

# Longitudinal Association Between Diet Quality and Asthma Symptoms in Early Adult Life in a Brazilian Birth Cohort

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**Background:** The role of diet in the etiology of asthma is still inconclusive. This paper evaluated the longitudinal association between diet quality and chest wheezing in young adults.

**Methods:** This is a longitudinal study with follow-up information from 18- and 22-year-olds (18y and 22y) of the 1993 Pelotas (Brazil) Birth Cohort. Chest wheezing occurrence and number of events in the last year were reported at 22y. Diet quality was measured with a revised version of the Healthy Eating Index (IQD-R) for the Brazilian population at 18y and 22y by food frequency questionnaire referring to the last 12 months. The diet quality continuity was classified as good (always 1st IQD-R tertile), intermediate (always 2nd tertile/change tertile) and poor (always 3rd tertile).

**Results:** A total of 2986 young individuals were evaluated; 51.4% were female. Prevalence of wheezing at 22y was 10.1% (95% CI: 9.1–11.2), and of these patients, 10% reported at least one event in the past year. Better IQD-R score, both at 18y and at 22y, the lower the odds of wheezing in the past year. Regarding the diet quality continuity from 18y to 22y, staying on a poor diet increased by more than three-fold the odds of chest wheezing (OR=3.28; 95% CI: 1.84–5.84) and of wheezing events (OR=3.32; 95% CI: 1.89–5.85) compared to staying on a good diet, after adjustment for confounding variables.

**Conclusion:** The overall quality of the diet seems to be more important than the individual components in the effect on asthma symptoms. Low-quality diet persistence increased the odds of chest wheezing and the number of events.

**Keywords:** diet, wheezing, asthma, longitudinal studies

## Introduction

Chronic wheezing, caused by reversible bronchospasm, is the main characteristic of asthma, a chronic inflammatory disease that affects more than 300 million people worldwide.<sup>1</sup> In Brazil, asthma is considered a public health problem, and 4.4% (95% CI: 4.1–4.7)<sup>2</sup> of individuals aged 18 years or older, especially women and young adults, reported a medical diagnosis of asthma in a representative sample of the country; in Rio Grande do Sul (RS), this prevalence was approximately 7% (95% CI: 6.8 to 7.2).<sup>2</sup>

Although asthma is a common chronic disease, its etiology and exacerbation mechanisms are poorly understood.<sup>1</sup> The increased prevalence in recent decades has been associated with environmental and behavioral changes,<sup>1,3-5</sup> especially

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changes in dietary habits, with the increase in the consumption of ultra-processed foods together with the decline in the consumption of fruits and vegetables.<sup>4,6–9</sup> The role of diet is related to complex mechanisms underlying the modulation of the acquired or innate immune response, and the effect of the diet varies according to the antioxidant and lipid components of foods.<sup>7,10</sup>

A cross-sectional study conducted in Portugal concluded that asthmatics who consumed at a Mediterranean diet (high consumption of vegetables, legumes, fruits, nuts, whole grains, and unsaturated fatty acids and low meat intake) have reduced risk of exacerbations of the disease.<sup>3</sup> In France, a longitudinal study concluded that a good diet is associated with fewer exacerbations and greater asthma control.<sup>6</sup>

The role of foods and nutrients in the etiology of asthma is still inconclusive, probably due to the complexity of both exposure and disease and therefore their association. It is believed that eating habits are more likely to trigger symptoms rather than to be an etiological factor for the onset of asthma among adults.<sup>3</sup> Most studies assess specific foods or nutrients, and few studies evaluate food consumption as a whole. Since foods are not consumed in isolation, but rather in combination, a complete dietary assessment is needed.<sup>11</sup>

Diet scores have been used to investigate the role of food intake in the prevention of chronic diseases; therefore, the use of diet scores seems to be relevant to the assessment of food intake and exacerbation of asthma symptoms among adults.<sup>6</sup> Specific nutrients or food have not been identified as responsible for exacerbations of asthma.<sup>7,10</sup> Thus, the analysis of diet scores may provide some information on the simultaneous effects of foods and nutrients in asthma-related wheezing events.

The present study aimed to longitudinally evaluate the association between diet quality and wheezing and the number of events in the past year in young adults from the 1993 Pelotas (Brazil) Birth Cohort.

## Methodology

### Type of Study and Population

This was a longitudinal study that used data from the 1993 Pelotas (Brazil) Birth Cohort. More details on the method and follow-ups of the 1993 Cohort can be found in other studies.<sup>12,13</sup>

The original 1993 Cohort consisted of 5249 participants. At 18 years and at 22 years of age, 4106 and 3810

participants were interviewed, respectively. The eligible individuals in this analysis were the participants with valid outcome information at 22 years of age and exposure in the follow-ups at 18 and 22 years of age.

### Dependent Variable

Chest wheezing was measured at 22 years of age. Every time a participant reported having had a wheezing in his/her lifetime (answering “Yes” to “Have you ever had wheezing in your chest?”), they were asked “Since <MONTH> of last year, have you had wheezing in your chest?” (No/Yes). The occurrence of wheezing in the last 12 months was also assessed by the question: “Since last year, how many wheezing events did you have?” and the responses were classified into: none event/1 to 3 events/4 to 12 events/more than 12 events. For this study, the categories were categorized as: none event/1 to 3 events/4 or more events.

### Revised Brazilian Healthy Eating Index (IQD-R)

IQD-R was used to measure diet quality. For this purpose, data on dietary intake, collected using two digital and self-administered semi-quantitative food frequency questionnaires (FFQ) referring to the last 12 months of consumption, were used. A trained instructor guides the participant on how to fill in, on the computer, the FFQ. At age 18, the instrument consisted of 88 food items, and at age 22, of 92 foods. Only foods present in both instruments, which are available at [[http://www.epidemiologia.ufpel.br/site/content/coorte\\_1993/questionarios.php](http://www.epidemiologia.ufpel.br/site/content/coorte_1993/questionarios.php)], were used in the present study.

The IQD-R was constructed from the revised proposal for the Brazilian population of Previdelli et al (2011)<sup>14</sup> and adapted for the present study as done by Castilhos et al (2015).<sup>15</sup> The score consisted of 10 dietary components, the first seven based on the food groups available in the 2006 Brazilian Dietary Guidelines<sup>16</sup> (total grains; milk and dairy products; total fruits; total vegetables; dark-green and orange vegetables; meats, eggs and legumes; oils, oilseeds and fish fat), two nutrient-based components (sodium and saturated fat), and one component on specific dietary items (solid saturated and trans fat, alcohol, and added sugar—called SoFAAS). The score was calculated by summing the scores assigned to all of the components (0 to 10 points), for a maximum total score of 100 points. The higher the IQD-R score, the closer the individual’s diet was to the recommended diet (Table 1).

**Table I** Score of the Revised Version of the Brazilian Healthy Eating Index (IQD-R)

Components	Criterion for Minimum Score	Criterion for Intermediate Score	Criterion for Maximum Score	
			Portions	Points
Total Vegetables	No Consumption 0 points	Proportional Calculation	1.0 portion/1000 kcal	5 points
Dark-green and orange vegetables			0.5 portion/1000 Kcal	
Total fruits			1.5 portion/1000 kcal	10 points
Total grains			3 portions/1000 kcal	
Milk and dairy products			1.5 portions/1000 kcal	
Meat, eggs, and legumes			1.0 portion/1000 kcal	
Oils			0.5 portion/1000 kcal	
Saturated fat	≥ 15% of TEV <sup>a</sup> 0 points	10% of TEV 8 points	≤ 7% of TEV	20 points
Sodium	≥ 2.0 g/1000 kcal 0 points	1 g/1000 kcal 8 points	≤ 0.75 g/1000 Kcal	
SoFAAS <sup>b</sup>	≥ 35% of TEV 0 points	Proportional calculation	≤ 10% of TEV	20 points
<b>TOTAL</b>				<b>100 points</b>

**Notes:** <sup>a</sup>TEV: total energy value; <sup>b</sup>SoFAAS – calories from solid fat, alcohol, and added sugar. Reproduced and translated from Castilhos CB de, Schneider BC, Muniz LC, Assunção MCF. Quality of the diet of 18-year-old adolescents belonging to the birth cohort of 1993 in Pelotas in the State of Rio Grande do Sul, Brazil. *Cien Saude Colet* [Internet]. 2015 Nov;20(11):3309. Creative Commons license and disclaimer available from: <http://creativecommons.org/licenses/by/4.0/legalcode>.<sup>15</sup>

To evaluate the longitudinal association between diet quality and wheezing in the past year and the number of wheezing events, the first step was to categorize the IQD-R score (at 18 and 22 years of age) into tertiles. Tertile 1 of the score was represented by individuals with the lowest scores in the index, being classified as having a poor diet. Tertile 2 consisted of individuals with intermediate scores, who were classified as having an intermediate diet. Tertile 3 consisted of participants whose consumption was close to the ideal according to the recommendations, classified as a good diet. Then, diet quality was assessed longitudinally according to three “continuity” categories (how their category changed or not over time) based on the IQD-R tertiles from age 18 to age 22: 1) poor diet, for those who stayed in tertile 1 of the IQD-R score from 18 to 22 years of age; 2) intermediate diet, for those who at 18 years of age were in the 2nd tertile of the IQD-R score and were in this tertile at age 22 or who changed tertiles in any way (from 1st, 2nd, or 3rd to any other tertile); and 3) good diet, for those who stayed in the 3rd tertile of the IQD-R score from 18 to 22 years of age.

## Confounding Variables

Besides diet, other independent variables were evaluated at 18 years of age: sex (male/female), skin color (white/black/

brown/other), schooling of the participant and of the head of household in years (0–4/5–8/9–11/>12), maternal history of asthma (no/yes), asset index (in quintiles, quintile 1 being the poorest and quintile 5 being the richest), smoking at some point in life (smoking at least once a week—no/yes), alcohol abuse (no/yes) was measured using the Alcohol Use Disorder Identification Test (AUDIT).<sup>17</sup> This test evaluates the alcohol consumption pattern in the last 12 months, through 10 items with response alternatives ranging from 1 to 4 points. Higher scores indicate problems; we used the cutoff point >7 points to indicate alcohol abuse according to Babor et al.<sup>17,18</sup> Physical activity (insufficiently active: <300 minutes per week/active: ≥300 minutes per week), and body mass index (BMI) by age according to WHO 2007<sup>19</sup> criteria and classified in low weight/normal 2At 22 years of age, the use of corticosteroids was also investigated—“In the past three months, did you use any corticosteroid or cortisone for allergy or asthma?” (no/yes)—as was the use of an inhaler for relief of wheezing—“How many times have you used an inhaled medication (or inhaler) to relieve wheezing in the last month?”, with the following response options: none, once a week or less, a few times a week, 1 or 2 times a day, and 3 or more times a day (asked only of those who answered “Yes” to inhaler usage).

## Statistical Analysis

Statistical analyses were performed using Stata software version 15. In the descriptive analyses, Pearson's or Fischer's chi-squared test was performed. Logistic regression was used to assess associations between diet and wheezing, and the relationship between diet and the number of wheezing events was analyzed using ordinal logistic regression.  $P < 0.05$  was considered to signify statistically significant risks (as shown by the odds ratio—OR). In the adjusted analysis, the confounding variables were all inserted at the same hierarchical level, and  $p < 0.20$  was adopted to keep them in the final model.

## Results

Of the 2986 individuals with complete information at both follow-ups, the majority were female (51.4%), white (65.3%), 9 to 11 years of schooling (55.5%), and physically active (60.3%) – [Table 2](#). Approximately 20.0% of the young people reported smoking in their lifetime, and 14.1% of them reported smoking at 18 years of age ([Table 1](#)). [Table 2](#) also presents information about the differences between our sample and the number originally at 18 years of age. Our sample has a slight reduction in the proportion of non-white individuals, who studied between 0 and 8 years, the lowest quintile of the goods index and who smoked. The proportion of overweight/obesity was also slightly lower.

Chest wheezing in the past year was reported by 10.1% (95% CI 9.1–11.2) ( $n=301$ ) of the study sample, with no statistically significant difference between men and women. Approximately 7.0% reported between one and three wheezing events in the past year, and 3.0% reported four or more (data not shown in [Table](#)).

Diet quality was assessed by the median and mean scores of the total IQD-R and its components for the entire sample ( $n=2986$ ) at 18 and 22 years of age, as shown in [Table 3](#). The mean IQD-R was similar at 18 and 22 years of age (62.0 and 61.3, respectively). The lowest IQD-R score was observed for the “dark-green and orange vegetables” component (3.0 points) at 18 years of age, whereas at 22 years of age, the lowest score was observed for the “fruits” component (1.5 points). In regards to tertiles of diet quality, at 18 years, the mean score in the 1st tertile was 48.9 (SD $\pm$ 6.1), in the 2nd tertile was 62.3 (SD $\pm$ 3.1) and in the 3rd tertile was 75.2 (SD $\pm$ 5.4), whereas at 22 years of age, the mean score was 49.4 (SD $\pm$ 5.0), 61.0 (SD $\pm$ 3.1), and 73.6 (SD $\pm$ 5.2), respectively.

The mean score for total IQD-R was lower among participants who reported wheezing in the last year (59.2 [SD $\pm$ 11.5] at age 18 vs 59.1 [SD $\pm$ 10.9] at age 22) ([Table 4](#)). The same was observed for the variable “number of wheezing events”, whose mean score decreased as the category increased. The means of each component of the IQD-R were also evaluated according to the report of wheezing in the chest and number of events in the last year, and it was found that the only component of the index related to the outcomes, at both 18 and 22 years of age, was the SoFAAS, which was lower among those who presented wheezing and those with a higher number of wheezing events ([Table 4](#)).

[Table 5](#) shows the effect of diet quality at 18 years of age, at 22 years of age, and from 18 to 22 years, along with the occurrence of wheezing and the occurrence of wheezing events in the past year as reported by the 22-year-olds. With each 1-point increase in the total IQD-R, both at 18 and at 22 years, there was a reduction of approximately 13% in the odds of presenting with wheezing and having a higher number of wheezing events, respectively. In the analysis of the tertiles of diet quality, there was a 1.97-fold (95% CI: 1.33–2.91) higher odds of having wheezing among those who had a poor diet (1st tertile) than in those who had a diet considered good (3rd tertile) at 18 years of age, and a 1.98-fold higher odds (95% CI: 1.36–2.87) at age 22. Higher odds of wheezing events in the past year were also found in the young adults with diet quality classified as poor at 18 (OR=2.06; 95% CI: 1.40–3.04) and at 22 years of age (OR=1.97; 95% CI: 1.36–2.85).

Regarding the association between continuity in the same tertile of diet quality and the outcomes studied, it was found that staying on a poor diet from ages 18 and 22 increased the odds of having wheezing by more than three-fold (OR=3.28; 95% CI: 1.84–5.84) when compared to the group that was always on a good diet. Regarding the increase in the number of wheezing events in the past year, it was observed that staying on a poor diet increased by 3.3-fold the odds of a higher number of wheezing events compared with the group who stayed on a good diet ([Table 5](#)).

[Supplementary materials](#) are available with results on the relationship between quality diet and chest wheezing and events number at 22 years of age stratified by BMI ([Supplementary Table 1](#)), smoking status at 18 years of age ([Supplementary Table 2](#)) and sensitivity analysis of that association ([Supplementary Table 3](#)).

It was observed that among participants with low weight/adequate BMI, a poor diet at 22 years of age or

**Table 2** Characteristics of 1993 Pelotas (Brazil) Birth Cohort Study Participants

Variables	1993 Birth Cohort				p value
	Baseline		Sample		
	18y Follow-Up		(Valid Information at 18y and 22y)		
	N	%	N	%	
	4106		2986		
Gender					0.314
Male	2015	49.1	1451	48.6	
Female	2091	50.9	1535	51.4	
Skin color					0.028
White	2526	64.2	1894	65.3	
Black	568	14.4	405	14.0	
Brown	697	17.7	490	16.9	
Other	143	3.6	111	3.8	
Head of house schooling (years)					0.049
0–4	1022	26.3	714	25.1	
5–8	1347	34.6	999	35.1	
9–11	993	25.5	743	26.1	
≥12	527	13.5	389	13.7	
Participant schooling (years)					<0.001
0–4	196	4.8	107	3.6	
5–8	1663	41.0	1101	36.9	
9–11	2085	50.8	1657	55.5	
≥12	160	3.9	119	4.0	
Asset index (quintiles)					<0.001
1° (lowest)	837	20.4	534	17.9	
2°	803	19.6	587	19.7	
3°	821	20	614	20.6	
4°	822	20	629	21.1	
5° (higher)	820	20	620	20.8	
Smoking					<0.001
No	3179	77.4	2392	80.1	
Yes	926	22.6	594	19.9	
Alcohol abuse					0.084
No	3020	73.6	2218	74.3	
Yes	1086	26.5	768	25.7	
Physical activity (300min or +/week)					0.187
No	1600	39.1	1185	39.7	
Yes	2495	60.9	1801	60.3	
Body mass index classification					<0.001
Low weight	53	1.3	42	1.4	
Normal weight	2828	71.4	2177	72.9	
Overweight	680	17.2	498	16.7	
Obesity	400	10.1	269	9.0	



**Table 3** Median and Mean of Score Total, Components and Tertiles of Revised Brazilian Healthy Eating Index (IQD-R) at 18 and 22 Years of Age. 1993 Pelotas (Brazil) Birth Cohort. (n=2986)

Diet Quality	18 y			22 y		
	Median	Mean	SD	Median	Mean	SD
<b>IQD-R total score</b>	62.2	62.0	11.9	60.8	61.3	10.9
<b>IQD-R component score</b>						
Fruits	2.3	3.7	3.5	0.8	1.5	1.9
Grains	4.0	5.2	3.0	3.8	4.9	2.9
Milk and dairy products	2.9	3.7	3.0	4.2	4.8	3.1
Meat, eggs, and legumes	8.2	7.7	2.5	9.1	8.1	2.3
Vegetables	4.2	3.4	1.8	5.0	4.0	1.5
Dark-green and orange vegetables	3.3	3.0	2.0	5.0	3.3	2.0
Sodium	9.9	9.3	1.1	10.0	6.6	0.8
Saturated fat	7.9	6.9	2.7	7.1	6.3	2.9
Oils	10	10	0.03	10	10	0.03
SoFAAS <sup>#</sup>	10.1	9.3	8.0	8.7	8.8	7.9
<b>IQD-R tertile score</b>						
1° (poor)	50.3	48.9	6.1	50.5	49.4	5.0
2° (intermediate)	62.4	62.3	3.1	60.9	61.0	3.1
3° (good)	74.3	75.2	5.4	72.6	73.6	5.2

Notes: <sup>#</sup>SoFAAS – calories from solid fat, alcohol, and added sugar.

remaining on a poor diet or intermediate diet from age 18 and 22, increased the odds of having chest wheezing by 1.88-fold (95% CI: 1.21–2.90), 2.52-fold (95% CI: 1.30–4.87), respectively - [Supplementary Table 1](#). Among participants with overweight/obesity BMI, a poor diet at 18 or a poor diet at 22 increased the odds of having chest wheezing by 3.33 (95% CI: 1.53–7.25) and 2.15 (95% CI: 1.01–4.59) compared to participants with a good diet, respectively. Remaining on a poor diet from ages 18 and 22 increased the odds of chest wheezing by more than six-fold at 22 years of age. The increase in the wheezing events number ([Supplementary Table 1](#)) was significantly associated with a poor diet at 18, at 22 or persistence from 18 to 22 years of age in low weight/adequate BMI and overweight/obesity BMI individuals.

As for smoking status ([Supplementary Table 2](#)), it was seen that among nonsmokers, the chance of wheezing at 22 years of age was higher among those who reported a poor diet at 18 (OR=1.74; 95% CI: 1.11–2.72) and at 22 (OR=2.01; 95% CI: 1.30–3.11), in relation to young people with a good diet. In addition, persistence on a poor or intermediate diet increased the odds of wheezing in the chest by approximately 3.5 and 2 times in the last year, respectively. Among smokers, only a poor diet at 18 years of age was associated with higher odds for wheezing at 22 years of age. In relation to the increase in the wheezing events number

among non-smokers, it was associated with a poor diet at 18 and 22 years of age, as well as the continuity in it from 18 to 22 ([Supplementary Table 2](#)). Among smokers, a poor diet or an intermediate diet only at the age of 18 increased the odds of increasing the number of wheezing events by approximately 3.5 and 2.5 times ([Supplementary Table 2](#)).

Additionally, in [supplementary material](#), we show sensitivity analyses about the effect of quality of diet on the effect of the association between quality diet and chest wheezing and events number for participants without the outcome at 18 years of age ([Supplementary Table 3](#)). It was noted that a poor diet at 18 or 22 years of age increased the odds of having chest wheezing at 22 by almost twice. The continuity in a poor diet from 18 to 22 years of age increased the odds of having chest wheezing by approximately three times (OR=2.81; 95% CI: 1.46–5.42). Similar effects were observed for the increase in the number of wheezing events in the last year.

## Discussion

In this study, diet quality in late adolescence and early adulthood was associated with current symptoms of asthma in young adults. A lower score of the component SoFAAS at 18 and 22 years of age was observed among individuals who reported chest wheezing in the 12 months before the interview and among those who reported

**Table 4** Chest Wheezing and Wheezing Events Number Last 12 Months at 22 Years Age According to Mean Score of Total and Components of Revised Brazilian Healthy Eating Index (IQD-R) at 18 and 22 Years Age. 1993 Pelotas (Brazil) Birth Cohort. (n=2986)

Diet quality	Wheezing Last 12 Months at 22y			Wheezing Events Number Last 12 Months at 22y			
	No	Yes	p value	None	1 to 3	≥4	p value
	μ (SD)	μ (SD)		μ (SD)	μ (SD)	μ (SD)	
At 18y							
<b>IQD-R total score</b>	<b>62.3 (11.9)</b>	<b>59.2 (11.5)</b>	<b>&lt;0.001</b>	<b>62.2 (11.9)</b>	<b>60.0 (11.8)</b>	<b>57.8 (11.0)</b>	<b>&lt;0.001</b>
<b>IQD-R component score</b>							
Fruits	3.6 (3.5)	3.4 (3.0)	0.211	3.7 (3.5)	3.4 (3.3)	3.3 (3.3)	0.431
Grains	5.2 (3.0)	4.9 (3.0)	0.179	5.2 (3.0)	5.0 (3.0)	4.9 (2.8)	0.454
Milk and dairy products	3.7 (3.0)	3.4 (3.1)	0.050	3.7 (3.0)	3.3 (3.0)	3.4 (3.2)	0.117
Meat, eggs, and legumes	7.7 (2.4)	7.7 (2.5)	0.877	7.7 (2.4)	7.7 (2.6)	7.6 (2.5)	0.953
Vegetables	3.4 (1.8)	3.4 (1.8)	0.992	3.4 (1.8)	3.4 (1.8)	3.2 (1.9)	0.596
Dark-green and orange vegetables	3.0 (2.0)	3.0 (2.0)	0.939	3.0 (2.0)	3.1 (2.0)	2.6 (2.1)	0.109
Sodium	9.3 (1.1)	9.3 (1.0)	0.765	9.3 (1.1)	9.3 (1.0)	9.2 (1.1)	0.634
Saturated fat	6.9 (2.7)	6.8 (2.8)	0.659	6.9 (2.7)	6.7 (2.8)	7.0 (2.6)	0.590
Oils	10 (0.0)	10 (0.0)	0.623	10 (0.0)	10 (0.0)	10 (0.0)	0.889
SoFAAS <sup>#</sup>	<b>9.5 (7.9)</b>	<b>7.4 (8.0)</b>	<b>&lt;0.001</b>	<b>9.5 (7.9)</b>	<b>8.0 (8.2)</b>	<b>6.5 (7.6)</b>	<b>&lt;0.001</b>
At 22y							
<b>IQD-R total score</b>	<b>61.5 (10.8)</b>	<b>59.1 (10.9)</b>	<b>&lt;0.001</b>	<b>61.5 (10.8)</b>	<b>59.7 (10.6)</b>	<b>58.0 (10.1)</b>	<b>&lt;0.01</b>
<b>IQD-R component score</b>							
Fruits	1.5 (2.0)	1.5 (1.9)	0.859	1.5 (2.0)	1.5 (1.9)	1.5 (2.0)	0.952
Grains	4.9 (2.9)	4.7 (2.9)	0.310	4.9 (2.9)	4.7 (2.9)	4.8 (2.9)	0.423
Milk and dairy products	4.8 (3.1)	4.6 (3.0)	0.242	4.8 (3.1)	4.7 (3.0)	4.3 (3.0)	0.262
Meat, eggs, and legumes	8.1 (2.3)	8.0 (2.4)	0.584	8.1 (2.3)	8.1 (2.4)	7.9 (2.5)	0.727
Vegetables	4.0 (1.5)	3.8 (1.6)	0.171	4.0 (1.5)	3.9 (1.6)	3.7 (1.7)	0.246
Dark-green and orange vegetables	3.3 (2.0)	3.2 (2.0)	0.363	3.3 (2.0)	3.2 (2.0)	3.2 (2.0)	0.695
Sodium	9.6 (0.8)	9.6 (0.9)	0.265	9.6 (0.8)	9.6 (0.9)	9.5 (0.9)	0.386
Saturated fat	6.3 (2.9)	6.3 (3.0)	0.692	6.3 (2.9)	6.3 (3.0)	6.3 (3.0)	0.918
Oils	10 (0.0)	10 (0.0)	0.738	10 (0.0)	10 (0.0)	10 (0.0)	0.947
SoFAAS <sup>#</sup>	<b>9.0 (7.9)</b>	<b>7.4 (7.9)</b>	<b>&lt;0.001</b>	<b>8.9 (7.9)</b>	<b>7.8 (7.8)</b>	<b>6.9 (8.0)</b>	<b>&lt;0.01</b>

Notes: <sup>#</sup>SoFAAS – calories from solid fat, alcohol, and added sugar. Values with significance of p value < 0.05 are shown in bold.

a higher number of wheezing events (≥4) in this period. Similarly, persistence at the lowest tertile of the diet quality score (poor diet) increased the odds of reporting chest wheezing and having a higher number of wheezing events in the past year compared to staying at the highest tertile of diet quality (good diet).

Food intake has been shown to be an important modifiable factor in the development and progression of chronic conditions.<sup>10,20–22</sup> An unbalanced diet increases the risks of obesity and other health complications, as well as of respiratory problems.<sup>20,21,23–25</sup> On this background, the influence of food consumption on the risk of asthma in the various stages of life has been examined in recent decades.<sup>21,22</sup>

Changes in Brazilian food consumption have been experienced in recent decades. Between 2002/03 and 2017/18 there were stability level of purchase of vegetables and an increase in the levels of purchase of prepared foods.<sup>26,27</sup> In parallel, analysis from National Household Sample Survey/PNAD in 2003 and National Health Survey/PNS in 2013 with participants between 18 and 45 years of age showed that the prevalence of self-reported physician diagnosis of asthma increased from 3.6% in 2003 to 4.5% in 2013.<sup>2,28</sup>

There is evidence that adherence to a Western diet, characterized by a high intake of refined grains, processed foods, red meats, and desserts, and which is rich in (proinflammatory) saturated fats and omega-6 fatty acids,

**Table 5** Chest Wheezing and Wheezing Events Number Last 12 Months at 22 Years Age According to Total Score, Components, Tertiles and Continuity of Revised Brazilian Healthy Eating Index (IQD-R) from 18 to 22 Years Age. 1993 Pelotas (Brazil) Birth Cohort. (n=2986)

Diet Quality	Wheezing Last 12 Months at 22y *				Wheezing Events Number Last 12 Months at 22y **			
	Crude		Adjusted		Crude		Adjusted	
	OR	IC <sub>95%</sub>	OR	IC <sub>95%</sub>	OR	IC <sub>95%</sub>	OR	IC <sub>95%</sub>
At 18y								
IQD-R total score	<b>0.98</b>	<b>0.97–0.99</b>	<b>0.99</b>	<b>0.97–0.99</b>	<b>0.98</b>	<b>0.97–0.99</b>	<b>0.99</b>	<b>0.97–0.99</b>
IQD-R tertile score								
1° (poor)	<b>2.21</b>	<b>1.62–3.03</b>	<b>1.97</b>	<b>1.33–2.91</b>	<b>2.17</b>	<b>1.58–2.96</b>	<b>2.06</b>	<b>1.40–3.04</b>
2° (intermediate)	<b>1.71</b>	<b>1.23–2.37</b>	<b>1.54</b>	<b>1.04–2.27</b>	<b>1.65</b>	<b>1.18–2.29</b>	<b>1.53</b>	<b>1.04–2.25</b>
3° (good)	Ref.	-	Ref.	-	Ref.	-	Ref.	-
At 22y								
IQD-R total score	<b>0.98</b>	<b>0.97–0.99</b>	<b>0.97</b>	<b>0.96–0.98</b>	<b>0.98</b>	<b>0.97–0.99</b>	<b>0.97</b>	<b>0.96–0.99</b>
IQD-R tertile score								
1° (poor)	<b>1.61</b>	<b>1.20–2.16</b>	<b>1.98</b>	<b>1.36–2.87</b>	<b>1.59</b>	<b>1.18–2.15</b>	<b>1.97</b>	<b>1.36–2.85</b>
2° (intermediate)	1.12	0.82–1.53	1.38	0.94–2.03	1.13	0.83–1.55	1.39	0.95–2.04
3° (good)	Ref.	-	Ref.	-	Ref.	-	Ref.	-
From 18y to 22y								
IQD-R continuity in tertile								
Always poor (16.9%)	<b>3.09</b>	<b>1.94–4.91</b>	<b>3.28</b>	<b>1.84–5.84</b>	<b>3.03</b>	<b>1.90–4.83</b>	<b>3.32</b>	<b>1.89–5.85</b>
Intermediate (67.1%)	<b>1.92</b>	<b>1.26–2.92</b>	<b>2.13</b>	<b>1.29–3.52</b>	<b>1.85</b>	<b>1.21–2.82</b>	<b>1.99</b>	<b>1.21–3.26</b>
Always good (16.0%)	Ref.	-	Ref.	-	Ref.	-	Ref.	-

**Notes:** Values with significance of p value < 0.05 are shown in bold. \* Logistic regression. \*\* Ordinal logistic regression. Adjustment variables: sex, skin color, assets index, participant schooling, head of a family schooling, maternal history of asthma, alcohol abuse, physical activity, corticosteroid or inhaler use and wheezing at 18 years of age.

hinders the management of asthma.<sup>7,29–31</sup> Conversely, a Mediterranean-like diet, rich in fruits and vegetables which increases the dietary complement of micronutrients, antioxidants (such as carotenoids and flavonoids), and dietary fibers—and in omega-3 fatty acids has been positively correlated with the control of asthma due to its anti-inflammatory effects.<sup>7,9,21,32</sup>

Despite environmental factors, genetic susceptibility, smoke exposure, indoor and outdoor air pollution have a critical role in asthma pathophysiology the oxidative stress and inflammation are central processes in the clinical manifestation of asthma, and diet might be a key factor in this modulation. Low intake of saturated fat in the diet and high intake of dietary fiber have been associated with low neutrophilic and eosinophilic airway inflammation in individuals with asthma.<sup>3,7</sup> A balance in gut microbiota, in particular through an increase in short-chain fatty acids produced by bacteria in the gut during fermentation of insoluble fiber, reduces the

airway inflammation.<sup>32</sup> A greater intake of dietary fiber is largely due to the consumption of fruits and vegetables.

Guilleminault et al<sup>32</sup> conducted a literature review on the relationship between diet and asthma symptoms and concluded that a higher intake of fruits and vegetables is a protective factor for the development of asthma, especially in children. A meta-analysis<sup>33</sup> found that fruit intake was inversely associated with chest wheezing and asthma, with relative risks (RRs) of 0.81 (95% CI: 0.74–0.88) and 0.90 (95% CI: 0.86–0.94), respectively. Vegetable intake was also inversely associated with those outcomes: RR=0.88 (95% CI: 0.79–0.97) and RR=0.91 (95% CI: 0.82–1.00), respectively. In the present study, no relationship was found between the mean score of the components “fruits”, “total vegetables”, and “dark-green and orange vegetables” at 18 and 22 years of age and the report of wheezing in the past year at 22 years of age.



In the present study, the component SoFAAS showed lower means at 18 and at 22 years among the young people who reported wheezing in the past year and among those who reported a larger number of wheezing events ( $\geq 4$ ) in this period. This finding agrees with previous literature. Park et al<sup>30</sup> analyzed the data from the 2013 Behavioral Risk Factor Surveillance System for 146,990 adults ( $\geq 18$  years of age) in the United Kingdom and found that the odds of having current asthma were higher among those who consumed sugary drinks  $\geq 2$  times/day (OR=1.66; 95% CI: 1.39–1.99) than those who did not consume them. Excessive consumption of foods rich in fats and simple sugars, associated with insufficient physical activity, leads to increased body weight. A study in the same birth cohort of Pelotas found that being obese or belonging to the highest tertile of adiposity at two time-points showed a cumulative positive association with chest wheezing. Being in the highest tertile of total fat mass percentage at both follow-ups (measured by dual-energy X-ray absorptiometry) conferred an OR of 1.58 (95% CI: 1.14–2.20) for wheezing, and it conferred an OR of 1.16 (95% CI: 0.92–1.47) for atopy.<sup>34</sup>

The Global Initiative for Asthma Guidelines<sup>1</sup> includes among its recommendations a healthy diet for the primary prevention of asthma. Many studies have focused on the effects of individual foods or nutrients on respiratory outcomes.<sup>9,22,31,32,35</sup> However, this information may not fully capture the overall effect of diet on respiratory health or reflect real-life conditions, where foods or nutrients are consumed in various combinations. According to Varraso et al,<sup>3</sup> dietary components only have an effect on asthma in the context of the overall diet because foods are consumed in complex combinations, which include various nutrients and bioactive substances that interact with each other and influence each other's bioavailability and absorption. People consume a variety of foods and food groups in a meal instead of individual nutrients or food groups.<sup>20,32</sup>

In this context, the diet quality scores are based on the existing nutritional knowledge and have been proposed to evaluate the overall quality of the diet, providing a quantitative measure that takes into account the synergistic effects between nutrients and foods consumed. Similar to the present study, the NutriNet-Santé cohort study in France<sup>6</sup> with 34,766 French adults found that the highest scores in the Alternate Healthy Eating Index-2010, the Literature-based Adherence Score to Mediterranean Diet, and the modified Program National Nutrition Santé Guideline Score were associated with a lower score of asthma symptoms.

Additionally, because the overall quality of the diet seems to be more important than the individual components, keeping up a given diet quality had a significant impact in this study, as the exposure to a low-quality diet over time increased the odds of the participant having wheezing symptoms and recurrence.

To date, few epidemiological studies have been conducted on the association between overall diet scores and the diagnosis of asthma/wheezing in adults, and the level of evidence on this topic is still low. The heterogeneity of dietary assessment between studies hinders the production of strong and consistent evidence. Longitudinal information on the type of dietary exposure that young people experience at the beginning of adulthood is a strength of this study; we were able to assess the exact same information at both time points, using a food frequency questionnaire, which despite being the most frequently used method in epidemiological studies is susceptible to errors (daily variations in food intake, recall bias, the semi-quantitative nature of the evaluation, etc.).

Furthermore, although we have adjusted our statistical model for many factors, including the socioeconomic, we do not measure environmental factors that may increase the chance of triggering asthma symptoms such as live in poor areas with high densities of people or of roadways – that increase pollution air; working conditions and housing for individuals – that can increase contact with allergenic agents.

## Conclusion

Better diet quality was longitudinally associated with a lower occurrence of wheezing and of the number of wheezing events in the 12 months before the interview. Staying on a good diet reduced the occurrence of exacerbations/events of wheezing, while staying on a poor diet increased the odds of having wheezing and the number of wheezing events.

Given the high prevalence of asthma and its effect on individuals and society, it is necessary to identify interventions that can be used to complement conventional therapy and, more importantly, interventions to reduce the likelihood of asthma complications. Dietary interventions, consisting mostly of the encouragement of healthier eating and lifestyle habits based on current guidelines, should be incorporated into the routine clinical management of patients with asthma to achieve general benefits for health and management of the disease. Longitudinal studies should analyze dietary aspects

to better understand the mechanisms involved in the relationship between diet and the occurrence of asthma and its complications.

## Ethics and Consent Statement

All the follow-ups of the Pelotas (Brazil) Birth Cohorts were submitted to and approved by the Ethics Committee of the School of Medicine of the Federal University of Pelotas, and the process number of the follow-ups at 18 and 22 years of age were 5/11 and 1.250.366, respectively. Individuals who agreed to participate signed an informed consent form. The study was conducted in accordance with the Declaration of Helsinki.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Disclosure

Ana Maria Baptista Menezes reports personal fees from AstraZeneca, outside the submitted work. The authors report no other potential conflicts of interest in this work.

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