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Prevalence of Allergic Diseases of Schoolchildren in Central Taiwan

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ORIGINAL ARTICLE

Prevalence of Allergic Diseases of Schoolchildren in Central Taiwan

From ISAAC Surveys 5 Years Apart

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The prevalence of allergic disorders is increasing around the world. This study used the standardized written questionnaire from International Study of Asthma and Allergies in Childhood (ISAAC, phase III) to collect two cross-sectional appraisals of schoolchildren 5 years apart—one performed 2002 and another on 2007, to focus on the secular trends in prevalence of allergies in central Taiwan. This questionnaire was administered to schoolchildren from over 46 schools across Changhwa County in 2002, and again in 2007. The present study is a follow-up study and uses data collected from a previously reported study conducted in the year 2002 of the same location using the same methodology. Although the repeated cross-sectional survey after a 5-year lapse suggests a mere increase of diagnosed asthma cases from 7.1% to 7.4%, the prevalence of its related symptoms—nocturnal cough, rhinitis, and eczema—was found to increase significantly by 2.6% ($p < 0.0001$), 6.8% ($p < 0.001$), and 5.9% ($p < 0.001$), respectively. Additionally, comparing the secular trends in asthma prevalence, rhinitis, and eczema between several polluted areas in Changhwa County with its less polluted neighbors in 2002 and 2007 indicates that schoolchildren in TaiHao area, which is noted to be polluted by a petrochemical company, has a significantly increased prevalence of wheezing (3.7%, $p < 0.05$) and nocturnal cough (3.6%, $p < 0.05$). For schoolchildren living in the coastal areas, a 6% ($p < 0.05$) increase in the prevalence of rhinitis is noted. The prevalence of eczema uniformly increased for all areas of Changhwa County ($p < 0.01$). In the downtown areas, besides eczema, the prevalence of asthma and rhinitis also increased significantly ($p < 0.05$). Of note is the consistent finding in these two periods of the higher prevalence of childhood asthma, rhinitis, and eczema in the downtown areas compared with that from both the polluted and coastal areas. The secular trends in prevalence of asthma, rhinitis, and eczema in these two periods seem to correlate to environmental factors. While the symptoms of asthma, rhinitis, and eczema in schoolchildren affected boys more than girls, it is observed that affected girls have more marked manifestations, although it did not reach statistical significance.

Keywords prevalence, asthma, rhinitis, eczema, ISAAC, Taiwan

INTRODUCTION

Asthma, rhinitis, and eczema continue to be common chronic disorders in children (1). Many researchers have indicated the increase in the prevalence of these diseases around the world for the last few decades (2–6). However, other researchers have noted the potential end of the rise in the prevalence of allergic disorders (7–10). In 1992, the development of the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire provided a standardized methodology for evaluation of asthma, rhinitis, and eczema (11). The specific aims of ISAAC were (1) to describe the prevalence and severity of asthma, rhinitis, and eczema in children for comparison within and among countries; (2) to provide a baseline measurement for trends; and

(3) to provide a framework for future research (11). Comparing with data from around the world, the prevalence of asthma, rhinitis, and eczema in Taiwan falls within the middle range of reported values. The focus of this project is to study the secular trends in the prevalence of asthma, rhinitis, and eczema in schoolchildren of the Changhwa County of Taiwan. The ISAAC phase III protocol is used to assess the prevalence, severity and seasonal variation of asthma, rhinitis, and eczema in schoolchildren ranging from 6 to 8 years of age. Data collected in 2007 are then compared with those from a 2002 report (12) to evaluate the prevalence differences in these two time periods.

MATERIALS AND METHODS

Subjects and data collection

The study assessed data from an ISAAC written questionnaire survey of schoolchildren in Changhwa County between 2002 and 2007. Research subjects and data collections followed previous methodology in place from 2002 (12). According to ISAAC protocol, schools were deemed as

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sampling units (13–14). A total of 46 schools were randomly sampled from the entire list of schools in Changhwa County with 4,622 randomly selected schoolchildren included in the survey. The schoolchildren were first grade elementary students with ages ranging from 6 to 8 years. In addition, four areas in the Changhwa County were specially identified for comparison. The areas included (1) “TaiHao area” as it had heavy air-pollution due to a petrochemical company; (2) “XiZhou area” owing to its close proximity to a waste incineration plant located in the southern part of the county; (3) coastal area of the county; and (4) rest of the county.

Method

Research methods followed previous methodology (1). The study was approved by the Ethics committee of Han-Ming Hospital, the Changhwa County Ministry of Education, and the Changhwa County Ministry of Health. Parental consent was obtained for surveyed schoolchildren from the Department of School's Administration. Each child was given the ISAAC questionnaire by school instructors to take home and be completed by parents or a legal guardian. The ISAAC questionnaires were returned to school instructors within a week.

Questionnaires

The standard ISAAC step III core questions for wheezing, rhinitis, and eczema were used. In both studies, the social economic status of the correspondence was evaluated by including questions in identifying various types of residences (11, 13, 14). Also, questions concerning the factors of environment affections were included in the questionnaire. Both social economic status and factors of environment exposure were shown to be reliable indicators. The Mandarin version of the questionnaire has been translated as a validity check according to defined guidelines (11).

Statistical Analysis

The collected data were tabulated in frequency and percentage by the variables from the questionnaire in the 2002 and 2007 surveys, and the data were analyzed using SPSS 10.0 (SPSS Inc., Chicago, IL). All analysis with a p value of <0.05 representing statistical significance. In addition, the chi-square tests were performed to assess the prevalence of each specific allergic disorders of asthma, rhinitis, and eczema between the two surveys, and prevalence odds ratios (POR) and 95% confidence intervals (CI) were calculated. Similarly, the chi-square tests were performed to compare between the two areas with high air pollution, coastal area, and the rest of the Changhwa County.

RESULTS

There were 7,040 and 4,622 schoolchildren who responded to the survey in 2002 and 2007, respectively. The response rates were 89.49% in 2002 and 79.10% in 2007. Table 1 shows the demographic profiles of the respondents from both studies. The mean ages of the two studies were similar. The mean age of the responders was 6.81 years in 2002 (boys = 6.81 and girls = 6.80) and 6.85 years in 2007 (boys = 6.86 and girls = 6.85). The gender ratio in 2002 was 51.5% boys against 48.5% girls, and 53.2% boys against 46.8% girls in

TABLE 1.—Demographic profile of the survey responders.

Variable	2007	2002	<i>p</i>
Age	6.85 (0.52)	6.81 (0.38)	
Boys	6.86 (0.53)	6.81 (0.37)	
Girls	6.85 (0.53)	6.80 (0.38)	
Gender			0.064
Boys	2458 (53.2%)	3627 (51.5%)	
Girls	2164 (46.8%)	3413 (48.5%)	
Total schools sampled	46	47	
Northern Changhwa county	16 (34.8%)	19 (40.4%)	
Southern Changhwa county	11 (23.9%)	9 (19.1%)	
TaiHao area	3 (6.5%)	3 (6.4%)	
XiZhou area	6 (13.0%)	6 (12.8%)	
Coastal area	10 (21.8%)	10 (21.3%)	
Total subjects surveyed	4,622	7,040	<0.001
Northern Changhwa county	1924 (41.6%)	2988 (42.4%)	
Southern Changhwa county	1041 (22.5%)	1934 (27.5%)	
TaiHao area	565 (12.2%)	696 (9.9%)	
XiZhou area	217 (4.7%)	219 (3.1%)	
Coastal area	875 (18.9%)	1203 (17.1%)	
Response rate (%)	89.4	79.1	

p values are obtained by the chi-square test.

2007. The difference in gender ratio was insignificant (chi-square test $p = 0.064$, > 0.05). The total number of subjects surveyed dropped from 7,040 in 2002 to 4,622 in 2007. The number of subjects surveyed was determined to be adequate for comparison of secular trends. (chi-square test, $p < 0.05$).

Table 2 summarizes and compares the differences of the overall cumulative prevalence of asthma, rhinitis, and eczema and their symptoms in 2002 against 2007. While the prevalence of asthma had not changed significantly during these two periods (7.1% to 7.4%, POR 1.05, 95% CI 0.91–1.21), asthmatic symptoms of wheezing, and nocturnal coughing significantly increased by 1.5% (POR 1.16, 95% CI 1.03–1.31, $p < 0.001$), and 2.6% (POR 1.23, 95% CI 1.21–1.50, $p < 0.001$), respectively.

The prevalence of rhinitis significantly increased by 6.8% (POR 1.40, 95% CI 1.29–1.52, $p < 0.001$), with the prevalence of the rhinitis-associated symptom of itchy eyes (6.2%) being most significantly increased (POR 1.61, 95% CI 1.43–1.80, $p < 0.001$). Finally, the prevalence of eczema also increased by 5.9% (POR 1.44, 95% CI 1.31–1.57, $p < 0.001$), with the eczema-associated symptom of chronic rash with

TABLE 2.—Responses for core question on asthma, rhinitis, and eczema symptoms, with percentage change between 2002 and 2007 surveys.

Variable	2007(%) N = 4,622	2002(%) N = 7,040	Change	POR	95% CI
Responses for asthma					
Ever wheezed	11.9	10.4	1.5	1.16***	1.03–1.31
Wheeze in past year	6.0	5.0	1.0	1.21**	1.03–1.44
Wheeze with exercise	4.0	3.7	0.3	1.10	0.91–1.33
Nocturnal cough	15.8	13.2	2.6	1.23***	1.21–1.50
Diagnosed asthma	7.4	7.1	0.3	1.05	0.91–1.21
Responses for rhinitis					
Ever had rhinitis	35.4	31.6	3.8	1.18***	1.09–1.28
Rhinitis in past year	30.5	26.9	3.6	1.19***	1.07–1.32
Associated itchy eyes	19.0	12.8	6.2	1.61***	1.43–1.80
Diagnosed rhinitis	31.4	24.6	6.8	1.40***	1.29–1.52
Responses for eczema					
Chronic rash	7.7	5.8	1.9	1.39***	1.20–1.61
Chronic rash in past year	9.7	7.0	2.7	1.45***	1.25–1.67
Chronic rash with typical dist.	8.9	5.9	3.0	1.56***	1.34–1.83
Recover in past year	11.9	10.5	1.4	1.15	1.26–1.73
Diagnosed eczema	23.9	18.0	5.9	1.44***	1.31–1.57

p values are obtained by the chi-square test. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. POR, prevalence odds ratio; CI, confidence interval.

TABLE 3.—The prevalence of asthma and rhinitis are different from gender.

	2007				2002				Boys		Girls	
	Boy % (n = 2458)	Girl % (n = 2164)	POR ¹	95% CI	Boy % (n = 2458)	Girl % (n = 2164)	POR ¹	95% CI	POR ²	95% CI	POR ³	95% CI
Diagnosed asthma	8.7	5.3	1.71***	1.35–2.16	9.3	4.8	2.01***	1.65–2.44	0.97	0.81–1.16	1.11	0.87–1.42
Diagnosed rhinitis	34.3	25.9	1.50***	1.32–1.71	28.6	20.4	1.57***	1.40–1.75	1.30***	1.17–1.46	1.36***	1.20–1.55
Diagnosed eczema	24.0	22.5	1.09	0.95–1.25	18.6	17.3	1.10	0.97–1.24	1.38***	1.21–1.56	1.39***	1.21–1.59

p values are obtained by the chi-square test. * *p* < 0.05; ** *p* < 0.01; *** *p* < 0.001.

POR, prevalence odds ratio; CI, confidence interval.

POR¹ values are calculated from boys vs. girls.

POR² values are calculated from boys between 2002 and 2007 surveys.

POR³ values are calculated from girls between 2002 and 2007 surveys.

typical distribution being most significantly increased by 3.0%. (POR 1.56, 95% CI 1.34–1.83, *p* < 0.001).

Table 3 compares the prevalence of asthma, rhinitis, and eczema between genders in 2002 against 2007. Data show that the various allergic disorders predominantly affect boys. It is observed that for “diagnosed asthma”, girls showed an increase (4.8% to 5.3%, POR 1.11, 95% CI 0.87–1.42), while boys showed a decrease (9.3% to 8.7%, POR 0.97, 95% CI 0.81–1.16) from 2002 to 2007, although it did not reach statistical significance (*p* < 0.05). Both girls and boys showed an increase in rhinitis diagnosis between 2002 and 2007 (20.4% to 25.9%, POR 1.36, 95% CI 1.20–1.55, *p* < 0.001) for girls and 28.6% to 34.3% (POR 1.30, 95% CI 1.17–1.46, *p* < 0.001) for boys, respectively. For “diagnosed eczema”, both genders manifested a sharp increase between the 2 periods (17.3% to 22.5%, POR 1.39, 95% CI 1.21–1.59, *p* < 0.001 for girls, and 18.6% to 24.0%, POR 1.38, 95% CI 1.21–1.56, *p* < 0.001 for boys).

Table 4 compares the frequency of combination of the three diagnosed allergic disorders in 2002 and 2007 surveys. The prevalence of children with none of the allergic disorders had significantly decreased by 11.3% (*p* < 0.001). The combination of diagnosed rhinitis and eczema had significantly increased by 1.8% (*p* < 0.001). The combination of diagnosed asthma, rhinitis, and eczema had significantly increased by 1.0% (*p* < 0.001).

Table 5 compares the severity of asthma, rhinitis, and eczema in children who had been diagnosed with a specific allergic disorder in 2002 and 2007. Attacks of wheezing were less frequent in 2007 than in 2002 (13.5% and 14.1%, respectively) but never reached statistical significance. (*p* < 0.05). Symptoms of “being awoken at night by wheezing” (showing a 4.8% increase) and “wheezing attack limiting speech” (showing a 0.6% decrease) did not reach

statistical significance either (*p* > 0.05). Comparison of the severity of rhinitic symptoms interfering with daily activities and the severity of “itchy rash” between the two periods did not reach statistical significance (90.8% to 88.9%, *p* < 0.05, and 32%–37.3%, *p* > 0.05, respectively).

Table 6 compares the changes in responses of the population on various core issues on asthma, rhinitis, and eczema in 2002 and 2007. The data show a significant increase of both “ever wheezed” (6.7% to 10.3%, *p* > 0.005) and nocturnal cough (10.7% to 14.3%, *p* > 0.005) in the TaiHao area, significant increase of rhinitis in the coastal (20.4% to 26.4%, *p* < 0.05) and downtown areas (26% to 34.5%, *p* < 0.001), and a significant increase in eczema diagnosis in all TaiHao, XiZhou, coastal, and downtown areas (14.9% to 23.9%, *p* < 0.001; 11% to 20.3%, *p* < 0.05; 15.4% to 21.1%, *p* < 0.05; 19.3% to 25%, *p* < 0.001; respectively). For most of the downtown areas in Changhua County, the prevalence of asthma, rhinitis, and eczema increased significantly (*p* < 0.001). Attention must also be drawn to the observation that in these two cross-sectional surveys performed in 2002 and 2007, respectively, both unexpectedly but consistently presented a higher prevalence of childhood asthma, rhinitis, and eczema in downtown areas than in the polluted and coastal areas.

TABLE 5.—Severity of asthma, rhinitis, and eczema in children being diagnosed with specific allergic disorder in the 2002 and 2007 surveys.

Variable	2007(%) N = 4622	2002(%) N = 7040	<i>p</i> value
Severity of wheezing	(n = 266)	(n = 341)	
Wheezing attack in past year			0.888
Never	13.5	14.1	
1–3	67.7	69.5	
4–12	15.4	13.2	
> 12	3.4	3.3	
Wakened by wheeze			0.491
Never	61.0	65.9	
< 1 per week	33.3	29.2	
> 1 per week	5.6	4.9	
Wheezing attack limiting speech	5.9	6.5	0.746
Severity of rhinitis	(n = 1357)	(n = 1337)	
Interfering with daily activity			0.230
Never	11.1	9.2	
Little	46.8	43.4	
Moderate	32.1	37.0	
A lot	10.0	10.4	
Severity of itchy rash	(n = 415)	(n = 434)	
Kept awake by rash in past year			0.180
Never	62.7	68.0	
< 1 per week	26.5	21.2	
> 1 per week	10.8	10.8	

p values are obtained by the chi-square test.

TABLE 4.—Combination of the three diagnosed allergic disorder in the 2002 and 2007 surveys.

Variable	2007(%) N = 4622	2002(%) N = 7040	<i>p</i> value
None	2035 (44.0)	3896 (55.3)	<0.001
Asthma only	68 (1.5)	264 (3.8)	<0.001
Rhinitis only	724 (15.7)	954 (13.6)	0.107
Eczema only	495 (10.7)	632 (8.9)	0.040
Asthma and rhinitis	100 (2.2)	146 (2.1)	0.742
Asthma and eczema	43 (0.9)	58 (0.8)	0.544
Rhinitis and eczema	358 (7.7)	416 (5.9)	<0.001
Asthma and rhinitis and eczema	106 (2.3)	94 (1.3)	<0.001

p values are obtained by the chi-square test.

TABLE 6.—Change in different area responses for core question on asthma, rhinitis, and eczema between 2002 and 2007 surveys.

Variable	TaiHao area			XiZhou area			Coastal area			Rest area		
	2007(%)	2002(%)	p	2007(%)	2002(%)	p	2007(%)	2002(%)	p	2007(%)	2002(%)	p
Asthma												
Ever wheezed	10.3	6.7	0.006	12.4	8.2	0.107	10.3	9.8	0.463	12.6	11.2	0.005
Wheeze in past year	4.6	2.6	0.005	6.9	5.0	0.582	5.8	4.8	0.184	6.2	5.3	0.047
Wheeze with exercise	3.2	3.5	0.994	6.0	4.1	0.354	3.5	3.2	0.536	4.2	3.8	0.142
Nocturnal cough	14.3	10.7	0.008	15.7	11.0	0.121	13.3	14.3	0.995	16.8	13.4	<0.001
Diagnosed asthma	7.3	4.9	0.034	8.3	7.3	0.642	6.1	6.7	0.775	7.7	7.4	0.218
Rhinitis												
Ever had rhinitis	31.7	30.0	0.119	26.7	21.0	0.102	31.4	29.1	0.177	37.9	33.0	<0.001
Rhinitis in past year	26.0	25.9	0.246	25.3	18.7	0.236	27.0	23.0	0.161	32.7	28.4	<0.001
Associated itchy eyes	14.7	12.4	0.135	14.3	9.1	0.077	14.1	8.8	0.002	21.6	13.9	<0.001
Diagnosed rhinitis	27.4	24.5	0.140	19.4	16.9	0.563	26.4	20.4	0.007	34.5	26.0	<0.001
Eczema												
Chronic rash	6.5	4.6	0.096	8.3	5.9	0.365	6.6	5.4	0.314	8.2	5.9	<0.001
Chronic rash in past year	9.2	6.0	0.003	12.0	5.5	0.007	8.1	5.9	0.084	10.2	7.4	<0.001
Chronic rash with typical	8.0	5.0	0.010	9.7	6.8	0.092	8.0	4.7	0.009	9.3	6.2	<0.001
Recover in past year	9.9	8.6	0.054	13.4	8.7	0.271	12.3	8.5	0.645	12.1	11.4	0.198
Diagnosed eczema	23.9	14.9	<0.001	20.3	11.0	0.009	21.1	15.4	0.002	25.0	19.3	<0.001

p values are obtained by the chi-square test (2007 vs. 2002).

DISCUSSION

With the development of ISAAC questionnaires, the assessment of allergic disorders can now be standardized leading to more precise studies and better understanding of the secular trend of allergic disorders (15). The increasing prevalence of asthma and allergic disorders around the world has been described in the past decade (2–6). Although some recent studies suggest that the asthma burden might be leveling off (7–10), a comparison of our cross-sectional survey in 2002 against another conducted in 2007 of schoolchildren of Changhwa County of Taiwan did not show any leveling off; instead it showed an increased prevalence of important asthmatic symptoms, rhinitis, and eczema. The prevalence of “ever wheeze,” “wheeze in recent 12 months,” and “nocturnal cough” had all significantly increased in a 2007 cross-sectional survey when compared to another survey performed in 2002. We observed a consistent increase in the prevalence of asthma symptoms in schoolchildren 6 to 8 years of age. In our data of 2007, the prevalence of “wheeze ever,” “wheeze in last 12 months,” and “nocturnal cough” in Changhwa County were lower in comparison with international data and data from Taipei city, the capital of Taiwan (1, 15–19). Unexpectedly, the prevalence of “diagnosed asthma” has not increased significantly in 2007 (7.1% in 2002 to 7.4% in 2007, $p > 0.05$). But we believe that asthma is under-diagnosed by county physicians who often give the diagnosis of “allergic bronchitis” rather than “asthma due to local agents” because of concerns over health insurance policies on reimbursement—some insurance companies refusing reimbursement of medical fees with such a diagnosis. Moreover, most of the residents dislike the diagnosis of asthma because they believe asthma is a serious and incurable malady. Notwithstanding the evident increase in the prevalence of “rhinitis with nasal problem,” “itchy eyes,” and “diagnosed rhinitis” in 2007 against 2002 in our cross-sectional surveys, our data show only an intermediate prevalence when compared with database internationally or that from Taipei City (1, 17).

Finally, the prevalence of “eczema with recurrent rash,” or “recurrent rash lasting 12 months,” and “diagnosed eczema” all significantly increased in 2007. Our study reveals a large

increase in the prevalence of eczema, in parallel with other atopic disorders, such as rhinitis and asthma, but more importantly is the increase in its severity necessitating medical attention.

The secular trends study suggests the increase of allergic disorders in Changhwa County of Taiwan to be part of the global trend. Data show that the development of allergic disorders significantly hinders the daily activities of schoolchildren, disrupting daily routines. In 2007, 39.9% of schoolchildren’s sleep was disturbed by wheezing; 37.3% children were kept awake because of itching skin; and almost 88.9% of children with rhinitis had their daily activities interrupted. The data are similar with that of 2002, indicating that not only the severity of allergic disorders had not changed between these two periods, but little or no improvement was made despite various intervention and preventive efforts for allergic disorders during this time period.

Boys were the predominant gender with “physician-diagnosed asthma,” asthma symptoms and rhinitis in 2007, as well as in 2002. “Diagnosed eczema” showed no significant differences between boys and girls in 2002 and 2007. There was a tendency toward an increased prevalence of diagnosed rhinitis and eczema in both genders, although the prevalence of diagnosed asthma increased only in girls but stabilized among the boys.

The secular trends study also explores the various environments of the Changhwa County in these two time periods to identify environmental factors that lead to allergic disorders. The data comparison between 2002 and 2007 seems to indicate a correlation between the prevalence of asthma, rhinitis, eczema, and environment. Although the prevalence of allergic disorders seems to increase across the entire county as a whole (Table 6), the area with the heaviest air-pollution seems to correlate with an increase in the prevalence of allergic disorders in 2002 and 2007. The TaiHao area, heavily polluted by petroleum chemical, tends to be more closely correlated with the development of all the ISAAC asthmatic symptoms in children ($p < 0.05$) other than exercised-induced wheezing (20). The coastal and downtown areas seem to be correlated with the development of rhinitis-related itchy

eyes based on diagnosis made by physicians. ($p < 0.05$, $p < 0.001$, respectively).

Overall, the data suggest a much greater increasing prevalence of eczema in a background of lesser increase in asthma prevalence. While it is proposed that genetic and environmental factors contribute to asthmatic attacks and its prevalence (21–23), we hypothesize that the gene influencing the manifestation of eczema is different from that of asthma, accounting for the inproportionate increase in prevalence of eczema relative to the prevalence of asthma. This hypothesis is yet to be validated. We think that, as in asthma, ideally, there should also be a strict protocol for the treatment, control, and education of the eczema patient. Efforts should be directed to such a goal, making it one of our primary objectives. The observations above certainly are limitations to this epidemiologic survey. This, in fact, is an inherent limitation in any epidemiologic survey. Another limitation of our study is the school transfers of schoolchildren in and out of the demographic border during this span of time. Frequent moving in and out of schoolchildren beyond the confines of the county under study certainly could be a major confounder factor in this study.

This said, we conclude that (1) the environmental pollution seems to be the major determinant of the prevalence of asthma, rhinitis, and eczema, although further studies are required; (2) air pollution as a result of urbanization ranks foremost in importance and overshadows any natural environmental pollution, and even industrial pollution in rural areas; (3) the long-term secular trends in prevalence of asthma, rhinitis, and eczema is a valuable predictor of global trends and a useful tool in future research.

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