Association between factor analysis–derived dietary patterns at 24 months of age and allergic diseases in toddlers

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Hyoyeon Son MSc[1], Eunhee Ha PhD [2,3,4,5], Won Jang PhD [6], and Hyesook Kim PhD[1,7]

[1] Department of Food and Nutrition, Wonkwang University, Iksan, Korea
[2]Graduate Program in System Health Science and Engineering, College of Medicine, Ewha Womans University, Seoul, Republic of Korea
[3]Department of Environmental Medicine, School of Medicine, Ewha Womans University, Seoul, Republic of Korea
[4]Institute of Ewha-SCL for Environmental Health (IESEH), College of Medicine, Ewha Womans University, Seoul, Republic of Korea
[5]Department of Medical Science, College of Medicine, Ewha Medical Research Institute, Ewha Womans University, Seoul, Republic of Korea
[6]Department of Food Science and Nutrition, Dongseo University, Busan 47011, Republic of Korea
[7]Institute for Better Living, Wonkwang University, Iksan, Korea

Authors' email addresses and contributions:
HS: thsgydus0507@wku.ac.kr
Contribution: data analysis, visualization and manuscript drafting.

EH: eunheeha@ewha.ac.kr
Contribution: data collection

WJ: jangwon@gdsu.dongseo.ac.kr
Contribution: conceptualization, data analysis and manuscript drafting.

HK: hskim81@wku.ac.kr
Contribution: project management, data collection, conceptualization, funding acquisition, and supervision.

Corresponding Author: Prof Won Jang, Department of Food and Nutrition, Dongseo University, 47 Jurye-ro, Sasang-gu, Busan, 47011 Republic of Korea. Tel: 82-51-320-4664. Fax: 82-51-320-1781. Email: jangwon@gdsu.dongseo.ac.kr; Dr Hyesook Kim, Department of Food and Nutrition, Wonkwang University, 460 Iksan-daero, Iksan-si, Jeollabuk-do, 54538 Republic of Korea. Tel: 82-63-850-6896. Fax: 82-63-850-6896. Email: hskim81@wku.ac.kr

ABSTRACT

Background and Objectives: Early-life diet may influence immune development and the risk of allergic diseases. This study investigated associations between dietary patterns at 24 months of age and allergic diseases in Korean toddlers. **Methods and Study Design:** In this cross-sectional study, 433 toddlers from the Korean Mothers and Children's Environmental Health (MOCEH) cohort were included. Dietary intake was assessed using two non-consecutive 24-hour recalls. Factor analysis of 26 food groups identified dietary patterns, and individual pattern scores were categorized into tertiles based on ascending distribution. Allergic diseases were determined by caregiver questionnaires. Multivariable logistic regression was used to assess associations, adjusting for confounders. **Results:** Three dietary patterns were identified: Pattern 1 (white rice, kimchi, and non-salt-preserved vegetables), Pattern 2 (seasoning, butter, and meat), and Pattern 3 (milk and dairy products). Compared with the lowest tertile, the highest tertile of Pattern 2 was associated with higher odds of other allergic diseases (OR: 7.55; 95% CI: 1.62–35.23), and any allergic disease (OR: 2.03; 95% CI: 1.10–3.73). Pattern 3 was inversely associated with atopic dermatitis (OR: 0.51; 95% CI: 0.27–0.98), while Pattern 1 showed no significant association. **Conclusions:** Early childhood dietary patterns may influence the development of allergic disease. A pattern characterized by seasoning, butter, and meat was associated with an increased risk of allergic disease, whereas a dairy-based pattern was inversely associated with atopic dermatitis in Korean toddlers.

Key Words: dietary patterns, toddlers, factor analysis, allergic diseases, birth cohort

INTRODUCTION

Allergic diseases are a major public health concern in childhood, arising from dysregulated immune responses to otherwise harmless environmental antigens.[1] While many allergic conditions involve immunoglobulin E (IgE)–mediated responses, other immunological pathways also contribute to their pathogenesis.[2] Childhood allergic diseases include atopic dermatitis, allergic rhinitis, asthma, and food allergy. These conditions typically emerge during early development, when the immune system is still maturing.[3] During this vulnerable period, allergic manifestations may progress sequentially, a phenomenon known as the "allergic march."[4] Early-onset allergic conditions have been linked to increased susceptibility to developing additional allergic diseases in later life.[5] According to the Korea National Health and Nutrition Examination Survey (2016–2019), the prevalence of asthma, atopic dermatitis, and allergic rhinitis among children under 6 years of age was 2.1%, 11.4%, and

16.2%, respectively, with a corresponding increase in healthcare utilization.[6] Additionally, a national survey reported a food allergy prevalence of 3.15% among children aged 6–7, highlighting the substantial public health burden of allergic diseases in early childhood.[7]

Allergic diseases result from multifactorial interactions among genetic predisposition, environmental conditions, intestinal microbiota, and dietary influences.[8,9,10] Notably, toddlerhood represents a critical window for immune and gut microbial development.[11] During this period, nutritional exposures and diet–microbiota interactions play a pivotal role in immune maturation,[12] while environmental and lifestyle factors may increase vulnerability to allergic diseases.[13]

Previous research examining early-life allergic diseases and dietary factors has primarily focused on individual nutrients.[14,15,16,17] While these studies help elucidate the physiological roles of specific nutrients, they have inherent limitations in capturing the complexity of real-world dietary exposure patterns.[18]

Recently, nutrition research has shifted from reductionist approaches that focus on isolated nutrients or single foods to an emphasis on overall dietary patterns and their effects on health outcomes.[19] This shift recognizes the multifaceted interactions among dietary components and aims to provide a more comprehensive understanding of how real-world dietary exposures impact health.[20] Accordingly, dietary pattern analysis, reflecting overall food group consumption, has gained prominence in nutritional epidemiology.[21,22]

Several studies have examined associations between dietary patterns and asthma or allergic diseases in school-aged children. For instance, higher adherence to a Mediterranean diet is associated with lower prevalence of respiratory allergic symptoms, whereas Western dietary patterns high in meat and refined grains are linked to increased asthma risk.[23,24,25] More recently, a study of children aged 1–8 years found that patterns high in refined carbohydrates, sugars, and sugar-sweetened beverages increased asthma risk, whereas patterns rich in vegetables, fish, and legumes were protective.[26]

However, most studies have focused on school-aged children or older preschoolers. Research examining dietary patterns and allergic diseases during the first 24 months of life—a period of rapid immune maturation and heightened allergic susceptibility—remains limited. Dietary patterns can be derived using methods such as principal component analysis, cluster analysis, and factor analysis. Among these, factor analysis summarizes correlated food intakes into major recurring patterns within a population.[27,28]

Factor analysis reflects observed dietary behaviors at a given time point and, unlike index-based approaches, offers flexibility in capturing population-specific dietary characteristics.[18]

Despite these strengths, few studies have investigated dietary patterns and allergic diseases among 24-month-old children in Korea. Therefore, this study aimed to identify dietary patterns among Korean toddlers aged 24 months using factor analysis and to examine their associations with allergic diseases. This research provides insight into the potential role of early-life dietary patterns in the development of allergic disease.

MATERIALS AND METHODS

Study design and participants

This analysis used data from the Mothers and Children's Environmental Health (MOCEH) cohort, a birth cohort recruited from hospitals and communities across Korea between 2006 and 2010.[29] The MOCEH cohort prospectively follows participants from birth to assess growth and health outcomes. For this cross-sectional analysis, dietary intake and allergic disease data were assessed at the 24-month follow-up. Of the 1,751 mother–child dyads enrolled, 108 toddlers were excluded due to Twin births (n = 31), stillbirth (n = 22), congenital anomalies (n = 10), intrauterine growth restriction (n = 6), or pregnancy complications (maternal hypertension or diabetes; n = 39). An additional 1,209 children lacking complete two-day 24-hour dietary records at 24 months and one child with missing sex information were also excluded. The final analytic sample comprised 433 toddlers, as shown in the participant selection flowchart (Figure 1), and baseline characteristics of participants included in and excluded from the final analysis are presented in Supplementary Table 1.

The MOCEH study was approved by the Institutional Review Boards of Ewha Womans University College of Medicine (IRB No. 12-07B-15), Dankook University Hospital (IRB No. 2011-09-0340), and Ulsan University Hospital (IRB No. 06-29). All procedures were conducted in accordance with relevant guidelines and regulations, and written informed consent was obtained from all participants.

Evaluation of allergic diseases

Assessment of allergic diseases was conducted at the 24-month follow-up using a standardized questionnaire based on the International Study of Asthma and Allergies in Childhood (ISAAC). Mothers reported their child's allergic disease history up to the 24-month follow-up, including atopic dermatitis, asthma, allergic rhinitis, food allergy, allergic conjunctivitis, and other allergic conditions. Information was obtained on allergy-related symptoms, medical visits for these symptoms, and caregiver-reported physician diagnoses.

The ISAAC instrument, originally developed for school-aged children, has been validated and adapted for use in birth cohort studies of children under 3 years of age, relying on parental reporting.[30,31] At 24 months, a child was classified as having an allergic disease if any of the following were present: (1) relevant allergic symptoms, (2) medical visits for these symptoms, or (3) a physician-confirmed diagnosis of atopic dermatitis, asthma, allergic rhinitis, food allergy, or allergic conjunctivitis.

Assessment of covariates

Maternal and child characteristics were evaluated as separate analytic components. Maternal information was collected using standardized questionnaires administered through in-person interviews by trained staff. The following maternal factors were included: age at childbirth; pre-pregnancy BMI calculated from self-reported height and weight; educational attainment (elementary school or below, middle school, college or above); average monthly household income (low [≤2 million KRW], middle [2–4 million KRW], high [>4 million KRW]); parity (no prior childbirths vs. one or more); cesarean delivery experience (yes/no); breastfeeding, including colostrum feeding (yes/no); use of dietary supplements during pregnancy (yes/no); and parental history of allergic conditions (present/absent, based on self-report or physician diagnosis). Child-related data were obtained from clinical records and caregiver questionnaires at the 24-month follow-up. Sex was recorded as male or female. Body height (cm) and weight (kg) were measured by trained examiners using standardized protocols at 24 months. These variables were used to assess growth status and included as covariates in statistical analyses.

Assessment of dietary intake

At 24 months, dietary intake was assessed through face-to-face interviews with the primary caregiver (usually the mother) by trained personnel using standardized procedures. To reflect habitual intake and minimize day-to-day variability, two non-consecutive 24-hour dietary recalls were collected. Reported foods and beverages were converted to energy and nutrient intakes using the Computer Aided Nutritional Analysis Program (CAN-Pro) version 3.0 (Korean Nutrition Society). Foods were then grouped into 26 categories based on nutrient composition and cooking method (Table 1). For dietary pattern analyses, each food group's intake was expressed as a percentage of total energy intake to adjust for overall energy differences and to evaluate relative dietary composition.

Derivation of dietary patterns

Dietary pattern analysis was conducted using two non-consecutive 24-hour dietary recall records. Intake data for 26 food groups were standardized prior to analysis. Factor analysis (principal component extraction with Varimax rotation) was used to identify dietary patterns. The number of factors retained was determined using eigenvalues >1.0 and scree plot inspection. Food groups with absolute factor loadings ≥0.20 were considered major contributors to each pattern. Factor scores for each dietary pattern were calculated for each participant. Participants were categorized into tertiles based on the ascending distribution of dietary pattern scores, with T1 representing the lowest scores and T3 the highest. Associations between dietary pattern tertiles and allergic diseases were evaluated using logistic regression.

Statistical analysis

Participant characteristics were summarized using descriptive statistics. Continuous variables are reported as means and standard deviations, while categorical variables are presented as frequencies and percentages. Dietary pattern scores were categorized into tertiles. Differences in continuous variables between dietary pattern groups were assessed using one-way ANOVA, and categorical variables were compared using chi-square tests. When ANOVA indicated significant differences, post hoc comparisons were conducted with the Scheffé method.

Allergic outcomes were defined as follows: atopic dermatitis and asthma were analyzed as separate endpoints. Other allergic diseases were defined as the presence of at least one of the following: allergic rhinitis, food allergy, or allergic conjunctivitis. The combined outcome, any allergic disease, was defined as the presence of at least one allergic condition (atopic dermatitis, asthma, allergic rhinitis, food allergy, or allergic conjunctivitis). All allergic outcomes were treated as binary variables in the analyses.

Associations between dietary patterns and allergic disease outcomes were examined using multivariable logistic regression models. Linear trends were assessed by including dietary pattern scores as continuous variables in the regression models.

All regression analyses were adjusted for potential confounders: maternal covariates (age at delivery, pre-pregnancy BMI, educational attainment, household income, parity, use of dietary supplements during pregnancy, and parental history of allergic diseases, colostrum/breastfeeding, caesarean section) and child covariates (sex, body weight, and height at 24 months). Statistical analyses were conducted using SAS software (version 9.4), and statistical significance was defined as a two-sided p-value <0.05.

RESULTS

Dietary patterns among toddlers

Table 1 shows the food group classifications used in the dietary pattern analysis. Based on these groups, three distinct dietary patterns were identified using factor analysis (Table 2).

Pattern 1 was characterized by higher intakes of refined white rice (0.63), plant oils (0.53), non-salt-preserved vegetables (0.51), kimchi and salted vegetables (0.28), eggs (0.29), and fishes (0.29), and lower intakes of wheat flour, bread, snack, and chocolate (−0.46), sugar-sweetened beverages (−0.50), and flour processed foods (−0.52).

Pattern 2 showed positive factor loadings for potatoes and tubers (0.35), non-salt-preserved vegetables (0.31), butter and margarine (0.43), seasoning (0.68), and meats and meat products (0.41), while negative factor loadings were observed for fishes (−0.35), processed meats (−0.25), and eggs (−0.25).

Pattern 3 was characterized by a strong positive loading for milk and dairy products (0.73), with negative loadings for whole grains (−0.26), non-salt-preserved vegetables (−0.22), fishes (−0.34), poultry (−0.41), shellfishes (−0.23), nuts (−0.32), sugar-sweetened beverages (−0.39), and plant oils (−0.37).

Participant characteristics

Participant characteristics across tertiles of the three dietary pattern scores are summarized in Table 3. For all three dietary patterns, there were no statistically significant differences among tertiles for maternal age, pre-pregnancy BMI, household income, educational attainment, parity, use of nutritional supplements during pregnancy, or parental history of allergic diseases. In addition, colostrum/breastfeeding status showed a significant difference across tertiles of Pattern 2 ($p = 0.019$).

For Pattern 2, statistically significant differences in body weight and height at 24 months were observed across tertiles (body weight, $p = 0.035$; height, $p = 0.017$). Mean body weight decreased from 12.4 ± 1.3 kg in the lowest tertile (T1) to 12.2 ± 1.3 kg in the highest tertile (T3), and mean height similarly decreased from 87.0 ± 3.3 cm in T1 to 86.7 ± 3.2 cm in T3. No significant differences in any variables, including body weight and height, were found across tertiles in Patterns 1 and 3.

Energy and nutrient intakes by dietary pattern tertiles

Nutrient intakes by dietary pattern tertiles are shown in Table 4. All nutrient intakes were adjusted for total energy intake and expressed per 1,000 kcal. Nutrient variables were log-transformed before analysis to improve normality.

With increasing Pattern 1 scores, intakes of protein, dietary fiber, PUFA, n-3 fatty acids, and zinc significantly increased across tertiles. No significant differences were observed for carbohydrate, n-6 fatty acid, or vitamin A intakes, and total energy intake was not associated with Pattern 1 scores.

For Pattern 2, higher scores were associated with significantly increased intakes of carbohydrates and dietary fiber. Conversely, intakes of protein, fat, SFA, PUFA, MUFA, n-3 fatty acids, and n-6 fatty acids significantly decreased across tertiles.

For Pattern 3, higher scores were associated with marked decreases in dietary fiber, PUFA, n-3 fatty acids, and n-6 fatty acids, whereas intakes of SFA and vitamin A increased across tertiles.

Associations between dietary patterns and allergic diseases

Associations between dietary pattern tertiles and allergic disease outcomes are presented in Table 5.

For Pattern 1, no significant changes in OR were observed for T2 or T3 compared with T1 for any allergic disease outcome, including atopic dermatitis, asthma, other allergic diseases, or any allergic disease. No significant linear trend was detected, indicating that Pattern 1 was not associated with the risk of allergic diseases.

In contrast, Pattern 2 showed significant associations with multiple allergic disease outcomes, including atopic dermatitis. For other allergic diseases, toddlers in T3 had a significantly higher risk than those in T1 (OR: 7.55; 95% CI: 1.62–35.23), with a significant linear trend across the tertiles (p-trend = 0.005). Similarly, for any allergic disease, T3 showed a significantly increased risk (OR: 2.03; 95% CI: 1.10–3.73), along with a significant linear trend (p-trend = 0.024). These findings suggest that higher Pattern 2 scores are associated with increased risk of overall allergic diseases.

For Pattern 3, an association was observed only for atopic dermatitis. The OR for T3 was significantly lower compared with T1 (OR: 0.51; 95% CI: 0.27–0.98), and a significant linear trend was identified (p-trend = 0.039), indicating that higher Pattern 3 scores were associated with a reduced risk of atopic dermatitis.

Associations between continuous dietary pattern scores and allergic diseases

Associations between continuous dietary pattern scores and allergic diseases are shown in Table 6.

For Pattern 1, no significant associations were observed with any allergic disease outcome, including atopic dermatitis (p = 0.791), asthma (p = 0.348), other allergic diseases (p = 0.770), or any allergic disease (p = 0.619).

In contrast, Pattern 2 showed significant positive associations with several allergic disease outcomes. The risk of atopic dermatitis increased significantly with each one-unit increase in Pattern 2 score (OR: 1.32; 95% CI: 1.03–1.68; p = 0.027). A similar increase in risk was observed for other allergic diseases (OR: 1.58; 95% CI: 1.06–2.35; p = 0.024). In addition, a significant increase in risk was identified for any allergic disease, representing overall allergic disease burden (OR: 1.32; 95% CI: 1.03–1.68; p = 0.026). These findings suggest that dietary components characteristic of Pattern 2 may be associated with increased risk of allergic diseases.

Pattern 3 demonstrated evidence of a protective association for atopic dermatitis. Specifically, higher Pattern 3 scores were significantly associated with a reduced risk of atopic dermatitis (OR: 0.75; 95% CI: 0.58–0.97; p = 0.029), suggesting that dietary characteristics represented by Pattern 3 may be associated with a lower risk of atopic dermatitis in toddlers. No significant associations were observed between Pattern 3 and other allergic disease outcomes, including asthma, other allergic diseases, or any allergic disease.

In summary, among the three dietary patterns identified, Pattern 2 was associated with higher risks of atopic dermatitis, other allergic diseases, and any allergic disease. Pattern 3 was associated with a reduced risk of atopic dermatitis, while Pattern 1 showed no significant association with any allergic disease outcome.

DISCUSSION

In this study, three dietary patterns were identified among 24-month-old toddlers from the Korean MOCEH cohort using factor analysis of food group intake data.[29] Pattern 2 (seasoning, butter, and meat) was significantly associated with an increased risk of atopic dermatitis and other allergic diseases, whereas Pattern 3 (milk and dairy products) showed an inverse association with atopic dermatitis. No significant associations were observed for Pattern 1 (white rice, kimchi, and non-salt-preserved vegetables).

Pattern 2 was characterized by higher intakes of potatoes and tubers, non-salt-preserved vegetables, butter and margarine, seasonings, and meats and meat products, along with lower intakes of fishes, processed meats, and eggs. Of the three dietary patterns, Pattern 2 was most strongly associated with increased risk of allergic diseases, particularly atopic dermatitis, other allergic diseases, and any allergic disease.

Nutrient intake analysis showed that higher Pattern 2 scores were associated with lower intakes of protein, total fat, PUFA, MUFA, and both n-3 and n-6 fatty acids, whereas intakes of carbohydrates and dietary fiber increased. This nutrient profile may contribute to an imbalance in fatty acid composition. In particular, reduced intake of n-3 fatty acids may promote inflammatory immune responses by decreasing the production of anti-inflammatory lipid mediators and impairing immune regulation.[32,33]

These findings are consistent with previous research. Higher meat intake during early infancy has been associated with increased risk of subsequent asthma,[34] while a dietary pattern high in butter and potatoes has been linked to greater risk of allergic rhinitis in school-aged children.[35] Early childhood is a critical developmental period when the immune system and gut microbiota rapidly mature, and dietary exposures during this window may have long-term effects on immune tolerance and allergic susceptibility.[13] Dietary patterns such as Pattern 2 may therefore create an unfavorable environment for immune development in early life, potentially increasing the risk of allergic diseases.

Pattern 3 was characterized by higher intakes of milk and dairy products and lower intakes of whole grains, non-salt-preserved vegetables, fishes, poultry, shellfishes, nuts, sugar-sweetened beverages, and plant oils. In this study, higher Pattern 3 scores were associated with a reduced risk of atopic dermatitis.

Raw milk consumption has been associated with reduced risk of asthma and atopic dermatitis in children, suggesting a potential role for dairy intake in immune tolerance.[36] Yogurt consumption during infancy (at 12 months) has also been significantly associated with a lower risk of atopic dermatitis and food sensitization at age 5.[37] Experimental evidence demonstrates that bioactive components in milk can directly suppress IgE-mediated mast cell activation and modulate allergic immune responses by reducing the secretion of interleukin-6 (IL-6) and interleukin-13 (IL-13), and inhibiting intracellular calcium influx.[38]

Although Pattern 3 primarily reflects consumption of commercially available milk and dairy products, which differ from raw milk in processing and composition, the observed inverse association with atopic dermatitis may share common mechanistic pathways. These findings are partially consistent with previous epidemiological and mechanistic evidence suggesting that early-life dairy intake can modulate the gut microbiota and immune responses, potentially reducing the risk of allergic disease. Although n-3 intake was lower in Pattern 3, the inverse association with atopic dermatitis suggests that fatty acid composition alone may not fully account for the relationship. Previous studies have shown that dairy products have immunomodulatory properties,[36,37,38] which may contribute to the observed protective effect.

A major strength of this study is the use of a domestic birth cohort to examine the association between dietary pattern and allergic disease in 24-month-old children. Dietary intake was assessed using two non-consecutive 24-hour recalls, which may improve the reliability of dietary assessment by partially reflecting day-to-day variation. In addition, dietary patterns were derived using factor analysis of food group intake, capturing the overall dietary structure of early childhood. Linking these empirically derived dietary patterns with allergic disease outcomes provides important evidence for the relationship between early-life dietary habits and immune development.

Several limitations should be considered. First, because this study was based on a cross-sectional analysis conducted at the 24-month follow-up, causal relationships between dietary patterns and allergic diseases could not be established. In the MOCEH cohort, the 24-month survey represented the timing of follow-up assessment rather than the exact onset of allergic diseases. Therefore, although dietary intake and allergic outcomes were assessed at the same follow-up period, some allergic symptoms, physician visits, or diagnoses may have occurred before dietary assessment. Accordingly, the possibility of reverse causation cannot be excluded. Second, only 433 participants from the original cohort were included in the final analysis, raising the possibility of selection bias. To evaluate this issue, we compared the baseline characteristics of included and excluded participants and presented the results in a supplementary table. Third, the relatively small sample size and limited number of cases for certain allergic diseases, particularly asthma and allergic rhinitis, may have reduced the statistical power to detect significant associations. Therefore, the findings should be interpreted with caution, and further large-scale prospective studies are warranted to confirm these associations.

In conclusion, dietary patterns at 24 months of age were associated with allergic disease outcomes in Korean toddlers. A Western-style dietary pattern, characterized by higher consumption of processed foods and seasonings, was associated with increased odds of allergic diseases, whereas a dairy-based dietary pattern was inversely associated with atopic dermatitis. These findings highlight the potential role of early-life dietary composition in immune development and suggest that dietary patterns during toddlerhood may influence susceptibility to allergic diseases.

SUPPLEMENTARY MATERIALS

All supplementary tables and figures are available upon request from the editorial office, and are also accessible on the journal's webpage (apjcn.qdu.edu.cn).

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare that they have no conflicts of interest.

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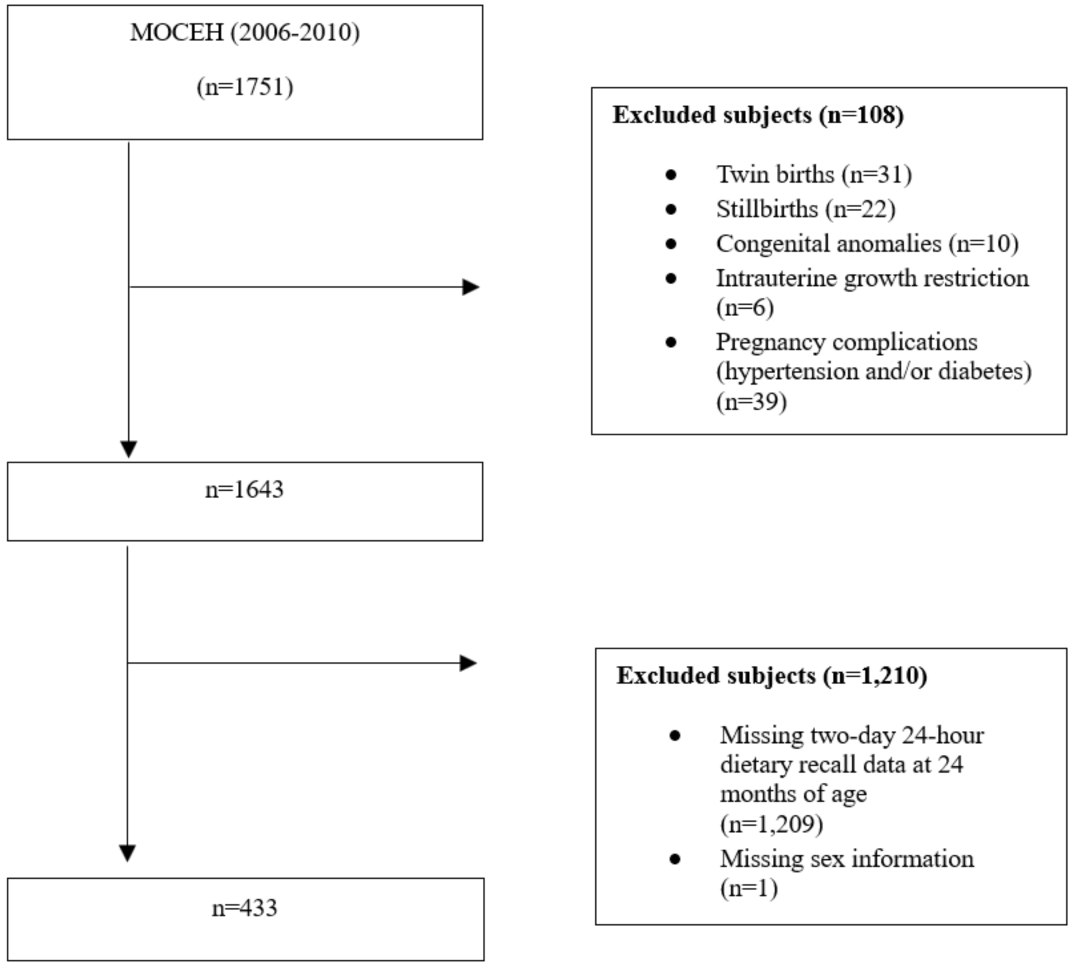

Figure 1. Flowchart of the study population

Table 1. Food groupings used in the factor analysis

Food groups	Food items
Refined white rice	White rice, rice cakes (white rice–based)
Whole grains	Barley, buckwheat, corn, mixed whole-grain powder
Non-salt- preserved vegetables	Radish, carrot, broccoli, spinach, onion
Kimchi & Salted vegetables	Kimchi, pickled vegetables, pickled radish
Potatoes, Tubers	Potatoes, sweet potatoes
Legumes & Tofu, soymilk	Soybeans and soy products (tofu, soy milk), peas
Mushrooms	Mushrooms
Fruits & fruits juice	Tomatoes, strawberries, oranges, fruit juice (including tomato juice)
Wheat flour, bread, snack, chocolate	Cereals, bread, white bread, biscuits, cookies, cakes, chocolate
Meats and meat products	Pork, beef, pork cutlet (breaded and fried pork)
Processed meats	Ham, sausage
Poultry	Chicken, fried chicken, chicken soup
Eggs	Whole egg, egg white, egg yolk
Fishes	Mackerel, hairtail, pollock, anchovy, saury
Shellfishes	Clam, hard clam, sea snail, mussel, abalone
Salted and fermented seafood	Salted shrimp, salted squid, salted hairtail, fish sauce
Seaweeds	Gim (dried laver), miyeok (sea mustard), dashima (kelp)
Milk & Dairy products	Milk, low-fat milk/non fat milk, yakult, fermented milk, cheese
Nuts	Peanut, almond, walnut
Sugar sweetened beverages	Syrups, jams, carbonated beverages, sugar-sweetened beverages
Plant oil	sesame oil, soybean oil, olive oil
Butter, Margarine	Butter, margarine
Seasoning	Gochujang, doenjang, mayonnaise, salt, pepper, soy sauce
Congee	Red bean porridge, pumpkin porridge, tuna porridge, vegetable porridge
Flour processed foods	Buckwheat noodles, udong noodles, sandwiches, pizza, dumplings, instant noodles (ramen)
Stock	Instant noodle soup base, beef stock, seasoning powder (Dashida)

Table 2. Factor loadings and explained variance of food groups for dietary patterns identified by factor analysis

Food groups	Pattern 1	Pattern 2	Pattern 3
	White rice, kimchi, and non-salt-preserved vegetables	Seasoning, butter, and meat	Milk and dairy products
Refined white rice	0.63		
Whole grains			-0.26
Non-salt-preserved vegetables	0.51	0.31	-0.22
Kimchi & Salted vegetables	0.28		
Potatoes, Tubers		0.35	
Legumes & Tofu, soymilk			
Mushrooms			
Fruits & fruits juice			
Wheat flour, bread, snack, chocolate	-0.46		
Meats and meat products		0.41	
Processed meats		-0.25	
Poultry			-0.41
Eggs	0.29	-0.25	
Fishes	0.29	-0.35	-0.34
Shellfishes			-0.23
Salted and fermented seafood			
Seaweeds			
Milk & Dairy products			0.73
Nuts			-0.32
Sugar sweetened beverages	-0.5		-0.39
Plant oils	0.53		-0.37
Butter, margarine		0.43	
Seasoning	0.2	0.68	
Congee			
Flour processed foods	-0.52		
Stock		0.3	

Factor analysis was conducted to derive dietary patterns.
All food group variables were standardized prior to analysis.
Dietary patterns were retained based on eigenvalues ≥1.0, and Varimax rotation was applied to enhance interpretability.
Food groups with absolute factor loadings ≥0.20 were considered to contribute meaningfully to each pattern.

Table 3. Characteristics of the study participants according to tertiles of dietary pattern scores[†‡]

Variables	Pattern1 White rice, kimchi, and non-salt-preserved vegetables				Pattern 2 Seasoning, butter, and meat			
	T1 (n=144)	T2 (n=145)	T3 (n=144)	*p*-value	T1 (n=144)	T2 (n=145)	T3 (n=144)	*p*-value
Mothers								
Age y	30.2 ± 3.4	29.9 ± 3.7	30.5 ± 3.6	0.393	29.9 ± 3.7	30.4 ± 3.4	30.5 ± 3.6	0.314
Pre-pregnancy BMI (kg/m^2)	21.7 ± 3.6	21.2 ± 3.2	20.9 ± 2.3	0.102	21.0 ± 2.7	21.6 ± 3.8	21.2 ± 2.6	0.297
Education								
Secondary school	32 (22.2)	42 (28.9)	31 (21.5)	0.572	35 (24.3)	35 (24.1)	35 (24.3)	0.995
University degree or higher	109 (75.7)	99 (68.3)	109 (75.7)		105 (72.9)	107 (73.8)	105 (72.9)	
No response	3 (2.1)	4 (2.8)	4 (2.8)		4 (2.8)	3 (2.1)	4 (2.8)	
Income (KRW)[§] (million, KRW/month)								
Low	40 (27.8)	45 (31.0)	39 (27.1)	0.841	42 (29.2)	41 (28.3)	41 (28.5)	0.999
Middle	80 (55.6)	78 (53.8)	75 (52.1)		76 (52.8)	79 (54.5)	78 (54.2)	
High	20 (13.9)	16 (11.0)	23 (15.9)		21 (14.6)	19 (13.1)	19 (13.2)	
No response	4 (2.8)	6 (4.1)	7 (4.9)		5 (3.5)	6 (4.1)	6 (4.2)	

Variables	Pattern 3 Milk and dairy products			
	T1 (n=144)	T2 (n=145)	T3 (n=144)	*p*-value
Mothers				
Age y	30.2 ± 3.6	30.3 ± 3.5	30.3 ± 3.7	0.944
Pre-pregnancy BMI (kg/m^2)	21.2 ± 3.3	21.6 ± 3.3	21.0 ± 2.6	0.291
Education				
Secondary school	32 (22.2)	31 (21.4)	42 (29.2)	0.214
University degree or higher	110 (76.4)	111 (76.6)	96 (66.7)	
No response	2 (1.4)	3 (2.1)	6 (4.2)	
Income (KRW)[§] (million, KRW/month)				
Low	40 (27.8)	44 (30.3)	40 (27.8)	0.667
Middle	81 (56.3)	80 (55.2)	72 (50.0)	
High	19 (13.2)	16 (11.0)	24 (16.7)	
No response	4 (2.8)	5 (3.5)	8 (5.6)	

BMI, body mass index
[†]Tertiles were defined based on the ascending distribution of dietary pattern scores; T1 represents the lowest tertile and T3 the highest.
[‡]Differences in continuous variables across tertiles were examined using one-way ANOVA, and categorical variables were analyzed using the chi-square test.
[§]Income categories were defined as ≤2,000,000, 2,000,000-4,000,000, and >4,000,000 KRW per month.
[a,b] within a row that do not share a common superscript letter differ significantly ($p < 0.05$).
p-value < 0.05 was considered statistically significant

Table 3. Characteristics of the study participants according to tertiles of dietary pattern scores†‡ (cont.)

Variables	Pattern1 White rice, kimchi, and non-salt-preserved vegetables				Pattern 2 Seasoning, butter, and meat			
	T1 (n=144)	T2 (n=145)	T3 (n=144)	*p*-value	T1 (n=144)	T2 (n=145)	T3 (n=144)	*p*-value
Mothers								
Parity								
0	62 (43.1)	63 (43.5)	76 (52.8)	0.371	75 (52.1)	60 (41.4)	66 (45.8)	0.317
≥1	66 (45.8)	64 (44.1)	57 (39.6)		55 (38.2)	66 (45.5)	66 (45.8)	
No response	16 (11.1)	18 (12.4)	11 (7.6)		14 (9.7)	19 (13.1)	12 (8.3)	
Colostrum/breastfeeding								
Yes	135 (93.8)	138 (95.2)	140 (97.2)	0.730	140 (97.2)	133 (91.7)	140 (97.2)	0.019
Caesarean section								
Yes	21 (14.6)	21 (14.5)	21 (14.6)	0.930	19 (13.2)	26 (17.9)	18 (12.5)	0.654
Nutritional supplements								
Yes	71 (49.3)	72 (49.7)	80 (55.6)	0.515	76 (52.8)	73 (50.3)	74 (51.4)	0.483

Variables	Pattern 3 Milk and dairy products			
	T1 (n=144)	T2 (n=145)	T3 (n=144)	*p*-value
Mothers				
Parity	67 (46.5)	74 (51.0)	60 (41.7)	0.151
0	64 (44.4)	61 (42.1)	62 (43.1)	
≥1	13 (9.0)	10 (6.90)	22 (15.3)	
No response	32 (22.2)	31 (21.4)	42 (29.2)	
Colostrum/breastfeeding				
Yes	134 (93.1)	143 (98.6)	136 (94.4)	0.108
Caesarean section				
Yes	22 (15.3)	17 (11.7)	24(16.7)	0.662
Nutritional supplements				
Yes	80 (55.6)	80 (55.2)	63 (43.8)	0.209

BMI, body mass index
†Tertiles were defined based on the ascending distribution of dietary pattern scores; T1 represents the lowest tertile and T3 the highest.
‡Differences in continuous variables across tertiles were examined using one-way ANOVA, and categorical variables were analyzed using the chi-square test.
§Income categories were defined as ≤2,000,000, 2,000,000-4,000,000, and >4,000,000 KRW per month.
[a,b] within a row that do not share a common superscript letter differ significantly ($p < 0.05$).
p-value < 0.05 was considered statistically significant

Table 3. Characteristics of the study participants according to tertiles of dietary pattern scores†‡ (cont.)

Variables	Pattern1 White rice, kimchi, and non-salt-preserved vegetables				Pattern 2 Seasoning, butter, and meat			
	T1 (n=144)	T2 (n=145)	T3 (n=144)	*p*-value	T1 (n=144)	T2 (n=145)	T3 (n=144)	*p*-value
Mothers								
Maternal history of allergic disease								
Yes	42 (29.2)	53 (36.6)	47 (32.6)	0.451	56 (38.9)	44 (30.3)	42 (29.1)	0.409
Paternal history of allergic disease								
Yes	37 (25.7)	40 (27.6)	41 (28.5)	0.653	46 (31.9)	31 (21.4)	41 (28.5)	0.345
Toddlers								
Weight at 24 months (kg)	12.5 ± 1.4	12.3 ± 1.2	12.4 ± 1.3	0.333	12.4 ± 1.3^{ab}	12.6 ± 1.3^{a}	12.2 ± 1.3^{b}	0.035
Height at 24 months (cm)	87.6 ± 3.4	86.9 ± 3.1	87.1 ± 3.3	0.218	87.0 ± 3.3^{ab}	87.8 ± 3.3^{a}	86.7 ± 3.2^{b}	0.017
Sex								
Boy	81 (56.3)	76 (52.4)	76 (52.8)	0.771	79 (54.9)	84 (57.9)	70 (48.6)	0.269
Girl	63 (43.8)	69 (47.6)	68 (47.2)		65 (45.1)	61 (42.1)	74 (51.4)	
Energy (kcal/d)	1045.4 ± 277.8	1072.8 ± 258.9	1054.5 ± 219.5	0.646	1050.8 ± 254.8	1050.9 ± 263.9	1071.2 ± 240.6	0.734

Variables	Pattern 3 Milk and dairy products			
	T1 (n=144)	T2 (n=145)	T3 (n=144)	*p*-value
Mothers				
Maternal history of allergic disease				
Yes	49 (34.0)	50 (34.5)	43 (29.9)	0.869
Paternal history of allergic disease				
Yes	42 (29.2)	41 (28.3)	35 (24.3)	0.850
Toddlers				
Weight at 24 months (kg)	12.4 ± 1.4	12.3 ± 1.1	12.5 ± 1.4	0.356
Height at 24 months (cm)	87.1 ± 3.4	87.3 ± 3.1	87.1 ± 3.3	0.826
Sex				
Boy	82 (56.9)	76 (52.4)	75 (52.1)	0.652
Girl	62 (43.1)	69 (47.6)	69 (47.9)	
Energy (kcal/d)	1056.2 ± 249.4	1067.2 ± 258.9	1049.3 ± 251.7	0.832

BMI, body mass index
†Tertiles were defined based on the ascending distribution of dietary pattern scores; T1 represents the lowest tertile and T3 the highest.
‡Differences in continuous variables across tertiles were examined using one-way ANOVA, and categorical variables were analyzed using the chi-square test.
§Income categories were defined as ≤2,000,000, 2,000,000-4,000,000, and >4,000,000 KRW per month.
[a,b] within a row that do not share a common superscript letter differ significantly ($p < 0.05$).
p-value < 0.05 was considered statistically significant

Table 4. Nutrient intakes according to tertiles of dietary pattern scores derived by factor analysis†‡

Variables	Pattern 1 White rice, kimchi, and non-salt-preserved vegetables					Pattern 2 Seasoning, butter, and meat				
	T1 (n=144)	T2 (n=145)	T3 (n=144)	p-value	p-trend[§]	T1 (n=144)	T2 (n=145)	T3 (n=144)	p-value	p-trend[§]
Energy (kcal)	1045.4 ± 277.7	1072.8 ± 258.9	1054.5 ± 219.4	0.645	0.759	1050.8 ± 254.8	1050.9 ± 263.9	1071.2 ± 240.6	0.734	0.495
Carbohydrate (g)	162.4 ± 48.9	162.7 ± 33.7	165.6 ± 36.2	0.458	0.211	160.8 ± 47.6	162.7 ± 34.2	167.1 ± 37.6	0.143	0.049
Total dietary fiber g/1000 kcal	8.3 ± 3.6b	8.5 ± 2.9b	9.9 ± 3.4a	<0.001	<0.001	8.1 ± 3.6b	8.8 ± 3.1ab	9.7 ± 3.4a	<0.001	<0.001
Protein g/1000 kcal	33.5 ± 6.1b	34.2 ± 5.6b	36.8 ± 5.8a	<0.001	<0.001	37.4 ± 6.1a	33.5 ± 5.5b	33.6 ± 5.7b	<0.001	<0.001
Fat g/1000 kcal	29.0 ± 6.7a	25.8 ± 6.6b	26.0 ± 5.6b	<0.001	<0.001	28.4 ± 6.0a	26.8 ± 7.1ab	25.6 ± 6.2b	<0.001	<0.001
SFA g/1000 kcal	12.7 ± 3.6a	11.0 ± 3.5b	10.8 ± 3.0b	<0.001	<0.001	11.9 ± 3.5a	11.8 ± 3.8a	10.9 ± 3.1a	0.048	0.019
MUFA g/1000 kcal	8.6 ± 2.1a	7.7 ± 2.3b	7.5 ± 2.1b	<0.001	<0.001	8.3 ± 2.2a	7.8 ± 2.4a	7.7 ± 2.2a	0.044	0.028
PUFA g/1000 kcal	4.4 ± 2.1ab	4.2 ± 1.8b	4.7 ± 1.7a	0.010	0.037	4.9 ± 1.9a	4.3 ± 1.9b	4.1 ± 1.7b	<0.001	<0.001
n–3 fatty acids g/1000 kcal	0.6 ± 0.3b	0.6 ± 0.3b	0.8 ± 0.5a	<0.001	<0.001	0.8 ± 0.5a	0.6 ± 0.4b	0.5 ± 0.4b	<0.001	<0.001
n–6 fatty acids g/1000 kcal	3.9 ± 1.8	3.6 ± 1.6	3.9 ± 1.5	0.119	0.596	4.1 ± 1.7a	3.7 ± 1.7b	3.6 ± 1.5b	0.008	0.004
Vitamin A µg RE/1000 kcal	218.2 ± 86.2	216.1 ± 83.8	231.2 ± 87.3	0.185	0.172	226.9 ± 90.4	226.1 ± 87.2	212.3 ± 79.5	0.490	0.287
Zinc mg/1000 kcal	4.8 ± 0.9c	5.0 ± 0.9b	5.4 ± 0.7a	<0.001	<0.001	5.1 ± 0.9	4.9 ± 0.9	5.1 ± 0.9	0.179	0.415

Variables	Pattern 3 Milk and dairy products				
	T1 (n=144)	T2 (n=145)	T3 (n=144)	p-value	p-trend[§]
Energy (kcal)	1056.1 ± 249.4	1067.2 ± 259.0	1049.3 ± 251.7	0.832	0.819
Carbohydrate (g)	160.7 ± 36.1	165.2 ± 34.1	164.7 ± 48.8	0.463	0.566
Total dietary fiber g/1000 kcal	9.9 ± 3.5a	8.9 ± 3.2b	7.8 ± 3.2c	<0.001	<0.001
Protein g/1000 kcal	35.7 ± 6.9	34.5 ± 5.9	34.3 ± 4.9	0.169	0.092
Fat g/1000 kcal	27.7 ± 6.3a	25.5 ± 6.6b	27.4 ± 6.6ab	0.007	0.603
SFA g/1000 kcal	11.1 ± 3.1b	10.8 ± 3.2b	12.7 ± 3.8a	<0.001	<0.001
MUFA g/1000 kcal	8.1 ± 2.3ab	7.6 ± 2.3b	8.2 ± 2.2a	0.023	0.701
PUFA g/1000 kcal	5.1 ± 2.2a	4.2 ± 1.7b	3.9 ± 1.6b	<0.001	<0.001
n–3 fatty acids g/1000 kcal	0.8 ± 0.5a	0.7 ± 0.4a	0.5 ± 0.3b	<0.001	<0.001
n–6 fatty acids g/1000 kcal	4.3 ± 1.9a	3.6 ± 1.5b	3.5 ± 1.4b	<0.001	<0.001
Vitamin A µg RE/1000 kcal	191.7 ± 76.9b	212.4 ± 79.0b	261.4 ± 86.5a	<0.001	<0.001
Zinc mg/1000 kcal	5.1 ± 1.1	5 ± 0.8	5.1 ± 0.9	0.708	0.528

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; RE, retinol equivalents
Values are expressed as means ± standard deviations (SDs).
[†]Tertiles were defined based on the ascending distribution of dietary pattern scores; T1 represents the lowest tertile and T3 the highest.
[‡]Differences across tertiles were assessed using one-factor ANOVA for continuous variables, with Scheffé's post hoc test applied when significant.
[§]p-trend was evaluated by modeling the median value of each tertile as a continuous variable in linear regression.
[a,b] within a row that do not share a common superscript letter differ significantly ($p < 0.05$).

Table 5. Associations between dietary pattern scores derived by factor analysis and allergic disease risk across tertiles[†‡]

Variables	Pattern 1 White rice, kimchi, and non-salt-preserved vegetables				Pattern 2 Seasoning, butter, and meat			
	T1 (n=144)	T2 (n=145)	T3 (n=144)	p-trend	T1 (n=144)	T2 (n=145)	T3 (n=144)	p-trend
Atopic dermatitis	1 (ref)	1.012 (0.538-1.903)	0.915 (0.493-1.696)	0.774	1 (ref)	1.399 (0.726-2.697)	1.802 (0.969-3.353)	0.063
Asthma	1 (ref)	NA‡	NA‡	NA‡	1 (ref)	5.846 (0.554-61.677)	5.374 (0.461-62.710)	0.182
Other allergic diseases§	1 (ref)	0.979 (0.293-3.275)	1.256 (0.404-3.907)	0.685	1 (ref)	3.042 (0.550-16.825)	7.547 (1.617-35.227)	0.005
Any allergic disease§	1 (ref)	1.232 (0.668-2.273)	0.877 (0.477-1.610)	0.658	1 (ref)	1.614 (0.853-3.052)	2.025 (1.100-3.727)	0.024

Variables	Pattern 3 Milk and dairy products			
	T1 (n=144)	T2 (n=145)	T3 (n=144)	p-trend
Atopic dermatitis	1 (ref)	0.685 (0.378-1.243)	0.509 (0.265-0.977)	0.039
Asthma	1 (ref)	0.221 (0.019-2.604)	1.991 (0.366-10.819)	0.468
Other allergic diseases[§]	1 (ref)	2.469 (0.788-7.735)	0.935 (0.235-3.726)	0.967
Any allergic disease[§]	1 (ref)	0.723 (0.403-1.296)	0.624 (0.334-1.165)	0.129

NA, not applicable; odds ratios could not be estimated due to the absence of cases in the corresponding tertile.
Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated across tertiles of dietary pattern scores.
[†]Tertiles were defined based on the ascending distribution of dietary pattern scores; T1 represents the lowest tertile and T3 the highest.
[‡]Associations with allergic diseases were examined using multiple logistic regression, adjusting for maternal characteristics (age, pre-pregnancy BMI, education, income, parity, supplement use during pregnancy, and parental history of allergic diseases, breastfeeding status, mode of delivery (cesarean section) and child factors (sex and height and weight at 24 months).
[§]"Other allergic diseases" included food allergy, allergic rhinitis, and allergic conjunctivitis, while "Any allergic disease" additionally included atopic dermatitis and asthma.
Statistical significance was set at $p < 0.05$.

Table 6. Associations between continuous factor analysis dietary pattern scores and allergic disease risk†

Variables	Pattern 1 White rice, kimchi, and non-salt-preserved vegetables		Pattern 2 Seasoning, butter, and meat		Pattern 3 Milk and dairy products	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Atopic dermatitis	0.968 (0.760-1.232)	0.791	0.968 (0.760-1.232)	0.791	0.748 (0.576-0.972)	0.029
Asthma	1.467 (0.659-3.268)	0.348	1.467 (0.659-3.268)	0.348	1.322 (0.552-3.170)	0.531
Other allergic diseases‡	0.934 (0.590-1.478)	0.770	0.934 (0.590-1.478)	0.770	1.018 (0.626-1.657)	0.941
Any allergic disease‡	0.942 (0.745-1.191)	0.619	0.942 (0.745-1.191)	0.619	0.829 (0.645-1.067)	0.146

Dietary pattern scores derived from factor analysis were analyzed as continuous variables.
Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to estimate the change in allergic disease risk per one-unit increase in dietary pattern scores.
†Logistic regression models were adjusted for maternal factors (age, pre-pregnancy BMI, education level, household income, parity, use of nutritional supplements during pregnancy, and parental history of allergic diseases, breastfeeding status, mode of delivery (cesarean section) and child characteristics (sex and height and weight at 24 months).
‡"Other allergic diseases" included food allergy, allergic rhinitis, and allergic conjunctivitis, whereas "Any allergic disease" additionally included atopic dermatitis and asthma, representing a combined allergic disease indicator.
Statistical significance was set at $p < 0.05$.