

ORIGINAL ARTICLE

Maternal dietary patterns during pregnancy and risk of wheeze and eczema in Japanese infants aged 16–24 months: The Osaka Maternal and Child Health Study

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To cite this article: Miyake Y, Okubo H, Sasaki S, Tanaka K, Hirota Y. Maternal dietary patterns during pregnancy and risk of wheeze and eczema in Japanese infants aged 16–24 months: The Osaka Maternal and Child Health Study. *Pediatr Allergy Immunol* 2011; Doi: 10.1111/j.1399-3038.2011.01176.x.

Keywords

eczema; Japanese children; maternal dietary patterns; pregnancy; wheeze.

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Accepted for publication 27 March 2011

DOI:10.1111/j.1399-3038.2011.01176.x

Abstract

Background: Maternal diet during pregnancy might influence the development of childhood allergic disorders.

Aims: This prospective study examined the relationship between maternal dietary patterns during pregnancy and the risk of wheeze and eczema in the offspring aged 16–24 months.

Materials & Methods: Subjects were 763 mother–child pairs. Data on maternal intake during pregnancy were assessed with a diet history questionnaire. Dietary patterns were derived from factor analysis of 33 predefined food groups. Symptoms of wheeze and eczema were based on criteria of the International Study of Asthma and Allergies in Childhood. Adjustment was made for maternal age, gestation, residential municipality, family income, maternal and paternal education, maternal and paternal history of allergic disorders, changes in maternal diet in pregnancy, season at baseline, maternal smoking during pregnancy, baby's older siblings, sex, birth weight, age at the third survey, household smoking, and breastfeeding duration.

Results: Three dietary patterns were identified: 'healthy', characterized by high intake of green and yellow vegetables, seaweed, mushrooms, white vegetables, pulses, potatoes, fish, sea products, fruit, and shellfish; 'Western', characterized by high intake of vegetable oil, salt-containing seasonings, beef and pork, processed meat, eggs, chicken, and white vegetables; and 'Japanese', characterized by high intake of rice, miso soup, sea products, and fish. There was a tendency for an inverse exposure–response relationship between the maternal Western pattern during pregnancy and the risk of childhood wheeze by crude analysis. After adjustment for the confounding factors under study, the inverse relationship was strengthened: the adjusted OR between extreme quartiles was 0.59 (95% CI: 0.35–0.98, *p* for trend = 0.02). No such inverse association was observed for childhood eczema. Neither the maternal healthy pattern nor the Japanese pattern during pregnancy was related to childhood wheeze or eczema.

Conclusion: The maternal Western pattern during pregnancy may be preventive against wheeze in the offspring.

The fetal environment may provide important insights into the etiology of allergic disorders. The feto-placental unit generates Th-2 cytokines such as IL-4 and IL-13 to down-regulate maternal Th-1 immune responses to feto-paternal antigens that might otherwise lead to a maternal immune rejection of the pregnancy (1). Such a circumstance is likely to bias the fetal immune response toward a Th-2 phenotype (1).

Interest has increased in the possibility that maternal diet during pregnancy might influence the development of childhood allergic disorders (2). Studies have variously reported associations between maternal intake of fruit and vegetables (3–7), antioxidants (7–10), vitamin D (11–14), fish (3–6, 15–17), polyunsaturated fatty acids (17), dairy products (4–6, 14), nuts (4–6), and B vitamins (18) during pregnancy and the risk of wheeze, asthma, eczema, and/or allergic rhinitis in

the offspring. However, the contributions of individual foods and nutrients remain unclear.

Dietary pattern analysis, which allows evaluation of the effects of combinations of many foods simultaneously, offers a perspective different from the traditional approach in relation to a single or a few nutrients or foods (19). Dietary pattern analysis circumvents methodological limitations of the traditional approach, including failure to account for interactions between nutrients, intercorrelations between nutrients, and the inability to detect small effects from single nutrients (20). In a prospective study in Spain, a higher maternal adherence to a Mediterranean diet during pregnancy was significantly related to a reduced risk of wheeze and atopy in the children at 6.5 yr (6). The Avon Longitudinal Study of Parents and Children (ALSPAC) showed no relationships between dietary patterns in pregnancy and childhood asthma and related outcomes (21).

The purpose of this study was to determine dietary patterns in a population of Japanese pregnant women and to examine the prospective relationship between maternal dietary patterns during pregnancy and the risk of wheeze and eczema in infants at 16–24 months of age using data from the Osaka Maternal and Child Health Study (OMCHS).

Methods

Study population

The OMCHS is a prospective cohort study. Details of the OMCHS have been published elsewhere (22). At baseline, pregnant women were recruited (Fig. 1). Eligible pregnant women were those who lived in Neyagawa City, which is one of the 43 municipalities in Osaka Prefecture, a metropolis in Japan. Of the 3639 eligible subjects in Neyagawa City, 627 women (17.2%) participated in the OMCHS between

November 2001 and March 2003. In order to increase the sample size, pregnant women living in municipalities other than Neyagawa City were also recruited. Eight pregnant women who did not live in Neyagawa City but who had become aware of the OMCHS at an obstetric clinic before August 2002 decided by themselves to participate in the OMCHS. Also, there were 77 participants who received explanations of the OMCHS from public health nurses in six other municipalities from August 2002 to March 2003. From October 2002 to March 2003, 290 participants were recruited from a university hospital and three obstetric hospitals in three other municipalities.

Finally, a total of 1002 pregnant women between the 5th and 39th week of pregnancy gave their fully informed consent in writing and completed the baseline survey. Of the 1002 subjects, 867 mother–child pairs participated in the second survey from 2 to 9 months postpartum. Of the 867 mother–child pairs, 763 participated in the third survey from 16 to 24 months postpartum and remained available for analysis. The ethics committee of the Osaka City University School of Medicine approved the OMCHS.

Measurements

Baseline assessment of the OMCHS included a set of two self-administered questionnaires. Also, a self-administered questionnaire was answered in both the second and third surveys. Participants mailed these materials to the data management center at the time of each survey. Research technicians completed missing or illogical data by telephone interview.

In the baseline survey, dietary habits during the preceding month were assessed using a self-administered diet history questionnaire (DHQ). Estimates of daily intake for 150 food and beverage items, energy, and selected nutrients were calculated using an ad hoc computer algorithm for the DHQ based on the Standard Tables of Food Composition in Japan. According to similar nutrient profiles and culinary usage of the food items, 145 food items on the DHQ were grouped into 33 predefined food groups to extract dietary patterns (23). Five items were excluded (cornflakes, nutritional supplement bars, Japanese-style pancakes, noodle soup, and drinking water). Information on dietary supplements was not used in the calculation of dietary intake.

Another questionnaire at baseline inquired about maternal age, gestation, family income, maternal and paternal education, maternal and paternal history of asthma, atopic eczema, allergic rhinitis, and changes in diet in the previous 1 month. A paternal or maternal history of asthma, atopic eczema, and allergic rhinitis was defined as positive if the respective parent had been treated with medications for any of these allergic disorders at some time prior to the start of the survey.

A self-administered questionnaire in the second survey elicited information on the baby's sex, birth weight and date of birth, number of baby's older siblings, maternal smoking during pregnancy, and smoking in the household. A self-administered questionnaire in the third survey included questions on breastfeeding duration in months and symptoms of

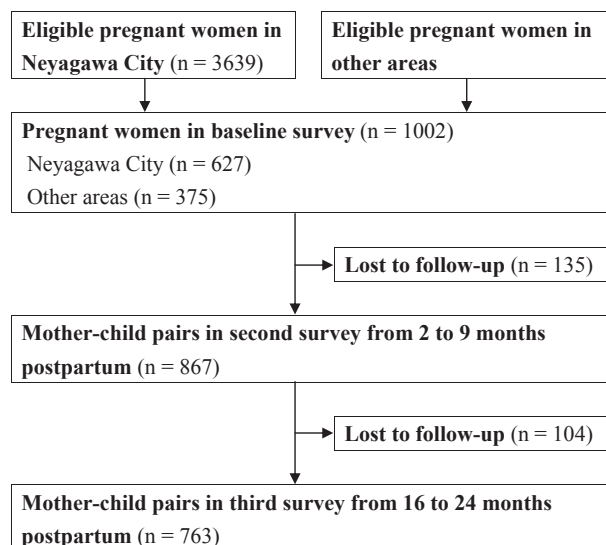


Figure 1 Eligibility for and participation in the Osaka Maternal and Child Health Study.

wheeze and eczema based on the International Study of Asthma and Allergies in Childhood (ISAAC) phase-I questionnaire (24, 25). Wheeze was defined as present if the mother answered 'yes' to the written question 'Has your child had wheezing or whistling in the chest in the last 12 months?'. For eczema, affirmative answers to the following three questions were required: 'Has your child ever had an itchy rash which was coming and going for at least 6 months?', 'Has your child had this itchy rash at any time in the last 12 months?', and 'Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears, or eyes?'.

Statistical analysis

All computations were performed using the SAS software package version 9.1 (SAS Institute, Inc., Cary, NC, USA). Factor analysis to derive dietary patterns based on the 33 predefined food groups from the DHQ was conducted via the PROC FACTOR procedure. Intake of these food groups (g food per day) was adjusted for total energy intake using the residual method (30). The number of factors was determined based on the scree plot and interpretability. A factor solution with the three identified factors was found to be reasonable and meaningful. The proportion of variance explained by each factor was calculated by dividing the sum of the squares of the respective factor loadings by the number of variables. The factor scores for each pattern and for each individual were determined by summing the intake of each food group weighted by the factor loading. All data presented here are from the Varimax rotation. The validity of dietary patterns derived from the DHQ has been previously reported (23).

Scores for each dietary pattern were categorized at quartile points based on the distribution in 763 subjects. Maternal age, gestation at baseline, residential municipality, family income, maternal and paternal education, maternal and paternal history of asthma, atopic eczema, allergic rhinitis, changes in maternal diet in the previous 1 month, season when data at baseline were collected, maternal smoking during pregnancy, baby's older siblings, baby's sex, baby's birth weight, household smoking in the same room as the infant, breastfeeding duration, and time of delivery before the third survey were *a priori* selected as potential confounding factors.

The relationship between quartiles of the dietary pattern scores and risk of wheeze and eczema was examined by the use of logistic regression analysis. Multiple logistic regression analysis was employed to control for potential confounding factors. Trend of association was assessed by a logistic regression model assigning consecutive integers (1–4) to the quartiles of the exposure variables.

Results

Of the 1002 pregnant women who participated in the baseline survey, 763 mother–child pairs participated in the third survey. There were no material differences between the 239 non-

participants and the 763 participants in the third survey with regard to distribution of maternal age, maternal and paternal history of asthma, atopic eczema, allergic rhinitis, maternal intake of total energy, and maternal dietary patterns. Compared with non-participants in the third survey, participants were less likely to report low family income and a low maternal and paternal educational level.

In the third survey, the prevalence of wheeze and eczema was 22.1% and 18.6%, respectively, among 763 infants. About 75% of infants had been breastfed for 6 months or longer (Table 1). Slight or substantial changes in diet in the previous 1 month were reported by 551 mothers owing to nausea gravidarum ($n = 453$), maternal and fetal health ($n = 89$), and other reasons ($n = 9$).

Table 2 gives the factor-loading matrices for the three identified dietary patterns. The first factor was termed the 'healthy pattern' because it represented a high intake of green and yellow vegetables, seaweed, mushrooms, white vegetables, pulses, potatoes, fish, sea products, fruit, and shellfish and low intake of confectioneries and soft drinks. The second factor was characterized by high intake of vegetable oil, salt-containing seasonings, beef and pork, processed meat, eggs, chicken, and white vegetables and low intake of fruit, soft drinks, and confectioneries and was named the 'Western pattern'. The third factor represented high intake of rice, miso soup, sea products, and fish and low intake of bread, confectioneries, and dairy products and was labeled the 'Japanese pattern'. These dietary patterns accounted for 10.0%, 6.4%, and 6.0%, respectively, of the variance in food intake and together explained 22.4% of the variability.

Mean energy-adjusted nutrient intake for the lowest (Q1) and highest (Q4) quartiles of each dietary pattern and the Pearson correlation coefficients between the dietary patterns and nutrient intake are shown in Table 3. Compared with the lowest quartile of the healthy pattern, there was a significantly higher intake of selected nutrients excluding total fat in the highest quartile. The healthy pattern was significantly correlated with intake of α -linolenic acid ($r = 0.10$, $p = 0.005$), docosahexaenoic acid ($r = 0.44$, $p < 0.0001$), linoleic acid ($r = 0.15$, $p < 0.0001$), calcium ($r = 0.46$, $p < 0.0001$), vitamin D ($r = 0.39$, $p < 0.0001$), β -carotene ($r = 0.62$, $p < 0.0001$), and vitamin E ($r = 0.48$, $p < 0.0001$). The Western pattern was significantly correlated with intake of α -linolenic acid ($r = 0.51$, $p < 0.0001$), linoleic acid ($r = 0.58$, $p < 0.0001$), β -carotene ($r = 0.10$, $p < 0.0001$), and vitamin E ($r = 0.33$, $p < 0.0001$). The Japanese pattern was significantly correlated with intake of docosahexaenoic acid ($r = 0.27$, $p < 0.0001$), calcium ($r = -0.30$, $p < 0.0001$), vitamin D ($r = 0.15$, $p < 0.0001$), and vitamin E ($r = -0.16$, $p < 0.0001$).

Table 4 provides odds ratios (ORs) and 95% confidence intervals (CIs) for the risk of wheeze and eczema in the offspring according to maternal dietary patterns during pregnancy. There was a tendency for an inverse exposure–response relationship between the maternal Western pattern during pregnancy and the risk of childhood wheeze by crude analysis. After adjustment for the confounding factors under study, the inverse relationship was strengthened: the adjusted

Table 1 Distribution of selected characteristics of 763 parent–child pairs

Variable	n (%) or mean (s.d.)
Baseline characteristics	
Maternal age (yr)	30.0 (4.0)
Gestation (weeks)	17.7 (6.7)
Residential municipality (%)	
Neyagawa City	457 (59.9)
Other than Neyagawa City	306 (40.1)
Family income (% yen/yr)	
<4 000 000	211 (27.7)
4 000 000–5 999 999	313 (41.0)
6 000 000+	239 (31.3)
Maternal education (%yr)	
<13	212 (27.8)
13–14	329 (43.1)
15+	222 (29.1)
Paternal education (%yr)	
<13	289 (37.9)
13–14	127 (16.6)
15+	347 (45.5)
Maternal history of asthma (%)	80 (10.5)
Maternal history of atopic eczema (%)	120 (15.7)
Maternal history of allergic rhinitis (%)	256 (33.6)
Paternal history of asthma (%)	64 (8.4)
Paternal history of atopic eczema (%)	72 (9.4)
Paternal history of allergic rhinitis (%)	143 (18.7)
Changes in diet in the previous 1 month (%)	
None or seldom	212 (27.8)
Slight	336 (44.0)
Substantial	215 (28.2)
Season when data were collected (%)	
Spring	241 (31.6)
Summer	127 (16.6)
Fall	167 (21.9)
Winter	228 (29.9)
Characteristics at postnatal assessment	
Maternal smoking during pregnancy (%)	97 (12.7)
Baby's older siblings (% 1 or more)	381 (49.9)
Baby's sex (% male)	403 (52.8)
Baby's birth weight (g)	3071.0 (415.5)
Household smoking in same room as infant	195 (25.6)
Breastfeeding duration (% months)	
<6	189 (24.8)
6+	574 (75.2)
Age of infant at third survey (% months)	
16–19	263 (34.5)
20	370 (48.5)
21–24	130 (17.0)

ORs in the first, second, third, and fourth quartiles were 1 (reference), 0.72 (95% CI: 0.44–1.17), 0.52 (95% CI: 0.31–0.87), and 0.59 (95% CI: 0.35–0.98), respectively, and the inverse linear trend was statistically significant (p for trend = 0.02). No such inverse association was observed for childhood eczema. Neither the maternal healthy pattern nor the Japanese pattern during pregnancy was materially related to the risk of wheeze or eczema in the offspring.

Table 2 Factor-loading matrix for major dietary patterns in 763 pregnant women at baseline*

Food group	Healthy pattern	Western pattern	Japanese pattern
Green and yellow vegetables	0.69	0.14	–0.07
Seaweed	0.63	0.00	0.08
Mushrooms	0.62	0.03	–0.02
White vegetables	0.59	0.33	–0.04
Pulses	0.58	0.10	0.14
Potatoes	0.47	–0.02	0.11
Fish	0.47	0.00	0.26
Sea products	0.39	0.07	0.30
Fruit	0.37	–0.34	–0.12
Shellfish	0.34	0.01	0.05
Nuts	0.21	–0.19	–0.15
Noodles	–0.10	–0.10	0.04
Vegetable oil	–0.06	0.59	0.01
Salt-containing seasonings	0.21	0.50	0.07
Beef and pork	0.06	0.48	0.09
Processed meat	–0.14	0.46	0.00
Eggs	0.00	0.40	0.08
Chicken	0.20	0.34	0.07
Butter	–0.02	0.24	–0.09
Sugar	0.11	0.22	–0.04
Coffee and cocoa	–0.04	0.21	–0.13
Other soup	0.05	0.16	0.05
Japanese and Chinese tea	0.04	0.13	0.10
Fruit and vegetable juice	–0.04	–0.25	0.04
Soft drinks	–0.32	–0.33	–0.02
Rice	–0.06	–0.07	0.78
Miso soup	0.17	–0.12	0.52
Pickled vegetables	0.13	0.05	0.25
Alcoholic beverages	–0.07	0.00	0.11
Black tea	–0.04	0.08	–0.11
Dairy products	0.17	–0.03	–0.28
Confectioneries	–0.33	–0.30	–0.51
Bread	–0.19	–0.15	–0.61
Variation explained	10.0	6.4	6.0

*Values less than –0.25 or >0.25 are expressed in bold.

Discussion

Data from a birth cohort study from Japan identified three dietary patterns among pregnant women, labeled the healthy, Western, and Japanese dietary patterns, that explained 22.4% of the variance in responses to 145 food items on the DHQ. The maternal Western, but not the healthy or Japanese, pattern during pregnancy was significantly associated with a reduced risk of wheeze in the offspring, whereas none of the three dietary patterns was related to the risk of childhood eczema. To our knowledge, this is the first study in a non-Western population to investigate the relationship between maternal dietary patterns during pregnancy and allergic disorders in the offspring.

In our previous findings using data from the OMCHS, higher maternal intake of α -linolenic acid, docosahexaenoic acid (17), vitamin E (7), vitamin D, calcium, and total dairy

Table 3 Nutrient intake for the lowest (Q1) and highest (Q4) quartiles of each dietary pattern and Pearson correlation coefficients between the dietary patterns and nutrient intake

Nutrient*	Healthy pattern			Western pattern			Japanese pattern		
	Q1 (n = 190)†	Q4 (n = 191)	r	Q1 (n = 190)†	Q4 (n = 191)	r	Q1 (n = 190)†	Q4 (n = 191)	r
Protein (% of energy)	11.9 (0.1)	15.0 (0.1)‡	0.61	12.6 (0.1)	14.1 (0.1)‡	0.30	13.3 (0.1)	13.3 (0.1)	0.01
Total fat (% of energy)	29.6 (0.4)	30.7 (0.4)	0.08	26.0 (0.3)	34.7 (0.3)‡	0.61	32.1 (0.4)	27.7 (0.4)‡	-0.30
α -Linolenic acid (g)	1.7 (0.04)	1.9 (0.04)‡	0.10	1.4 (0.04)	2.2 (0.04)‡	0.51	1.7 (0.04)	1.8 (0.04)	0.05
Docosahexaenoic acid (g)	0.21 (0.01)	0.40 (0.01)‡	0.44	0.28 (0.01)	0.31 (0.01)	0.06	0.24 (0.01)	0.37 (0.01)‡	0.27
Linoleic acid (g)	10.9 (0.2)	11.9 (0.2)‡	0.15	9.1 (0.2)	13.3 (0.2)‡	0.58	11.2 (0.2)	11.1 (0.2)	0.004
Calcium (mg)	430 (11)	648 (11)‡	0.46	544 (12)	526 (12)	-0.02	608 (12)	468 (12)‡	-0.30
Vitamin D (μ g)	4.2 (0.2)	8.1 (0.2)‡	0.39	6.2 (0.3)	6.2 (0.3)	0.01	5.6 (0.3)	7.2 (0.3)‡	0.15
β -Carotene (μ g)	1333 (93)	4226 (93)‡	0.62	2338 (119)	2720 (119)	0.10	2659 (120)	2533 (119)	-0.002
Vitamin E (mg)	6.9 (0.1)	9.2 (0.1)‡	0.48	7.1 (0.1)	8.6 (0.1)‡	0.33	8.3 (0.1)	7.4 (0.1)‡	-0.16

*Nutrient intake was adjusted for total energy intake using the residual method.

†Values are mean (s.e.).

‡Significance level with the first quartile (Q1) of each dietary pattern by Dunnett's *t*-test: *p* < 0.05.

Table 4 Odds ratios (ORs) and 95% confidence intervals (CIs) for wheeze and eczema in 763 infants aged 16–24 months by quartiles of maternal dietary patterns during pregnancy

Variable	Wheeze			Eczema		
	No. cases	Crude OR (95% CI)	Adjusted OR (95% CI)*	No. of cases	Crude OR (95% CI)	Adjusted OR (95% CI)*
Healthy pattern						
Q1 (n = 190)	48	1.00	1.00	44	1.00	1.00
Q2 (n = 191)	42	0.83 (0.52–1.34)	0.80 (0.49–1.32)	33	0.69 (0.42–1.15)	0.76 (0.44–1.28)
Q3 (n = 191)	39	0.76 (0.47–1.23)	0.72 (0.42–1.21)	30	0.62 (0.37–1.03)	0.62 (0.35–1.07)
Q4 (n = 191)	40	0.78 (0.48–1.26)	0.68 (0.40–1.15)	35	0.74 (0.45–1.22)	0.70 (0.41–1.20)
p for trend		0.28	0.14		0.20	0.15
Western pattern						
Q1 (n = 190)	51	1.00	1.00	38	1.00	1.00
Q2 (n = 191)	45	0.84 (0.53–1.34)	0.72 (0.44–1.17)	35	0.90 (0.54–1.50)	0.85 (0.49–1.46)
Q3 (n = 191)	33	0.57 (0.35–0.93)	0.52 (0.31–0.87)	27	0.66 (0.38–1.13)	0.69 (0.39–1.21)
Q4 (n = 191)	40	0.72 (0.45–1.16)	0.59 (0.35–0.98)	42	1.13 (0.69–1.85)	1.09 (0.64–1.85)
p for trend		0.08	0.02		0.89	0.92
Japanese pattern						
Q1 (n = 190)	41	1.00	1.00	32	1.00	1.00
Q2 (n = 191)	36	0.84 (0.51–1.39)	0.77 (0.45–1.30)	37	1.19 (0.70–2.01)	1.15 (0.66–1.99)
Q3 (n = 191)	41	0.99 (0.61–1.62)	0.94 (0.56–1.59)	36	1.15 (0.68–1.95)	1.13 (0.64–2.00)
Q4 (n = 191)	51	1.32 (0.83–2.13)	1.41 (0.86–2.35)	37	1.19 (0.70–2.01)	1.11 (0.64–1.94)
p for trend		0.18	0.12		0.58	0.76

*Adjustment for maternal age, gestation at baseline, residential municipality at baseline, family income, maternal and paternal education, maternal and paternal history of asthma, atopic eczema and allergic rhinitis, changes in maternal diet in the previous 1 month, season when data at baseline were collected, maternal smoking during pregnancy, baby's older siblings, baby's sex, baby's birth weight, household smoking in same room as infant, breastfeeding duration, and age of infant at third survey.

products (14) during pregnancy was significantly related to a reduced risk of wheeze, whereas maternal intake of green and yellow vegetables, citrus fruit, β -carotene (7), and vitamin D (14) during pregnancy was significantly inversely associated with the risk of eczema in the children aged 16–24 months; however, maternal linoleic acid intake in pregnancy was significantly positively related to childhood eczema (17). On the

basis of our previous findings, we hypothesized that the healthy dietary pattern would be inversely associated with the risk of childhood allergic disorders. In fact, the healthy pattern in the current study, characterized by high intake of green and yellow vegetables, seaweed, mushrooms, white vegetables, pulses, potatoes, fish, sea products, fruit, and shellfish and low intake of confectioneries and soft drinks,

was significantly positively correlated with intake of α -linolenic acid, docosahexaenoic acid, linoleic acid, vitamin E, vitamin D, calcium, and β -carotene. However, we failed to substantiate significant inverse relationships between such a pattern and the risk of childhood wheeze or eczema although all adjusted ORs for both outcomes in the second, third, and fourth quartiles were below unity. The Western pattern in this study, characterized by high intake of vegetable oil, salt-containing seasonings, beef and pork, processed meat, eggs, chicken, and white vegetables and low intake of fruit, soft drinks, and confectioneries, was significantly positively correlated with intake of α -linolenic acid, vitamin E, and β -carotene. After further control for maternal α -linolenic acid during pregnancy, the inverse exposure-response relationship between the maternal Western pattern and childhood wheeze was not statistically significant: the further adjusted ORs in the first, second, third, and fourth quartiles were 1 (reference), 0.75 (95% CI: 0.46–1.24), 0.57 (95% CI: 0.33–0.98), and 0.69 (95% CI: 0.38–1.23), respectively (p for trend = 0.13). Likewise, after additional control for maternal vitamin E intake, the further adjusted OR for wheeze in the highest quartile for the Western pattern and the inverse linear trend were not significant: the further adjusted ORs in the first, second, third, and fourth quartiles were 1 (reference), 0.75 (95% CI: 0.45–1.22), 0.58 (95% CI: 0.34–0.99), and 0.68 (95% CI: 0.40–1.17), respectively (p for trend = 0.11). The observed significant inverse association between the Western pattern and childhood wheeze might be to some extent ascribed to the intake of α -linolenic acid and vitamin E. Moreover, intake of α -linolenic acid, but not vitamin E, was more strongly correlated with the Western pattern than with the healthy pattern. The observed null relationship with the healthy pattern and inverse association with the Western pattern might be partly explained by the role of dietary α -linolenic acid. The Japanese pattern in this study, characterized by high intake of rice, miso soup, sea products, and fish and low intake of bread, confectioneries, and dairy products, was significantly inversely correlated with the intake of vitamin E and calcium and was not correlated with the intake of α -linolenic acid and β -carotene. The lack of associations between the maternal Japanese pattern of diet and childhood wheeze and eczema in this study might be to some extent attributable to maternal intake of calcium, vitamin E, α -linolenic acid, and β -carotene.

In the ALSPAC, the following five dietary patterns in pregnancy were identified: 'health conscious', 'traditional', 'processed', 'vegetarian', and 'confectionery', and none of the five dietary patterns were related to the risk of eczema at 2.5 yr, wheezing at 3.5 and 7.5 yr, and asthma at 7.5 yr (21). The results regarding the 'health conscious' pattern in the ALSPAC, which was highly loaded with salads, fruit, fruit juices, rice, pasta, oat/bran-based breakfast cereals, fish, pulses, cheese, and non-white bread, are in partial agreement with our findings in relation to the lack of associations between the healthy and Japanese patterns, which have some similarities with the 'health conscious' pattern in the ALSPAC, during pregnancy and the risk of childhood wheeze and eczema. However, the results associated with the

'processed' pattern in the ALSPAC, which was highly loaded with meat pies, sausages, burgers, fried foods, pizza, chips, crisps, white bread, eggs, and baked beans, are not in agreement with our findings regarding the significant inverse relationship between the maternal Western dietary pattern in pregnancy and childhood wheeze.

A cohort study in Spain showed significant inverse associations of a maternal adherence to a Mediterranean diet, which was characterized by higher intake of vegetables, legumes, fruit and nuts, cereal, fish, and dairy products and lower intake of meat, during pregnancy with the risk of childhood wheeze and atopy at 6.5 yr (6). These observations are not consistent with our results regarding the healthy pattern. According to data from the ISAAC Phase One study, the prevalence of wheeze and eczema in children aged 6–7 yr was 18.4% and 13.0% in the UK, 6.2% and 3.3% in Spain, 17.3% and 16.9% in Japan, and 9.6% and 3.5% in Taiwan, respectively (24, 25). Adherence to a Mediterranean dietary pattern might be preventive against allergic disorders.

In the Nurses' Health Study, two major dietary patterns were identified: 'prudent' and 'Western', and the Western pattern was characterized by high consumption of red meat, processed meat, French fries, refined grains, high-fat dairy products, condiments, eggs, sweets and desserts, mayonnaise, snacks, sugar drinks, butter, margarine, potatoes, and pizza (26). In contrast, the Western pattern in the current study was characterized by low consumption of soft drinks and confectioneries. The Western pattern in Japan might be still better than the Western pattern in the USA.

Major methodological advantages of the current study include the homogeneity of study subjects in terms of having the same residential background, the comprehensive assessment of potential confounding factors and the prospective design. The definition of wheeze and eczema was based on the ISAAC questions. However, no attempt was made to ascertain outcome status through reviews of medical records. Moreover, the outcomes under investigation were measured at varying ages between 16 and 24 months, and additionally, wheeze in infancy is known not to be a good predictor of asthma over the longer term. The consequence would bias the magnitude of the observed association toward the null.

Other limitations of the present study should be clarified. Our DHQ could only approximate consumption. The consequence would introduce a bias toward the null. Our DHQ was designed to assess dietary intake for 1 month prior to completing the questionnaire. This disadvantage is likely to be alleviated after adjustment for the season when data were collected, however. Changes in diet in the past 1 month were controlled for because pregnant women are likely to change their diet. However, two studies in UK and Spain showed that dietary patterns do not change significantly throughout pregnancy (27, 28). The results of a sensitivity analysis confined to infants whose mothers had not substantially changed their diet at the time of the baseline survey ($n = 548$) were similar to those in the overall analysis although the inverse relationship between the maternal Western pattern and infantile wheeze was completely disappeared in the sensitivity anal-

ysis: the adjusted ORs for childhood wheeze in the first, second, third, and fourth quartiles for the maternal Western pattern were 1 (reference), 0.90 (95% CI: 0.49–1.64), 0.68 (95% CI: 0.36–1.25), and 0.84 (95% CI: 0.46–1.51), respectively (p for trend = 0.41).

Of the 1002 participants at baseline, 239 mother–child pairs did not take part in the third survey. Moreover, at baseline, the participation rate in Neyagawa City was only 17.2%, and in other areas, the participation rate could not be calculated because the exact number of eligible subjects among the sources from which participants were recruited was not available. Thus, the mother–child pairs in this study were likely not representative of Japanese mother–child pairs in the general population. In fact, educational levels were higher in the mothers in our study than in the general population. According to the 2000 population census of Japan, the proportions of women aged 30–34 yr in Osaka Prefecture with years of education of <13, 13–14, 15+, and unknown were 49.2%, 32.3%, 13.6%, and 4.9%, respectively. The present population might have had a greater awareness about health than the general population. The lifetime prevalence of atopic eczema might be higher among parents in this analysis than among the general population. The lifetime prevalence of atopic eczema was reported to be 4.2% and 4.4%, respectively, for Japanese men and women aged 30–39 yr according to UK Working Party's diagnostic criteria (29). On the other hand, the prevalence of atopic eczema might be lower among infants reported here than among the general population. For example, a report from Japan showed that eczema was observed in 32% of the 10-month-old infants and 20% of the 3-yr-old children who came to public health examinations (30).

The current findings suggest that the maternal dietary pattern during pregnancy characterized by high intake of vegetable oil, salt-containing seasonings, beef and pork, processed meat, eggs, chicken, and white vegetables and low intake of fruit, soft drinks, and confectioneries may be preventive against wheeze in the offspring. However, such an inverse association was not detected for childhood eczema. Thus, we cannot eliminate the possibility that the maternal Western dietary pattern in pregnancy might be related to a reduced risk of childhood respiratory infections rather than atopy. Further control for maternal α -linolenic acid or vitamin E intake during pregnancy removed the inverse relationship between the maternal Western pattern during pregnancy and childhood wheeze. The beneficial relationship may be attributable to some extent to α -linolenic acid and vitamin E. Future studies are needed to assess the effect of maternal dietary patterns during pregnancy on the risk of allergic disorders in the children.

Acknowledgments

The authors acknowledge the Neyagawa City Government, Hirakata City Government, Katano City Government, Shijonawate City Government, Kaizuka City Government, Takai-shi City Government, Hannan City Government, Neyagawa City Medical Association, Hirakata City Medical Association, and the Kadoma City Medical Association for their valuable support.

This study was supported by KAKENHI (13770206, 16790351), Health and Labour Sciences Research Grants, Research on Allergic Disease and Immunology from the Ministry of Health, Labour, and Welfare, Japan, and Japan Dairy Association.

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