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Original Article

Risk factors for asthma and allergic diseases among 13–14-year-old schoolchildren in Japan

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Abstract

Background: To identify risk factors for childhood wheezing and allergies, a questionnaire regarding family histories and environmental factors was added to the International Study of Asthma and Allergies in Childhood (ISAAC) Phase One questionnaire and the associations between current prevalence and risk factors were analyzed.

Methods: Questionnaires were completed by 4466 schoolchildren, who were 13–14 years of age, in Tochigi Prefecture. Children were divided into groups on the basis of risk factors and the severity of each allergic disease according to answers to the ISAAC questionnaire.

Results: In analyses of family histories, the odds ratios (OR) of children who have a family history with no symptoms were significantly lower by risk factor-based analyses compared with those children with a family history of symptoms of wheezing (OR = 2.34–4.39), rhinitis (1.76–2.68) and eczema (2.54–7.81), and significant correlations were observed between severity and family history in all diseases by the Mantel test ($P < 0.001$). Although the OR of household smoking was not significant, heavier smoking in a household had an effect on severity and showed a significant correlation with severity in rhinitis ($P < 0.05$) and eczema ($P < 0.01$). Regarding road traffic, the percentage of children living in an area with heavy traffic showed a significant correlation with the severity of wheezing ($P < 0.05$) and no children with severe wheezing lived in areas with light traffic. In addition, the mean percentage of children with current wheezing between school locations was significantly higher in the city area (10.2 ± 0.7%) compared with that in the suburbs (6.6 ± 0.9%; $P = 0.01$) and industrial areas (6.6 ± 0.7%; $P = 0.01$).

Conclusions: These results suggest that the family histories may have potential effects on the severity of allergic diseases and that household smoking for rhinitis and eczema and heavy road traffic for asthma may be more important modifiable risk factors for severity in Japan.

Key words: allergy, asthma, childhood, International Study of Asthma and Allergies in Childhood, prevalence, risk factor.

Introduction

Some environmental factors contribute to the onset and severity of allergic diseases and one of the most important treatments is to avoid risk factors. In the early 1960s in Japan, the prevalence of asthma was suddenly increased in particular areas, such as Yokkaichi City and Yokohama City.[1,2] Because it was proven that these problems were caused by air pollution, such as exhaust gases from factories and automobiles,[3–5] factories took measures against exhaust gases and the Japanese government controlled the pollution under a new law. Although air pollution improved by these countermeasures,[1] it has been reported that the global prevalence of allergic diseases among children in Japan is increasing.[6] In addition, in many other countries, the

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prevalence of allergic diseases among children is increasing, the same as in Japan.[7,8] To identify the etiology for the increase in allergic diseases among children, other risk factors, such as household smoking, foods or ethnicity, have been evaluated in many publications (see Discussion) and it has been proven that these factors may contribute to the onset or activation of allergic diseases, but the definitive risk factor for allergic diseases had not yet been determined. In 1995, in order to analyze the prevalence and severity of asthma, rhinitis and eczema in children living in different countries, the International Study of Asthma and Allergies in Childhood (ISAAC) was developed and the Phase One ISAAC evaluations were administered to approximately 720 000 children in 155 centres of 56 countries, including Japan, between 1994 and 1995.[9] We have already reported the results of the ISAAC Phase One study conducted in Tochigi, Japan.[10] Although this ISSAC study surveyed the prevalence and severity of allergic diseases as the first step, questionnaires regarding environmental factors were drawn up and administered simultaneously with the ISAAC Phase One study in order that important risk factors in Japan could be analyzed epidemiologically. We statistically analyzed the relationship between environmental factors and the prevalence of allergic diseases among 13–14-year-old schoolchildren in Tochigi, Japan, and herein report the results.

METHODS

Study subjects

According to the ISAAC protocol,[11,12] all second grade junior high school students (13–14 years old) in Utsunomiya City and Tochigi City, including Mibu Town, were our study targets. The ISAAC questionnaires were distributed in 16 of 22 schools in Utsunomiya city and in eight of nine schools in Tochigi city via the educational committee from September 1995 to March 1996. Seven schools refused to participate. The total number of students sampled was 4466 (3157 students from Utsunomiya city and 1309 students from Tochigi city).

Study design

Tochigi Prefecture is located 100 km north of Tokyo and has approximately 2 000 000 inhabitants. Utsunomiya City is located in the center of Tochigi Prefecture and has approximately 440 000 inhabitants and is the largest city in Tochigi Prefecture. 'Utsunomiya' station of the Tohoku Shinkansen is in the center of the city and the 'Utsunomiya' interchange of the Tohoku highway is in the suburbs. Although there are many inhabitants and large commercial areas in the center, there are both industrial areas and farmlands in the suburbs. Utsunomiya City is a typical large city in the country. Tochigi City is located in the south of Tochigi Prefecture and has approximately 85 000 inhabitants, making it the third-largest city in Tochigi Prefecture. There is a small castle in the town center and commercial activities are mainly agriculture. Tochigi city is a typical small city. In school locations, 10 schools are in the city area, five schools are adjoining factory areas and the other nine schools are in the suburbs.

Protocol

As more important factors, family histories and four environmental risk factors (household smoking, unbalanced diet, residence and traffic) were chosen and nine questions concerning those factors were drawn up (Table 1). Those questions were added in the ISAAC Phase One written questionnaires for 13–14 year olds[12] and were administered simultaneously. The ISAAC Phase One written questionnaires were translated into Japanese by our group. The Japanese questionnaires were translated back to English by another group, which confirmed that the Japanese language questionnaires had been translated correctly.

Data analysis

Three questions that reflect the severity of allergies were selected from the ISAAC Phase One questionnaire for this analysis: (i) 'How many attacks of wheezing have you had in the last year?' for wheezing; (ii) 'How much did your nose problem interfere with your daily activities?' for rhinitis; and (iii) 'How often, on average, have you been kept awake at night by your itchy rash?' for eczema. Percentages and 95% confidence intervals (CI) of positive responses were calculated and are given in Table 1. As a standard method, groups based on risk factor were divided up according to the severity of each allergy, then percentages of frequency distribution and odds ratios (OR) analyses, including 95% CI, were calculated.[13] In addition, in order to analyze trends between severities and risk factors, groups based on the severity of allergies were analyzed by the Mantel test and results are given in Tables 2–4. According to symptoms, answers for wheezing (W) and rhinitis (R) were renamed as no symptom

Table 1 Prevalence of wheezing, rhinitis and eczema in the past 12 months and positive responses of risk factors

Question	Positive response (%)
1 How many attacks of wheezing have you had?	
Never	90.7 (89.9–91.6)
Mild (1–3 times)	5.5 (4.8–6.2)
Moderate (4–12 times)	1.6 (1.2–2.0)
Severe (more than 12 times)	0.6 (0.4–0.9)
2 How much did your nose problem interfere with your daily activities?	
Never	67.8 (66.4–69.2)
Mild (a little)	22.1 (20.8–23.3)
Moderate (a moderate amount)	6.2 (5.6–6.9)
Severe (a lot)	1.3 (1.0–1.7)
3 How often, on average, have you been kept awake at night by your itchy rash?	
Never	96.1 (95.5–96.7)
Mild (less than one night/week)	1.9 (1.5–2.3)
Severe (one or more night/week)	0.6 (0.4–0.8)
4 Does your family have allergic diseases?	
Asthma	
Total	18.9 (17.7–20.0)
Grandparent(s)	5.7 (5.0–6.4)
Mother and/or Father	4.6 (4.0–5.3)
Brother(s) and/or sisters(s)	8.8 (7.9–9.6)
Rhinitis	
Total	57.3 (55.9–58.8)
Grandparent(s)	4.3 (3.7–4.8)
Mother and/or Father	42.6 (41.4–44.3)
Brother(s) and/or sister(s)	25.0 (23.7–26.3)
Eczema	
Total	25.3 (24.1–26.6)
Grandparent(s)	2.7 (2.2–3.1)
Mother and/or Father	12.0 (11.0–13.0)
Brother(s) and/or sister(s)	15.5 (14.4–16.5)
5 Do you have a smoker in your family?	
Total	67.0 (65.6–68.3)
Grandparent(s)	12.2 (11.2–13.2)
Father	58.5 (57.0–59.9)
Mother	10.9 (9.9–11.8)
5.1 If yes, how many cigarettes does your family smoke in a day?	
Lighter (Less than 5)	7.6 (6.8–8.4)
Moderate (5–20)	41.6 (40.2–43.0)
Heavy (21–40)	15.1 (14.0–16.1)
Heavier (More than 40)	2.0 (1.6–2.4)
6 Do you have unbalanced diets?	
Yes	47.2 (45.7–48.6)
7 How old is your house?	
Newer (Less than 5 years)	15.2 (14.1–16.2)
New (5–15 years)	39.9 (38.4–41.3)
Old (16–25 years)	28.9 (27.6–30.3)
Older (More than 25 years)	12.3 (11.3–13.2)
8 What floor is in your room (chose all)?	
Carpet	33.9 (32.5–35.3)
Japanese tatami	38.9 (37.4–40.3)
Hardwood	27.5 (26.2–28.8)
9 How much traffic is near your house?	
Heavy	22.4 (21.2–23.7)
Moderate	68.4 (67.1–69.8)
Light	7.9 (7.1–8.6)

Data are the average percentages with 95% confidence intervals given in parentheses.

Table 2 Adjusted prevalence percentages, odds ratios (OR), 95% confidential intervals (adjusted for risk factors) and the Mantel tests (calculated by percentages and OR adjusted for severity) of the association between the severity of wheezing and risk factors

	No symptoms		Mild		Moderate		Severe		Mantel test
	Prevalence (%)	OR (95% CI)	Prevalence (%)	OR (95% CI)	Prevalence (%)	OR (95% CI)	Prevalence (%)	OR (95% CI)	(*P*)
Family history									
No history	93.7 (3367/3593)	1.00	4.4 (157/3593)	1.00	1.0 (35/3593)	1.00	0.4 (15/3593)	1.00	
At least one	83.6 (704/842)	0.89 (0.87–0.92)	10.2 (86/842)	2.34 (1.87–2.81)	4.3 (36/842)	4.39 (2.98–5.80)	1.4 (12/842)	3.41 (1.49–5.34)	< 0.001
Grandparent(s)	24.6 (207/842)	0.26 (0.23–0.29)	3.2 (27/842)	0.73 (0.46–1.01)	1.7 (14/842)	1.71 (0.82–2.60)	0.7 (6/842)	1.71 (0.34–3.07)	< 0.001
Parent(s)	19.4 (163/842)	0.21 (0.18–0.24)	3.3 (28/842)	0.76 (0.48–1.04)	1.2 (10/842)	1.22 (0.47–1.97)	0.7 (6/842)	1.71 (0.34–3.07)	< 0.001
Brother(s)/sister(s)	39.5 (333/842)	0.42 (0.39–0.46)	4.9 (41/842)	1.11 (0.78–1.45)	1.4 (12/842)	1.46 (0.64–2.29)	0.2 (2/842)	0.57 (–0.22–1.36)	< 0.001
Smoking									
No smoker	91.6 (1333/1455)	1.00	5.6 (81/1455)	1.00	1.2 (18/1455)	1.00	0.5 (7/1455)	1.00	
At least one	91.8 (2746/2990)	1.00 (0.99–1.01)	5.4 (162/2990)	0.97 (0.83–1.12)	1.8 (53/2990)	1.43 (1.05–1.82)	0.7 (21/2990)	1.46 (0.84–2.08)	NS
Grandparent(s)	16.8 (503/2990)	0.18 (0.17–0.20)	0.9 (27/2990)	0.16 (0.10–0.22)	0.3 (10/2990)	0.27 (0.10–0.44)	0.2 (5/2990)	0.35 (0.04–0.65)	NS
Father	80.2 (2399/2990)	0.88 (0.86–0.89)	4.6 (137/2990)	0.82 (0.69–0.96)	1.7 (51/2990)	1.38 (1.00–1.75)	0.6 (18/2990)	1.25 (0.68–1.83)	NS
Mother	14.5 (433/2990)	0.16 (0.14–0.17)	1.3 (38/2990)	0.23 (0.17–0.30)	0.3 (9/2990)	0.24 (0.08–0.40)	0.1 (4/2990)	0.28 (0.06–0.55)	NS
Heavy smoker (over 21 per day)	23.4 (699/2990)	0.26 (0.24–0.27)	1.3 (38/2990)	0.23 (0.17–0.30)	0.5 (15/2990)	0.41 (0.20–0.61)	0.2 (6/2990)	0.42 (0.08–0.75)	NS
Diet									
Balanced	91.9 (2150/2339)	1.00	5.3 (125/2339)	1.00	1.5 (35/2339)	1.00	0.6 (15/2339)	1.00	
Unbalanced	91.6 (1929/2107)	1.00 (0.98–1.01)	5.6 (119/2107)	1.06 (0.87–1.24)	1.7 (36/2107)	1.14 (0.77–1.51)	0.6 (13/2107)	0.96 (0.44–1.48)	NS
House history									
Less than 16 years	91.0 (2237/2458)	1.00	6.0 (148/2458)	1.00	1.7 (42/2458)	1.00	0.7 (17/2458)	1.00	
Over 16 years	92.5 (1702/1840)	1.02 (1.00–1.03)	5.0 (92/1840)	0.83 (0.67–1.00)	1.5 (28/1840)	0.89 (0.56–1.22)	0.5 (10/1840)	0.79 (0.30–1.27)	NS
Floor type(s)									
Carpet	93.1 (1411/1515)	1.00	4.6 (69/1515)	1.00	1.3 (20/1515)	1.00	0.5 (7/1515)	1.00	< 0.05
Japanese tatami	90.8 (1577/1736)	0.98 (0.96–0.99)	6.1 (106/1736)	1.34 (1.09–1.59)	1.7 (29/1736)	1.27 (0.81–1.72)	0.8 (14/1736)	1.75 (0.83–2.66)	NS
Hard wood	91.2 (1120/1228)	0.98 (0.96–1.00)	5.9 (73/1228)	1.31 (1.01–1.60)	1.8 (22/1228)	1.36 (0.79–1.92)	0.7 (8/1228)	1.41 (0.44–2.39)	NS
Traffic									
Light or moderate	92.1 (3137/3407)	1.00	5.5 (186/3407)	1.00	1.4 (48/3407)	1.00	0.5 (18/3407)	1.00	
Heavy	90.5 (907/1002)	0.98 (0.96–1.00)	5.6 (56/1002)	1.02 (0.76–1.29)	2.3 (23/1002)	1.63 (0.97–2.29)	1.0 (10/1002)	1.89 (0.72–3.06)	< 0.05

CI, confidence interval.

Table 3 Adjusted prevalence percentages, odds ratios (OR), 95% confidential intervals (adjusted for risk factors) and the Mantel tests (calculated by percentages and OR adjusted for severity) of the association between the severity of rhinitis and risk factors

	No symptoms		Mild		Moderate		Severe		Mantel test
	Prevalence (%)	OR (95% CI)	Prevalence (%)	OR (95% CI)	Prevalence (%)	OR (95% CI)	Prevalence (%)	OR (95% CI)	(*P*)
Family history									
No history	80.0 (1499/1873)	1.00	15.3 (287/1873)	1.00	3.2 (59/1873)	1.00	0.7 (14/1873)	1.00	
At least one	62.4 (1598/2561)	0.78 (0.76–0.80)	26.9 (689/2561)	1.76 (1.64–1.87)	8.4 (216/2561)	2.68 (2.34–3.02)	1.8 (45/2561)	2.35 (1.67–3.03)	< 0.001
Grandparent(s)	4.1 (104/2561)	0.05 (0.04–0.06)	2.3 (58/2561)	0.15 (0.11–0.19)	1.0 (26/2561)	0.32 (0.20–0.45)	0.0 (1/2561)	0.05 (–0.05–0.16)	< 0.001
Parent(s)	44.7 (1145/2561)	0.56 (0.54–0.58)	21.4 (548/2561)	1.40 (1.29–1.50)	6.8 (173/2561)	2.14 (1.84–2.45)	1.5 (38/2561)	1.99 (1.36–2.61)	< 0.001
Brother(s)/sister(s)	27.7 (710/2561)	0.35 (0.33–0.37)	10.8 (277/2561)	0.71 (0.63–0.78)	4.0 (103/2561)	1.28 (1.04–1.52)	0.7 (18/2561)	0.94 (0.51–1.37)	< 0.001
Smoking									
No smoker	69.0 (1004/1455)	1.00	22.3 (324/1455)	1.00	6.8 (99/1455)	1.00	1.2 (18/1455)	1.00	
At least one	70.5 (2108/2990)	1.02 (1.00–1.05)	21.6 (646/2990)	0.97 (0.90–1.04)	5.8 (174/2990)	0.85 (0.73–0.98)	1.4 (41/2990)	1.11 (0.77–1.45)	NS
Grandparent(s)	13.4 (400/2990)	0.19 (0.18–0.21)	3.5 (106/2990)	0.16 (0.13–0.19)	1.0 (30/2990)	0.15 (0.10–0.20)	0.2 (5/2990)	0.14 (0.02–0.25)	NS
Father	61.4 (1835/2990)	0.89 (0.86–0.92)	18.8 (563/2990)	0.85 (0.78–0.91)	5.4 (162/2990)	0.80 (0.68–0.92)	1.1 (34/2990)	0.92 (0.61–1.23)	NS
Mother	11.9 (356/2990)	0.17 (0.16–0.19)	3.3 (99/2990)	0.15 (0.12–0.18)	0.8 (24/2990)	0.12 (0.07–0.17)	0.2 (5/2990)	0.13 (0.02–0.25)	NS
Heavy smoker (over 21 per day)	17.5 (524/2990)	0.25 (0.23–0.27)	5.6 (168/2990)	0.25 (0.22–0.29)	1.6 (49/2990)	0.24 (0.17–0.31)	0.6 (17/2990)	0.46 (0.24–0.68)	< 0.05
Diet									
Balanced	71.1 (1662/2339)	1.00	21.7 (508/2339)	1.00	5.6 (132/2339)	1.00	1.1 (25/2339)	1.00	
Unbalanced	68.9 (1451/2107)	0.97 (0.94–1.00)	22.0 (464/2107)	1.01 (0.93–1.10)	6.7 (142/2107)	1.19 (1.00–1.38)	1.6 (34/2107)	1.51 (1.01–2.01)	NS
House history									
Less than 16 years	68.2 (1677/2458)	1.00	23.5 (577/2458)	1.00	5.9 (146/2458)	1.00	1.7 (41/2458)	1.00	
Over 16 years	71.8 (1321/1840)	1.05 (1.02–1.08)	20.4 (375/1840)	0.87 (0.79–0.95)	6.4 (118/1840)	1.08 (0.89–1.27)	1.0 (18/1840)	0.59 (0.32–0.86)	< 0.05
Floor type(s)									
Carpet	71.2 (1079/1515)	1.00	19.9 (302/1515)	1.00	6.7 (102/1515)	1.00	1.2 (18/1515)	1.00	NS
Japanese tatami	71.0 (1232/1736)	1.00 (0.97–1.03)	21.4 (372/1736)	1.07 (0.98–1.17)	5.9 (103/1736)	0.88 (0.72–1.05)	1.2 (21/1736)	1.02 (0.59–1.45)	NS
Hard wood	67.1 (824/1228)	0.94 (0.91–1.98)	25.0 (307/1228)	1.25 (1.13–1.38)	5.8 (71/1228)	0.86 (0.67–1.05)	1.6 (20/1228)	1.37 (0.77–1.97)	< 0.05
Traffic									
Light or moderate	70.8 (2412/3407)	1.00	21.1 (720/3407)	1.00	6.0 (206/3407)	1.00	1.4 (47/3407)	1.00	
Heavy	67.0 (671/1002)	0.95 (0.91–0.99)	24.8 (248/1002)	1.17 (1.05–1.30)	6.7 (67/1002)	1.11 (0.85–1.36)	1.2 (12/1002)	0.87 (0.38–1.36)	NS

CI, confidence interval.

Table 4 Adjusted prevalence percentages, odds ratios (OR), 95% confidential intervals (adjusted for risk factors) and the Mantel tests (calculated by percentages and OR adjusted for severities) of the association between the severity of eczema and risk factors

	No symptoms		Mild		Severe		Mantel test
	Prevalence (%)	OR (95% CI)	Prevalence (%)	OR (95% CI)	Prevalence (%)	OR (95% CI)	(*P*)
Family history							
No history	97.9 (3190/3258)	1.00	1.3 (43/3258)	1.00	0.2 (7/3258)	1.00	
At least one	94.5 (1070/1132)	0.97 (0.95–0.98)	3.4 (38/1132)	2.54 (1.75–3.34)	1.7 (19/1132)	7.81 (4.32–11.30)	< 0.001
Grandparent(s)	9.9 (112/1132)	0.10 (0.08–0.12)	0.2 (2/1132)	0.13 (–0.05–0.32)	0.4 (5/1132)	2.06 (0.26–3.86)	< 0.001
Parent(s)	44.2 (500/1132)	0.45 (0.42–0.48)	1.9 (21/1132)	1.41 (0.81–2.00)	1.1 (13/1132)	5.35 (2.45–8.24)	< 0.001
Brother(s)/sister(s)	58.1 (658/1132)	0.59 (0.56–0.62)	1.8 (20/1132)	1.34 (0.76–1.92)	0.9 (10/1132)	4.11 (1.57–6.65)	< 0.001
Smoking							
No smoker	97.0 (1412/1455)	1.00	1.9 (27/1455)	1.00	0.5 (7/1455)	1.00	
At least one	96.6 (2889/2990)	1.00 (0.99–1.00)	1.9 (56/2990)	1.01 (0.75–1.27)	0.6 (19/2990)	1.32 (0.73–1.91)	NS
Grandparent(s)	17.7 (530/2990)	0.18 (0.17–0.20)	0.3 (10/2990)	0.18 (0.07–0.29)	0.1 (3/2990)	0.21 (–0.03–0.45)	NS
Father	84.2 (2519/2990)	0.87 (0.86–0.88)	1.7 (50/2990)	0.90 (0.65–1.15)	0.6 (19/2990)	1.32 (0.73–1.91)	NS
Mother	15.7 (470/2990)	0.16 (0.15–0.18)	0.2 (6/2990)	0.11 (0.02–0.20)	0.2 (5/2990)	0.35 (0.04–0.65)	NS
Heavy smoker (over 21 per day)	24.2 (724/2990)	0.25 (0.23–0.27)	0.7 (22/2990)	0.40 (0.23–0.56)	0.3 (8/2990)	0.56 (0.17–0.94)	< 0.01
Diet							
Balanced diet	97.0 (2268/2339)	1.00	1.7 (40/2339)	1.00	0.5 (12/2339)	1.00	
Unbalanced diet	96.6 (2035/2107)	1.00 (0.99–1.00)	2.0 (42/2107)	1.17 (0.82–1.52)	0.7 (14/2107)	1.30 (0.62–1.97)	NS
House history							
Less than 16 years	96.9 (2382/2458)	1.00	1.7 (41/2458)	1.00	0.6 (15/2458)	1.00	
Over 16 years	96.7 (1779/1840)	1.00 (0.99–1.01)	2.1 (39/1840)	1.27 (0.88–1.67)	0.5 (9/1840)	0.80 (0.28–1.32)	NS
Floor type(s)							
Carpet	97.0 (1470/1515)	1.00	2.0 (30/1515)	1.00	0.4 (6/1515)	1.00	NS
Japanese tatami	96.4 (1674/1736)	0.99 (0.99–1.00)	1.6 (28/1736)	0.81 (0.52–1.11)	0.7 (12/1736)	1.75 (0.76–2.73)	NS
Hard wood	96.8 (1189/1228)	1.00 (0.99–1.01)	2.0 (24/1228)	0.99 (0.60–1.38)	0.8 (10/1228)	2.06 (0.79–3.33)	NS
Traffic							
Light or moderate	96.6 (3292/3407)	1.00	2.0 (68/3407)	1.00	0.6 (20/3407)	1.00	
Heavy	97.2 (974/1002)	1.01 (1.00–1.02)	1.5 (15/1002)	0.75 (0.37–1.13)	0.6 (6/1002)	1.02 (0.21–1.84)	NS

CI, confidence interval.

(Nor), mild (Mil), moderate (Med) and severe (Sev), and those for eczema (E) were renamed as no symptom (Nor), mild (Mil) and severe (Sev) for easy understanding.

RESULTS

Observations with missing and inconsistent data

In answers to questions about allergic symptoms, an average of 0.7% (minimum and maximum percentages 0.2 and 2.4%, respectively) had missing and inconsistent data. For environmental factors, the average of missing and inconsistent answers was 1.1% (minimum and maximum percentages 0.5 and 3.5%, respectively).

Relationship between prevalence and family histories

As shown Tables 2–4, positive responses of family histories were significantly fewer in children with no symptom by OR analysis compared with those with mild symptoms (OR (95% CI) 2.34 (1.87–2.81), 1.76 (1.64–1.87) and 2.54 (1.75–3.34) for W, R and E, respectively). For eczema, positive responses of family histories were dependent on the severity of the disease in the children (7.81 (4.32–11.30) for Sev), whereas the differences between moderate and severe groups were similar for wheezing (4.39 (2.98–5.80) *vs* 3.41 (1.49–5.34), respectively) and rhinitis (2.68 (2.34–3.02) *vs* 2.35 (1.67–3.03), respectively). Although positive percentages in children with moderate symptoms in wheezing and rhinitis were more than those with severe symptoms, the correlation between severities and family histories showed a significant positive association in all diseases by severity based on the Mantel test ($P < 0.001$). In addition, with analysis of prevalences in grandparents, parents and brothers/sisters, a significant positive association was observed in all diseases by the Mantel test ($P < 0.001$).

Relationship between prevalence and household smoking

Results of the relationship between the prevalence and percentages of household smoking and the relationship between the prevalence and the total number of cigarettes smoked/day are shown in Tables 2–4. The prevalence of wheezing was little increased in children in the moderate and severe groups by OR analysis (1.43 (1.05–1.82) *vs* 1.46 (0.84–2.08), respectively) compared with no symptoms (1.00 (0.99–1.01)) and mild symptoms (0.97 (0.83–1.12)). However, no significant association was observed according to severity based on the Mantel test. In addition, no differences in wheezing were found between the prevalence and the total number of cigarettes smoked/day, although the OR was increased in the moderate and severe groups. For rhinitis, no trends and differences were observed between prevalence and household smoking. However, the percentage of children in a household with heavier smokers, who smoked over 21 cigarettes/day, was increased in the severe group following severity based analysis (25.2, 26.2, 28.5 and 41.5% for the Nor, Mil, Med and Sev groups, respectively) and a positive significant correlation was shown by the Mantel test ($P < 0.05$). For eczema, the results were similar as those for rhinitis and significant results were not observed by risk factor-based OR analysis. With the analyses of number of cigarettes smoked/ day, the percentage of children in households with heavier smokers was increased in the mild and severe groups following severity based analysis (25.3, 40.0 and 42.1% for the Nor, Mil and Sev groups, respectively) and a positive significant association was shown between that percentage and severity by the Mantel test ($P < 0.01$).

Relationship between prevalence and unbalanced diets

Positive responses of unbalanced diets were increased with severity in rhinitis and eczema by risk factor-based OR analysis and significant results were observed in moderate and severe rhinitis. However, no significant correlations between unbalanced diets and the prevalence of allergies were shown by the severity based Mantel text.

Relationship between prevalence and residence condition

Regarding housing history, the percentage of children living in older houses (over 16 years) was significantly decreased in mild and severe rhinitis following risk factor-based OR analysis and the Mantel test-based severity also showed a significant negative correlation between house history and severity of rhinitis. However, no correlation was found for wheezing and eczema with the two different analyses.

Following analysis of the floor type that the children mainly live on, significant results were not observed in moderate and severe wheezing by risk factor-based OR analysis, although OR of Japanese tatami and hard wood were increased in the more severe groups. However, a negative correlation was shown in wheezing with carpet by the severity based Mantel test (34.7, 28.3, 28.2 and 25.0% for the Nor, Mil, Med and Sev groups, respectively; $P < 0.05$). For rhinitis, no correlation was found by risk factor-based OR analysis, but the percentage of children with a hard wood floor was shown to have a significant positive correlation by the severity based Mantel test. The OR of severe eczema was increased for Japanese tatami and hard wood, but no significant OR and trends were observed by the two different analyses.

Relationship between prevalence and traffic in the residence area

In this evaluation, the prevalences divided by severity in wheezing were significantly correlated with traffic in the residence area by the Mantel test (22.4, 23.1, 32.4 and 35.7% for the Nor, Mil, Med and Sev groups, respectively), although risk factor-based OR analyses did not show any significant differences. In addition, no students with severe symptoms were found who lived in light traffic areas. To reconfirm the relationship between prevalence and traffic, the mean prevalence in each school was calculated and the relationship between the mean prevalence in the school and the school location is shown in Fig. 1a,b. The mean (±SEM) percentage prevalence of wheezing in each school was significantly increased in schools located in city areas compared with those in factory areas and suburbs (10.2 ± 0.7 *vs* 6.6 ± 0.7 and 6.6 ± 0.9, respectively; $P = 0.01$; Fig. 1a). In addition, the number of children with severe wheezing symptoms was significantly increased in schools located in city areas compared with factory areas and suburbs (2.8 ± 0.3 *vs* 1.4 ± 0.6 ($P < 0.05$) and 1.4 ± 0.3 ($P < 0.01$), respectively; Fig. 1b). However, no correlations or trends were found for rhinitis and eczema by those analyses.

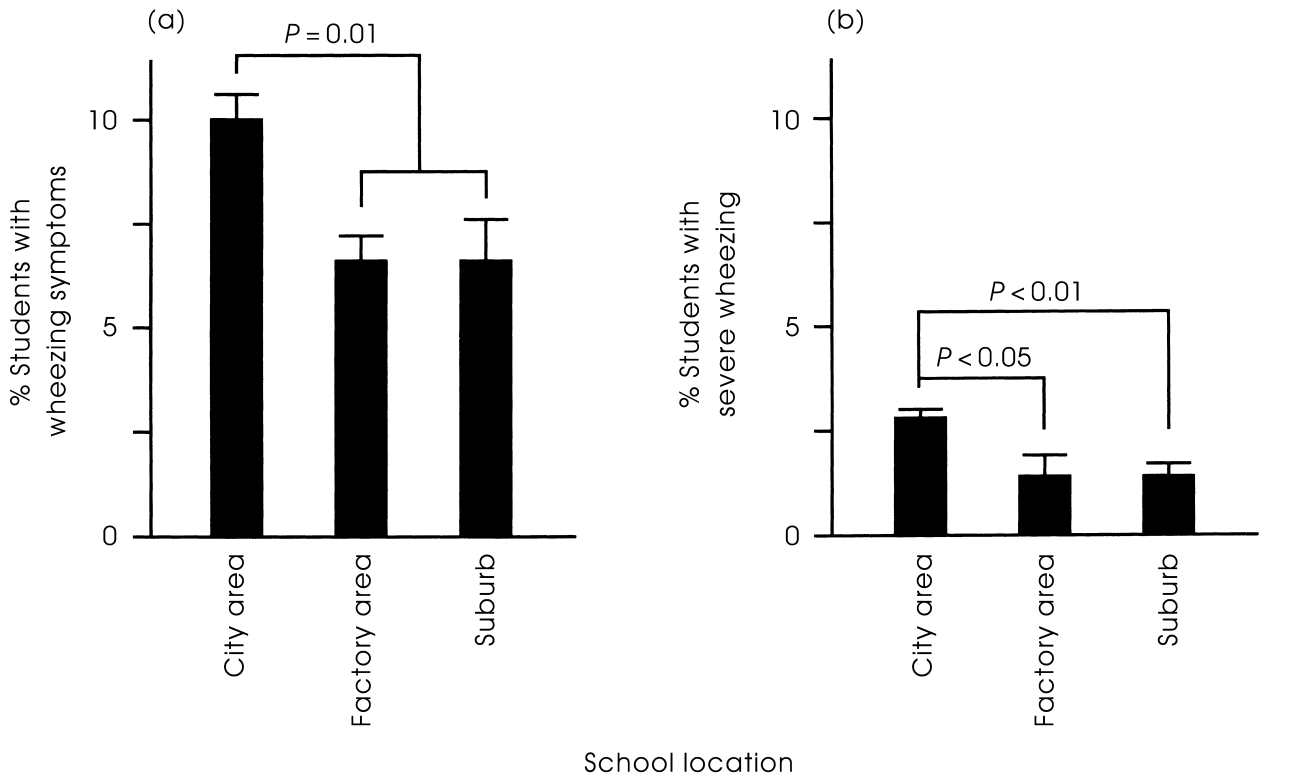

Fig. 1 Relationship between school location and the mean prevalence of wheezing symptoms (a) and severe wheezing (b). The average percentage of mean prevalence of wheezing in each school was significantly increased in schools located in city areas compared with those in factory areas ($P = 0.01$) and suburbs ($P = 0.01$). In addition, the prevalence of severe wheezing symptoms was also significantly increased in schools located in city areas compared with those in factory areas ($P < 0.05$) and suburbs ($P < 0.01$). Data are the mean ± SEM.

Discussion

In many counties, including Japan, the prevalence of allergic diseases among children is increasing[6–8] and the ISAAC Phase One study also showed a high prevalence of allergic diseases among schoolchildren.[14–16] In Japan, 8.4, 42.1 and 13.0% of children had symptoms of wheezing, rhinitis and eczema, respectively, in the preceding 12 months.[10] Allergic diseases are decreasing the ability of these children to concentrate on their studies. In addition, asthma has the risk of causing death and asthmatic attacks contribute to limiting the activities of the children and contributes to their absence from school. Thus, many children with allergic symptoms in the world are caused many problems by these symptoms. Avoiding allergens is one of the most important treatments for allergic diseases and many patients in hospitals are informed, for example, how to avoid dusts, mites, animal and pollen, which are identified allergens. Recently, in addition to allergens, environmental factors, such as household smoking, have also been thought to be important as risk factors that exacerbate allergic symptoms and the relationship between allergic diseases and those risk factors have been studied in many countries, together with basic research, the purpose of which is to elucidate the mechanism of allergy. However, few studies regarding risk factors have been reported in Japan. There was a good opportunity with the ISAAC Phase One study, which was planned to study a large population, to add environmental questions to the survey.

We think that our study areas, Utsunomiya City and Tochigi City, are typical country cities in Japan and we verified the reliability of the ISAAC questionnaire. The prevalence values for wheezing and eczema were similar to the world average in the ISAAC Phase One Study. However, the prevalence values for rhinitis were in excess of those for asthma or eczema and were higher than those in other cities or countries. In Tochigi Prefecture, which was our study area, there exists the biggest Japanese cedar-covered mountains in Japan, a major

source of pollen aeroallergens. In addition, the prevalence of nasal symptoms increases in the spring, the season with increased pollen levels. Thus, the heightened prevalence of rhinitis is likely to be attributable to environmental exposure to pollen, whereas the characteristic environmental factors, which heightened the prevalence of asthma or eczema, were not pointed out in our study area. In addition, in our study the average smoking rates of children's parents were 58.9% of fathers and 10.9% of mothers. The average smoking rates in Japan in 1995 were reported by the Ministry of Health and Welfare to be 52.7% for men and 10.6% for women.[17] The average smoking rate for mothers in our study area is equal to that for women in Japan, whereas that for fathers is slightly higher than that for men in Japan. However, the average smoking rate for men shows differences depending on age and the rate for men in their 30s and 40s, which is expected to apply for most of the fathers in the present study, was 60.8 and 58.4%, respectively; this is very similar to the results of the present study. Therefore, the smoking rate in our study area is thought to be about average for Japan. In contrast, the World Health Organization (WHO) reported that the world average smoking rates in 1999 were 47% for men and 20% for women and these rates are lower than the rate for fathers and higher than the rate for mothers in the present study.[18] Thus, our study areas are typical country cities in Japan, except for having the biggest Japanese cedar-covered mountains, which increases seasonal rhinitis.

In the evaluation of the relationship between prevalence and family history, our results showed that children without symptoms had significantly smaller percentages of family histories by risk factor-based OR analyses compared with those with symptoms. In addition, the associations between severities and family histories were strongly significant in all diseases by the severity based Mantel test, which is one of the trend analyses. Although the percentage of family histories with moderate symptoms for wheezing and rhinitis was more than for severe symptoms, the reason is expected to be that the number of children with severe symptoms is small number and thus significant results were shown statistically. It is suggested that family history may be important for severity as an unmodifiable risk factor.

For the effects of household smoking, the OR of household smoking was increased slightly in children with severe and moderate wheezing symptoms, but a significant difference and correlation was not observed. Many studies regarding the effects of smoking as a risk factor of asthma have been performed and household smoking is now regarded as one of most important risk factors. Exposure to environmental smoking was associated with asthma severity for children and the avoidance of exposure to smoking for children decreases the severity.[19–22] In particular, a mother smoking during pregnancy has a crucial effect on the onset of asthma.[23,24] In the present study, it did not seem that mother's smoking had any effect on asthma severity, although the smoking rate of mothers in the present study was very small compared with the average smoking rate for women in the world, as mentioned earlier. In addition, the number of cigarettes smoked by a household was not associated with the severity of wheezing in our study, whereas the percentage of households with heavier smokers was significantly associated with the severity of rhinitis and eczema. Exposure to environmental smoking is clearly an important risk factor for all allergic diseases, including rhinitis or eczema. As one possibility why the number of cigarettes smoked was not associated with the severity of wheezing, it is thought that Japanese doctors advise parents to avoid environmental smoking as a risk factor for wheezing. Thus, parents make efforts to decrease smoking if they are smokers, even if they do not stop, and the number of heavy smokers may be decreased for children with severe wheezing. In contrast, parents of children with rhinitis or eczema did not make an effort to decrease or stop smoking, because environmental smoking is an air exposure and they may not recognize it as a risk factor. It it suggested that we should recognize environmental smoking as an important risk factor for rhinitis and eczema.

With regard to unbalanced diets, significant OR with unbalanced diets showed more severe rhinitis only and no correlations or trends were found for wheezing and eczema by the severity based Mantel test. Diet is thought to have an effect on the onset or severity of allergic diseases, and it has been reported that food cultures may contribute to differences in the prevalence of allergic diseases between countries and that an Asian diet was shown to have a lower risk of allergic diseases.[25] In addition, many children in Japan tend to like the Western diet, containing many meats and few vegetables, and those unbalanced diets are thought to relate to the recent increase of allergic diseases, hyperlipidemia or obesity in childhood in Japan.[26,27] Therefore, we do not know why unbalanced diets were not associated with the severity in the present study. Although children with severe symptoms may make efforts to avoid unbalanced diets

according to this information, we may be able to be clear the relationship between the unbalanced diets and allergic diseases by more concrete questions, for example, 'Which do you like, meats, fish or vegetables?'.

As for residence conditions, no trends were observed in the histories of residences for wheezing and eczema, but significant results were observed for rhinitis by OR analysis and the Mantel test. Although the correct reason for this has not been determined, one possibility for no association is that most Japanese residences are new, and the most frequent answer regarding residence history is 5–15 years old, as shown in Table 1. However, it is not clear whether a residence history really does not have any effect on those diseases or whether no differences were observed because of a small range of residence histories. In addition, we also cannot comment on why a significant association between severity and the percentage of newer house (< 16 years) was shown for rhinitis. We may need another study to answer those questions. In contrast, in the evaluation of floor types, the OR of carpet were decreased and those of Japanese tatami were increased in children with severe wheezing and eczema. In addition, those of hard wood were increased in children with severe rhinitis and eczema. Carpets are widely known as one of the risk factors for allergic diseases and physicians have advised patients with asthma and eczema or their parents to avoid carpets. Therefore, we think that this knowledge may have been taken into consideration and we do not think that Japanese tatami or hard wood is a risk factor. However, in order to verify our prediction, we may need to ask the parents of the children in the present study the reason they chose their floor covering; for example, 'Why did you chose carpet, Japanese tatami or hard wood?'. Our prediction will be supported if parents answer 'for avoiding my child's allergy'. Japanese tatami may be a risk factor, although no publication has pointed out it.

With regard to the relationship between severity and traffic, the percentage of heavy traffic in children's residence area was significantly associated with the severity of wheezing, although the OR analyses did not show any significant difference. In addition, no child with severe wheezing lived in a light traffic area, whereas no differences were found for rhinitis and eczema. In addition, in the evaluation of the average prevalence of wheezing between schools, where children spend considerable time each day, the average prevalence in schools located in city areas was significantly increased compared with that in factory areas or suburbs. It has been reported in Italy and Germany that exposure to heavy vehicular traffic may be associated with the increased prevalence of allergic diseases in children who live in metropolitan areas[28,29] and these results agree with our results. Diesel exhaust particles are already proven to exacerbate airway inflammation or hyperresponsiveness.[30,31] Now, the Japanese government is discussing the control of diesel exhaust particles under a new law. In contrast, it has been reported that city or traffic activity is not a major risk factor.[32,33] These studies were conducted in small cities and it has also been reported that the prevalence of allergic diseases may be related to population density.[34] The areas of Utsunomiya City and Tochigi City are 312 and 122 km^2, respectively, and those areas are small compared with local cities in many other countries. In addition, populations in those areas are approximately 440 000 and 85 000, respectively, and most people live in the city area. Thus, heavy traffic activities in the city area are caused by this high population density and may contribute to the prevalence of asthma in city areas. In contrast, the average prevalence of wheezing in factory areas was similar with that in the suburbs. This suggests that exhaust gases from factories are controlled well. Our results support that heavy traffic is now one of the most important risk factors for asthma.

We planned to add more questions, but five groups with nine questions, as shown in Table 1, were finally included. Because the aim of the study was to perform the ISAAC Phase One Study completely, we were concerned that if we included too many extra questions we would get low answer rates or many incorrect answers. The results indicated that the answer rates were good and incorrect answers were few compared with those in the ISAAC Phase One Study in other countries;[10,35] therefore, the number of questions added regarding environmental factors was considered reasonable. The ISAAC Phase Three study, to be performed from 2001, plans to add questions about environments. These may further identify relationships between allergic diseases and environmental exposure.

In conclusion, family histories may have potential effects on the severity of allergic diseases. Household smoking is also a risk factor for all allergic diseases and parents of children with wheezing symptoms may recognize this, whereas those with children with rhinitis and eczema may not be aware of this. With regard to the floor type of children's rooms, carpets tended to be avoided for children with wheezing. Air pollution caused by factories is now well controlled; in contrast, heavy traffic may be

an important risk factor for asthma. It is suggested that parents of children with rhinitis and eczema need to be enlightened about household smoking as an important risk factor and that further studies are needed to determine what is of most importance concerning heavy traffic as a risk factor.

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