

PROFESSOR KANGMO AHN (Orcid ID : 0000-0003-0618-3947)

PROFESSOR HAE-KWAN CHEONG (Orcid ID : 0000-0003-2758-9399)

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Spectrum of susceptibility to air quality and weather in individual children with atopic dermatitis

Su Ryeon Noh^{1,2}, Jin-Seob Kim³ Eun-Hye Kim⁴, Byoung-Hak Jeon⁴, Jong-Hun Kim⁴,
Young-Min Kim^{5,6}, Jihyun Kim,^{5,6} Youngshin Han⁵, Kangmo Ahn^{5,6*}, Hae-Kwan Cheong^{4*}

¹Department of Environmental Health, Graduate School of Public Health, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea;

²Department of Public Health and Environment, Kosin University, 194 Wachi-ro, Yeongdo-gu, Busan 49104, Republic of Korea;

³Department of Preventive Medicine, Graduate School of Public Health, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea;

⁴Department of Social and Preventive Medicine, Sungkyunkwan University School of Medicine, 2066 Seobu-ro, Jangan-gu, Suwon, Gyeonggi-do 16419, Republic of Korea;

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⁵Environmental Health Center for Atopic Diseases, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, Republic of Korea;

⁶Department of Pediatrics, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, Republic of Korea

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Address correspondence to

H.K. Cheong, Department of Social and Preventive Medicine, Sungkyunkwan University School of Medicine, 2066 Seobu-ro, Jangan-gu, Suwon, Gyeonggi-do 16419, Republic of Korea. E-mail: hkcheong@skku.edu.

K. Ahn, Department of Pediatrics, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, Republic of Korea. E-mail: kmaped@skku.edu.

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Abstract

Background: Exposure to air pollution aggravates symptoms of atopic dermatitis (AD) in children in the population studies. Variability in individual patient’s response from individual susceptibility is needed to be explored.

Objective: This study aimed to investigate spectrum of individual variability in the associations between AD symptoms and air quality.

Methods: We enrolled 89 children aged 0–6 years with AD (22,890 person-days). Daily manifestation of symptoms was recorded for an average of 257 days (range 100–499). Both an individual analysis using logistic regression models and an overall analysis using a generalized estimating equation were performed.

Results: The odds ratios of an individual ranged 0.24–8.11 for particulate matter less than 10 micrometer in diameter (PM₁₀), 0.09–101.92 for nitrogen oxide (NO₂), 0.03–44.00 for ozone (O₃), 0.11–58.30 for sulfur dioxide (SO₂), 0.00–15.83 for carbon monoxide (CO), 0.00–39,446.94 for temperature, and 0.03–5.18 for relative humidity, demonstrating a wide individual variability. In the overall analysis, PM₁₀, NO₂, SO₂, and CO had a significantly positive association, whereas temperature and relative humidity were negatively associated with AD symptoms. Air pollution was responsible for aggravation of symptoms from 24.7% (O₃) to 39.3% (SO₂) of AD children. Overall, 71.9% of the AD children responded to at least one or more air pollution and weather.

Conclusion: Responses of AD children to air pollution and weather were considerably variable among individuals. An individualized model would be useful to forecast and manage AD symptoms in patients.

Key words: atopic dermatitis; air quality; weather; susceptibility; individualized model; epidemiology; time series data analysis; forecast

Introduction

Air pollutants are risk factors of allergic diseases, such as asthma [1] and atopic dermatitis (AD) [2,3]. In our previous studies, we elucidated that several indoor [4] and outdoor air pollutants [3, 5], such as particulate matter of less than 10 micrometer diameter (PM₁₀) and total volatile organic compounds, were associated with worsening of AD symptoms. These air pollutants appear to induce barrier dysfunction and/or immune dysregulation in the skin; which might be mediated by oxidative stress [2]. However, previous epidemiologic studies indicated that its effect size is relatively small, presented as relative risks usually in the range of less than 1%, even if the study was conducted among the allergic populations [5]. Considering the nature of the allergic disease in terms of its individual susceptibility, manifestation of the allergic symptoms in such a low level of effect size from the aggregated sample needs additional interpretation on its applicability to a specific patient.

Individual response to a specific air pollutant could represent an individual susceptibility to air pollutants. Sources of susceptibility of health risks from exposure to air pollution was referred to the genetic factors, life stage, gender, ethnicity, obesity, preexisting disease, and socioeconomic status [6-8]. Susceptibility of allergic or atopic diseases were poorly documented in detail by previous studies and few studies have investigated such individual variability in response. Customized action plans based on individually identified response patterns could provide a better approach to managing AD patients by making the effective avoidances of environmental triggers. Proper identification of the environmental triggers in individual can prevent AD symptom worsening and allow for effective management. In this study, we focused on demonstrating the phenotype of the susceptibility, by describing its scope among AD children living in a metropolitan area.

Methods

1. 1 Study design and subjects

This study was a part of the Allergy and Gene-environmental Link (ANGEL) Study, a panel study to investigate the impact of air pollution on allergic diseases. Children with AD who regularly visited a special clinic for AD at Samsung Medical Center in Seoul and living in Seoul or the surrounding metropolitan area were enrolled in the present study. The diagnosis of AD was based on Hanifin and Rajka's criteria [9]. The severity of AD was assessed using the SCORing AD (SCORAD) by pediatric allergists (JK and KA) at the beginning of the visit to the clinic and again at each subsequent visit. An environmental questionnaire survey was additionally conducted that included the patient's age; sex; history of allergy; family history of allergy; history of AD management; history of maternal smoking during pregnancy; history of living in a newly built house during the first year of life and also the general residential environment, such as current parental smoking, frequency of vacuuming, and frequency of ventilation; distance to nearest major roads, hazardous facilities, and transmission towers; recent indoor renovation activities, like painting, installing new floor coverings, wallpapering, and purchasing new furniture; and exposure to domestic pets.

The Institutional Review Board (IRB) of Samsung Medical Center approved the study protocol (IRB No. 2013-05-009). Written informed consent was obtained from parents of all participating children before the children were enrolled in the study.

1.2 Measurement of air pollutants and weather conditions

Air pollution data, including PM₁₀, NO₂, O₃, SO₂, and CO, were obtained from the National Institute of Environmental Research, Ministry of the Environment. Air quality data are collected daily from monitoring posts across the nation, which are densely distributed in localities near the capital area, typically one post per district or municipality with a population less than 500,000. Weather data, including temperature and relative humidity, were obtained from the Korean Meteorological Administration. We calculated daily 24-hour average levels of PM₁₀, NO₂, SO₂, CO, temperature, and relative humidity, as well as maximum 8-hour average O₃ concentrations from the air quality and weather data. Clinical data regarding symptom onset obtained from the symptom diary of each child were matched with air pollution and weather data from the monitoring station nearest to their current residence [5]. The mean distance from the residence to the monitoring station of air pollution and weather was 2.3 km (range: 0.3–8.7 km) and 2.8 km (range: 0.2–11.0 km), respectively. Different exposure scales were also considered, including lags and moving averages, for up to the previous two days.

1.3 Symptoms of atopic dermatitis

The presence of AD symptoms was recorded daily using a smartphone application provided to the parents, who kept a daily symptom diary from August 2013 to December 2014. Itching, sleep disturbances, erythema, dryness, oozing, and edema were noted on a scale from 0–4 (0 = no symptoms and 4 = extremely severe symptoms). We calculated a binary index in which a positive symptom was defined as a score of 2 or higher in the sum of two subjective symptoms (i.e., itching and sleep disturbance) and was accompanied by at least two symptoms from the following that occurred on the same day: erythema, dryness, edema, or oozing.

1.4 Statistical analysis

To estimate the effects of air pollution and weather on daily AD symptoms at the individual level, we separately applied a logistic regression model for each of the 177 individual datasets. Daily AD symptoms were transformed into a dichotomous response variable. To enable logistic regression analysis of individual-based associations, we excluded 88 children who had fewer than 100 entries and who identically responded or differently responded less than five in the daily AD symptoms among 177 children, leaving 89 children for the individual-based association analysis.

We developed individual crude models to estimate the increase in AD symptom aggravations caused by each air pollutant, temperature, and relative humidity. We also considered the possibility of lag effects of the air pollutants and weather variables on the AD symptoms. Two different lag structures, including a single-day lag of 0, 1, and 2 days and a multi-day average starting from lag 0 up to 2, were used to observe whether not just for the current day but for several preceding days affect daily symptoms on a given day. Among various lag structures, we finally chose a three-day moving average of the current and two preceding days as being representative of the concentration of air pollutants and weather variables by minimizing Akaike's Information Criterion (AIC).

For our overall analysis, we used generalized estimating equation (GEE) models for repeated measurements within subjects [10], assuming a compound symmetry working correlation structure to assess the associations between environmental conditions, including air pollution and weather, and daily AD symptoms. The overall dataset included 22,890 person-days of observation. The model was adjusted for confounding factors, such as age, sex, season, SCORAD at the initial visit, and fever. Result of this analysis was presented in our previous report [3].

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All effect sizes of air pollution and weather on symptom aggravation were presented as odds ratio (OR) and 95% confidence interval (CI) per interquartile range (IQR) increase.

The alpha level used to define statistical significance was set to 0.05. For the statistical analysis, we used PROC LOGISTIC for the individual analysis and PROC GENMOD for the overall analysis, adopting a binomial distribution and the logit link in SAS version 9.4 (SAS Institute, Cary, NC, USA). Plots were created in R version 3.2.2 using a ggplot2 (R Development Core Team, Vienna, Austria).

Results

Among 89 participants, 56 were male (62.9%) (Table 1). Their ages ranged from 0.3–6.4 years, with a mean age of 2.2 years. Half of the study participants were younger than one year. The mean SCORAD score was 30.6 (SD 12.2). In the last month, 76 percent of young patients responded that they used any therapeutics. The uses of antihistamine and topical corticosteroids were 40% and 69%, respectively. The children's daily symptoms were recorded for 257 days on average (range: 100–499 days), and their symptoms were exacerbated for a mean of 108 days (range: 6–400 days). During the study period, the IQRs of PM₁₀, NO₂, O₃, SO₂, CO, temperature, and relative humidity were 25.7 µg/m³, 15.4 ppb, 27.4 ppb, 2.3 ppb, 231.5 ppb, 15.7°C, and 16.3%, respectively (Table 2).

Based on the results of logistic regression for the individual analysis in 89 datasets, the range of OR was 0.24–8.11 for PM₁₀, 0.09–101.92 for NO₂, 0.11–58.30 for SO₂, 0.00–15.83 for CO, 0.00–39446.94 for temperature, and 0.03–5.18 for relative humidity, respectively (Table 3 and Figure 1). No significant association was seen for O₃ among the seven air pollutants or weather variables in the overall analysis (Table 5). The OR range of O₃ was 0.03–44.0, and 24.7% participants showed significantly positive responses in the individual analysis.

Twenty-five children (28.1%) did not react to any of the five air pollutants or the two weather variables (Table 4). More than half of the children (53.9%) were sensitive to fewer than three of the seven environmental triggers. The environmental variables, in order of greater symptom aggravation, were temperature (40 children, 44.9%), relative humidity (39 children, 43.8%), SO₂ (35 children, 39.3%), PM₁₀ (34 children, 38.2%), NO₂ (30 children, 33.7%), CO (26 children, 29.2%), and O₃ (22 children, 24.7%).

Using the GEE models for our overall analysis in one dataset, we found significantly increased risks of symptom aggravation associated with an IQR increase in PM₁₀ (OR 1.16), NO₂ (1.11), SO₂ (1.22), and CO (1.15). We also identified significantly decreased risks associated with temperature (0.73) and relative humidity (0.80) (Table 5).

Female sex, severity of AD by SCORAD score, severity of AD determined by the use of antihistamine and topical steroid medications, a history of living in a newly built home during the first year of life and experiencing a new AD occurrence or symptom aggravation in the newly built house, vacuuming every day, levels of air pollutants, and hazardous facilities and transmission towers in the residential area marginally or significantly influenced the individual variability (Table S1 and Figure S1).

Discussion

We found that the effects of air pollutants and weather conditions considerably varied across AD children. Differences of at least 10-fold were noted in the effect size between individuals. Approximately 30% of the children showed no reaction to any of the air pollutants and weather variables. Air pollutants had a significantly positive association,

whereas weather variables, including temperature and relative humidity, had a significantly negative association with AD symptoms in the overall analysis.

The roles of air pollution and weather in AD remain uncertain, although many studies have demonstrated that air pollutants and weather conditions act as risk factors in the development or aggravation of AD [2,11]. These controversies are likely due to the variable effects of air pollutants and weather conditions on AD symptoms. Some patients showed worsening disease flares in the winter, while others experienced in the summer [12]. Some air pollutants exhibited a significant association with AD, whereas other air pollutants did not, highlighting these slight differences in the research [5,13]. Our findings that increases in air pollutants and decreases in temperature and relative humidity seem to be associated with AD symptom aggravation are consistent with those of previous studies [14,15].

The variability in individual responses to air pollution and weather in children with AD showed that the results of a population cannot be applied to individuals [16]. The individuals did not respond to all environmental triggers, even though they are all well-known environmental triggers to AD. Our findings show that approximately 30% of young children did not react to any of the five air pollutants or two weather variables. About 10% of our participants reacted to only one type of variable. More than half of the total (53.9%) reacted to fewer than three of the seven environmental triggers. Only one child (1.1%) reacted to all seven environmental triggers. This result suggests that the avoidance of environmental triggers for the management of AD should be individualized to minimize unnecessary efforts and costs.

Personalized behavioral guidelines, such as minimizing outdoor activity, applying medications, and supportive care such as humidification, may be given. If a child responds to only one of the seven environmental triggers, he or she should be alert only when the factor is

high, instead of unnecessary attention to all factors. These individualized proper cares in atopic patients would effectively reduce costs, including use of medications.

We additionally attempted to find a factor for the individual variability in response to air pollution and weather. We considered several factors related to physical and genetic status, current health status, residential environment, indoor air quality, and outdoor air quality. Women demonstrated marginally greater individual variability than men. The individual variability in response to air pollutants, particularly PM₁₀, significantly increased according to the severity of AD using the SCORAD score. The AD severity group showed more individual variability in response to air pollution and weather. However, it might be difficult to predict individual susceptibility based on these constitutional or environmental determinants. This study shows that longitudinal observation of individual could provide a direct assessment of susceptibility on individual basis.

The study has unique strengths. This study attempted a separate analysis of individual factors when investigating the relationship between environmental conditions and symptom aggravation in children with AD. Another strength of this study is that we analyzed long-term daily symptom diaries of our included subjects: about 499 days for 89 young children. We acquired a sufficiently large sample size for the individual and overall analyses.

Our study has limitations in that we did not measure indoor levels of the air pollutants, temperature, or relative humidity, although young children generally spend most of their time indoors. Even though it was estimated that the indoor levels of air pollutants were similar to outdoor condition from our previous study [17], the indoor levels of temperature and relative humidity might quite differ from outdoor condition. For these reasons, our results may differ from results using actual indoor levels. Medication uses including antihistamine and topical corticosteroids were not considered in the individual

analysis. However, analysis of risk factors (Table S1) suggests that it might be a significant factor in our cases. We did not control for any variables, such as season, in our individual analysis because of small sample size. Meanwhile, the variables of age, sex, socioeconomic status, education level of parents, and genotype do not need to be considered because they cannot be changed within-person variation.

We observed substantial inter-individual differences in effect size and reaction to well-known environmental triggers on symptom aggravation. The results indicate that for children with pre-existing AD, it is recommended to manage their symptoms based on the identified individualized triggering factors rather than applying generalized guidance in order to prevent symptom aggravation. Our study has direct relevance for health service delivery (i.e., individualized self-management, management advice, and personalized information) and quality of life in participating individuals as well as providing a basis for understanding the effects of environmental change in young children with AD.

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Table 1. Characteristics of 89 pediatric patients with atopic dermatitis

Characteristic	N (%)
Age, years	2.2 ± 1.7 (0.3–6.4)*
0	28 (31.5)
1–2	31 (34.8)
3–4	21 (23.6)
5–6	9 (10.1)
Sex	
Female	33 (37.1)
Male	56 (62.9)
Therapeutics [†]	
No	18 (20.2)
Yes	68 (76.4)
Non-response	3 (3.4)
Antihistamine [‡]	
No	50 (56.2)
Yes	36 (40.4)
Non-response	3 (3.4)
Topical corticosteroids [‡]	
No	25 (28.1)
Yes	61 (68.5)
Non-response	3 (3.4)
Severity of atopic dermatitis (SCORAD ^{**} score)	30.6 ± 12.2 (15.0–58.3)*
Mild (<25)	37 (41.6)
Moderate (25–49)	45 (50.6)
Severe (≥50)	7 (7.9)
No. of symptom recordings, days	257 ± 109 (100–499) [†]
No. of symptom aggravations, days	108 ± 95 (6–400) [†]

*Mean ± SD (range)

[†]Medication use within the last month

[‡]Multiple responses available

^{**}SCORing Atopic Dermatitis

Table 2. Status of air pollutants and weather variables during the study period

Environmental condition	All (22,890 person-days)	
	Mean $\pm$ SD	IQR [†]
PM ₁₀ ($\mu\text{g}/\text{m}^3$)	45.2 $\pm$ 22.2	25.7
NO ₂ (ppb)	32.8 $\pm$ 11.5	15.4
O ₃ (ppb)	37.9 $\pm$ 18.0	27.4
SO ₂ (ppb)	5.3 $\pm$ 1.8	2.3
CO (ppb)	540.4 $\pm$ 195.6	231.5
Temperature ($^{\circ}\text{C}$)	15.1 $\pm$ 9.4	15.7
Relative humidity (%)	65.1 $\pm$ 11.8	16.3
[†] Interquartile range		

Table 3. Individual variability in response to air pollutants and weather variables in children with atopic dermatitis

Individual (n=89)						
	OR range	Effect size by OR [†]				
		1.00– 1.99	2.00– 2.99	3.00– 3.99	4.00– 4.99	≥5.00
Air pollution						
PM ₁₀ (µg/m ³)	0.24 – 8.11	11 (12.4)	10 (11.2)	8 (9.0)	2 (2.2)	3 (3.4)
NO ₂ (ppb)	0.09 – 101.92	8 (9.0)	11 (12.4)	3 (3.4)	1 (1.1)	7 (7.9)
O ₃ (ppb)	0.03 – 44.00	3 (3.4)	6 (6.7)	3 (3.4)	4 (4.5)	6 (6.7)
SO ₂ (ppb)	0.11 – 58.30	4 (4.5)	6 (6.7)	4 (4.5)	5 (5.6)	16 (18.0)
CO (ppb)	0.00 – 15.83	2 (2.2)	8 (9.0)	5 (5.6)	0 (0.0)	11 (12.4)
Effect size by OR [‡]						
Weather		≥0.40	0.39– 0.30	0.29– 0.20	0.19– 0.10	0.09–0.00
Temperature (°C)	0.00 – 39446.94	8 (9.0)	4 (4.5)	6 (6.7)	6 (6.7)	16 (18.0)
Relative humidity (%)	0.03 – 5.18	14 (15.7)	11 (12.4)	6 (6.7)	3 (3.4)	5 (5.6)

Odds ratio (OR) and 95% confidence interval (CI) calculated for an interquartile range (IQR) increase, 25.7 µg/m³ in PM₁₀, 15.4 ppb in NO₂, 27.4 ppb in O₃, 2.3 ppb in SO₂, 231.5 ppb in CO, 15.7°C in temperature, and 16.3% in relative humidity.

[†]No. with statistically significant positive responses (%)

[‡]No. with statistically significant negative responses (%)

Table 4. The number of responses to air pollutants and weather variables in 89 children with atopic dermatitis

No. of responses [†]	N (%)	Response, n						
		PM ₁₀	NO ₂	O ₃	SO ₂	CO	Temperature	Humidity
0	25 (28.1)	0	0	0	0	0	0	0
1	10 (11.2)	0	1	6	0	0	1	2
2	13 (14.6)	4	2	5	2	0	6	7
3	10 (11.2)	4	4	4	4	4	5	5
4	8 (9.0)	5	5	3	6	2	5	6
5	11 (12.4)	9	6	3	11	8	11	7
6	11 (12.4)	11	11	0	11	11	11	11
7	1 (1.1)	1	1	1	1	1	1	1
Total (%)	89 (100.0)	34 (38.2)	30 (33.7)	22 (24.7)	35 (39.3)	26 (29.2)	40 (44.9)	39 (43.8)

[†]The number of responses was a sum of the number of statistically significant positive responses to each air pollutant and the number of statistically significant negative responses to each weather variable.

Table 5. Overall effect sizes in response to air pollution and weather in children with atopic dermatitis

Air pollution and weather	All (22,890 person-days)			
	OR (95% CI) [†]	<i>p</i> -Value	OR (95% CI) [‡]	<i>p</i> -Value
PM ₁₀ (µg/m ³)	1.16 (1.08–1.26)	0.0001	1.17 (1.08–1.27)	0.0002
NO ₂ (ppb)	1.11 (1.01–1.23)	0.03	1.12 (1.01–1.24)	0.03
O ₃ (ppb)	0.92 (0.81–1.04)	0.20	0.91 (0.80–1.05)	0.19
SO ₂ (ppb)	1.22 (1.09–1.36)	0.0004	1.24 (1.10–1.40)	0.0004
CO (ppb)	1.15 (1.02–1.26)	0.01	1.15 (1.05–1.29)	0.009
Temperature (°C)	0.73 (0.61–0.88)	0.0009	0.72 (0.59–0.88)	0.001
Relative humidity (%)	0.80 (0.72–0.89)	0.0001	0.79 (0.70–0.88)	<0.0001

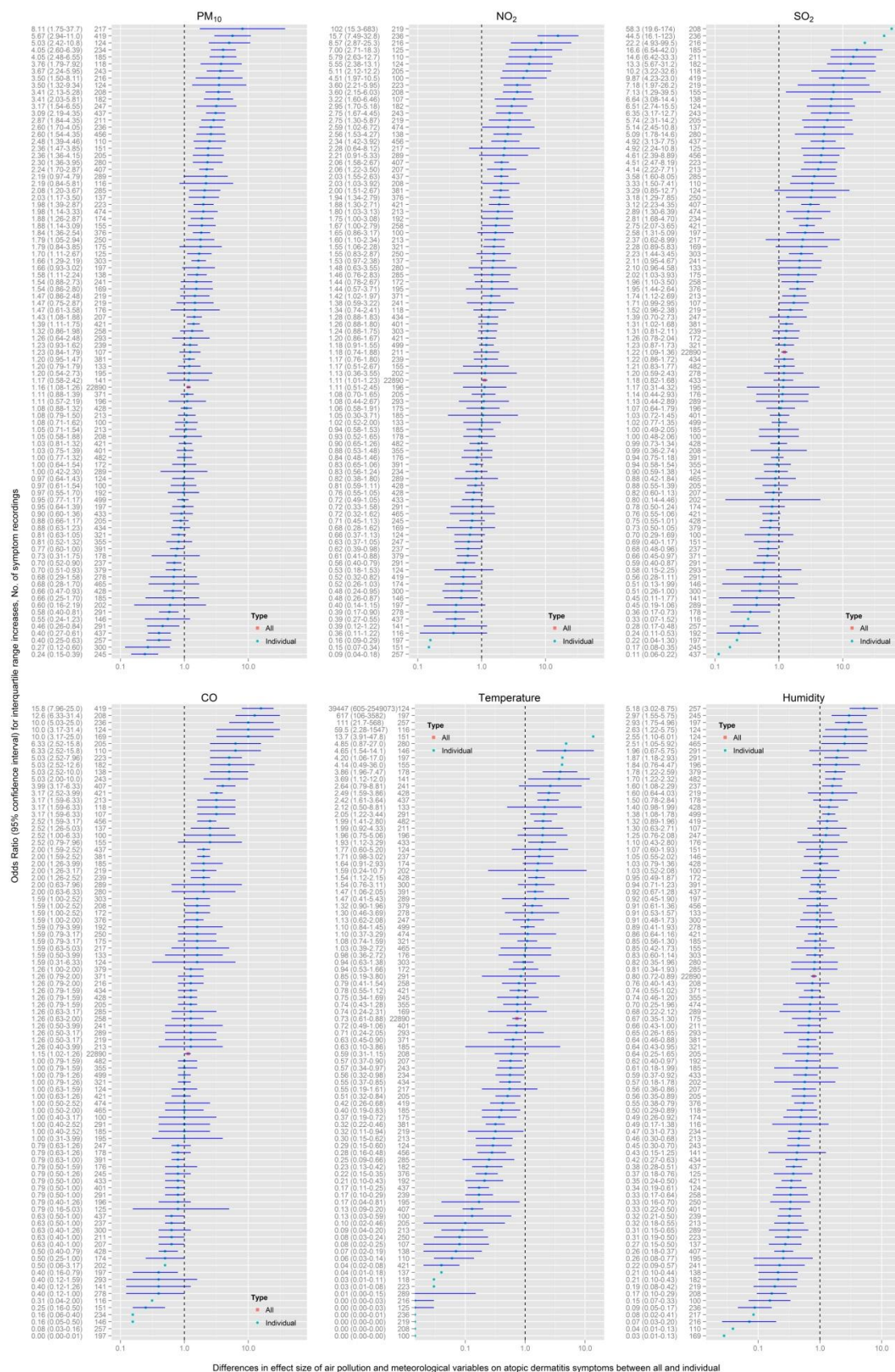
Odds ratio (OR) and 95% confidence interval (CI) calculated for an interquartile range (IQR) increase, 25.7 µg/m³ in PM₁₀, 15.4 ppb in NO₂, 27.4 ppb in O₃, 2.3 ppb in SO₂, 231.5 ppb in CO, 15.7°C in temperature, and 16.3% in relative humidity.

[†]Values were as in Figure 1.

[‡]Adjusted for age (continuous), sex (male, female), season (spring and autumn, summer and winter), SCORAD at initial visit (mild <25, moderate 25–49, severe ≥50), and fever (yes, no).

Figure legend

Figure 1. Differences in effect size of air pollution and weather variables on atopic dermatitis symptoms between the entire sample and among individuals.



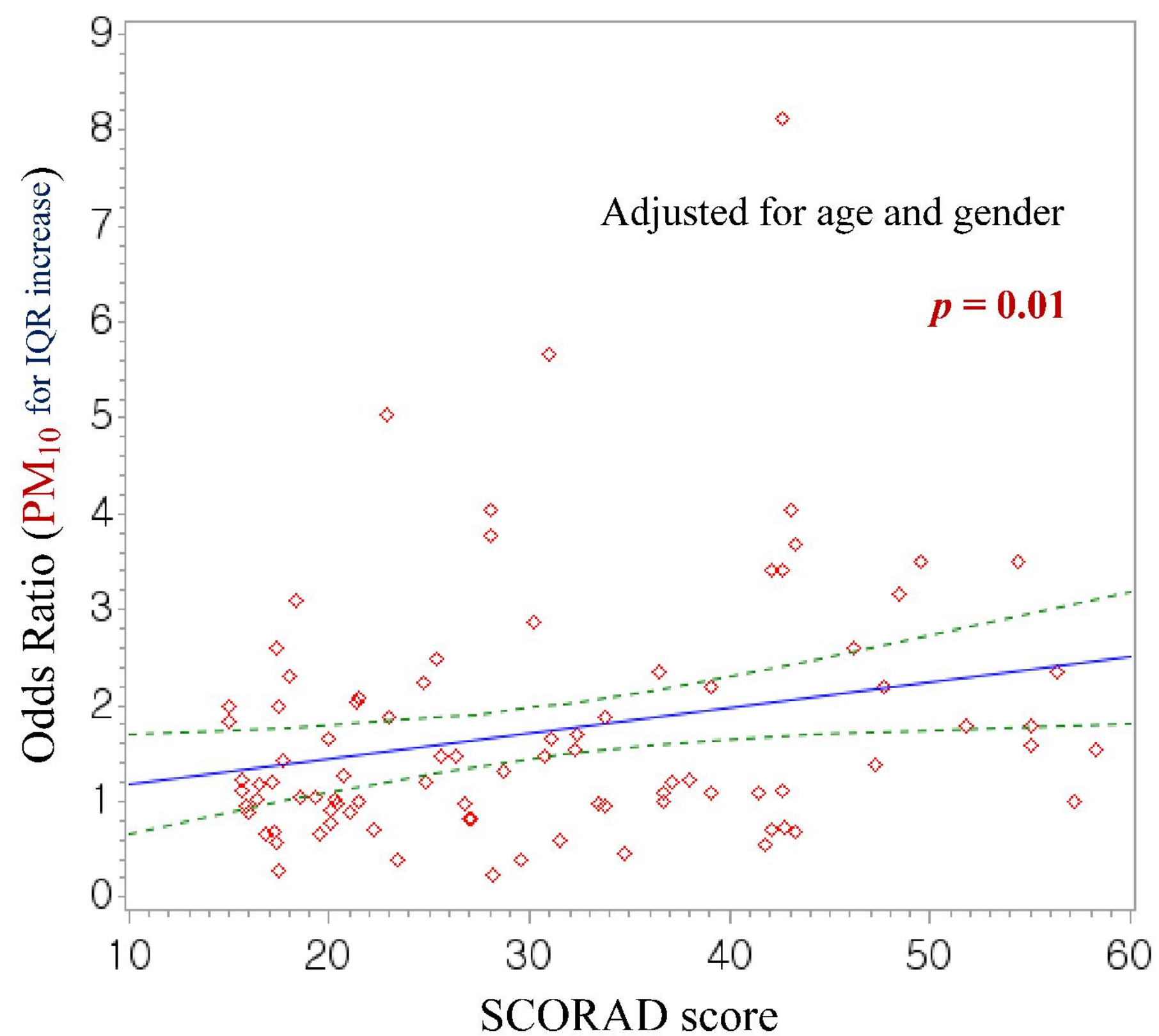


Table S1. Influence of risk factors on individual effect size based upon responses to air pollutants and weather variables (n=89)

Table S1. Influence of risk factors on individual effect size based upon responses to air pollutants and weather variables (n=89)

during the first year of life	1.10	0.004	-1.24	0.71	0.04	0.99	4.02	0.11	1.15	0.17	3079	0.02	-0.01	0.98
AD occurrence or aggravation	0.97	0.01	-1.15	0.73	-0.22	0.92	4.04	0.11	1.12	0.18	-496	0.70	-0.17	0.50
Indoor renovation activities ^{*d}	-0.01	0.98	-1.92	0.43	-0.27	0.87	2.73	0.14	0.30	0.63	-743	0.43	0.02	0.91
Using carpet and/or a fabric sofa [*]	-0.19	0.70	-1.22	0.77	2.10	0.44	-2.69	0.39	-0.57	0.59	-514	0.75	0.17	0.57
Living with domestic pets [*]	-0.55	0.23	-1.96	0.62	-1.56	0.55	-2.42	0.41	-0.80	0.42	4386	0.003	0.85	0.002
Maternal smoking during pregnancy [*]	0.97	0.30	-1.42	0.86	2.85	0.59	-0.73	0.90	0.57	0.78	-478	0.88	-0.20	0.73
Indoor air quality														
Current parental smoking [*]	-0.16	0.59	-2.12	0.39	1.74	0.29	0.05	0.98	-0.39	0.54	1292	0.18	-0.01	0.97
Fungus at home [*]	-0.16	0.60	-1.28	0.61	-2.41	0.15	-0.47	0.81	0.56	0.38	-688	0.49	-0.11	0.56
Ventilation every day [*]														
In summer	0.07	0.84	1.26	0.69	2.06	0.32	1.91	0.42	0.22	0.79	567	0.64	0.16	0.49
In winter	0.18	0.54	-2.47	0.31	0.19	0.91	1.69	0.36	0.81	0.19	789	0.40	0.14	0.45
Vacuuming every day [*]	0.03	0.92	-2.85	0.24	0.10	0.95	-3.35	<u>0.06</u>	-0.78	0.20	1056	0.26	0.38	0.03
Using an air cleaner [*]	0.41	0.15	-1.60	0.50	-0.87	0.59	0.03	0.99	0.47	0.44	-848	0.36	-0.12	0.49
Using a humidifier in winter [*]	-0.08	0.78	-2.48	0.30	1.07	0.50	-1.52	0.41	-0.83	0.17	-1050	0.26	-0.01	0.97
Outdoor air quality														
Inhabiting high-level area ^b	-0.32	0.24	-2.41	0.30	2.92	0.05	-3.63	0.04	-0.95	<u>0.10</u>	890	0.32	-0.12	0.49
Distance to the nearest major roads (<100 m) [*]	-0.14	0.63	-2.62	0.28	1.68	0.30	-2.39	0.20	-0.29	0.64	1153	0.22	0.22	0.22
Hazardous facilities (<2 km) ^{*e}	0.88	0.005	4.91	<u>0.07</u>	-2.04	0.26	0.09	0.97	1.07	0.12	-623	0.56	-0.04	0.86
Transmission tower (<5 km) [*]	1.08	0.05	-2.16	0.65	-1.07	0.73	0.60	0.87	2.01	<u>0.09</u>	6565	0.0002	0.25	0.47

^{*}n=86. Three values were missing from the environmental questionnaire.

^{**}Odds ratio (OR) was calculated for an interquartile range (IQR) increase, 25.7 µg/m³ in PM₁₀, 15.4 ppb in NO₂, 27.4 ppb in O₃, 2.3 ppb in SO₂, 231.5 ppb in CO, 15.7°C in temperature, and 16.3% in relative humidity.

^aMeasured up to six times per individual.

^bDivided into high-level and low-level by median (PM₁₀, 45.1 µg/m³; NO₂, 32.8 ppb; O₃, 38.8 ppb; SO₂, 5.2 ppb; CO, 531.4 ppb; temperature, 15.5 °C; relative humidity, 65.1%) and matched with respect to the same variable ,i.e., relationship between OR in PM₁₀ of the each individual and residing high-level of the PM₁₀ area.

^cExperienced within 6 months after living in a newly built house.

^dIndoor renovating activities, such as painting, floor covering, wallpapering, and new furniture in current house.

^eIncluded facilities such as waste incinerators, landfills, sewage treatment plants, chemical plants, bus or taxi terminals, and crematorium.

Illustration

Figure S1. The relationship between SCORAD score at the initial visit and odds ratio for an interquartile increase in PM₁₀ (25.7 µg/m³) in 89 children.