personal and indoor environmental factors

Type of factor	OR (95% CI)			
	Ever had asthma	Doctor's diagnosed asthma	Eczema	Pollen or cat allergy
Age (1 year) ^a	0.90 (0.68–1.20)	1.13 (0.73–1.75)	1.09 (0.88–1.36)	0.99 (0.83–1.17)
Female gender	0.51 (0.23–1.12)	0.68 (0.23–1.97)	0.51 (0.28–0.92)*	1.09 (0.61–1.94)
Rural childhood	0.17(0.05–0.60)**	0.15(0.03–0.81)*	0.29(0.13–0.66)**	0.50 (0.25–0.99)*
Now living in a city	1.75 (0.24–12.7)	5.13 (0.27–100)	5.05 (1.11–23.3)*	1.01 (0.28–3.68)
Indoor painting at home in the last 12 months	1.57 (0.51–4.81)	1.61 (0.37–7.03)	1.02 (0.42–2.49)	1.38 (0.62–3.07)
New floor material at home in the last 12 months	0.71 (0.18–2.84)	0.94 (0.17–5.36)	1.27 (0.49–3.28)	1.30 (0.52–3.28)
Current ETS exposure at home ^b	1.00 (0.37–2.66)	1.46 (0.36–5.90)	1.00 (0.64–2.20)	1.43 (0.65–3.14)

Odds ratio (OR) with 95% confidence interval (CI) calculated by multiple logistic regression, keeping age, gender, rural childhood, current urban residency, indoor painting, new floor material, and ETS in the dwelling in the model simultaneously

P* < 0.05; *P* < 0.01^a OR calculated for a change of age by 1 year^b OR calculated for the extremes (never exposed versus daily exposure)

was not related to asthma, eczema, or allergy. Size of the dwelling, age of the dwelling, and type of building material in the house was tested by bivariate analysis, only. None of these domestic factors was significantly related to any of the health parameters (Table 5).

Finally, the association between dietary factors and asthma, eczema, and allergy was investigated. As there were associations between different dietary factors, as well as between diet and environmental factors, two different statistical models were used. Initially, a simple

model (I) was used, evaluating each food item separately, controlling for age and gender, only. Then, a complex model was applied (II), keeping age, gender, all five environmental variables, and all eight variables simultaneously in the model (Table 6). In most cases, the results were similar with both regression models, when comparing OR. Some of the results, however, were statistically significant in one model only. The most consistent results were the protective effect of fruit consumption. Frequent fruit consumption was

Table 6 Associations between dietary factors and asthma, eczema, and pollen or pet allergy

Frequency of consumption	OR (95% CI)			
	Ever had asthma	Doctor's diagnosed asthma	Eczema	Pollen or cat allergy
Meat				
Model I	1.54 (0.85–2.78)	1.37 (0.59–3.20)	1.19 (0.75–1.89)	1.08 (0.67–1.72)
Model II	1.77 (0.82–3.81)	0.89 (0.33–2.41)	0.82 (0.48–1.40)	0.77 (0.44–1.34)
Fish				
Model I	0.94 (0.43–2.02)	0.55 (0.16–1.92)	1.04 (0.57–1.90)	2.13 (1.21–3.73)**
Model II	0.32 (0.11–0.97)*	0.15 (0.03–0.80)*	0.55 (0.26–1.17)	2.15 (1.07–4.32)*
Fruit				
Model I	0.53 (0.30–0.92)*	0.96 (0.37–2.51)	0.96 (0.58–1.58)	0.62 (0.40–0.98)*
Model II	0.40 (0.19–0.82)*	0.90 (0.31–2.60)	0.88 (0.50–1.54)	0.49 (0.29–0.84)**
Raw vegetables				
Model I	0.95 (0.60–1.52)	0.89 (0.45–1.73)	1.16 (0.81–1.66)	0.96 (0.66–1.39)
Model II	1.28 (0.72–2.26)	1.12 (0.52–2.41)	1.32 (0.88–1.97)	0.92 (0.59–1.42)
Cooked vegetables				
Model I	0.62 (0.37–1.05)	1.32 (0.47–3.78)	0.82 (0.52–1.30)	1.07 (0.60–1.88)
Model II	0.82 (0.43–1.56)	2.41 (0.53–11.0)	0.92 (0.55–1.55)	1.32 (0.67–2.59)
Hamburgers				
Model I	2.05 (1.09–3.87)*	1.50 (0.59–3.85)	1.84 (1.12–3.04)*	1.56 (0.92–2.65)
Model II	2.28 (0.89–5.80)	0.97 (0.23–4.17)	1.41 (0.70–2.85)	0.74 (0.33–1.64)
Fruit juices				
Model I	1.45 (0.81–2.61)	1.37 (0.60–3.13)	1.28 (0.81–2.03)	1.31 (0.82–2.11)
Model II	1.74 (0.80–3.80)	1.45 (0.50–4.17)	0.87 (0.49–1.58)	0.94 (0.50–1.79)
Carbonated soft drinks				
Model I	0.76 (0.39–1.48)	0.70 (0.27–1.82)	1.12 (0.70–1.82)	1.81 (1.13–2.91)*
Model II	0.39 (0.17–0.91)*	0.42 (0.13–1.39)	0.95 (0.53–1.69)	1.98 (1.05–3.72)*

Odds ratio (OR) with 95% confidence interval (CI) calculated by multiple logistic regression, for a change of two units on the dietary frequency scale (0–4)

* $p < 0.05$; ** $p < 0.01$

Model I adjustment for age and gender only, analysing each dietary variable separately; *Model II* adjustment for age, gender, rural childhood, current urban residency, indoor painting, new floor materials, ETS in the dwelling, and all other dietary variables at the same time

associated with a lower risk for both asthma and atopic sensitisation (pollen/cat allergy). Frequent fish consumption was associated with a lower cumulative incidence of asthma, less doctor's diagnosed asthma, but more atopy. A similar pattern was observed for carbonated soft drinks. Frequent consumption of soft drinks was associated with less asthma, but more pollen or cat allergy. Finally, those with a frequent consumption of hamburgers had a higher cumulative incidence of asthma and more eczema. The association was significant in the simple model only. When controlling for many different factors in model II, the OR was similar, but the associations did not reach statistical significance (Table 6).

Discussion

Reports on asthma, eczema and allergy to pollen or furry pets were uncommon among Chinese school children in Shanxi. Growing up on the countryside was associated with less asthma, eczema, and atopic sensitisation. Dietary factors seem to be of importance, par-

ticularly consumption of fruit, fish, and fast food. The higher prevalence of both asthma, eczema and allergy among children born in the beginning of the 1990s, as compared with those born in the 1980s, indicated an increase of asthma and allergy in the younger generations. Totally, 1.7% ever had asthma, 0.8% had doctors' diagnosed asthma, 2.6% eczema, 1.4% pollen allergy, 1.7% cat allergy, and none reported dog allergy. When asking the same questions to Swedish pupils (13–14 years), much higher figures were obtained. Totally, 8.0% ever had asthma, 7.7% had doctor's diagnosed asthma, 25% had childhood eczema, 10% pollen allergy, and 10% had pet allergy (Smedje et al. 1997). This indicates that despite the much more heavy air pollution in China as compared with Sweden, for example, monitored by satellite instruments (Richter et al. 2005), asthma and allergies were less common.

Selection bias because of low response rate is less likely as the participation rate was high (90%), and the schools were arbitrary selected. Information bias can be a potential problem in questionnaire studies, when no clinical diagnosis or objective exposure assessment

is performed. The study is sharing this weakness with other large questionnaire studies on asthma, for example, the phase I of the ISAAC study (Apter et al. 1998), and the large national asthma study in China (Chen 2004). A systematic classification error in a diet questionnaire is of importance in an epidemiological study only if it is associated to the disease, otherwise it would most likely lead to non-differential misclassification. Food frequency questionnaires (FFQ) are widely used in epidemiological studies, and has been validated for fish and fruit consumption against dietary records (Van Assema et al. 2002; Khani et al. 2004), omega-3-fatty acids measurements in serum (Sasaki et al. 2000), or spouse versus husbands' report on fish consumption (Li et al. 2005), with acceptable agreement. Validation of questionnaires can be culture dependent and we have found no diet validation studies from China. Some authors have concluded that as the associations between FFQ and dietary records are moderate, in general, only strong associations between diet and health can be detected by using FFQ. Self-reported asthma and doctor's diagnosed asthma are commonly used in epidemiological studies and has a high specificity, but lower sensitivity.

A strong association between self-reported physician diagnosed asthma and airway hyperresponsiveness, measured by methacholine challenge test, has been demonstrated in Chinese children (Xu et al. 2001). The authors concluded that it was appropriate to ask on self-reported doctor's diagnosed asthma in rural China. Asthma medication was virtually non-existing in the countryside, and questions on doctor-diagnosed asthma and persistent wheeze gave virtually identical results (Xu et al. 2001). We have no specific information on diagnostic criteria for childhood asthma or eczema during the 1990s in the Shanxi province. The medical services in Taiyuan are relatively well developed, and patients come to asthma and allergy specialists in the central hospitals both from the city and the surrounding rural areas. Moreover, there are two regional hospitals and several local hospitals in Qingxu county, one of the more wealthy counties in Shanxi, and with good infrastructure. Thus, we have no reason to believe that there are considerable differences in diagnostic criteria for asthma or allergy, or considerable differences in access to medical services, when comparing Taiyuan and Qingxu counties. Recently, we have performed another study on asthma and respiratory symptoms in junior high school pupils in Taiyuan city (Zhao et al. 2006), indicating a possible underdiagnosis of asthma, or overreporting of respiratory symptoms. The discrepancy between asthma diagnosis and respiratory symptoms indicate a need to

include a clinical diagnosis of asthma and allergy testing in future studies.

Our question on eczema was similar as the question on eczema in the ISAAC study, which has been validated in Chinese children, using clinical examination as golden standard. Specificity and sensitivity was similar and fairly good, 67 and 71%, respectively (Chan et al. 2001). Our question on pollen allergy was similar, but not exactly as the ISAAC question on pollen allergy (hay fever) used in the Chinese translation of ISAAC (Lee et al. 2004). In a subsequent school study in Shanghai (Mi et al. 2006), we have used both questions. They gave the same prevalence of pollen allergy in Shanghai pupils (4.4% with our question and 4.5% with the ISAAC question). Previous validation studies in children from Sweden and Norway have demonstrated fairly good agreement between self-report and skin-prick test, but with somewhat higher prevalence of self-reported pollen and pet allergy (Hattevig et al. 1987; Dotterud et al. 1995). We have found no similar validation studies on atopy in Chinese children. Our prevalence of cat allergy (1.7%) is lower than the prevalence of cat allergy detected by skin-prick test in urban children in Beijing (5.6–10.8%), in suburban children outside Beijing (3.7%), Guangzhou (4.3%), and Hong Kong (3.7%) (Chen et al. 2003; Zhao et al. 2003). Thus, a majority of those reporting asthma, eczema, and allergy in our study could be expected to actually have asthma, eczema, or allergic sensitisation, but some underestimation of the true prevalence could be expected.

The prevalence of asthma was low in Shanxi, but similar as in another study including data from urban children in Taiyuan. This study is a national survey, performed in 1990 and 2000 across 27 cities in China, including a population of 287,329 children (0–14 years) in 2000. They reported an overall asthma prevalence of 1.51% in 2000 in urban China, while the asthma prevalence was only 1.02% in Taiyuan (Chen 2004). The ISAAC study reported a higher cumulative incidence of asthma (ever asthma) in China, ranging from 7.1% in Shanghai to 3.9% in Guangzhou in 1994–1995 (Asher et al. 1998). Few population studies are available on asthma prevalence in rural areas in China. One study in young adults found a low prevalence of current asthma (0.67%) in villages outside of Beijing (Chan-Yeung et al. 2002).

We found 2.6% of eczema, similar as in previous studies in China. In ISAAC, China had the second lowest prevalence of atopic eczema symptoms (1–2%) in the world (ISAAC 2000). In another study, comparing eczema in Urumqi in North West China with Beijing, there were no significant differences in the prevalence

of eczema (2.8 in Beijing versus 2.0% in Urumqi) (Zhao et al. 2000).

There is little data on self-reported hay fever (pollinosis) from China, but our data are comparable with previous data from Hong Kong, where 1.2% of children (6–7 years) reported pollinosis in 1994–1995 and 1.4% of the same age reporting pollinosis in 2000–2001 (Lee et al. 2004). In addition, our data on self-reported pollen and pet allergy are comparable with other studies from China, using skin-prick tests. The total prevalence of atopy, defined by at least one positive skin prick test, is relatively high in China, but this is mainly due to frequent allergy to house dust mites and cockroaches. The prevalence of atopy was 41.2% in Hong Kong, 23.9% in Beijing, and 30.8% in Guangzhou (Wong et al. 2002). Allergy to mixed grass pollen was 0.7, 1.2, and 1.1% in Hong Kong, Beijing, and Guangzhou, respectively. Allergy to mixed tree pollen was 0.1, 1.0, and 0.5%, respectively. Cat allergy was somewhat higher, 3.7, 5.6, and 4.3%, respectively (Wong et al. 2002). Another study reported that the prevalence of cat allergy was 10.8% in urban children in Beijing, but only 3.7% in suburban children outside Beijing (Zhao et al. 2003). Thus, our data on pollen and cat allergy is in line with what could be expected, as most of our population was from rural areas.

Despite the low prevalence of asthma, eczema, and allergy, we could demonstrate significant associations with environmental and dietary factors. Age was a significant predictor in the bivariate analysis, with a higher prevalence of asthma and allergies among children born in the period 1990–1992, as compared with those born earlier. The interpretation of this as a cohort effect, with an increase of asthma and allergies in Shanxi, is in agreement with data from the large national survey in children (0–14 years) from 27 cities in China. They reported an overall increase of the prevalence asthma from 0.91% in 1990 to 1.50% in 2000. In Taiyuan, the prevalence of asthma increased from 0.51% in 1990 to 1.02% in 2000 (Chen 2004). On the contrary, it has been reported from ISAAC that in Hong Kong that there has been no substantial increase of asthma, the cumulative incidence being 7.8% in 1995 and 7.9% in 2001 (Lee et al. 2004). Interestingly, we found that age was no longer significant in the multivariate analysis when we controlled for diet and environmental factors, suggesting that the cohort effect may be related to changes in the childhood environment and dietary factors.

We could statistically separate the effect of growing up in the countryside, from the effect currently living on the countryside. A rural childhood was associated with less asthma, eczema and atopic sensitisation, while

current urban residency was a risk factor for eczema only. A protective effect of a rural childhood with respect to the development of asthma and atopic sensitisation has been reported from other parts of the world (Braun-Fahlander 2001; von Mutius 2000), as well as from China (Chan-Yeung et al. 2002). We did not ask specifically about growing up on a farm. As a majority of children in rural Shanxi live in families involved in agriculture, it is likely that many are exposed to farm animals. A study on urban children (14–16 years) in Wuhan, an industrial city in mid-China, reported that 21.3% had a cat at home, 19.9% had a dog, 15.3% had contact with farm animals, and 20.6% had current contact with other animals. Totally, 51.4% have had early childhood (0–6 years) animal exposure (Salo et al. 2004). In contrast to studies from other countries, they found that early-life childhood exposure to animals (no specification of type of animal), was a risk factor for asthma (Salo et al., 2004). This indicates that urban children in China can have frequent animal exposure, and it could be expected that contact with animals, especially farm animals, is even higher in the countryside. We found that children with an urban childhood had a higher current consumption of meat, fish, fruit, hamburgers, fruit juice, and carbonated soft drinks. Thus, moving to the city may involve dietary changes that can have both positive and negative effects, with respect to asthma and allergy development.

When analysing dietary risk factors in our study, the most consistent result was the beneficial effect of high fruit consumption. This is in agreement with some previous studies, mainly focusing on obstructive lung disease (Romieu and Trenga 2001). Those with a more frequent consumption of fish reported less asthma, but more pollen and cat allergy. Evidence for a beneficial effect of fish consumption on asthma have been reported from western countries (Hodge et al. 1996; Nafstad et al. 2003), including one study in Swedish school children using the same FFQ as in our study (Kim et al. 2005). The effect has been suggested to be related to a higher intake of omega-3-fatty acids from deep-sea fish (Romieu and Trenga 2001). Shanxi province is situated far away from the sea, the fish consumption was relatively low, and mostly not deep-sea fish, suggesting that there may be other beneficial components in fish. The positive association between fish consumption and atopic sensitisation remains unclear. Children may have immunoglobulin E (IgE)-mediated allergy to fish proteins, but we have no information on such allergies in this study.

Finally, consumption of hamburgers, a proxy variable for consumption of fast food, was associated with

more asthma and eczema. In western countries, fast food is inexpensive and tended to be more common among those with lower income. In China, western fast food (e.g. hamburgers and pizza) is fashionable, and more expensive than ordinary restaurant food. Fast food consumption is linked to obesity (Binkley et al. 2000), and has been reported to be linked to an increase of childhood asthma in Saudi Arabia (Hijazi et al. 2000), New Zealand (Wickens et al. 2005), and Sweden (Kim et al. 2005). Carbonated soft drinks were included as another indicator of fast food consumption and western life-style, but did not show the same associations as for hamburger consumption. Frequent soft drink consumption was associated with a lower prevalence of asthma but a higher prevalence of atopic sensitisation. The reasons remain unclear. Adverse health effects of soft drinks have been reviewed, and may include allergic reactions to additives, for example, preservatives or aspartame (Amato et al. 1997). As fast food consumption is increasing in the world, further studies on possible effects of these dietary changes on asthma and allergy development are needed.

In conclusion, reports on asthma, eczema, and allergy to pollen or furry pets were uncommon. Growing up on the countryside was associated with less asthma, eczema, and allergy, in agreement with the “hygiene hypothesis”. Dietary factors seem to be of importance, even when controlling for other factors. Frequent consumption of fruit seems to be beneficial for both asthma and allergy, and frequent fish consumption could be beneficial for asthma. The higher prevalence of both asthma, and eczema among children born in the beginning of the 1990s, as compared with those born in the 1980s, may indicate that there is an increase of asthma and atopic sensitisation among children in the Shanxi province.

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