



Air pollution and exacerbation of skin itching and sleep disturbance in Iranian atopic dermatitis patients

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Abstract

Background For about three decades now, the number of people suffering from atopy including atopic dermatitis (AD) has been increasing in developed countries. Genetic background and environmental factors including air pollution play an effective role in its incidence. This study examined the association between air pollutants and exacerbation of AD symptoms including sleep disturbance and itching in AD patients of Tehran.

Methods In this panel study, 31 patients with AD who admitted to Razi Hospital, dermatology hospital in Tehran, entered the research. Daily information including questions on disease symptoms (sleep disturbance, itching) and duration of outdoor stay (in hours) were collected using a questionnaire. The mean 24-h concentrations of PM_{2.5} and PM₁₀ pollutants were obtained from the Air Quality Control Company. The relationship between the concentrations of the pollutants and exacerbation of the disease symptoms was investigated using the GEE (Generalized Estimating Equations) model.

Results There was a significant relationship between the concentrations of air pollutants and exacerbation of sleep disturbance and itching on the same day, before, and after adjusting the effects of the confounding variables, so that the estimated odds ratios (95% confidence interval) between PM₁₀ and PM_{2.5} and exacerbation of itching were 1.06 (1.02–1.10) and 1.17 (1.07–1.28), respectively.

Conclusions There was a significant statistical relationship between the concentration of particulate matter (PM_{2.5} and PM₁₀) and exacerbation of sleep disturbance and itching. PM_{2.5} showed a stronger relationship with the exacerbation of symptoms compared to PM₁₀.

Keywords Air pollution · Atopic dermatitis · Particulate matter · Itching · Sleep disturbance

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Background

Atopic dermatitis (AD) is a chronic, pruritic inflammatory skin disease and a global health issue. The prevalence of AD is 10–20% in children and 1–3% in adults [1, 2]. According to reports, the number of people with atopy, including atopic dermatitis, has grown steadily over the last three decades in developed countries where air pollution is one of the major problems [3–9]. A number of factors contribute to the development of this disease, including genetics, smoking, age, gender, lifestyle, stress, family history of the disease, and environmental stimuli such as dust, mites, molds, cigarette smoke, air pollution, heating system, aerogens, and climate change [4, 10–16]. The disease is usually associated with severe itching, sleep disturbance, educational and social status impairment, decreased quality of life, physical and psychological stresses on the

family and related people resulting from this disease, and imposition of economic costs [17–22].

Although the mechanism of the effect of exposure to air pollutants in exacerbating allergic diseases is unknown, some studies have shown that pollutants cause skin disorder or disruptions the immune system and exacerbate pulmonary diseases through the mechanism of oxidative stress [23, 24]. These pollutants include particulate matters that can cause respiratory disorders including asthma, especially in susceptible individuals, and skin inflammation in patients with AD [25–28]. Song et al. showed that particles can have a more negative effect on pulmonary function in people with atopic dermatitis than others and, therefore, these people are more vulnerable [25].

Several studies have been carried out on air pollutants and development of allergic diseases including AD [5, 9, 29–33]. A study in Spain on air pollutants (SO₂, NO₂, and CO) and allergic diseases (asthma, allergic rhinitis, and dermatitis) reported a significant relationship between CO and incidence of dermatitis, so that the odds ratio (95% confidence interval) was 1.55 (1.17–2.04) [5]. A study in Korea showed that the risk of AD symptoms (95% confidence interval) increased by 3.2% (1.5–4.9), 5.0% (1.4–8.8), and 6.1% (3.2–9.0) per 10 units increase in the concentration of PM₁₀, NO₂, and O₃, respectively [9]. Lee et al. examined the relationship between air pollutants and occurrence of dermatitis in 317,926 students in Taiwan and noticed a significant relationship between dermatitis and NO_x and CO, which was more pronounced in girls [34]. However, no significant relationship has been reported in some other studies [35–37].

Although studies have been conducted on the relationship between air pollutants and incidence of AD, there are fewer studies into the relationship between concentrations of these pollutants and exacerbation of the disease symptoms. Given the increasing concentration of air pollutants in Tehran due to uncontrolled growth and the presence of vehicles, and since identification of factors influencing occurrence of any disease in a community is necessary for its prevention and treatment, the present study aimed to examine the association between particulate matters and exacerbation of sleep disturbance and itching in patients with atopic dermatitis living in Tehran.

Methods

Study location

This study was conducted in Tehran Metropolis, the most polluted city in Iran. Tehran is located at a longitude of 51°17' to 51°33' E, a latitude of 35°36' to 35°44' N, and an altitude of 900–1800 m. According to the last census in 2016, it had an estimated population of 8,737,510.

Study design and population

This panel study was conducted on 31 patients (non-smoker and resident of Tehran) with atopic dermatitis diagnosed by specialists according to clinical criteria who admitted to Razi Hospital, dermatology hospital in Tehran, during February 2013 and were willing to participate in this research and declared their oral informed consent. Information related to these patients including age, BMI in kg/m², gender, family history of skin disease, level of education, parents' educational level, allergy, stress, exposure to cigarette smoke at home, and keeping pets at home) was collected. Moreover, severity of disease was determined as mild (0–25), moderate (25–35), or severe (35–50) in each patient based on the Scoring Atopic Dermatitis (SCORAD) index [38]. The daily living questionnaire containing questions on sleep disturbance (no disturbance /AD-induced disturbance), itching (no itching/AD-induced itching), consumption of antihistamines, passive smoking, and hours of outdoor stay was given to each participant. The patients were taught and asked to fill out the questionnaires at each day based on symptoms of the previous day. The questionnaires were completed for 62 consecutive days (from 21 April 2013 to 21 June 2013). Weekly telephone calls were made to all of the patients to remind them of completing the questionnaires, and the questionnaires were collected every week. The ambiguities in the answers were resolved during telephone conversations with the patients or in face-to-face meetings. The study has been approved by institutional review board (Institute for Environmental Research;92-01-46-22,328).

Air pollutants and meteorological variables

Information regarding the mean 24-h concentrations of PM_{2.5} and PM₁₀ (µg/m³) was obtained from the Air Quality Control Company. Since the pollutants information was not recorded at all stations ($n = 44$) for the 62 consecutive days, the information of those stations which results included at least 90% of the study period was used. The average 24-h temperature (°C) and relative humidity (%) were also obtained from the National Climatic Data Center (NCDC).

Statistical analyses

The continuous and categorical characteristics of the study subjects were represented through mean with standard deviation (SD) and count (percentage), respectively. The 24 h averages of air pollutants and meteorological variables were described by minimum, maximum, mean, SD, and quartiles. The patients' self-reported symptoms were regarded as binary outcomes and generalized estimating equations (GEE) with logit link and first-order autoregressive (AR(1)) working correlation matrix structure was applied to assess the association

between each air pollutant and each health outcome (skin itching and sleep disturbance). The model was adjusted for the effect of outdoor stay (in hours) and relative humidity (%). All effect estimates were expressed by odds ratio (OR) with 95% confidence interval (CI). To consider the delayed effect of each pollutant on the study symptoms, lag 1 and lag 2 of each air pollutant concentration were also regarded in model which respectively show the concentration on 2 and 3 days before symptom reporting. *P* values less than 0.05 were considered as statistically significant. All analyses were performed in IBM SPSS Statistics for Windows (Version 20.0. Armonk, NY: IBM Corp.).

Results

Out of 31 patients with AD, 26 were females and 5 were males. The mean age of participants was 23.65 ± 9.66 years (Min: 7, Max: 47 years). None of them had any family history of the disease or kept pets at home. According to the SCORAD index, most of the studied patients ($n = 19$, 61.3%) exhibited severe symptoms. Tables 1 and 2 represent

Table 1 Characteristics of the study participants (Mean \pm SD or Number (%))

Atopic dermatitis patients ($n = 31$)		
Age (years)		23.65 \pm 9.66
BMI (kg/m ²)		21.82 \pm 3.64
Gender	Male	5 (16.1%)
	Female	26 (83.9%)
SCORAD Index	Mild	1 (3.2%)
	Moderate	11 (35.5%)
	Severe	19 (61.3%)
History of dermal diseases	No	31 (100%)
Educational level of patients	Student	14 (45.1%)
	Bachelor's degree	13 (41.9%)
	Higher than Bachelor's degree	4 (12.9%)
	Diploma	15 (48.4%)
Educational level of parents	Bachelor's degree	15 (48.4%)
	Higher than Bachelor's degree	1 (3.2%)
	Diploma	15 (48.4%)
Allergy	Yes	4 (12.9%)
	No	27 (87.1%)
Stress	Yes	12 (38.7%)
	No	19 (61.3%)
Pets at home	No	31 (100%)
Exposure to cigarette smoke at home	No	31 (100%)
Outdoor stay (hour)	Min:0 Max:6	1.44 \pm 0.81

Table 2 Summary of daily self-reported symptoms among the study participants from 21 April to 21 June, 2013

Health outcomes		Among 1922 symptom diaries (62 reports of 31 subjects)
Skin itching	Yes	1430 (74.4%)
	No	492 (25.6%)
Sleep disturbance	Yes	1098 (57.1%)
	No	824 (42.9%)

the characteristics of the study participants and their self-reported symptoms, respectively.

During the 62-day study period, the average 24-h concentrations of PM_{2.5} and PM₁₀ were 30.52 ± 11.64 and 89.02 ± 33.74 ($\mu\text{g}/\text{m}^3$), respectively, and the mean temperature and relative humidity were 22.41 ± 4.12 °C and $24.13 \pm 8.26\%$ (Table 3).

Based on Table 4, there was a statistically significant relationship between the concentration of PM_{2.5} and PM₁₀ and exacerbation of AD symptoms before and after adjustment for the effects of relative humidity and outdoor stay. For every 10 $\mu\text{g}/\text{m}^3$ increase in PM_{2.5}, the odds of exacerbation of itching and sleep disturbance on the same day increased by 17% (OR = 1.17) and 24% (OR = 1.24), respectively. Moreover, regarding lag 2, the odds of itching and sleep disturbance increased by 18% (OR = 1.18) and 33% (OR = 1.33) per 10 $\mu\text{g}/\text{m}^3$ increase in concentration of PM_{2.5}, respectively. In other words, it took 1–3 days that increment in the concentration of PM_{2.5} exhibits its effect on sleep disturbance and itching in AD patients. The greater effects on the exacerbation of AD symptoms were observed in Lag 2.

Discussion

This research studied the relationship between the concentrations of the PM_{2.5} and PM₁₀ pollutants and exacerbation of sleep disturbance and itching in patients with AD who lived in Tehran. Results indicated a significant relationship between these pollutants and exacerbation of the disease symptoms.

In this study, the concentration of PM_{2.5} and PM₁₀ were significantly related to exacerbation of AD symptoms before and after adjusting the effects of relative humidity and outdoor stay. According to the odds ratios, PM_{2.5} had a stronger relationship with exacerbation of AD symptoms compared to PM₁₀. This was due to the smaller size of PM_{2.5} that allowed it to penetrate deeper into the skin and exert greater adverse effects on human health.

Table 3 Descriptive statistics of 24-h averages of air pollutants and meteorological variables at the study site from 21 April to 21 June, 2013

	Mean	SD	Percentile			Minimum	Maximum
			25 th	50 th	75 th		
PM _{2.5} (µg/m ³)	30.52	11.64	21.66	28.10	36.75	14.62	67.08
PM ₁₀ (µg/m ³)	89.02	33.74	64.56	83.89	114.04	42.65	190.36
Temperature (°C)	22.41	4.12	20.50	22.15	25.80	13.90	30.60
Relative humidity (%)	24.13	8.26	18.50	20.95	30.77	9.90	44.10

Some studies reported relationships between PM and exacerbation of AD symptoms [30, 39, 40]. For example, a panel study similar to the present one was performed by Song et al. in Korea on the relationship between PM and exacerbation of AD symptoms on forty-one patients which showed that increased concentrations of ultrafine particles (UFPs) exacerbate AD symptoms. Moreover, exacerbation of symptoms was influenced by the increase in the concentrations of these particles on the previous day so that there was a 3.11% (0.17–6.14) increase in itching symptoms in the patients per interquartile-range increase in the concentrations of the UFPs on the previous day [30].

In another study by Oh et al. in South Korea, a significant relationship was found between PM_{2.5} and PM₁₀ and exacerbation of AD symptoms. PM_{2.5} had a stronger relationship (OR = 1.39; 95% CI: 1.21–1.61) with exacerbation of the symptoms than PM₁₀ which is consistent with the findings of the present research [40].

A cross-sectional study in Taiwan on 1023 atopic dermatitis patients reported a significant relationship between PM_{2.5}

and the disease progress. The adjusted odds ratio (95% CI) was 1.02 (1.01–1.03) [41].

Penard-Morand et al. carried out a research on the relationship between air pollution and respiratory and atopic problems in 6 French cities. Results revealed a positive relationship between SO₂, PM₁₀, and ozone concentrations and the mentioned outcomes. Our findings is in agreement with this study [29].

The present study was the first panel study conducted in Tehran and, of course, it had some limitations. Since it was conducted only in one season of the year and with a relatively small sample size, it seems that future research should be conducted on larger sample sizes in all seasons of the year. In addition, because the information received from the stations assessing air pollutants was not complete, the relationships between the ozone, carbon monoxide, nitrogen dioxide, and sulfur dioxide pollutants with the exacerbation of AD symptoms were not investigated. Moreover, considering previous studies, it is suggested to investigate the relationship between UFPs and the aforementioned outcomes.

Table 4 Estimated crude and adjusted odds ratios for the association between pollutants and symptoms among the study participants using generalized estimating equations (GEE)

Pollutant	#	Symptoms				Symptoms			
		Skin itching		Sleep disturbance		Skin itching		Sleep disturbance	
		Crude OR (95%CI)	p value	Crude OR (95%CI)	p value	Adjusted OR ** (95%CI)	p value	Adjusted OR** (95%CI)	p value
PM _{2.5} (µg/m ³)*	Same day	1.20 (1.09–1.32)	<0.001	1.26 (1.17–1.35)	<0.001	1.17 (1.07–1.28)	0.001	1.24 (1.14–1.34)	<0.001
	Lag 1	1.14 (1.03–1.27)	0.015	1.18 (1.09–1.27)	<0.001	1.18 (1.05–1.32)	0.005	1.21 (1.12–1.30)	<0.001
	Lag 2	1.16 (1.06–1.27)	0.001	1.31 (1.20–1.44)	<0.001	1.18 (1.06–1.30)	0.002	1.33 (1.22–1.45)	<0.001
PM ₁₀ (µg/m ³)*	Same day	1.07 (1.03–0.10)	<0.001	1.10 (1.07–1.13)	<0.001	1.06 (1.02–1.10)	0.001	1.09 (1.06–1.13)	<0.001
	Lag 1	1.04 (1.01–1.08)	0.023	1.04 (1.02–1.07)	0.001	1.05 (1.00–1.10)	0.029	1.05 (1.02–1.08)	0.001
	Lag 2	1.08 (1.04–1.13)	<0.001	1.12 (1.08–1.16)	<0.001	1.09 (1.04–1.14)	<0.001	1.13 (1.09–1.17)	<0.001

Same day, Lag1, Lag2 represent the air pollutant concentrations on 1, 2, and 3 days before symptom reporting, respectively

* OR for 10µg/m3 increase in concentration of air pollutant

** Adjusted by outdoor stay and relative humidity

Conclusion

This research determined the relationships between $PM_{2.5}$ and PM_{10} and sleep disturbance and itching in patient with atopic dermatitis who lived in Tehran. Results showed that particulate matters had a great influence in exacerbation of AD symptoms. In addition, among the studied particles, $PM_{2.5}$ had a stronger relationship with exacerbation of AD. Moreover, it was observed that exacerbation of itching and sleep disturbance can be influenced by increased concentrations of the particles 1–3 days before the occurrence of symptoms.

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Compliance with ethical standards

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Conflict of interest The authors declare that they have no conflict of interest.

Abbreviations AD, atopic dermatitis; CIs, Confidence intervals; GEE, Generalized Estimating Equations; NCDC, National Climatic Data Center; ORs, Odds ratios; $PM_{2.5}$, Particulate matter ≤ 2.5 μm in aerodynamic diameter; PM_{10} , Particulate matter ≤ 10 μm in aerodynamic diameter; SCORAD, Scoring Atopic Dermatitis; SD, Standard deviation

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