

Letter to the Editor

Symptoms of atopic dermatitis are influenced by outdoor air pollution

To the Editor:

It is well known that outdoor air pollution affects the health of patients with allergic diseases. Outdoor air pollution is related to exacerbation of pre-existing asthma and even with the development of atopic diseases or allergic sensitization.^{1,2} In contrast, there are few studies to show the association between air pollution and atopic dermatitis (AD). We carried out a long-term study to evaluate the clinical effects of outdoor air pollution on skin symptoms in patients with AD. This study was approved by the institutional review board at Samsung Medical Center in Seoul, Korea.

Twenty-two patients (17 boys and 5 girls) with AD living in Seoul were enrolled and followed for 18 months between July 2009 and December 2010. Their median age at the time of

enrollment was 35 months, ranging from 16 to 85 months. Parents were instructed to record a symptom diary describing the extent of itching and sleep disturbance by using a scale of 0 to 10 and the degree of erythema, oozing, and edema (0-3) on a daily basis. Frequency of bathing, application of moisturizers, and the use of topical corticosteroids was also recorded. We obtained daily mean concentrations of particulate matters (PMs), nitric oxides (NO, NO₂, and NO_x), volatile organic compounds (VOCs) including benzene, toluene, ethyl-benzene, xylene, and styrene, and 24-hour average temperature and relative humidity from the closest monitoring sites to each patient's residence during the study period to estimate each patient's exposure to outdoor air pollution and meteorologic condition. These sites were operated by Seoul Metropolitan Government Research Institute of Public Health and Environment. A generalized linear mixed model was used to assess the association between outdoor air quality and AD

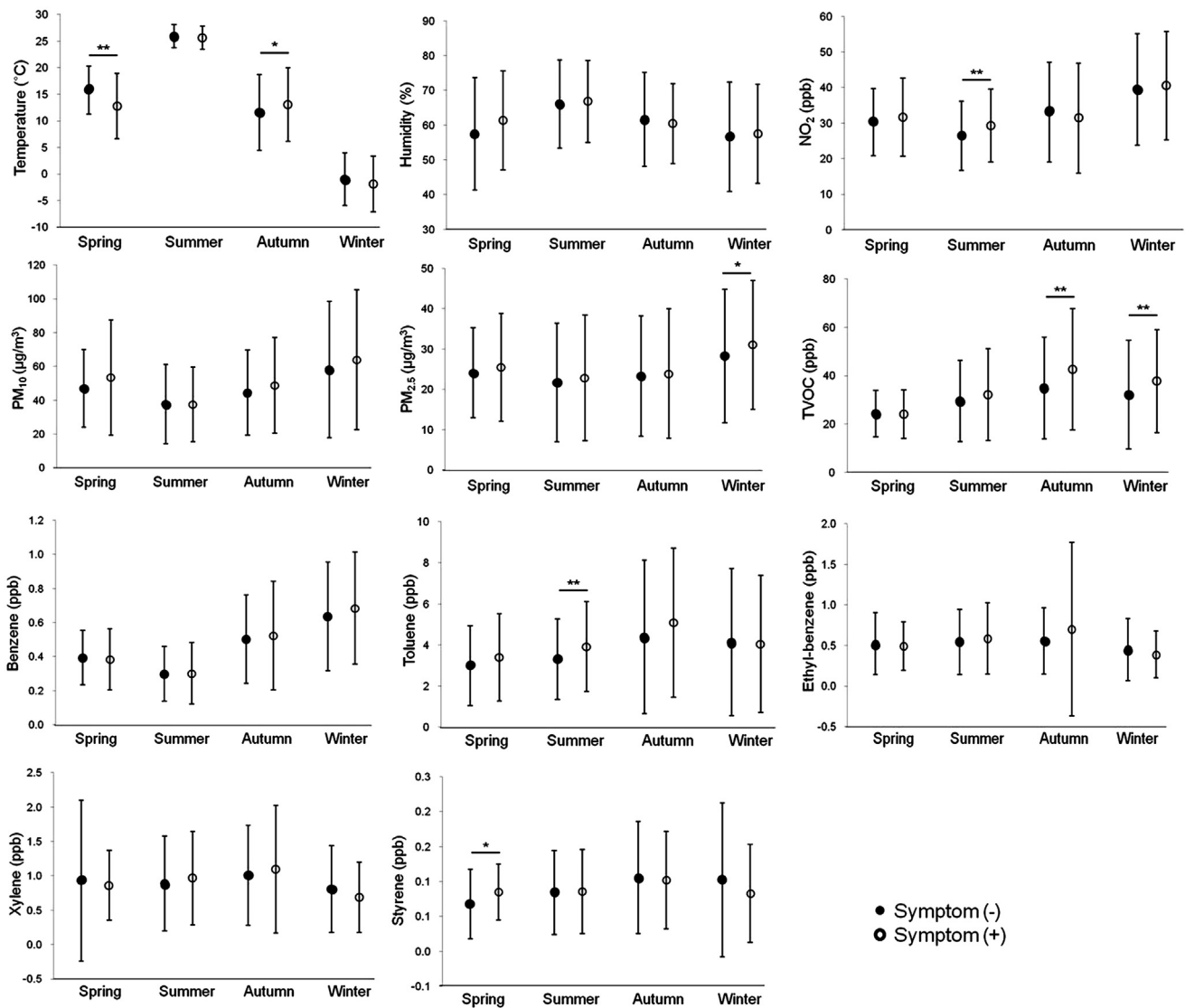


FIG 1. Seasonal distribution of outdoor air pollutants between days with and without AD symptoms. Circles and bars represent geometric mean $\pm$ 1 geometric SD. * $P < .05$, ** $P < .01$.

TABLE I. The time-lagged effect of meteorologic factors and air pollutants on symptom scores in patients with atopic dermatitis

	Air pollutants*			
	Concentrations on lag 1†		Concentrations on lag 2†	
	Percent change of risk	95% CI	Percent change of risk	95% CI
Temperature (°C)	0.33	−2.18 to 2.91	−2.06	−4.55 to 0.48
Humidity (%)	0.12	−0.58 to 0.83	0.73	0.04 to 1.44
NO (ppb)	0.03	−0.32 to 0.38	−0.08	−0.43 to 0.27
NO ₂ (ppb)	0.67	−0.10 to 1.44	−0.34	−1.10 to 0.43
NO _x (ppb)	0.09	−0.17 to 0.35	−0.08	−0.34 to 0.17
PM ₁₀ (μg/m ³)	0.44	0.12–0.77	0.06	−0.23 to 0.36
PM _{2.5} (μg/m ³)	0.67	−0.03 to 1.38	0.08	−0.60 to 0.77
Benzene (ppb)	27.38	3.54–56.72	−4.70	−22.18 to 16.71
Toluene (ppb)	10.71	−3.33 to 26.77	4.24	−9.07 to 19.49
Ethyl-benzene (ppb)	10.55	−5.09 to 28.78	4.61	−10.30 to 22.01
Xylene (ppb)	4.63	−3.01 to 12.89	1.91	−5.64 to 10.06
Styrene (ppb)	2.06	−9.60 to 15.22	0.62	−11.02 to 13.80
TVOC (ppb)	25.86	4.01–52.30	18.90	−1.81 to 43.96

Note. Percent change in risk and 95% CI were calculated by using a regression coefficient (β) and the following equation: percent change in risk = $(\exp[\beta] - 1) \times 100$ and 95% CI = $\exp(|\beta| - 1 \pm 1.96 \text{ SE})$. Percent change in risk indicates a change in AD symptoms according to the increase of 1 unit of each pollutant.

SCORAD, SCORing Atopic Dermatitis.

*Adjusted by temperature, humidity, seasons, SCORAD at initial visit, and age.

†Delayed effects of air pollution on skin symptoms.

symptoms. The model specifications are as follows: $\log E(Y) = \beta_0 + \beta_1(\text{pollutant}) + \beta_2(\text{temperature}) + \beta_3(\text{relative humidity}) + \beta_4(\text{season}) + \beta_5(\text{SCORing Atopic Dermatitis index at initial visit}) + \beta_6(\text{age}) + \gamma_1(\text{children}) + \gamma_2(\text{date})$, where $E(Y)$ is the expected presence of AD symptom, γ_1 is random effect, and γ_2 is random effect within the child. The time (date) effect for each child is a residual effect with a first-order autoregressive covariance structure, using the residual. This id covariance matrix of autoregressive(1) : $\text{cov}[e_i, e_j] = \sigma^2 \rho^{|i^* - j^*|}$, where the value i^* and j^* are derived for the i th and j th observations and are not necessarily the observation numbers. We analyzed the level of air pollutants from the same day, the previous day (lag 1), and 2 days (lag 2) before the report of AD symptoms in separate models. Parent-reported symptom scores were dichotomized and treated as dependent variables, and levels of outdoor pollutants as independent variables. The presence of AD symptoms in the diary was defined by using a symptom scale of 4 or more for itching and sleep disturbance accompanied by at least 1 of the following symptoms: erythema, edema, or oozing.

From symptom records of 1880 person-days, 257 were written in spring, 440 in summer, 543 in fall, and 640 in winter. The mean SCORing Atopic Dermatitis index at initial visit was 21.2 (range, 6.0–43.1). In spring, temperature was lower and the level of styrene was higher on days when patients reported AD symptoms than on days without AD symptoms ($P < .001$ and $P = .010$, respectively). In summer, concentrations of NO₂ and toluene were higher on days when patients presented AD symptoms than on days without AD symptoms ($P = .004$ and $.003$, respectively). In autumn, temperature and the level of total VOC (TVOC) were higher on days with AD symptoms than on days without symptoms ($P = .020$ and $.002$, respectively). In winter, concentrations of PM with diameter of less than 2.5 μm (PM_{2.5}) and TVOC were higher on days with AD symptoms than on days without symptoms ($P = .032$ and $.002$, respectively) (Fig 1).

Throughout the study period, concentrations of outdoor PM with diameter of less than 10 μm (PM₁₀), PM_{2.5}, toluene, and TVOC were higher on days when patients had symptoms of AD than on days when they reported no AD symptoms ($P = .021$,

.043, $< .001$, and $< .001$, respectively) (see Table E1 in this article's Online Repository at www.jacionline.org). An increased concentration of PM₁₀ by 1 μg/m³ was significantly associated with a 0.44% (95% CI, 0.12–0.77) increase in AD symptoms on the following day (lag 1), while an elevated benzene concentration by 1 ppb was associated with a 27.38% (95% CI, 3.54–56.72) increase in AD symptoms (Table I). An increased concentration of TVOC by 1 ppb was associated with a 25.86% (95% CI, 4.01–52.30) increase in AD symptoms on the following day. However, this statistical significance disappeared 2 days after the exposure to outdoor air pollutants.

This study investigated the clinical effects of pollutants and climate on eczema symptoms by using a longitudinal study design for the duration of 18 months. We found that AD symptoms were associated with the levels of outdoor air pollutants such as PM, toluene, and TVOC. Interestingly, this association varied according to season, and the lag effect of PM₁₀, benzene, and TVOC on AD symptoms was found after exposure. Our results suggest that different strategies are required in different regions for better control of outdoor air pollution for patients with AD, as the composition of particulate air pollutants varies according to the predominant source of particles, season, and prevailing weather.^{3–5}

Our findings support the previous studies in which air pollutants such as ultrafine particles, formaldehyde, or VOCs aggravate skin symptoms of AD or impair the epidermal barrier function.^{4,6,7} Although the exact mechanism remains unclear, air pollutants–induced inflammation could occur in the skin, as in the respiratory system. Particulate mass and chemical composition, especially enriched metals in urban air particulates, have been regarded to contribute to inflammatory responses.⁵ Exposure to air pollutants is related to neutrophilic inflammation, pH reduction, and an increase in cytokine levels, IgE production, and eosinophils.^{2,8,9} Further research is needed to elucidate the mechanism by which ambient pollutants influence exacerbation of skin symptoms in AD. In conclusion, our results suggest that outdoor air pollution acts as an aggravating factor for AD and may need to be controlled for better management of AD.

Jihyun Kim, MD, PhD^{a,b}
Eun-Hye Kim, MS^{b,c}
Inbo Oh, PhD^d
Kweon Jung, PhD^e
Youngshin Han, PhD^b
Hae-Kwan Cheong, MD, PhD^{b,c}
Kangmo Ahn, MD, PhD^{a,b}

From ^athe Department of Pediatrics, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea; ^bthe Environmental Health Center for Atopic Diseases, Samsung Medical Center, Seoul, Korea; ^cthe Department of Social and Preventive Medicine and Samsung Biomedical Research Institute, Sungkyunkwan University School of Medicine, Suwon, Korea; ^dthe Environmental Health Center, University of Ulsan College of Medicine, Ulsan, Korea; and ^eSeoul Research Institute of Public Health and Environment, Gwacheon, Korea. E-mail: kmaped@skku.edu.

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TABLE E1. The relationship between symptoms of AD and air pollutants

Variable	Symptoms of AD (n = 1846)		P value*
	No	Yes	
Temperature (°C)	13.1 ± 0.2	12.6 ± 0.2	.084
Humidity (%)	59.1 ± 0.5	60.0 ± 0.4	.155
NO (ppb)	21.6 ± 1.0	22.4 ± 0.9	.527
NO ₂ (ppb)	32.1 ± 0.5	32.8 ± 0.4	.314
NO _x (ppb)	53.7 ± 1.4	55.2 ± 1.3	.420
PM ₁₀ (μg/m ³)	46.9 ± 1.2	50.5 ± 1.1	.021
PM _{2.5} (μg/m ³)	24.2 ± 0.5	25.6 ± 0.5	.043
Benzene (ppb)	0.5 ± 0.009	0.5 ± 0.009	.054
Toluene (ppb)	3.4 ± 0.1	4.0 ± 0.1	<.001
Ethyl-benzene (ppb)	0.5 ± 0.02	0.5 ± 0.02	.083
Xylene (ppb)	0.8 ± 0.03	0.9 ± 0.03	.239
Styrene (ppb)	0.1 ± 0.003	0.1 ± 0.002	.971
TVOC (ppb)	29.1 ± 0.7	33.8 ± 0.7	<.001

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*Adjusted by temperature, humidity, seasons, SCORAD at initial visit, and age.