

# Primary care

## Factors associated with difference in prevalence of asthma in children from three cities in China: multicentre epidemiological survey

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### Abstract

**Objective** To determine the factors associated with difference in prevalence of asthma in children in different regions of China.

**Design** Multicentre epidemiological survey.

**Setting** Three cities in China.

**Participants** 10 902 schoolchildren aged 10 years.

**Main outcome measures** Asthma and atopic symptoms, atopic sensitisation, and early and current exposure to environmental factors.

**Results** Children from Hong Kong had a significantly higher prevalence of wheeze in the past year than those from Guangzhou and Beijing (odds ratio 1.64, 95% confidence interval 1.35 to 1.99). Factors during the first year of life and currently that were significantly associated with wheeze were cooking with gas (odds ratio 2.04, 1.34 to 3.13), foam pillows (2.58, 1.66 to 3.99), and damp housing (1.89, 1.26 to 2.83). Factors protecting against wheeze were cotton quilts and the consumption of fruit and raw vegetables.

**Conclusion** Environmental factors and diet may explain the differences in prevalence of asthma between children living in different regions of China.

### Introduction

Asthma is one of the most common chronic disorders in children, and its prevalence varies worldwide.<sup>1</sup> Consistent reports from different countries indicate an increase in prevalence of asthma and allergies.<sup>2-6</sup> This increasing trend is unlikely to be explained by genetic factors. Despite numerous studies in different communities, the factors related to the increasing prevalence of asthma are largely unknown, probably because the factors are so widespread that it is difficult for epidemiological studies to identify them.

In China the prevalence of asthma seems to be lower than in the West,<sup>1</sup> and within China the prevalence varies between regions—for example, over one year, 12.4% and 10.1% of children aged 13 and 14 years in Hong Kong had wheeze compared with 4.2% and 2.0% of children in mainland China.<sup>7</sup> As children from these regions have a similar genetic background, it may be possible to determine the environmental factors associated with asthma.

The international study of asthma and allergies in childhood phase II study was designed to assess the prevalence of objective markers of atopic diseases and to investigate the association with lifestyle and environmental factors.<sup>8</sup> Using this protocol, we

compared the environmental and lifestyle factors related to asthma in children from Hong Kong and “mainland China” (areas of China not in the special administrative region of Hong Kong).

### Methods

Our study took place in Hong Kong, Beijing, and Guangzhou. Hong Kong is a westernised city located in the coastal area of China, which has a subtropical climate. Guangzhou is situated 200 km north of Hong Kong and has a similar climate. Beijing, in the temperate zone, has a relatively lower humidity than the other two cities. The selection of participants and the methods are reported elsewhere.<sup>9</sup> Briefly, we randomly selected primary schools from the three cities and recruited children aged 10 years. A questionnaire was completed by the parents or guardians of each child. Overall, 10 902 of 11 608 (93.9%) questionnaires were returned.

We randomly selected subgroups of children from each city to undergo a skin prick test for sensitivity to eight common aeroallergens (*Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, cat, *Alternaria tenuis*, mixed tree pollen, mixed grass pollen, cockroach, and mixed moulds).<sup>10</sup> Children with one or more positive reactions were considered atopic. We classified symptoms as current if they occurred in the past year. Asthma was defined as asthma ever if diagnosed sometime by a doctor and current asthma if current wheeze occurred in addition to asthma ever.

Exposures analysed in the participants’ first year of life and currently were cooking with gas, foam pillows, cotton quilts, damp housing (mould on ceiling or walls), pets, and contact with cats, dogs, or farm animals. We also considered consumption of fruit, cooked green vegetables, and raw vegetables.

### Statistical analysis

The data, entered by two people (double data entry), were managed and analysed using SPSS version 10.0 and SAS version 8.2. We created a propensity score (“mainland propensity score”) for children from Guangzhou and Beijing to reduce the chance of bias from differences in distribution of factors between the cities.<sup>11</sup>

We evaluated the associations between current wheeze and environmental factors and diet by using multiple logistic regression analyses adjusted for the propensity score and sex. Identified factors were included in a multiple logistic regression model, adjusted for propensity score and sex. We also investigated whether the factors could explain the protection against wheeze in children living on the mainland. We used a

**Table 1** Prevalence of asthma symptoms and atopic sensitisation in schoolchildren from three cities in China

Characteristic	Hong Kong (n=3110)		Beijing (n=4227)		Guangzhou (n=3565)	
	No of children	Prevalence (95% CI)	No of children	Prevalence (95% CI)	No of children	Prevalence (95% CI)
Mean (SD) age (years)		10.3 (0.7)		10.4 (0.6)		10.1 (0.4)
No (%) boys		1648 (52.9)		2156 (51.0)		1783 (50.0)
Symptoms in past year:						
Wheeze:	179	5.8 (4.9 to 6.6)	159	3.8 (3.2 to 4.3)	121	3.4 (2.8 to 4.0)
≥4 attacks	40	1.3 (0.9 to 1.7)	33	0.8 (0.5 to 1.1)	18	0.5 (0.3 to 0.7)
Speech limiting	54	1.7 (1.3 to 2.2)	20	0.5 (0.3 to 0.7)	16	0.4 (0.2 to 0.7)
Exercise induced	239	7.7 (6.7 to 8.6)	193	4.6 (3.9 to 5.2)	109	3.1 (2.5 to 3.6)
Current asthma	104	3.3 (2.7 to 4.0)	98	2.3 (1.9 to 2.8)	75	2.1 (1.6 to 2.6)
Skin prick test*:						
		n=1341		n=1044		n=1098
Atopic†	552	41.2 (38.5 to 43.8)	249	23.9 (21.3 to 26.4)	337	30.8 (28.1 to 33.5)
<i>Dermatophagoides pteronyssinus</i>	457	34.1 (31.5 to 36.6)	78	7.5 (5.9 to 9.1)	219	20.0 (17.6 to 22.4)
<i>Dermatophagoides farinae</i>	347	25.9 (23.5 to 28.2)	59	5.7 (4.3 to 7.1)	196	17.9 (15.6 to 20.2)
Cat	50	3.7 (2.7 to 4.7)	58	5.6 (4.2 to 6.9)	47	4.3 (3.1 to 5.5)
Cockroach	154	11.5 (9.8 to 13.2)	139	13.3 (11.3 to 15.4)	186	17.0 (14.8 to 19.2)

\*Sensitivities <3% not shown.  
†One or more positive test results.

step by step modelling approach to investigate this “protective mainland effect”; initially we estimated an unadjusted mainland effect then we adjusted for the propensity score. In each subsequent model we added the environmental or dietary factor that led to the highest reduction in the Akaike’s criterion at that particular step.<sup>12</sup>

**Results**

Overall, 10 902 children took part in the survey, of whom 3483 underwent a skin prick test. Table 1 summarises the prevalence of asthma symptoms and atopic sensitisation in the three study populations. The prevalence of wheeze in the past year was sig-

nificantly higher in children from Hong Kong (odds ratio 1.64, 95% confidence interval 1.35 to 1.99). Other symptoms, including speech limiting wheeze and exercise induced wheeze, were also significantly more common in children from Hong Kong. Factors significantly associated with being a child living on the mainland were age, school grade, parents’ level of education, parental history of rhinitis and eczema, history of sharing a bedroom, smoking in the home, parents’ birth place, and presence of older siblings. After adjustment for the propensity score, six factors were related to current wheeze: cooking with gas, foam pillows, cotton quilts, damp housing, consumption of fruit more than once a day, and consumption of raw vegetables once or more a week (table 2). Foam pillows and cooking with gas were

**Table 2** Associations of environmental and dietary exposure factors and current wheeze in Chinese schoolchildren, adjusted for mainland propensity score (see text) and sex

Exposure factor	Univariate model			Multivariate model		
	Unadjusted prevalence of current wheeze	Adjusted odds ratio (95% CI)	P value	Unadjusted prevalence of current wheeze	Adjusted odds ratio (95% CI)	P value
Cooking with gas:						
None	24/1142 (2.1)	1.0	0.001	24/1058 (2.3)	1.0	0.004
During first year but not at present	9/207 (4.3)	2.11 (0.97 to 4.61)		6/186 (3.2)	1.53 (0.61 to 3.80)	
At present only	71/1957 (3.6)	1.44 (0.89 to 2.33)		55/1609 (3.4)	1.40 (0.85 to 2.31)	
At present and during first year	298/6316 (4.7)	2.04 (1.34 to 3.13)		255/5470 (4.7)	2.00 (1.29 to 3.09)	
Foam pillow:						
None	329/8473 (3.9)	1.0	<0.001	287/7571 (3.8)	1.0	0.002
During first year but not at present	1/25 (4.0)	1.04 (0.14 to 7.71)		1/21 (4.8)	1.43 (0.19 to 10.85)	
At present only	39/681 (5.7)	1.24 (0.87 to 1.79)		27/529 (5.1)	1.04 (0.67 to 1.61)	
At present and during first year	26/236 (11.0)	2.58 (1.66 to 3.99)		25/202 (12.4)	2.49 (1.55 to 3.98)	
Cotton quilt:						
None	75/1167 (6.4)	1.0	0.036	60/939 (6.4)	1.0	0.062
During first year but not at present	29/895 (3.2)	0.58 (0.37 to 0.91)		22/793 (2.8)	0.51 (0.31 to 0.86)	
At present only	23/531 (4.3)	0.61 (0.38 to 0.98)		14/392 (3.6)	0.64 (0.35 to 1.18)	
At present and during first year	273/7016 (3.9)	0.72 (0.54 to 0.97)		244/6199 (3.9)	0.82 (0.59 to 1.14)	
Damp housing:						
None	294/7774 (3.8)	1.0	<0.001	255/6788 (3.8)	1.0	0.012
During first year but not at present	31/664 (4.7)	1.31 (0.90 to 1.92)		29/616 (4.7)	1.41 (0.94 to 2.09)	
At present only	43/641 (6.7)	1.67 (1.19 to 2.33)		32/556 (5.8)	1.44 (0.98 to 2.12)	
At present and during first year	28/400 (7.0)	1.89 (1.26 to 2.83)		24/363 (7.0)	1.78 (1.15 to 2.75)	
Fruit more than once daily:						
No	285/6203 (4.6)	1.0	0.003	247/5436 (4.5)	1.0	0.004
Yes	116/3442 (3.4)	0.71 (0.57 to 0.89)		93/2887 (3.2)	0.70 (0.54 to 0.89)	
Raw vegetables once or more a week:						
No	208/4458 (4.7)	1.0	0.048	196/4228 (4.6)	1.0	0.082
Yes	162/4696 (3.4)	0.80 (0.65 to 1.00)		144/4095 (3.5)	0.81 (0.64 to 1.03)	

**Table 3** Regression analysis to determine protective effect of living on mainland China and risk of current wheeze in relation to environmental factors and diet

Model	Description	Odds ratio (95% CI)
1	Unadjusted model	0.61 (0.49 to 0.77)
2	Model 1 plus propensity score	0.62 (0.41 to 0.94)
3	Model 2 plus sex	0.64 (0.42 to 0.97)
4	Model 3 plus foam pillow	0.78 (0.50 to 1.20)
5	Model 4 plus fruit	0.79 (0.51 to 1.22)
6	Model 5 plus cooking by gas	0.83 (0.54 to 1.30)
7	Model 6 plus damp housing	0.86 (0.55 to 1.33)
8	Model 7 plus cotton quilt	0.87 (0.55 to 1.37)
9	Model 8 plus raw vegetables	0.99 (0.61 to 1.60)

associated with the highest risk for current wheeze; protective factors were cotton quilts, consumption of fruit more than once a day, and consumption of raw vegetables at least once a week.

After adjustment for the propensity score and sex, factors that remained significantly associated with current wheeze were cooking with gas, foam pillows, damp housing, and consumption of fruit. The association between cotton quilts and current wheeze was of borderline significance.

Living on the mainland was associated with a significantly reduced risk of current wheeze (odds ratio 0.61, 95% confidence interval 0.49 to 0.77; table 3). With the sequential addition to the logistic regression model of the six factors identified as protecting mainland children against current wheeze along with adjustment for the propensity score and sex, the odds ratios gradually increased from 0.61 to 0.99.

## Discussion

Environmental factors and diet can explain the difference in prevalence of asthma in children living in Hong Kong and mainland China (Beijing and Guangzhou). Asthma is more common in developed countries. Because of rapid economic improvements in mainland China many of its cities are at different stages of modernisation. As the participants had the same genetic background, the differences in prevalence of asthma are likely to be due to exposure to different environmental factors.

Our large scale study used the standardised phase II protocol of the international study of asthma and allergies in childhood to evaluate environmental and lifestyle factors associated with asthma in schoolchildren recruited from three Chinese cities. Asthmatic symptoms occurring in the past year were up to three times more common in children from Hong Kong than in those from the other two cities. Our questionnaire has been validated against methacholine induced bronchial hyperresponsiveness<sup>10</sup>; a positive response to the question on current wheeze had a sensitivity of 0.82 and a specificity of 0.71 for predicting such hyperresponsiveness. To avoid bias from differences in the distribution of factors associated with living in mainland China, we created a propensity score from 13 variables identified by logistic regression, and we adjusted for this score. Six factors were significantly associated with current wheeze and current asthma: cooking with gas, foam pillows, cotton quilts, damp housing, consumption of fruit more than once a day, and consumption of raw vegetables once or more a week. Of these, only foam pillows and the consumption of raw vegetables were associated with a positive skin prick test result. Other environmental factors were associated with atopy but not with asthma or wheeze (data not shown), suggesting that these factors do not contribute to asthma.<sup>13</sup>

One potential limitation of our study was bias due to missing information, but this amounted to only 3%. Although questionnaires were returned for 10 902 participants, we included only 8323 (76.3%) in our multivariate analysis with all six factors in one model and 9154 to 9645 (83.9% to 88.5%) in the univariate analyses. The results for both models were consistent. Furthermore, the prevalence of asthma symptoms not included in the risk factor analyses was similar to the prevalence of those included in the multivariate analysis. It is unlikely that missing data would have led to major bias.

Cooking with gas was strongly associated with current wheeze. Studies in England and Canada have reported a higher prevalence of asthma in young people exposed to cooking with gas at home.<sup>14-16</sup> A recent study also found an association between cooking with gas at home and sensitisation to house dust mite and reduction of lung function in children.<sup>17</sup> It should be noted that homes in Hong Kong and urban mainland China are smaller than those in England and Canada—most people in China live in apartments averaging 40-50 m<sup>2</sup>. The possible effects of cooking with gas are therefore likely to be less pronounced in British and Canadian homes. In our survey, 96.2% of children in Hong Kong were currently exposed to cooking gas compared with 81.2% of children in mainland China.

Foam pillows were strongly associated with current wheeze. Traditionally, cotton has been the most common material used for pillows and bedding in China. Several studies have shown an association between synthetic bedding and asthma in children.<sup>18, 19</sup> Why cotton bedding should protect Chinese children against asthma remains to be determined. Studies of asthma in both children and adults have shown an association with damp housing.<sup>20-21</sup> Dampness measured objectively by hygrometer also confirmed a relation with severity of asthma.<sup>22</sup> In our survey, damp housing was more common in Hong Kong than in mainland China (17.0% *v* 8.3%).

Frequent consumption of fruit and raw vegetables was associated with a reduced risk of wheezing. A case-control study of 1471 adults in south London found that consumption of fruit and vegetables reduced the risk of asthma, and a recent study of young adults in Australia found that the consumption of apples and pears was associated with a lower prevalence of asthma and bronchial hyperresponsiveness.<sup>23, 24</sup> Our final analysis showed that children living in Guangzhou and Beijing had a 40% lower risk of current wheeze than children in Hong Kong. The odds ratio gradually shifted towards unity with the sequential addition of the six factors significantly associated with current wheeze and current asthma. This suggests that these factors or unmeasured factors associated with these may be responsible for the lower prevalence of asthma among children in mainland China.

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Ethical approval: This study was approved by the ethics committees of the three participating institutions. Informed consent was obtained from the parents or guardians.

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**What is already known on this topic**

The prevalence of asthma has increased over the past three decades in many countries

This prevalence differs widely between developing and developed countries

No studies have identified the factors associated with this difference

**What this study adds**

The prevalence of asthma and atopic symptoms is higher in children in Hong Kong than those in mainland China

Factors related to the environment and diet could explain this difference

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