



Higher environmental composite quality index score and risk of asthma and allergy in Northeast China

To the Editor,

Asthma and allergy in childhood are common chronic diseases worldwide.¹ Over the last few decades, the incidence of asthma and allergy among children increases year by year around the world,² especially in developing countries. Many studies have shown that the environment and lifestyle were the risk factors for asthma and allergy among children.³ It has been reported that children living in a green environment have a 79% lower risk of asthma compared with living in traditional communities.⁴ Another study found that the use of biomass fuel and kerosene for cooking, vs. the use of liquified petroleum gas or electricity, was associated with childhood asthma and rhinitis.⁵ To our knowledge, little research has explored how a combination of multiple environmental pollutants and household air quality may relate to asthma and allergy in children. Thus, our study extends previous findings by comprehensively assessing a panel of thirteen indoor and outdoor environmental factors in combination and constructing an environmental composite quality index score (ECQI). We aim to investigate the association between both outdoor environmental quality and household air quality with asthma and allergy in children.

The institutional review board approval of the China Medical University and written informed consent were obtained before data collection. Details for recruitment and methods are provided in this article's online Supporting Information.

1 | RESULTS

A total of 3,158 children were enrolled in the cross-sectional survey, the prevalence of asthma among children aged 2–17 in Fuxin city of China was 3.1%, the prevalence of rhinitis was 5.1%, and the prevalence of eczema was 39.2%. Participants with higher environmental pollution exposure were more likely to have family allergic history and lower income (Table S1 and Table S2).

Comparing the top with bottom category of ECQI score and asthma and allergy still existed after adjusting other potential confounding factors, the odds ratio of ECQI score with asthma were 2.47 (95% CI, 1.41–4.33, *p* for trend = 0.004), 1.51 for eczema (95% CI, 1.18–1.93; *p* for trend = 0.002), and 1.83 for rhinitis (95% CI: 1.12–3.00; *p* for trend = 0.017) (Table 1). Moreover, we generally

found similar associations with asthma and allergy in subgroups defined by age, gender, overweight, annual household income, and family allergic history, although some were not statistically significant (Table S7).

In the analyses for thirteen pollutants (outdoor components and indoor components) of the ECQI, distance from the factory (≤ 500 m) and distance from the chimney (≤ 500 m) were positively associated with the risk of asthma, eczema, and rhinitis. The risk of housing along the street and rhinitis was 1.47 (95% CI; 1.02–2.12), and the risk between polluting heating fuel and asthma was 2.34 (95% CI; 1.12–4.88). Moreover, the gutter had a significant association with asthma and eczema except for rhinitis (Table 2). The factor analysis was used in our study to develop the ECQI to evaluate its effect of asthma and allergy (Table S5 and Table S6).

2 | DISCUSSION

The present study evaluated the relationship of the outdoor environment around residences and household air quality with children's asthma and allergy in the highly industrial area of northeast China. We found that a higher ECQI score was significantly associated with asthma and allergy.

Compared with the evaluation of the effects of a single factor, research on ECQI considers the entire indoor and outdoor risk factors and thus captures the complex interaction between multiple risk factors. Our results showed that compared with a low ECQI score, a positive relationship among the risk of asthma and allergy, increasing with the accumulation of indoor and outdoor risk factors. Also, after adjusting for other factors, ECQI had a similar relationship with asthma, eczema, and rhinitis.

We observed that asthma, rhinitis, and eczema had two common risk factors, including distance from the factory and the chimney. These findings could be explained by individuals living in the factories and chimneys were more likely to be exposed to air pollutants, such as NO₂, SO₂, PM₁₀, and dust.⁶ The mechanism of atmospheric pollutants causing asthma and allergy is not yet clear. However, some studies have found that air pollutants might cause oxidative injury to the airways and promote

Abbreviations: COF, cooking oil fume; ECQI, environmental composite quality index.

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	Environmental composite quality index score ^a , OR (95% CI)			
Disease	0–2	3–4	≥5	<i>p</i> trend
Asthma				
N	1,373 (47.89)	1,040 (36.27)	454 (15.83)	
Model 1	1 (Reference)	1.07 (0.63–1.82)	3.50 (2.13–5.77)^{***}	<0.001
Model 2	1 (Reference)	1.09 (0.64–1.87)	3.47 (2.10–5.73)^{***}	<0.001
Model 3	1 (Reference)	1.02 (0.58–1.78)	2.47 (1.41–4.33)^{**}	0.004
Eczema				
N	1,367 (47.98)	1,029 (36.12)	453 (15.90)	
Model 1	1 (Reference)	1.02 (0.87–1.21)	1.51 (1.22–1.87)^{**}	0.001
Model 2	1 (Reference)	1.05 (0.89–1.25)	1.50 (1.21–1.87)^{**}	0.001
Model 3	1 (Reference)	1.08 (0.90–1.31)	1.51 (1.18–1.93)^{**}	0.002
Rhinitis				
N	1,367 (47.86)	1,035 (36.24)	454 (15.90)	
Model 1	1 (Reference)	1.22 (0.83–1.78)	1.94 (1.26–2.99)^{**}	0.004
Model 2	1 (Reference)	1.20 (0.82–1.76)	1.98 (1.29–3.05)^{**}	0.004
Model 3	1 (Reference)	1.29 (0.85–1.97)	1.83 (1.12–3.00)[*]	0.017

Note: Model 1: Adjust for none.

Model 2: Adjust for age (<8 years, ≥8 years).

Model 3: Adjust for Model 2 + gender (female or male), overweight (yes or no), annual household income (<30,000 or ≥30,000), family allergic history (yes or no).

^aEnvironmental composite quality index score was computed by summing 13 binary variables: housing along the street (yes or no), gutter (yes or no), garbage dump (yes or no), noise (yes or no), chemical pollution (yes or no), dust pollution (yes or no), traffic arteries (yes or no), factory (yes or no), chimney (yes or no), use polluting cooking fuel (1 or 0), use polluting heating fuel (1 or 0), smoke stimulating symptoms during cooking (1 or 0), cooking oil fume outside kitchen (1 or 0). Each factor was assigned to 0 (no) and 1 (yes).

**p* value significant at <0.05.

***p* value significant at <0.005.

****p* value significant at <0.0001.

Parameter estimates with 95% confidence intervals (CI), not including 0, were considered statistically significant at the 0.05 level. Odds ratios (ORs) and confidence intervals (CIs) in bold are statistically significant.

TABLE 1 Associations of environmental composite quality index score with asthma and allergy in different models

the release of inflammatory factors in the body, which could cause clinical asthma symptoms.⁷ Air pollution also can enhance T helper lymphocyte immune responses and make the antiviral immune response unregulated, which can cause allergic symptoms.⁸ Our study found that the relationship between the use of heating materials that produce air pollution has a significant correlation with childhood asthma. A Polish study found that the use of solid fuel for heating has an impact on asthma.⁷ This is because the burning of biological materials such as coal and wood indoor will also produce air pollutants, such as NO₂, SO₂, CO, CO₂, and PM.⁹ Indoor air pollution may share the mechanism with outdoor air contaminants in the onset of asthma.

Our study had several limitations. One limitation was that the exposure was based on a questionnaire survey, and there was no actual measurement. However, the questionnaire survey is a common way for environmental research. The main reason might be due to it was difficult to obtain qualitative data. Further study of the geographic information system (GIS) measuring outdoor

and indoor pollution could be needed to verify these findings. Second, we only surveyed children in urban areas and did not survey children's residential areas in the questionnaire, which might not account for clustering by place or school in our models. However, we adjusted for the variable of the housing location, similar results were observed. Third, we also did not investigate the amount of time the children were exposed to the outdoors and indoors. Fourth, we did not investigate the current symptoms of asthma and allergy. Finally, this study was a cross-sectional study so it is difficult to know whether the diagnoses occurred before or after exposure, which cannot conclude causal relationships.

In summary, we observed that a higher ECQI score might be associated with a higher risk of asthma and allergy among children. Our findings also suggested that the government should pay attention to the surrounding pollutants and promote a green living environment. Future research is necessary to confirm our findings in other regions and clarify the specific mechanism.

TABLE 2 Logistic regression analysis of the relationship of major components of environmental composite quality index score with asthma and allergy

Components (outdoor pollutant) ^e	N	Asthma	Eczema	Rhinitis
Housing along the street				
No	1,923	1 (Reference)	1 (Reference)	1 (Reference)
Yes	1,074	1.20 (0.75–1.91)	0.90 (0.75–1.07)	1.47 (1.02–2.12)*
Gutter				
No	3,081	1 (Reference)	1 (Reference)	1 (Reference)
Yes	77	4.64 (2.00–10.75)**	2.06 (1.22–3.48)*	1.20 (0.42–3.45)
Garbage dump				
No	2,853	1 (Reference)	1 (Reference)	1 (Reference)
Yes	305	0.49 (0.17–1.37)	0.85 (0.64–1.14)	0.61 (0.30–1.24)
Noise				
No	2,485	1 (Reference)	1 (Reference)	1 (Reference)
Yes	673	0.73 (0.40–1.34)	0.90 (0.73–1.10)	1.43 (0.96–2.14)
Chemical pollution				
No	3,115	1 (Reference)	1 (Reference)	1 (Reference)
Yes	43	1.96 (0.55–7.01)	1.24 (0.63–2.44)	1.03 (0.24–4.43)
Dust pollution				
No	3,030	1 (Reference)	1 (Reference)	1 (Reference)
Yes	128	1.48 (0.61–3.59)	1.30 (0.87–1.95)	1.45 (0.70–3.00)
Distance from traffic arteries (meters)				
>200	1,316	1 (Reference)	1 (Reference)	1 (Reference)
≤200	1,745	1.30 (0.81–2.10)	1.13 (0.95–1.33)	1.14 (0.78–1.65)
Distance from factory (meters)				
>500	2,764	1 (Reference)	1 (Reference)	1 (Reference)
≤500	301	4.63 (2.66–8.08)***	2.04 (1.53–2.71)***	2.25 (1.37–3.70)**
Distance from chimney (meters)				
>500	2,749	1 (Reference)	1 (Reference)	1 (Reference)
≤500	307	3.00 (1.71–5.28)**	1.78 (1.35–2.34)***	1.71 (1.01–2.87)*
Components (indoor pollutant) ^f				
Fuel or energy used for cooking				
Clean cooking fuel ^a	3,014	1 (Reference)	1 (Reference)	1 (Reference)
Polluting cooking fuel ^b	144	1.20 (0.45–3.19)	1.13 (0.74–1.71)	0.56 (0.17–1.81)
Fuel used for space heating in winter				
Clean heating fuel ^c	2,979	1 (Reference)	1 (Reference)	1 (Reference)
Polluting heating fuel ^d	179	2.34 (1.12–4.88)*	1.22 (0.84–1.76)	1.53 (0.74–3.15)
Smoke stimulating symptoms during cooking				
No	2,656	1 (Reference)	1 (Reference)	1 (Reference)
Yes	402	1.06 (0.56–2.00)	0.95 (0.74–1.23)	1.29 (0.79–2.12)
COF outside kitchen				
No	1,912	1 (Reference)	1 (Reference)	1 (Reference)
Yes	1,246	1.42 (0.88–2.28)	1.05 (0.88–1.25)	1.21 (0.83–1.75)

Abbreviations: COF, cooking oil fume.

^aClean cooking fuel (or energy) including electricity or coal gas/liquefied gas.^bPolluting cooking fuel including coal, wood, or kerosene.^cClean heating fuel (or energy) including central heating or electrical heater.^dPolluting heating fuel including coal stove/heated brick bed or gas fire.^eAdjust for age (<8 years, ≥8 years), gender (female or male), overweight (yes or no), annual household income (<30,000 or ≥30,000), family allergic history (yes or no) and indoor pollutant (use polluting cooking fuel, use polluting heating fuel, smoke stimulating symptoms during cooking, cooking oil fume outside kitchen).^fAdjust for age (<8 years, ≥8 years), gender (female or male), overweight (yes or no), annual household income (<30,000 or ≥30,000), family allergic history (yes or no) and outdoor pollutant (housing along the street, gutter, garbage dump, noise, chemical pollution, dust pollution, traffic arteries, factory, chimney).

*p value significant at <0.05.

**p value significant at <0.005.

***p value significant at <0.0001.

Parameter estimates with 95% confidence intervals (CI), not including 0, were considered statistically significant at the 0.05 level. Odds ratios (ORs) and confidence intervals (CIs) in bold are statistically significant.

KEYWORDS

asthma, eczema, environmental composite quality index score, rhinitis

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CONFLICT OF INTEREST

The author has no conflicts of interest to declare.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

Appendix S1

Methods

1. Study Population

In this cross-sectional study, we only investigated the children who live in the urban area, the stratified cluster sampling method was used to select the study participants from five administrative districts (including the Haizhou, Xinqiu, Taiping, Qinghem, and the Xihe) in Fuxin City, Liaoning Province in 2015. The implementation details were as follows: Two kindergartens, primary schools, or secondary schools were randomly selected, from which one class in each grade of each school was selected to be included in the study. Finally, a total of 120 classes from 30 schools were included as the final study units.

All students from the selected classes and their adult guardians were included in the present study with their consent. Each child was required to deliver a questionnaire with an informed consent form to their guardian. A total of 4147 questionnaires were distributed and 4130 questionnaires were collected. We excluded individuals older than 18 years old or incomplete data. Finally, 3158 children were enrolled in the present study.

2. Standard protocol approval and patient consent

The institutional review board approval of the China Medical University and written informed consent were obtained before data collection. Meanwhile, we obtained permission from school administrators in Fuxin, Liaoning province. The researchers and headteachers were asked to explain in detail the meaning and procedures of the study. The parents or guardians who participated in the study submitted the informed consent to headteachers on the next day.

3. Questionnaire Assessments

The information was collected through the validated questionnaire. The questionnaire was originated from the China Children Homes Health (CCHH) study. The CCHH study is a multicenter study about environmental exposure and child health launched in 10 major cities of China^[1]. The questions about asthma and allergic diseases are the same as those of the International Study of Asthma and Allergy in Children (ISAAC)^[2], the content of the residence and environment was modified according to DBH study^[3] and Chinese housing characteristics^[4]. The questionnaire was similar to those previously used in Bulgaria^[5], Singapore^[6], the United States^[7]. The questionnaire consisted of demographic factors (date of birth, sex, height, weight, annual family income, etc.), the health status of children and family members (including asthma, eczema, and rhinitis), and family environment and housing characteristics.

3.1 Assessment of environmental factors and derivation of the risk score

Information on environmental factors was collected from parents/guardians of the child using the self-report questionnaire. Each factor was answered by “yes” or “no” and assigned with 0 (no) and 1 (yes). Based on the previous study^[8-10], we then used a binary score for each evaluated factor to add up to a summary score.

3.2 Definition of the environmental composite quality index score

Based on the previous study^[11-13], to capture the environmental quality of both indoor and outdoor, we constructed a combined environmental composite quality index (ECQI) score by summing up the 13 binary environmental pollutants (range: 0-13). We included four indoor pollutant components and outdoor pollutant components. The higher scores indicating a worse indoor and outdoor environment quality, scores were categorized as low (0-2), moderate (3-4), and high (≥ 5).

Indoor pollutants such as polluting cooking fuel (such as coal, wood, or kerosene), polluting heating fuel (such as coal stove, heated brick bed, or gas fire), smoke-creating during cooking (whether there is smoke

irritation when cooking), and cooking oil fume outside kitchen (whether there is smoke outside the kitchen when cooking).

Outdoor pollutants, including the following environmental pollution, exist within 100 meters of your home, gutter (gutter with a foul odor resulting from a poor drainage system) (1 or 0), garbage dump (1 or 0), noise (1 or 0), chemical pollution (1 or 0), dust pollution (1 or 0); and the presence of arterial roads (1 or 0), factories (1 or 0), and chimneys (1 or 0) surrounding the house, the housing on the street (1 or 0). Each factor was assigned to 0 (no) and 1(yes).

3.3 Definition of the environmental composite quality factor score

We employed the principal components analysis (PCA) approach to construct the environmental composite quality factor score^[14]. We included four indoor pollutant components (polluting cooking fuel (such as coal, wood, or kerosene), polluting heating fuel (such as coal stove, heated brick bed, or gas fire), smoke-creating during cooking (whether there is smoke irritation when cooking), and cooking oil fume outside kitchen (whether there is smoke outside the kitchen when cooking).and outdoor pollutant components (gutter, garbage dump, noise, chemical pollution, the presence of arterial roads, factories, and chimneys surrounding the house, the housing on the street). We extracted 5 common factors and 6 common factors respectively and calculated the comprehensive factor score in the two cases, discussed in detail in Supplementary Table 3-4.

3.4 Ascertainment of asthma and allergy

Symptoms of asthma, rhinitis, and eczema were identified via self-reported questionnaires. Reported asthma was defined as a positive response to the question: "Has the child ever been diagnosed with asthma by a doctor?" Rhinitis symptoms were obtained by asking: "Has the child been diagnosed with hay fever or allergic rhinitis?" with the response "Yes" or "No". Reported eczema was determined by a positive answer to: "Has the child ever been diagnosed with eczema by a doctor?" All self-reported illnesses should be ever diagnosed by a doctor.

4. Statistical Analyses

We defined the environmental quality index score as a categorical variable. We employed binary logistic regression to estimate the relationship of ECQI score (0-2, 3-4, and ≥ 5) with asthma and allergy. The multi-variable adjusted model included age, gender, overweight, annual household income, and family history of allergic disease. Meanwhile, we explored the association between each indoor or outdoor environment pollutant and asthma with allergy.

In stratified analyses, we did subgroup analyses using age (<8 years old or ≥ 8 years old), gender (female or male), overweight (yes or no), annual household income (<30,000 Chinese yuan or $\geq 30,000$ Chinese yuan), family allergic history (yes or no). Then, we did an interaction test by comparing the model with product terms between stratified covariates and several environment quality indices with the models without these terms. All statistical tests were two-sided and performed using the IBM SPSS Statistics 21.0 software (IBM, ASiaAnalytics Shanghai).

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Supplementary Table 1. Baseline characteristics of participants according to the environmental composite quality index score

Characteristic	Environmental composite quality index score ^a			P-value
	0-2	3-4	≥5	
N	1380	1043	456	
Age (years)				0.107
≤8	604 (43.77)	425 (40.75)	211 (46.27)	
>8	776 (56.23)	618 (59.25)	245 (53.73)	
Gender				0.112
Female	736 (54.84)	526 (51.57)	222 (49.89)	
Male	606 (45.16)	494 (48.43)	223 (50.11)	
Overweight				0.142
No	985 (76.53)	728 (74.29)	309 (72.03)	
Yes	302 (23.47)	252 (25.71)	120 (27.97)	
Annual household income (yuan)				<0.001
<30,000	448 (35.70)	411 (43.17)	223 (53.35)	
≥30,000	807 (64.30)	541 (56.83)	195 (46.65)	
Family allergic history				0.003

No	1199 (87.52)	884 (85.25)	366 (81.15)
Yes	171 (12.48)	153 (14.75)	85 (18.85)

Values were n (%).

The values of polytomous variables may not sum to 100% due to rounding.

Supplementary Table 2. Associations of subject characteristics with asthma and allergy

Characteristic	Statistics	Asthma	Eczema	Rhinitis
		OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
≤8	1344 (42.56)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
>8	1814 (57.44)	0.39 (0.25-0.59)***	0.38 (0.33-0.45)***	1.61 (1.15-2.25)*
Gender				
Female	1636 (53.08)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Male	1446 (46.92)	1.58 (1.05-2.38)*	1.18 (1.02-1.36)*	1.57 (1.14-2.17)*
Overweight				
No	2216 (75.20)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Yes	731 (24.80)	1.31 (0.83-2.08)	1.20 (1.01-1.42)*	1.08 (0.74-1.59)
Annual household income (yuan)				
<30,000	1197 (42.21)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
≥30,000	1639 (57.79)	1.11 (0.72-1.73)	1.61 (1.37-1.88)***	1.05 (0.75-1.46)
Family allergic history				
No	2661 (85.89)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Yes	437 (14.11)	4.36 (2.86-6.67)***	2.22 (1.81-2.73)***	3.14 (2.21-4.45)***

P* value significant at <0.05, *P* value significant at <0.005 and ****P* value significant at <0.0001.

Values were n (%).

The values of polytomous variables may not sum to 100% due to rounding.

Supplementary Table 3. Environmental composite quality load distribution (5 factors)

Components	Factory and chimney	Heating and cooking fuel	Pollution around the house	Traffic pollution	Cooking fumes and irritation symptoms
Housing along the street	-0.14	0.02	0.07	0.77	-0.002
Gutter	0.03	0.24	0.53	-0.01	0.05
Garbage dump	-0.05	0.10	0.43	0.09	0.33
Noise	-0.08	-0.09	0.37	0.59	0.14
Chemical pollution	0.31	0.01	0.47	-0.03	-0.06
Dust pollution	0.12	-0.08	0.68	0.10	-0.01
Distance from traffic arteries (meters)	0.38	0.01	-0.26	0.62	-0.01
Distance from factory (meters)	0.82	0.16	0.10	-0.01	0.09
Distance from chimney (meters)	0.82	0.07	0.17	-0.03	0.05
Fuel or energy used for cooking	0.09	0.84	0.09	0.01	0.05

Fuel used for space heating in winter	0.12	0.83	0.06	-0.04	0.07
Smoke Stimulating Symptoms During Cooking	-0.06	0.08	0.06	0.03	0.75
COF outside kitchen	0.20	0.01	-0.01	0.02	0.75

Supplementary Table 4. Environmental composite quality load distribution (6 factors)

Components	Traffic arteries and factory	Heating and cooking fuel	Voice	Smell	Chemical And dust	COF outside kitchen
Housing along the street	-0.15	0.03	0.77	-0.001	0.09	0.05
Gutter	0.04	0.18	-0.03	0.56	0.30	-0.07
Garbage dump	-0.01	0.02	0.08	0.77	0.06	-0.04
Noise	-0.08	-0.06	0.56	0.18	0.27	0.36
Chemical pollution	0.25	0.08	0.02	0.01	0.60	-0.12
Dust pollution	0.06	-0.04	0.08	0.16	0.69	0.17
Distance from traffic arteries (meters)	0.82	0.15	-0.02	0.05	0.11	0.04
Distance from factory (meters)	0.81	0.08	-0.04	0.04	0.20	0.04
Distance from chimney (meters)	0.39	-0.03	0.64	-0.01	-0.21	-0.21
Fuel or energy used for cooking	0.09	0.84	0.01	0.10	0.03	-0.02
Fuel used for space heating in winter	0.11	0.84	-0.03	0.04	0.02	0.05
Smoke Stimulating Symptoms During Cooking	0.31	0.01	0.02	0.51	-0.31	0.37
COF outside kitchen	0.04	0.04	0.04	-0.07	0.03	0.86

Supplementary Table 5. Logistic regression analysis of the relationship of environmental composite quality factor score with asthma and allergy (5 factors)

Disease	Environmental composite quality factor score	
	OR (95% CI)	P-value
Asthma		
Model 1	1.019 (1.013-1.024)	<0.001
Model 2	1.018 (1.012-1.023)	<0.001
Model 3	1.016 (1.010-1.023)	<0.001
Eczema		
Model 1	1.007 (1.004-1.010)	<0.001
Model 2	1.006 (1.003-1.009)	<0.001
Model 3	1.007 (1.004-1.011)	<0.001
Rhinitis		
Model 1	1.009 (1.003-1.014)	0.001
Model 2	1.009 (1.004-1.015)	0.001
Model 3	1.010 (1.004-1.016)	0.001

Model 1: Adjust for none.

Model 2: Adjust for Age (<8 years, ≥8 years).

Model 3: Adjust for Model 2+ gender (female or male), overweight (yes or no), annual household income (<30,000 or ≥30,000), Family allergic history (yes or no).

Supplementary Table 6. Logistic regression analysis of the relationship of environmental composite quality factor score with asthma and allergy (6 factors)

Disease	Environmental composite quality factor score	
	OR (95% CI)	P-value
Asthma		
Model 1	1.020 (1.014-1.025)	<0.001
Model 2	1.019 (1.013-1.024)	<0.001
Model 3	1.017 (1.011-1.024)	<0.001
Eczema		
Model 1	1.009 (1.006-1.012)	<0.001
Model 2	1.009 (1.006-1.012)	<0.001
Model 3	1.009 (1.006-1.012)	<0.001
Rhinitis		
Model 1	1.009 (1.004-1.014)	0.001
Model 2	1.010 (1.005-1.015)	<0.001
Model 3	1.010 (1.004-1.016)	0.001

Model 1: Adjust for none.

Model 2: Adjust for Age (<8 years, ≥8 years).

Model 3: Adjust for Model 2+ gender (female or male), overweight (yes or no), annual household income (<30,000 or ≥30,000), Family allergic history (yes or no).

Supplementary Table 7. Stratified analyses of environmental composite quality index score^a with asthma and allergy

Exposure	Asthma				Eczema				Rhinitis			
	0-2	3-4	≥5	<i>P</i> for interaction	0-2	3-4	≥5	<i>P</i> for interaction	0-2	3-4	≥5	<i>P</i> for interaction
Age (years)				0.935				0.199				0.507
≤8 (N=1345)	1.0 (Reference)	1.20 (0.61-2.37)	2.15 (1.06-4.36)*		1.0 (Reference)	1.04 (0.79-1.38)	1.90 (1.32-2.73)**		1.0 (Reference)	1.93 (0.86-4.30)	2.53 (1.05-6.07)*	
>8 (N=1854)	1.0 (Reference)	0.66 (0.24-1.86)	3.07 (1.21-7.79)*		1.0 (Reference)	1.12 (0.87-1.45)	1.25 (0.88-1.76)		1.0 (Reference)	1.10 (0.67-1.81)	1.58 (0.86-2.91)	
Gender				0.021				0.231				0.259
Female (N=1684)	1.0 (Reference)	1.37 (0.55-3.47)	5.26 (2.22-12.46)**		1.0 (Reference)	0.90 (0.70-1.17)	1.35 (0.96-1.90)		1.0 (Reference)	0.85 (0.45-1.62)	1.07 (0.49-2.35)	
Male (N=1498)	1.0 (Reference)	0.84 (0.41-1.74)	1.31 (0.59-2.92)		1.0 (Reference)	1.33 (1.01-1.74)*	1.71 (1.20-2.42)**		1.0 (Reference)	1.75 (0.99-3.09)	2.64 (1.37-5.06)**	
Overweight				0.353				0.002				0.587
No (N=2246)	1.0 (Reference)	1.16 (0.60-2.24)	2.23 (1.09-4.55)*		1.0 (Reference)	1.14 (0.92-1.41)	1.18 (0.88-1.57)		1.0 (Reference)	1.21 (0.73-1.99)	1.77 (0.995-3.16)	
Yes (N=738)	1.0 (Reference)	0.75 (0.25-2.26)	2.81 (1.08-7.33)*		1.0 (Reference)	0.98 (0.68-1.42)	2.89 (1.78-4.67)***		1.0 (Reference)	1.48 (0.67-3.27)	1.85 (0.71-4.82)	
Annual household income (yuan)				0.039				0.205				0.485
<30,000 (N=1243)	1.0 (Reference)	1.33 (0.45-3.96)	4.86 (1.83-12.94)**		1.0 (Reference)	1.11 (0.81-1.51)	1.90 (1.33-2.72)**		1.0 (Reference)	1.36 (0.67-2.78)	2.57 (1.24-5.34)*	
≥30,000 (N=1679)	1.0 (Reference)	0.92 (0.47-1.81)	1.53 (0.70-3.33)		1.0 (Reference)	1.08 (0.86-1.37)	1.22 (0.87-1.70)		1.0 (Reference)	1.23 (0.73-2.09)	1.33 (0.65-2.71)	
Family allergic history				0.010				0.031				0.020

No (N=2739)	1.0 (Reference)	0.96 (0.44-2.08)	3.89 (1.96-7.71)***	1.0 (Reference)	1.18 (0.97-1.45)	1.66 (1.27-2.18)**	1.0 (Reference)	1.24 (0.74-2.10)	2.65 (1.51-4.67)**
Yes (N=453)	1.0 (Reference)	1.05 (0.46-2.42)	0.96 (0.35-2.69)	1.0 (Reference)	0.67 (0.41-1.09)	0.91 (0.51-1.64)	1.0 (Reference)	1.31 (0.64-2.70)	0.66 (0.23-1.89)

P*-value significant at <0.05, *P*-value significant at <0.005 and ****P*-value significant at <0.0001

^a Environmental composite quality index score was computed by summing 13 binary variables: housing along the street (yes or no), gutter (yes or no), garbage dump (yes or no), noise (yes or no), chemical pollution (yes or no), dust pollution (yes or no), traffic arteries (yes or no), factory (yes or no), chimney (yes or no), use polluting cooking fuel (1 or 0), use polluting heating fuel (1 or 0), smoke stimulating symptoms during cooking(1 or 0), cooking oil fume outside kitchen(1 or 0). Each factor was assigned to 0 (no) and 1(yes).

Adjust for age (<8 years, ≥8 years), gender (female or male), overweight (yes or no), annual household income (<30,000 or ≥30,000), family allergic history (yes or no). Of note, the variables examined in this table were not adjusted.