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Research Paper

Environmental conditions associated with the childhood asthma in Japanese elementary school children

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ABSTRACT: *Since many environmental factors, especially air pollutants and meteorological conditions are closely related to the onset of childhood asthma, the author investigated the relationship between preschool children's exposure levels to air pollutants and meteorological conditions and the prevalence of childhood asthma after entering school.*
To clarify the relationship between prevalence of childhood asthma among Japanese elementary school children and preschool indoor and outdoor conditions such as smoking rate, photochemical oxidants, ambient temperature and relative humidity, multiple linear regression analysis was performed.
Stepwise multiple regression analysis with prevalence of childhood asthma as the objective variable, smoking rate, photochemical oxidants, ambient temperature and relative humidity as explanatory variables, revealed that photochemical oxidants and relative humidity were significant independent variables.
Present study suggests that preschool environmental conditions such as photochemical oxidants and relative humidity may be associated with the development of childhood asthma.

KEYWORDS: *childhood asthma; smoking rate; photochemical oxidants; ambient temperature; relative humidity*

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I. INTRODUCTION

The prevalence of asthma among elementary school students in Japan increased rapidly from around 1990 to around 2010, then plateaued and began to decline after 2017. Since many environmental factors, especially air pollutants and meteorological conditions are closely related to the onset of childhood asthma [1 – 11] , the author investigated the relationship between preschool children's exposure levels to air pollutants and meteorological conditions and the prevalence of childhood asthma after entering school.

II. METHODS

Prevalence of childhood asthma among elementary school children in Japan

The prevalence of childhood asthma among elementary school children in Japan is based on School Health Statistics Survey by the Ministry of Education, Culture, Sports, Science and Technology (https://www.e-stat.go.jp/stat-search/files?page=1&layout=dataset&toukei=00400002&tstat=000001011648&stat_infid=000040120025&toukei_kind=6&result_page=1).

Air pollutants

Smoking rate, as an indicator of indoor air pollution was obtained from National Nutrition Survey by the Ministry of Health, Labour and Welfare. The values were downloaded from Cancer Information Service, National Cancer Center, Japan.

(https://ganjoho.jp/reg_stat/statistics/dl/index.html#smoking). The smoking rate is the ratio of the total number of people (men and women over 20 years old) who answered "smoking daily" or "sometimes smoked" as a numerator and the "total number of respondents" as a denominator.

The annual average values of photochemical oxidants (maximum hourly values during the day) were provided by the Ministry of the Environment. (https://www.env.go.jp/press/press_03287.html)

Meteorological conditions

The annual average values of ambient temperature and relative humidity by prefecture were from Social Indicators by Prefecture. The values were downloaded from e-Stat (https://www.e-stat.go.jp/dbview?sid=0000010102). The arithmetic average of ambient temperature and relative humidity for the 47 prefectures was used as the average for Japan as a whole.

Statistical analysis

Stepwise multiple linear regression analysis was performed to determine the relationship between prevalence rate of childhood asthma and atopic dermatitis and preschool environmental conditions. $p < 0.05$ was considered as statistically significant.

III. RESULTS

Changes in prevalence of childhood asthma

Figure 1 shows changes in percentage of asthma among Japanese elementary school children from 1989 to 2023. The prevalence of asthma among elementary school children increased rapidly from around 1990 to around 2010, but has been decreasing since 2011.

Changes in air pollutants and meteorological conditions

Smoking rates from 1989 to 2023 have been declining linearly and significantly, while oxidants have been increasing significantly until around 2005, then plateaued and have been declining slightly since 2015 (Figure 2).

The annual average value of ambient temperature has shown a slight upward trend, while relative humidity showed a slight downward trend until around 2007 and has since shown an upward trend (Figure 3).

Stepwise multiple linear regression analysis

Table 1 shows prevalence of asthma among elementary school children from 1995 to 2023 and average exposure levels of air pollutants and ambient temperature and relative humidity during the six years before entering school. Stepwise multiple regression analysis with prevalence of asthma as the objective variable, smoking rate, photochemical oxidants, ambient temperature and relative humidity as explanatory variables, revealed that photochemical oxidants and relative humidity are significant independent variables.

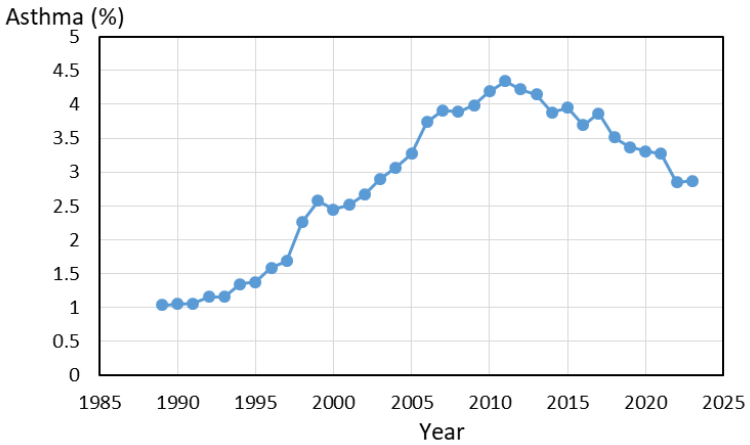

Figure 1. Changes in prevalence of asthma

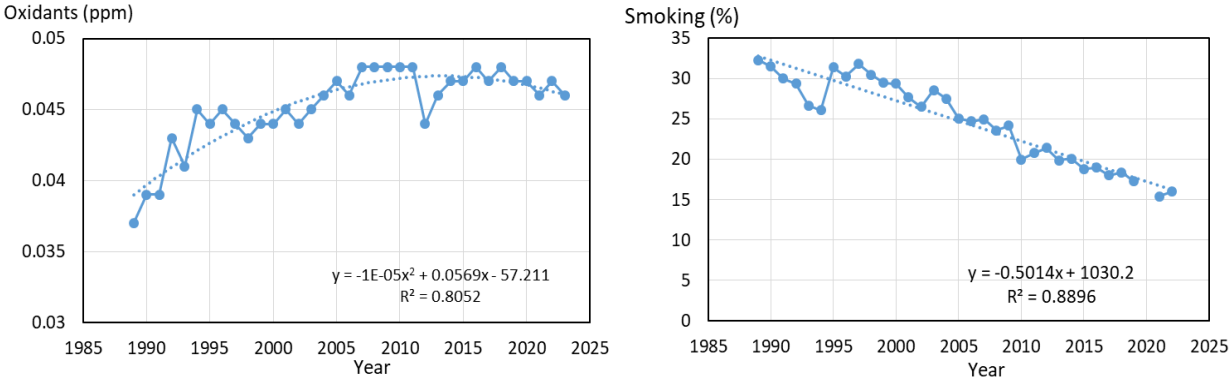

Figure 2. Changes in photochemical oxidants and smoking rate

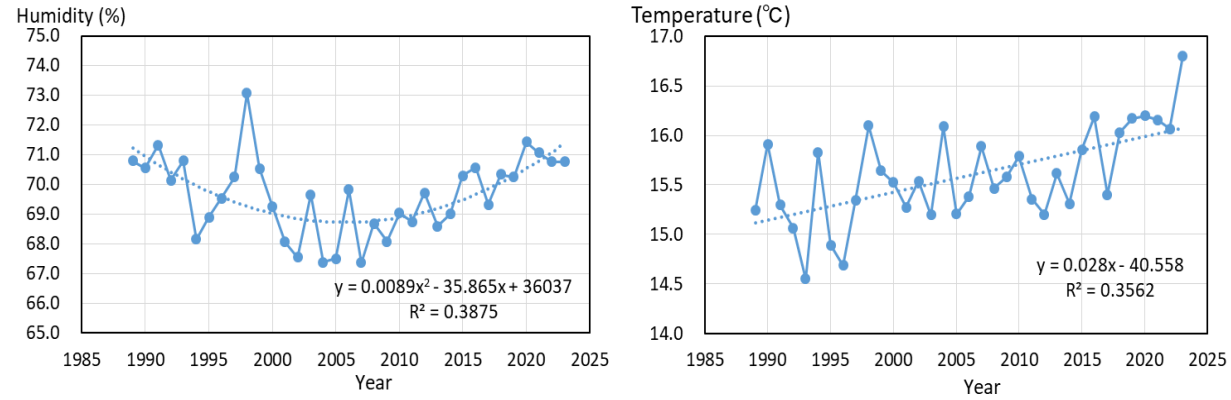

Figure 3. Changes in relative humidity and ambient temperature

IV. DISCUSSION

Since many environmental factors, especially air pollutants and meteorological conditions are closely related to the onset of childhood asthma, the author investigated the relationship between preschool children's exposure levels to air pollutants and meteorological conditions and the prevalence of childhood asthma after entering school. Stepwise multiple regression analysis revealed that photochemical oxidants and relative humidity were significant associated factors. However, there is a limitation in that the results of regression analysis cannot prove causality.

Photochemical oxidants are potent oxidative stressors that generate reactive oxygen species (ROS), such as superoxide (O2−) and hydrogen peroxide (H2O2), leading to increased inflammation and resulting in asthma symptoms [12]. ROS also cause skin barrier dysfunction and inflammation, leading to skin allergic diseases [13]. These conditions are often precursors to other allergic conditions such as asthma or food allergies [14].

Annual average values of relative humidity was a significant explanatory variable for asthma. It has been reported that asthma is associated with high humidity conditions [15], but the annual average change in relative humidity from 1995 to 2023 was only 71% to 68%, which is unlikely to reflect the relationship between childhood asthma and humidity. However, the relationship between humidity and asthma cannot be ignored when considering dry periods and changes in precipitation. During the dry season, the mucous membranes of asthma patients become dry and sensitive, making them more susceptible to attacks [16]. Low humidity also increases pollen dispersion [17 – 20] and promotes its transport to urban areas [21 - 23]. This may induce the exacerbation of atopic dermatitis and lead to asthma attacks [14, 24]. In addition, the annual mean change in relative humidity is thought to be associated with changes in precipitation, which is a negative risk factor for the development of asthma [15]. In fact, according to data from the Japan Meteorological Agency, annual precipitation in Japan showed a decreasing trend from 1950 to 2005, and has since increased (Figure 4) [25].

A regional comparative study in Japan conducted by the author showed that the prefectural smoking rate was significantly associated with the prevalence of childhood asthma in each prefecture. However, the contribution rate of smoking to childhood asthma was only 4-5% [26]. In this study, the effect of smoking rate on childhood asthma was not detected, possibly because the contribution rate of smoking to childhood asthma is low.

Table 1. Changes in prevalence of asthma and preschool environment.

Years	Asthma (%)	Preschool Environment			
		Oxidants (ppm)	Smoking (%)	Humidity (%)	Temperature (℃)
1995	1.4	0.041	29.3	70.3	15.3
1996	1.6	0.042	29.2	70.0	15.3
1997	1.7	0.043	29.0	69.8	15.1
1998	2.3	0.044	29.3	69.6	15.1
1999	2.6	0.044	29.5	70.1	15.2
2000	2.5	0.044	29.9	70.1	15.4
2001	2.5	0.044	30.5	70.3	15.4
2002	2.7	0.044	29.9	70.1	15.4
2003	2.9	0.044	29.2	69.8	15.6
2004	3.1	0.044	28.7	69.7	15.5
2005	3.3	0.045	28.2	68.7	15.5
2006	3.7	0.045	27.5	68.2	15.5
2007	3.9	0.046	26.7	68.3	15.4
2008	3.9	0.046	26.2	68.2	15.6
2009	4.0	0.047	25.8	68.4	15.5
2010	4.2	0.047	25.0	68.1	15.6
2011	4.3	0.048	23.8	68.4	15.6
2012	4.2	0.048	23.1	68.6	15.6
2013	4.2	0.047	22.5	68.6	15.5
2014	3.9	0.047	21.7	68.8	15.5
2015	4.0	0.047	21.1	68.9	15.5
2016	3.7	0.047	20.2	69.2	15.5
2017	3.9	0.047	20.0	69.5	15.6
2018	3.5	0.047	19.5	69.6	15.6
2019	3.4	0.047	19.0	69.7	15.7
2020	3.3	0.047	18.6	70.0	15.8
2021	3.3	0.047	18.3	70.4	16.0
2022	2.9	0.047	17.6	70.8	16.1
2023	2.9	0.047	17.0	70.8	16.8

Table 2. Stepwise multiple regression analysis with prevalence of asthma as the objective variable, smoking rate, photochemical oxidants, ambient temperature and relative humidity as explanatory variables.

Independent variables	Estimated regression coefficient B	95% confidence interval		Partial regression coefficient β	Cumulative R^2	*P*-value
		Lower bound	Upper bound			
Intercept	21.368	12.572	30.164	-	-	0.000
Oxidants	303.937	254.344	353.530	0.685	0.750	0.000
Humidity	-0.461	-0.572	-0.351	-0.467	0.935	0.000

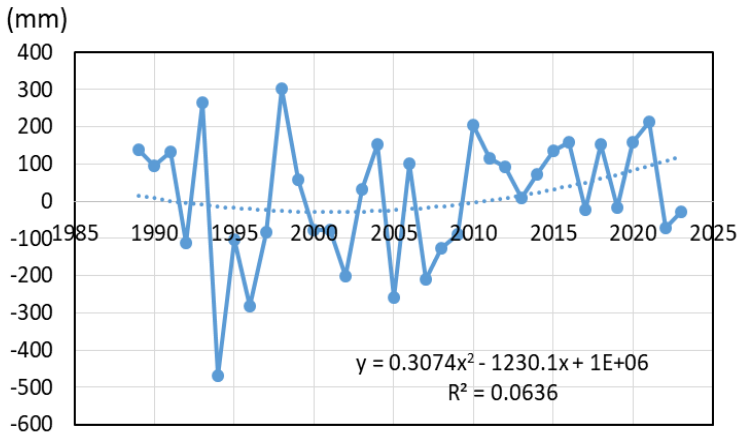

Figure 4. Annual trends in deviation from the average annual precipitation amount from 1991 to 2020

V. CONCLUSION

This study suggests that preschool environmental conditions, such as photochemical oxidants and relative humidity, may be associated with the development of childhood asthma in Japanese elementary school children.

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Disclosure of conflict of interest
There is no conflict of interest in this work.

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