Fruit and vegetable consumption in relation to allergy: Disease-related modification of consumption?

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Background: Previous largely cross-sectional studies suggest that fruit and vegetable consumption reduces the risk of allergic disease in children, but results are conflicting.
Objective: To investigate the association between current fruit or vegetable intake and allergic disease in 8-year-old Swedish children, and to evaluate the potential effect of disease-related modification of consumption.
Methods: Cross-sectional data were obtained from a Swedish birth cohort study. Information on fruit and vegetable consumption as well as symptoms and diagnoses of allergic diseases was obtained by parental questionnaires at the 8-year follow-up. Allergen-specific IgE levels against food and inhalant allergens were obtained from blood samples collected at age 8 years. In total, 2447 children were included. Data were analyzed with logistic regression.
Results: An inverse relation was observed between total fruit consumption and rhinitis (odds ratio, highest vs lowest quartile, 0.62; 95% CI, 0.45-0.86; *P* for trend, .002), whereas no association was observed for total vegetable intake. In analyses of individual foods, intake of apples/pears and carrots was inversely associated with rhinitis, asthma, and atopic sensitization. Fifty percent of the children with rhinitis were sensitized against birch pollen, which may cross-react with apples and carrots. After exclusion of children who reported food-related allergic symptoms, most of the observed inverse associations moved toward the null and became nonsignificant.
Conclusion: We confirm the inverse associations between fruit intake and allergic disease in children observed in earlier studies. However, our data also indicate that disease-related modification of consumption contributed to this association.
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Key words: *Allergy, rhinitis, asthma, eczema, atopy, reverse causation, FFQ, fruit, vegetables*

Abbreviations used
BAMSE: Swedish abbreviation for Children, Allergy, Milieu, Stockholm, Epidemiology
FFQ: Food frequency questionnaire
iso-BMI: Age-adjusted body mass index
OR: Odds ratio

Fruits and vegetables are rich sources of antioxidants, such as vitamin C, vitamin E, carotenoids, and selenium, which are thought to reduce airway inflammation by protecting the tissue from oxidative damage.[1,2] Previous epidemiologic studies of the association between fruit and/or vegetable consumption and allergic disease in children have therefore focused on asthma, wheezing, and rhinitis, whereas eczema and atopic sensitization have been less studied. Most studies reported a protective effect from fruit and/or vegetable intake,[3-10] but also increased risks[11,12] or no associations[13-15] have been observed. A majority of the studies were cross-sectional.[3-10,12,14]

Several proteins from fruits and vegetables are homologous to the major pollen allergens and may contribute substantially to the pollen–fruit/vegetable cross-reactivity.[16] The pattern of cross-reactivity differs between different countries.[17] In northern Europe, sensitization to birch is common[17] and starts early in life.[18,19] For example, in Sweden, the most common cross-reactivity is found between birch tree pollen and apple, stone fruit, and carrot, which may cause hypersensitivity reactions on consumption in subjects sensitized to birch tree pollen.[20] Such food-related symptoms have been reported from approximately 70% of individuals sensitized against birch pollen.[21] Children may avoid foods or eat them less often if they induce immediate symptoms,[22,23] thus modifying their consumption of fruit and/or vegetables because of allergic disease. Such disease-related modification of consumption may influence the observed associations between intake of certain fruits or vegetables and allergic disease if these children also are sensitized against, for example, birch pollen. Most previous studies on consumption of fruits and vegetables in relation to allergy have not investigated the possible effect of disease-related modification of consumption.

The aim of the current study was to investigate the associations between fruit or vegetable consumption and allergic disease in 8-year-old children. Because our questionnaire also included questions on food-related allergic symptoms, we had the possibility to exclude those children and thereby evaluate the potential effect of disease-related modification of consumption.

METHODS

Study design

A prospective birth cohort of 4089 newborn infants (BAMSE, Swedish abbreviation for Children, Allergy, Milieu, Stockholm, Epidemiology) was established among children born between February 1994 and November 1996, composed of 75% of all eligible children in a predefined area of Stockholm, Sweden. The study design has been described in detail

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elsewhere.[24,25] In brief, information on various background exposures, allergic heredity, socioeconomy, and other demographic data were obtained through a parental questionnaire when the children were on average 2 months old. Questionnaires focusing on symptoms related to allergic disease and on key exposures were also answered by the parents when the children were 1, 2, 4, and 8 years old. The response rates were 96%, 94%, 91%, and 84%, respectively. All children with answered questionnaires at age 8 years were invited to a clinical investigation including blood sampling. Sera of 2470 children (60%) were analyzed for specific IgE antibodies to common inhalant and food allergens. At the clinical examination, parents (together with the child) were asked to fill in a food frequency questionnaire (FFQ) containing questions about 98 foods and beverages frequently consumed in Sweden. The FFQ was included only at the 8-year follow-up, and in total, 2614 families (64%) filled out the FFQ.[26] Most often the FFQ was filled out by a parent (57%) or by a parent together with the child (40%). The study was approved by the Ethics Committee of Karolinska Institutet, Stockholm, Sweden.

Assessment of fruit and vegetable consumption

Information on fruit and vegetable consumption was collected from the FFQ, which contained questions about the frequency of consumption of 5 fruit items and 13 vegetable items. Participants were asked how often, on average, over the past year they had consumed each item. Eight categories for frequency of consumption were provided, ranging from never to 3 servings per day or more. The frequency responses were converted into average daily consumption of each fruit and vegetable item. "Total fruit consumption" included apples/pears, citrus fruits, bananas, berries, and other fruits. Fruit juice was not included in the group of total fruits. In addition, each fruit item was investigated separately. "Total vegetable consumption" included carrots, cabbage, cauliflower, broccoli/brussels sprouts, lettuce, tomato, cucumber, spinach/kale, onions/leek, green peas, pea soup (from dried peas), and beans (brown, white, soy)/lentils. We also combined specific vegetables into the following 2 subgroups: cruciferous and green vegetables (cabbage, cauliflower, broccoli/brussels sprouts, turnips/beets, spinach/kale) and legumes (green peas, pea soup, beans/lentils).

Definition of health outcomes

Assessment of current allergic disease (rhinitis, asthma, and eczema) was based on the follow-up questionnaire at age 8 years.

Rhinitis was defined as prolonged sneezing or a runny or blocked nose without a common cold in the last 12 months before the questionnaire at age 8 years.

Asthma was defined as having at least 4 episodes of wheezing in the last 12 months before the questionnaire at age 8 years or at least 1 episode of wheezing during the same period in combination with prescribed inhaled steroids occasionally or regularly.

Eczema was defined as dry skin in combination with an itchy rash for at least 2 weeks with typical localization during the last 12 months before the questionnaire at age 8 years, and/or a physician's diagnosis of eczema from the age of 7 years.

Atopic sensitization was indicated if the child had at least 1 allergen-specific IgE result of ≥0.35 kilounit antibodies per liter against common inhalant allergens (cat, dog, horse, birch, timothy, mugwort, *Dermatophagoides pteronyssinus*, and *Cladosporium* species [Phadiatop; Phadia AB, Uppsala, Sweden]) and/or common food allergens (cow's milk, hen's egg, cod fish, soy bean, peanut and wheat [fx5; Phadia AB]) using the ImmunoCAP System (Phadia AB), analyzed in blood samples obtained at the follow-up at age 8 years.

Statistical methods

The associations between fruit or vegetable consumption and the selected health outcomes were estimated by using odds ratios (ORs) and 95% CIs computed from logistic regression. Using blood sample data, analyzes were performed by combining each outcome with atopic sensitization. Quartiles were used when analyzing total fruit or total vegetable consumption, and tertiles when numbers were more limited. Several models were tested to identify potential confounders, and the final logistic regression model was adjusted for sex, parental history of allergic disease (physician-diagnosed asthma and/or hay fever in combination with allergy to furred pets and/or pollen in 1 or both parents), parental socioeconomic status (blue collar worker, white collar worker, other), maternal smoking during pregnancy and/or at baseline (the mother smoked at least 1 cigarette per day at any point of time during the pregnancy or when the child was around 2 months old), age-adjusted body mass index (iso-BMI),[27] and maternal age at baseline (<25 years, ≥25 years) because these variables changed the OR estimates. Differences in proportions between groups of consumption were tested with the χ^2 test and considered significant at a P value of less than .05. Tests for trend were conducted entering the exposure variable as a continuous term in the regression model. To examine potential effects of disease-related modification of consumption (reverse causation), we excluded children who reported food-related allergic symptoms—that is, children who reported allergic symptoms (wheezing, itchy eyes and/or runny nose, oral allergy syndrome, eczema, urticaria, or diarrhea/vomiting) from specific fruits or vegetables (apple, peach, kiwi, avocado, banana, fresh carrot, or any other specified fruit or vegetable) and/or who avoided any of these food items because of allergic symptoms.

To be included in the analyses, answers on the questionnaires at age 2 months (baseline data) and 8 years were required, together with a completed FFQ at age 8 years (where the questions on fruit and vegetable consumption had to be completed) and information on atopic sensitization at age 8 years. In total, 2447 children (1258 boys and 1189 girls) fulfilled these criteria. All statistical analyzes were performed with STATA Statistical Software (release 8.0; StataCorp, College Station, Tex).

RESULTS

Children included in the current study were highly representative compared with the children in the baseline cohort regarding distribution of exposure factors such as sex, parental allergic disease, socioeconomic status, maternal smoking, and breast-feeding (data not shown). The prevalence of asthma (7.4%), rhinitis (15.3%), and eczema (17.1%) at age 8 years in the study group was somewhat higher when compared with the cohort as a whole (6.3%, 13.3%, and 16.3%, respectively) but did not differ significantly.

The average consumption of fruit was 1.7 (SD, ±1.2) servings per day, whereas vegetables were consumed on average for 2.5 (SD, ±1.5) servings per day. Fig 1 shows the mean daily consumption of different groups of fruits and vegetables. Fruits consumed most frequently were apples/pears (25%), citrus fruits (9%), and bananas (8%), whereas cucumber (23%), carrots (15%), and tomatoes (13%) were the most consumed vegetables.

The distribution of potential confounding factors in relation to fruit and vegetable consumption is presented in Table I. Girls ate significantly more fruit and vegetables than boys ($P < .05$). Low maternal age, low socioeconomic status, and maternal smoking during pregnancy and/or at baseline were related to a lower intake of fruit and vegetables. Larger proportions of obese children (iso-BMI > 30) were found in the highest quartile of fruit and vegetable consumption compared with the lowest. An opposite trend was observed among overweight children (iso-BMI, 25-<30). Parental history of allergic disease, breast-feeding, and vitamin supplementation was not related to fruit and vegetable consumption. Similar results were observed when fruit and vegetable intakes were investigated separately.

Table II shows the association between total fruit or total vegetable intake and current allergic disease or atopic sensitization at 8 years of age. An inverse association was observed between total

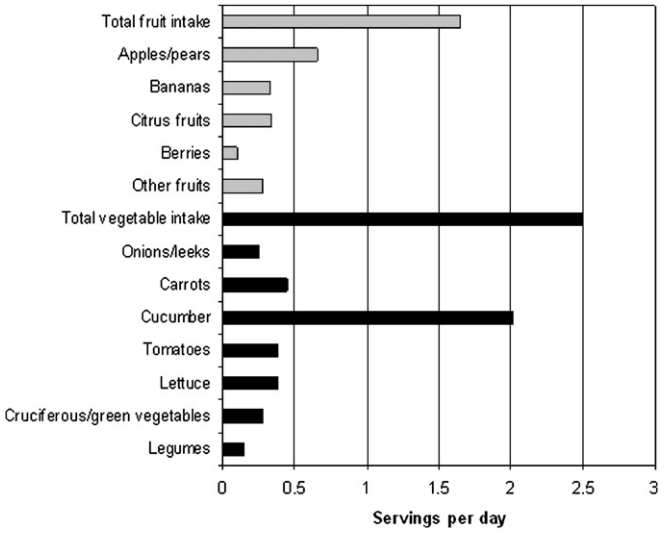


FIG 1. Frequency of mean daily consumption of fruits and vegetables during the last 12 months among 8-year-old children in the BAMSE cohort (n = 2447).

fruit intake and rhinitis (OR for the highest vs lowest quartile, 0.62; 95% CI, 0.45-0.86; *P* for trend, .002), whereas no statistically significant trend was apparent for total vegetable intake. In total, 238 children reported allergic symptoms related to at least 1 of 6 prespecified fruits or vegetables (apple, peach, kiwi, banana, avocado, fresh carrot) or any other fruit or vegetable (citrus fruit, strawberry, and tomato were the most commonly listed food items). When those children were excluded from the analyses, because they might have changed their diet as a result of allergic symptoms, the associations with total fruit consumption disappeared.

In analyses of individual or groups of fruit or vegetables (Table III), the strongest and most consistent inverse associations were observed between consumption of apples/pears, as well as carrots, and rhinitis, asthma, and atopic sensitization. Moreover, intake of legumes was inversely associated with asthma. In contrast, a tendency for increased risk of rhinitis was seen for consumption of onions/leek. Fruit juice was not associated with any allergic disease (data not shown). After excluding children who reported food-related allergic symptoms, all associations became nonsignificant except the association between legumes and asthma.

To distinguish between IgE-mediated and non–IgE-mediated disease, each outcome was combined with atopic sensitization. Table IV shows the associations between consumption of total fruit, apples/pears, and carrots, respectively, and current allergic disease combined with atopic sensitization analyzed in blood samples. Results are presented for the highest versus the lowest tertile of consumption. For intake of total fruit, apples/pears, and carrots, the inverse associations were restricted to IgE-mediated disease, whereas no statistically significant associations were observed for non–IgE-mediated rhinitis, asthma, or eczema. After exclusion of children who reported food-related allergic symptoms, all associations became nonsignificant except the association between carrot consumption and eczema. Total vegetable consumption was not associated with any IgE-mediated disease (rhinitis: OR for the highest vs lowest tertile, 0.90, 95% CI, 0.64-1.25; asthma: OR, 0.83, 95% CI, 0.53-1.30; eczema: OR, 0.96, 95% CI, 0.65-1.42).

TABLE I. Distribution of potential confounders in relation to fruit and vegetable consumption among 8-year-old children in the BAMSE cohort (n = 2447)

	Fruit and vegetable consumption (quartiles)			
Potential confounders	**1**	**2**	**3**	**4**
Mean frequency of consumption (servings/d ± 1 SD)	1.8 ± 0.6	3.2 ± 0.3	4.5 ± 0.4	7.1 ± 2.0
Total no. of children	602	611	612	622
Child's sex (%)*				
Boy	58.1	52.4	47.9	47.4
Girl	41.9	47.6	52.1	52.6
Parental history of allergic disease (%)				
Yes	33.6	31.3	33.9	29.6
No	66.4	68.7	66.1	70.5
Maternal age at baseline (%)*				
<25 y	8.8	7.7	7.5	5.0
≥25 y	91.2	92.3	92.5	95.0
Parental socioeconomic status (%)*†				
Blue collar worker	19.2	14.0	12.9	14.2
White collar worker	79.6	85.1	85.8	84.7
Maternal smoking during pregnancy and/or at baseline (%)*				
Yes	15.8	11.3	10.6	12.2
No	84.2	88.7	89.4	87.8
Iso-BMI at 8 y*‡				
<25	79.4	75.6	81.5	77.2
25-<30	16.6	21.6	15.0	15.9
>30	4.0	2.8	3.4	6.9
Exclusive breast-feeding (%)				
<4 mo	19.6	17.1	17.9	19.9
≥4 mo	80.4	82.9	82.1	80.1
Vitamin supplements the last 12 mo (%)				
Yes	42.3	43.8	39.1	44.7
No	57.7	56.2	60.9	55.3

*$P < .05$ for difference in frequency of fruit and vegetable consumption between groups (χ^2 test).
†Third category (consisting of students, unemployed, housewives/men) not shown because of low numbers.
‡Iso-BMI is an age-adjusted measure of BMI (kg/m^2) used up to 18 years of age.

Children sensitized to birch tree pollen may develop hypersensitivity reactions to certain foods—for example, apples or carrots[21]—which may lead to avoidance of these food items.[23] In our study, 16% of all children were sensitized to birch pollen, in particular children with atopic sensitization (46%), rhinitis (50%), asthma (45%), and eczema (26%). To explore whether children sensitized to birch pollen may have changed their diet because of allergic symptoms, birch pollen–sensitized children who reported food-related allergic symptoms (in total, 122 children) were excluded from the analyses. After this, all associations became nonsignificant and resembled those observed when all children who reported food related allergic symptoms were excluded (OR for the highest vs lowest quartile of total fruit intake in relation to rhinitis, 0.77; 95% CI, 0.55-1.13; *P* for trend, .167). Furthermore, we investigated the association between intake of fruit and vegetables and sensitization to birch pollen. Total fruit consumption was inversely associated with sensitization to birch

TABLE II. Associations between total fruit and total vegetable consumption, respectively, and current allergic disease among 8-year-old children in the BAMSE cohort (n = 2447), where children who reported food-related allergic symptoms were excluded

	Quartiles of consumption								
	1		2		3		4		
	n/N*	Ref	n/N*	OR (95% CI)†	n/N*	OR (95% CI)†	n/N*	OR (95% CI)†	*P* for trend
Total fruit consumption									
Mean frequency of consumption (servings/d ± 1 SD)	0.6 ± 0.2		1.1 ± 0.1		1.7 ± 0.2		3.2 ± 1.3		
All children‡									
Rhinitis	115/598	1.0	98/596	0.88 (0.65-1.19)	86/618	0.72 (0.52-0.98)	71/599	0.62 (0.45-0.86)	.002
Asthma	56/595	1.0	42/595	0.80 (0.52-1.22)	43/614	0.78 (0.51-1.19)	35/600	0.67 (0.43-1.05)	.082
Eczema	112/580	1.0	91/582	0.77 (0.56-1.04)	85/611	0.67 (0.49-0.92)	112/589	0.99 (0.74-1.34)	.787
Atopic sensitization	213/593	1.0	209/595	1.01 (0.79-1.29)	209/610	0.97 (0.76-1.23)	198/596	0.95 (0.75-1.22)	.638
After exclusion‡									
Rhinitis	71/520	1.0	66/536	0.95 (0.66-1.37)	69/568	0.92 (0.64-1.32)	60/551	0.85 (0.58-1.23)	.370
Asthma	44/542	1.0	33/547	0.92 (0.53-1.59)	37/567	1.23 (0.75-2.04)	26/549	1.12 (0.66-1.87)	.457
Eczema	85/504	1.0	73/523	0.79 (0.56-1.11)	78/561	0.79 (0.56-1.11)	96/541	1.07 (0.77-1.48)	.666
Atopic sensitization	180/541	1.0	178/548	1.10 (0.84-1.44)	180/564	1.14 (0.88-1.48)	172/545	1.19 (0.91-1.55)	.200
Total vegetable consumption									
Mean frequency of consumption (servings/d ± 1 SD)	0.9 ± 0.4		1.9 ± 0.2		2.8 ± 0.3		4.4 ± 1.2		
All children‡									
Rhinitis	90/595	1.0	101/603	1.12 (0.82-1.53)	89/605	0.98 (0.71-1.35)	90/610	1.01 (0.74-1.40)	.854
Asthma	48/591	1.0	48/601	0.98 (0.64-1.50)	38/603	0.79 (0.50-1.23)	43/611	0.90 (0.58-1.39)	.451
Eczema	95/579	1.0	96/591	0.98 (0.72-1.34)	100/595	1.01 (0.74-1.38)	110/599	1.15 (0.84-1.55)	.363
Atopic sensitization	197/591	1.0	221/602	1.16 (0.91-1.48)	201/598	1.02 (0.80-1.30)	211/605	1.11 (0.87-1.42)	.647
After exclusion‡									
Rhinitis	64/545	1.0	64/525	1.02 (0.70-1.48)	69/558	1.08 (0.75-1.55)	69/548	1.13 (0.79-1.64)	.469
Asthma	33/534	1.0	41/553	0.80 (0.48-1.32)	32/559	0.73 (0.44-1.22)	35/561	0.94 (0.58-1.54)	.719
Eczema	81/529	1.0	76/514	0.95 (0.67-1.33)	84/548	0.98 (0.70-1.36)	91/539	1.13 (0.81-1.57)	.464
Atopic sensitization	158/535	1.0	190/553	1.07 (0.82-1.39)	177/555	1.02 (0.79-1.33)	186/557	1.15 (0.89-1.49)	.374

Ref, Reference.

*n/N, No. of cases/total no. of children.

†Adjusted for sex, parental socioeconomic status, maternal smoking during pregnancy and/or at baseline, iso-BMI, maternal age at baseline, and parental history of allergic disease.

‡All children = 2447. Exclusions were made of children who reported food-related allergic symptoms (to specific fruits or vegetables; n = 238).

pollen (OR for the highest vs lowest tertile, 0.55; 95% CI, 0.42-0.73; *P* for trend <.001), whereas no significant association was observed for total vegetable consumption (OR for highest vs lowest tertile, 0.89; 95% CI, 0.64-1.24; *P* for trend, .483). The inverse associations with total fruit intake persisted after exclusion of children who reported food-related allergic symptoms (OR for the highest vs lowest tertile, 0.69; 95% CI, 0.50-0.96; *P* for trend, .017).

DISCUSSION

In this study of 2447 boys and girls, we observed inverse associations between total fruit consumption during the past year and rhinitis at 8 years of age. When individual food items were analyzed separately, the strongest and most consistent associations were observed for apples/pears and carrots, which were inversely associated with most of the studied outcomes including atopic sensitization. When combining each outcome with the results of the IgE analyses, the inverse associations observed for consumption of total fruit, apples/pears, and carrots were restricted to children with IgE-mediated disease. To evaluate potential disease-related modification of consumption, children who reported food-related allergic symptoms were excluded from the analyses. After this exclusion, most of the observed inverse associations moved toward null and became nonsignificant, suggesting that disease-related modification of consumption influenced our results (that is, the child's diet changed because of allergic disease/symptoms).

The strengths of the current study include the large number of participants, limited loss to follow-up, detailed information on fruit and vegetable intake, and detailed outcome assessment including information on atopic sensitization measured in serum. Misclassification of exposure could affect our results, because parents and children might find it difficult to remember the frequency of fruit and vegetable consumption during the last year. Despite this, validity of FFQs recording the consumption of fruit and vegetables among children and adolescents has been proven to be relatively good.[28,29] In a validation of the FFQ used in this study, the Spearman correlation coefficients ranged from 0.5 to 0.7 for fruit items and from 0.4 to 0.6 for vegetable items. However, this validation was performed in adults only (Wolk, 1992, unpublished data). Moreover, if misclassification of exposure is nondifferential between children with allergy and other children, it would only lead to underestimation of the true association.

Although we performed our analyses in a prospective cohort, the information on both fruit and vegetable intake and allergic symptoms was collected at the 8-year follow-up. This cross-sectional analysis is a major limitation of the study because children may change their diet as a result of allergic symptoms. Therefore, disease-related modification of consumption may affect our results for several reasons. First, the majority of children in our study also provided a blood sample for analysis of IgE antibodies at 4 years of

TABLE III. Associations between consumption of individual or groups of fruit or vegetables and current allergic disease among 8-year-old children in the BAMSE cohort (n = 2447), where children who reported food-related allergic symptoms were excluded

	Highest vs lowest tertile					
	All children†			After exclusion†		
	n/N*	OR (95% CI)‡	*P* for trend	n/N*	OR (95% CI)‡	*P* for trend
Fruits						
Apples/pears						
Rhinitis	122/976	0.46 (0.35-0.62)	<.001	106/904	0.77 (0.54-1.10)	.244
Asthma	62/973	0.63 (0.42-0.94)	.038	46/893	1.06 (0.63-1.78)	.694
Eczema	157/964	0.76 (0.57-1.02)	.143	134/892	0.80 (0.57-1.11)	.278
Atopic sensitization	316/969	0.69 (0.54-0.87)	.007	267/889	1.07 (0.82-1.41)	.576
Citrus						
Rhinitis	177/1162	0.86 (0.47-0.93)	.310	133/1058	0.92 (0.69-1.22)	.668
Asthma	77/1160	0.83 (0.59-1.19)	.290	64/1072	1.01 (0.66-1.54)	.987
Eczema	178/1140	0.79 (0.62-1.01)	.054	155/1037	0.86 (0.66-1.13)	.262
Atopic sensitization	403/1155	1.03 (0.85-1.25)	.758	354/1068	1.11 (0.90-1.37)	.312
Banana						
Rhinitis	126/798	0.83 (0.62-1.10)	.243	98/729	0.99 (0.72-1.38)	.871
Asthma	56/797	0.71 (0.49-1.05)	.099	41/731	1.01 (0.65-1.59)	.794
Eczema	141/791	0.98 (0.74-1.30)	.990	121/722	1.02 (0.75-1.38)	.795
Atopic sensitization	279/795	0.88 (0.70-1.09)	.306	240/730	0.99 (0.78-1.26)	.978
Berries						
Rhinitis	222/1468	0.74 (0.48-1.14)	.503	161/1324	0.68 (0.42-1.10)	.486
Asthma	104/1462	1.14 (0.58-2.26)	.972	85/1339	1.16 (0.52-2.58)	.959
Eczema	225/1437	0.88 (0.56-1.38)	.083	190/1297	0.77 (0.48-1.22)	.104
Atopic sensitization	494/1458	0.97 (0.68-1.39)	.690	428/1336	0.89 (0.62-1.30)	.711
Vegetables						
Onions/leek						
Rhinitis	165/965	1.31 (0.99-1.73)	.052	117/867	1.28 (0.92-1.76)	.123
Asthma	79/963	1.16 (0.79-1.70)	.424	60/865	1.15 (0.74-1.81)	.525
Eczema	167/942	0.99 (0.76-1.28)	.989	133/845	0.90 (0.68-1.20)	.521
Atopic sensitization	345/951	1.21 (0.98-1.50)	.092	288/857	1.12 (0.89-1.40)	.369
Carrots						
Rhinitis	164/1194	0.64 (0.49-0.84)	.004	126/1091	0.79 (0.57-1.10)	.232
Asthma	73/1192	0.66 (0.45-0.96)	.037	59/1090	0.82 (0.52-1.29)	.397
Eczema	180/1168	0.73 (0.56-0.95)	.024	157/1067	0.79 (0.58-1.06)	.129
Atopic sensitization	387/1181	0.77 (0.62-0.95)	.025	327/1081	0.87 (0.68-1.10)	.263
Cucumber						
Rhinitis	173/1103	0.97 (0.74-1.27)	.974	126/996	1.02 (0.75-1.39)	.808
Asthma	80/1102	0.81 (0.57-1.16)	.352	65/1014	0.86 (0.56-1.31)	.609
Eczema	195/1083	1.18 (0.91-1.55)	.204	158/978	1.18 (0.88-1.59)	.311
Atopic sensitization	380/1093	0.93 (0.76-1.14)	.620	331/1008	0.94 (0.75-1.17)	.756
Tomato						
Rhinitis	153/1051	0.76 (0.58-1.00)	.086	121/973	0.91 (0.66-1.25)	.736
Asthma	70/1053	0.74 (0.51-1.08)	.172	60/978	0.90 (0.57-1.41)	.649
Eczema	179/1036	0.90 (0.69-1.17)	.599	157/958	0.97 (0.72-1.31)	.963
Atopic sensitization	356/1044	0.89 (0.72-1.10)	.395	319/971	0.97 (0.77-1.23)	.940
Lettuce						
Rhinitis	140/907	0.82 (0.61-1.09)	.293	98/801	0.87 (0.62-1.23)	.547
Asthma	68/907	0.87 (0.58-1.30)	.619	60/851	0.75 (0.47-1.21)	.275
Eczema	150/889	0.93 (0.70-1.25)	.632	121/786	0.85 (0.62-1.16)	.356
Atopic sensitization	320/902	0.99 (0.79-1.24)	.877	294/847	0.95 (0.74-1.22)	.812
Cruciferous/green vegetables						
Rhinitis	148/946	0.95 (0.70-1.28)	.894	106/849	0.97 (0.69-1.38)	.973
Asthma	67/946	0.80 (0.53-1.20)	.355	57/863	0.89 (0.55-1.44)	.785
Eczema	173/928	0.96 (0.72-1.28)	.719	139/834	0.87 (0.63-1.18)	.718
Atopic sensitization	323/937	1.06 (0.83-1.34)	.746	278/857	1.11 (0.86-1.43)	.499
Legumes						
Rhinitis	146/980	0.84 (0.63-1.14)	.324	110/889	0.97 (0.69-1.38)	.962
Asthma	55/974	0.56 (0.37-0.84)	.004	44/887	0.61 (0.38-0.98)	.035
Eczema	162/958	0.95 (0.71-1.27)	.756	133/867	0.89 (0.65-1.22)	.507
Atopic sensitization	334/970	0.87 (0.69-1.10)	.359	285/883	0.88 (0.69-1.12)	.447

*n/N, No. of cases/total no. of children.
†All children, N = 2447. Children who reported food-related allergic symptoms (to specific fruits or vegetables) were excluded (n = 238).
‡Adjusted for sex, parental socioeconomic status, maternal smoking during pregnancy and/or at baseline, iso-BMI, maternal age at baseline, and parental history of allergic disease.

TABLE IV. Associations between consumption of total fruit, apples/pears, or carrots and current allergic disease combined with atopic sensitization among 8-year-old children in the BAMSE cohort (N = 2447), where children who reported food-related allergic symptoms were excluded

	Highest vs lowest tertile					
	All children†			After exclusion†		
	n/N*	OR (95% CI)‡	*P* for trend	n/N*	OR (95% CI)‡	*P* for trend
Total fruits						
Rhinitis and no sens	39/801	1.03 (0.64-1.64)	.909	35/735	1.11 (0.67-1.85)	.665
Rhinitis and sens	55/801	0.53 (0.37-0.75)	.001	43/735	0.78 (0.51-1.20)	.289
Asthma and no sens	19/802	1.16 (0.58-2.28)	.691	18/736	1.47 (0.70-3.09)	.330
Asthma and sens	28/802	0.56 (0.34-0.90)	.013	25/736	0.99 (0.57-1.75)	.964
Eczema and no sens	83/791	1.15 (0.81-1.63)	.420	75/725	1.20 (0.83-1.73)	.323
Eczema and sens	53/791	0.71 (0.49-1.05)	.074	42/725	0.83 (0.54-1.29)	.398
Apples/pears						
Rhinitis and no sens	47/966	1.22 (0.68-2.20)	.569	43/894	1.27 (0.69-2.37)	.432
Rhinitis and sens	73/966	0.33 (0.23-0.46)	<.001	61/894	0.64 (0.42-1.00)	.076
Asthma and no sens	21/963	1.26 (0.52-3.00)	.911	19/891	1.57 (0.58-4.26)	.596
Asthma and sens	40/963	0.44 (0.27-0.70)	.002	34/891	0.93 (0.50-1.72)	.935
Eczema and no sens	91/954	0.99 (0.65-1.52)	.967	81/882	1.04 (0.66-1.63)	.906
Eczema and sens	65/954	0.49 (0.33-0.73)	.003	52/882	0.66 (0.41-1.06)	.169
Carrots						
Rhinitis and no sens	52/1179	0.84 (0.51-1.37)	.514	45/1076	0.80 (0.47-1.35)	.425
Rhinitis and sens	110/1179	0.55 (0.40-0.76)	.001	79/1076	0.75 (0.50-1.12)	.224
Asthma and no sens	27/1177	0.98 (0.49-1.94)	.985	24/1074	1.24 (0.56-2.73)	.598
Asthma and sens	45/1177	0.50 (0.32-0.78)	.003	30/1074	0.60 (0.34-1.07)	.090
Eczema and no sens	115/1153	0.92 (0.64-1.35)	.906	106/1052	1.02 (0.69-1.51)	.729
Eczema and sens	63/1153	0.47 (0.32-0.69)	<.001	49/1052	0.52 (0.33-0.81)	.004

Sens, Sensitization.

*n/N, No. of cases/total no. of children.

†All children, N = 2447. Children who reported food-related allergic symptoms (to specific fruits or vegetables) were excluded (n = 238).

‡Adjusted for sex, parental socioeconomic status, maternal smoking during pregnancy and/or at baseline, iso-BMI, maternal age at baseline, and parental history of allergic disease.

age and were informed about the results a few months later. Thus, many parents knew whether their children had raised IgE antibodies against any of the tested inhalant or food allergens. We cannot exclude the possibility that this knowledge influenced which foods the parents gave to their children.

Second, it has previously been shown, by using data from this cohort, that children with food hypersensitivity early in life have an increased risk of allergic rhinitis, asthma, and eczema at 8 years of age.[30] It is plausible that previous or current food hypersensitivity may cause children to change their diets for a long time. Moreover, we had no information about allergic diseases accompanied by diet restrictions in siblings, which could have influenced the child's diet, but by adjusting for parental allergic disease, this problem may be reduced.

Third, birch pollen sensitization is common in Sweden.[20] In our study, sensitization to birch pollen was found in 16% of the children, especially among children with rhinitis (50%), asthma (45%), and atopic sensitization (46%). Some allergens in apples, pears, various stone fruits, carrots, and peanuts have a very similar structure to that of the major birch pollen allergen (Bet v 1), which is why such food may elicit allergic symptoms when consumed.[21] Thus, cross-reactivity between birch pollen and certain fruits and vegetables is very common in birch tree–rich areas, for example parts of Northern Europe and North America. Children sensitized against birch pollen may experience allergic symptoms on consumption of these foods and may therefore avoid them. The detailed assessment of allergic symptoms from specific foods involved in cross-reactions with birch pollen is another strength that allowed us to explore this potential disease-related modification of consumption. The fact that almost all inverse associations observed in our study became nonsignificant when excluding children who reported food-related allergic symptoms shows that disease-related modification of fruit or vegetable intake might affect the observed associations. Further, the results were similar when only birch pollen–sensitized children who reported food-related allergic symptoms (122 children) were excluded. Moreover, when we combined each outcome with atopic sensitization, the protective effect of total fruit consumption, and especially consumption of apples/pears and carrots, was present only among children with IgE-mediated allergic disease.

Although disease-related modification of exposure is likely to be a greater problem in cross-sectional studies, it is plausible that changes in the child's diet caused by the allergic disease, or early symptoms of allergic disease, may also be of importance in prospective studies. However, only 2 previous studies have considered this potential bias.[12,15]

Most previous studies report a protective effect from fruit and/or vegetable consumption.[3-10] Therefore, the associations between fruit intake and rhinitis observed in our study before the exclusions are in line with these results. In our study, consumption of legumes was still inversely associated with asthma after exclusion of children with food-related allergic symptoms. In a cross-sectional Spanish study, high consumption of legumes (pulses) was inversely associated with rhinoconjunctivitis but not with asthma in children 6 to 7 years old.[9] Another Spanish cross-sectional study reported an inverse association between intake of fruity vegetables, including green beans, and wheezing in 5-year-old children, but

because consumption of tomatoes, eggplant, zucchini, and cucumber was also included in the group of fruity vegetables, it is difficult to interpret the effect from single foods.[7]

In summary, our results suggest that disease-related modification of consumption may contribute to explaining the observed inverse associations between intake of specific fruits and vegetables and allergy in children. These results were based on Swedish children and may not be extrapolated to other countries because other allergens and cross-reactivities may occur in other geographic areas. Despite this, disease-related modification of consumption should be taken into account in studies of fruit and vegetable intake in relation to allergic diseases.

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Clinical implications: Children might modify their fruit and vegetable intake as a result of allergic symptoms caused by cross-reactivity with inhalant allergens. This aspect is important to consider when studying diet and allergy.

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