

Dietary patterns and asthma prevalence, incidence and control

Barros, R.¹, Moreira, A.², Padrão, P.^{1, 4}, Teixeira, VH^{1,3}, Carvalho, P.¹, Delgado, L.², Lopes, C.^{4,5}, Severo, M.^{4,5,6}, Moreira, P.^{1,3}

¹ Faculty of Nutrition and Food Sciences, University of Porto, Porto, Portugal

² Laboratory of Immunology, Basic and Clinical Immunology Unit, Faculty of Medicine, University of Porto, and Immunoallergology Department, Centro Hospitalar São João, Porto, Portugal

³ Research Centre on Physical Activity and Health, University of Porto, Porto, Portugal

⁴ Epiunit - Public Health Institute, University of Porto, Porto, Portugal

⁵ Department Clinical Epidemiology, Predictive medicine and Public Health, Faculty of Medicine, University of Porto, Porto, Portugal

⁶ Department of Medical Education and Simulation Clinical Epidemiology, Predictive medicine and Public Health, Faculty of Medicine, University of Porto, Porto, Portugal

Correspondence:

Renata Barros

Faculty of Nutrition and Food Sciences, University of Porto, Portugal,

Rua Dr. Roberto Frias

4200-465 Porto, Portugal

Telephone: +351 22 5074320

Fax: +351 22 5074329

E-mail: renatabarros@fcna.up.pt

Running Heading: Dietary patterns and asthma

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/cea.12544

This article is protected by copyright. All rights reserved.

Abstract

The increased asthma prevalence in westernized societies has been suggested to be related to environment exposures and lifestyle changes, particularly diet. We aimed to explore the association between dietary patterns and asthma prevalence, incidence and control in a nationally representative population.

Data from 32644 adults, 53% female, from the 4th Portuguese National Health Survey were analysed. Prevalence of asthma was 5.3%; “current asthma”, defined by asthma symptoms within previous year, 3.5%; “current medicated asthma” defined by use of asthma medication within previous year 3.0%; “current severe asthma” defined by emergency visit because of asthma within previous year 1.4%; and “incident asthma” 0.2%. Dietary patterns (DP) were identified by Latent Trait Models based on dietary intake. Unconditional logistic regression models were performed to analyse association between DP and asthma. Age, gender, education, family income, proxy reporting information, smoking, body mass index and physical activity level were analysed as confounders.

Two of the five identified DP were associated with asthma: *‘high fat, sugar and salt’* DP (positively correlated with pastry, chocolate and sweet desserts, candies, salty snacks, chips, fruit juices, soft drinks and alcoholic beverages consumption at snacks) was associated with asthma prevalence (OR=1.13, 95%CI=1.03, 1.24) and current severe asthma (OR=1.23, 95%CI=1.03, 1.48), while *“fish, fruit and vegetables”* DP (positively correlated with fish, vegetables and fruit intake at meals) was negatively associated with current (OR=0.84,

95%CI=0.73, 0.98), and current medicated asthma (OR=0.84, 95%CI=0.72, 0.98), after adjustment for confounders.

Our results suggest a protective association between *“fish, vegetables and fruit”* DP and current and current medicated asthma, and a detrimental association between *“high fat, sugar and salt”* DP and severe asthma prevalence, further supporting the rationale for diet and lifestyle intervention studies in asthma based on whole dietary patterns and physical activity.

Key-words: asthma, control, diet, dietary patterns, prevalence.

Introduction

The increased asthma prevalence in westernized societies has been suggested to be related to environment exposures and lifestyle changes, particularly diet. Actually, some of the western dietary characteristics have been associated with asthma: (1) an increased consumption of processed foods, particularly vegetable oils and margarines, and a decrease in butter, milk and fish intake, increasing the n-6/n-3 polyunsaturated fatty acids (PUFA); and (2) a reduction in vegetables and fruits consumption, decreasing the intake of antioxidant micronutrients [1]. These hypotheses have been supported by epidemiological studies reporting beneficial associations between asthma risk and dietary intake of n-3 PUFA, fish and nuts [2, 3], vitamins and antioxidant rich foods such as fruit and vegetables [1]. However, intervention studies with single foods or nutrients provide conflicting evidence [4-6], reflecting the complexity of dietary

Accepted Article

intake, and suggesting that looking at the whole dietary pattern (DP) is an important shift in approaching the synergistic effects between the interconnected systems of nutrients, foods, food groups, and meal structures. There is scarce evidence on the association between DP and asthma. However, beneficial effects of *Mediterranean diet* on asthma control [7], and symptoms [8] have been reported. In contrast, a “westernized” DP has been associated with asthma symptoms in children [9] and young adults [10], and asthma exacerbations in the E3N female study [11]. Additionally, fast food intake has been associated with asthma symptoms, exercise-induced bronchial hyper responsiveness (BHR) and increased risk of severe asthma in children [12, 13]. Effects of DP on adult asthma are still not clear and even with conflicting evidence [14, 15]. Therefore, we aimed to determine major dietary patterns and their association with measures of asthma prevalence, incidence and control in a nationwide representative adult population.

Material and methods

Participants and study design

Data from the 4th Portuguese National Health Survey (NHS), carried out by the National Institute of Health and National Institute of Statistics (NIS), between 2005 and 2006, was analysed. The methodology of the NHS has been previously described [16, 17]. In summary, the sampling frame was made based on census data and participants were selected from households during that period, using a multi-stage random probability design (hospitals, prisons, military houses and community care institutions were excluded). A representative sample of 41193 participants was included, according to the 7

main Portuguese territorial units (NUTS II), namely *North, Center, Lisbon region, Alentejo, Algarve, Madeira and Azores archipelagos*. The primary sampling unit (PSU) was the housing unit and sampling was based on the population and housing census. Two levels were defined within each NUTSII: the parish (corresponding to townships); and geographically defined units of 240 lodgings (within parish). The PSUs were then randomly selected within each territorial unit, and subjects living in the sampling unit were surveyed. Interviews were conducted in the households by trained staff interviewers, and the questionnaire included information on social and demographic characteristics, health, and chronic diseases including asthma. The survey response rate was 76%, as reported by NIS [16, 17]. For the purposes of this study, a representative subsample of all NHS surveyed adults (≥ 20 years-old) was analysed (32644 participants).

Asthma

The following asthma definitions were used: ever asthma (self-reported ever medical doctor diagnosis of asthma), current asthma (any self-reported asthma symptoms within previous 12 months), current medicated asthma (self-reported use of any asthma drugs within previous 12 months), current severe asthma (self-reported attending an emergency department because of asthma within 12 months), and incident asthma (self-reported medical diagnosis of asthma within previous 12 months).

Dietary intake

Dietary patterns were identified by Latent Trait Models (LTM), based on a list of 20 dichotomous questions ("Did you consumed any of the following foods

yesterday?”), addressing the previous day dietary intake of usual foods and beverages at meals (milk, cheese and yogurt; vegetable soup; bread and cereal products; meat; fish; potatoes, rice and pasta; pulses; vegetables; fruit; and pastry, chocolates or sweet desserts), and snacks (fruit; bread or sandwiches; milk, cheese and yogurt; juices; soft drinks; pastry, chocolates or sweet desserts; other candies; salty snacks; chips; and alcoholic beverages).

Socio-demographic, lifestyle and anthropometry

Age, gender, education, family income, smoking, physical activity level (PAL), weight, height, and body mass index were also addressed by NHS, and analysed as potential confounders.

Body mass index (weight/height²) was calculated based on self-reported weight (kilograms) and height (meters), and categorized according to the World Health Organization BMI Classification [18], in underweight (<18.5 kg/m²), normal weight (18.5-24.9 kg/m²), overweight (25.0-29.9 kg/m²), obesity class I (30.0-34.9 kg/m²), class II (35.0-39.9 kg/m²) and class III (≥ 40.0 kg/m²).

Physical activity level was classified as Low, Moderate and High based on questions from the short version of the International Physical Activity Questionnaire (IPAQ) [19], included in the NHS. The short 7 days self-administered version is a 7-item questionnaire that provides information about frequency and duration of 4 domains: sedentary activity, time spent walking and moderate- and vigorous-intensity PA. Physical activity within domains was estimated by weighting the reported frequency (events per week) by duration (minutes per event) and by a MET level assigned to each activity (Walking =

3.3; Moderate-intensity PA = 4.0; and Vigorous-intensity PA = 8.0). A combined total physical activity was computed as the sum of the activity domains scores (Total PA = Walking + Moderate-intensity PA + Vigorous-intensity PA) and reported as categorical score.

Three categories or levels of physical activity were calculated. High PA (category 3) was defined by any one of the following 2 criteria: vigorous-intensity activity on ≥ 3 days and accumulating at least 1500 MET-minutes/week; or 7 days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week. Moderate PA (category 2) was defined by any one of the following 3 criteria: ≥ 3 days of vigorous activity of at least 20 minutes per day; or ≥ 5 days of moderate-intensity activity or walking ≥ 30 minutes per day; or ≥ 5 of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 600 MET-min/week. Low PA level was defined for those individuals who not meet criteria for categories 2 or 3, and are considered low or inactive.

Statistical analysis

Descriptive analysis, including mean (standard deviation) and proportions, was performed to characterize the sample, and conducted considering the sampling weights.

Dietary patterns were identified by Latent Variable Models [20, 21], based on addressed food items intake at meals and snacks. Latent models can be divided into two frameworks: latent trait models (LTM), which assume that the

latent variables are metrical (factors), and latent class models (LCM) that consider latent variables as categorical (clusters). Latent trait model is a Binary Data Factor Analysis that considers one or more factors. LTM assume that the dietary intake of each individual is explained by one or more factors, usually called 'latent variables'. Interpretation of the model is done considering the standardized factor loadings, which expresses the correlation coefficient between the latent variable and an underlying continuous variable obtained from each food item. Coefficient correlations (r) > 0.350 and < -0.350 were considered for selecting food items. Geominrotation was applied to simplify the standardized factor loadings matrix, and the following criteria to determine the number of latent variables in the model was considered: the model with lowest value in the Bayesian information criteria, the global goodness of fit of the considered latent models assessed through the likelihood ratio test, via parametric bootstrapping (100 samples) and the residuals inspection. Unconditional logistic regression models were performed to analyse whether dietary patterns were associated with asthma prevalence, adjusted for confounders (age, gender, BMI, education, family income, proxy reporting information, smoking and physical activity). A 0.05 level of significance and 95% CI were considered. Data analysis was performed using the statistical package SPSS®, version 18.0 (SPSS Inc., Chicago, IL, USA), and the MPlus (v5.2; Muthen & Muthrn, Los Angeles, California, USA).

Results

The final analysis included 32644 adults, 52.6% female. **Table 1** summarizes socio-demographic characteristics of participants. Prevalence of ever asthma

was 5.3%, current asthma 3.5%, current medicated asthma 3.0%, current severe asthma 1.4%, and incident asthma 0.2%.

Considering dietary patterns analysis, five factors (F) were identified. The goodness-of-fit test suggests that the 5-factor LTM was the best solution, and it was improved after elimination of 2 food items from the 20 initially available and included (meat at meals and bread/sandwiches at snacks). The standardized loadings for the 5-factor latent trait model (LTM) are presented in **Table 2**. F1 (*"dairy and fruit"* DP) was positively correlated with milk and dairy products ($r=0.575$) at meals and snacks, fruit ($r=0.484$) at snacks, and negatively correlated with alcoholic beverages ($r=-0.405$) at snacks. F2 (*"soup and starchy foods"* DP) was positively correlated with vegetable soup ($r=0.526$), bread ($r=0.443$) and pulses ($r=0.432$) at meals. F3 (*"high fat, sugar and salt"* DP) was positively correlated with pastry, chocolate and sweet desserts ($r=0.370$), other candies ($r=0.630$), salty snacks ($r=0.711$), chips ($r=0.918$), fruit juices ($r=0.568$), soft drinks ($r=0.648$), and alcoholic beverages ($r=0.392$) at snacks. F4 (*"fish, fruit and vegetables"* DP) was positively correlated with fish ($r=0.443$), vegetables ($r=0.538$) and fruit ($r=0.448$) at meals. F5 (*"sugary and fatty foods"* DP) was positively correlated with, pastry, chocolate and sweet desserts at meals ($r=0.464$) and snacks ($r=0.395$).

After adjustment for the confounders (age, gender, BMI, education, family income, proxy reporting information, smoking), F3 (*"high fat, sugar and salt"* DP) was associated with ever asthma prevalence (OR=1.13, 95% CI =1.03, 1.24) and current severe asthma (OR=1.23, 95% CI=1.03, 1.48). F4 (*"fish, fruit and vegetables"* DP) was negatively associated with current asthma (OR=0.84, 95%

CI=0.73, 0.98), and current medicated asthma (OR=0.84, 95% CI=0.72, 0.98). The three other identified factors of DP had no significant associations with asthma outcomes (**Table 3** and **Figure 1**).

In the NHS, physical activity was only addressed in 14% of participants. Nevertheless we also performed logistic regression models adjusted for PAL in this subsample. F4 (*“fish, fruit and vegetables”* DP) still remains negatively associated with current asthma (OR=0.61, 95% CI=0.42, 0.89), but not with current medicated asthma (OR=0.77, 95% CI=0.50, 1.165); while F3 (*“high fat, sugar and salt”* DP) was no longer significantly associated with ever asthma prevalence (OR= 1.09, 95% CI=0.85, 1.38) and current severe asthma (OR= 1.14, 95% CI=0.73, 1.79).

Discussion

This study shows a protective association between essential components of a *Mediterranean diet*, such as eating *“fish, vegetables and fruit”*, and asthma prevalence and persistency. In contrast, *“high fat, sugar and salt”* dietary patterns, based on high-energy density/low micronutrient foods are associated with increased prevalence and severity of asthma, independent of other socio-economic and lifestyle factors.

Our study has some limitations. First, it is limited by the cross sectional nature of data not allowing to establish causal relationship. Secondly, dietary intake assessment was based on a checklist of usual foods intake at meals and snacks in the previous 24h, which could be considered less informative than other dietary assessment methods on frequency, portion weight, variety (other

Accepted Article

foods outside the list could have been excluded), and specificity (e.g. milk, cheese and yogurt are aggregated in the same question). Nonetheless, the European Food Safety Authority, recommend 24h diet recall for the collection of national food consumption data in adults [22]. Thirdly, asthma definitions were addressed by self-report use of medication and need of urgent medical care and may not directly represent asthma severity or control. Furthermore, we cannot exclude a recall bias, particularly when defining incident asthma on a retrospective manner. However, this has been the usual approach in large-scale studies assessing asthma and allergic diseases prevalence. Our findings are also supported by important strengths. It is a nationwide representative observational cross-sectional study, with a large sample of adults from both genders addressing DP and asthma. Additionally, this is the first study on asthma that derives DP by LTM analysis [20, 21], which allows an increase in the discrimination of dietary intake and will better support public health dietary recommendations. In addition, the NHS includes important socio-economic and lifestyle confounders regarding diet and asthma, such as age, gender, education, family income, BMI, smoking, proxy reporting information, and physical activity level. Although data of physical activity was available for only 14% participants, logistic regression analysis was performed for these showing that *“fish, fruit and vegetables”* DP still remained negatively associated with current asthma, while *“high fat, sugar and salt”* DP was no longer associated with ever asthma prevalence and current severe asthma. Despite these results cannot be extrapolated for the whole sample, they suggests that a *“fish, fruit and vegetables”* DP may have a protective role on asthma independently of physical activity, while physical activity could modulate the detrimental

association between a “westernized” DP and asthma prevalence and severity [23, 24].

There are few studies addressing diet and asthma by dietary patterns approach, and results have been controversial [15, 25, 26]. However, “fish, fruit and milk” has been previously associated with reduced asthma risk in young adults [10]. Comparison of dietary patterns between studies is complex, due to differences in the socio-geographic characteristics of the studied populations, and the methodological approaches to assess dietary intake and food patterns analysis [27], particularly in cross-sectional studies and with unmeasured confounders. Nevertheless, our findings are consistent with the reported literature, even when different dietary intake assessment methods were applied. In the European Community Respiratory Health Survey II, authors described a potential beneficial effect of fish, fruits and vegetable on current asthma and asthma symptoms [14]. Fish, vegetables and fruit are essential components of *Mediterranean Diet* [28]. We have previously reported that dietary intake of fruit ($\geq 300\text{g}$) was associated with better asthma control in adults [7], and data from ISAAC phase 3 reported also a protective effect of fruit (≥ 3 times/week) on severe asthma in children and adolescents [13]. Dietary intake of fish, fruit, nuts and vegetables has been beneficially associated with asthma outcomes in several epidemiological studies during lifecycle [1-3, 29]. Actually, these foods are rich in n-3 PUFA (EPA, DHA, alpha-linolenic acid), vitamins, minerals and methyl donors. The interaction between all these nutrients, foods and meals in a whole dietary pattern could explain the antioxidant, anti-inflammatory and immunomodulator mechanisms in asthma. In addition, fruit, vegetables, nuts and pulses [30] are also fiber food sources that seems to increase the

Accepted Article

proportion of *Bacteroidacea* in the microbiota. Dietary fiber has effects on the gut microbiota balance, in the short-chain fatty acids (SCFAs) production, including propionate, which potentially reduces AHR and the severity of allergic airway inflammation [31, 32]. These Mediterranean healthful food components [28] can have a favourable impact on several chronic inflammatory diseases [33-35], including reduced asthma risk in prospective studies in children [8], and better asthma control in adults [7]. Nevertheless, intervention studies based on whole healthy dietary patterns are still lacking.

Conversely, we also observed a detrimental association between “*high fat, sugar and salt*” DP and severe asthma prevalence. A “*Western*” DP has been previously associated with asthma symptoms in children [9], young adults [10], and asthma attacks in the E3N female study [11]. In addition, fast food intake has been associated with asthma symptoms, exercise-induced BHR and increased risk of severe asthma in children [12, 13]. Looking to the potential mechanisms, high-total fat meals and high-trans fatty acids meal have been associated with increase airway inflammation in asthmatic patients, resulted by an increase in sputum neutrophils and TLR4mRNA expression in sputum cells, activating the innate immune response. This fat induced inflammation impairs the airway response to bronchodilator and worse clinical outcomes, namely in non-atopic patients [36], suggesting that nutritional intervention strategies aimed at modifying dietary fat may be useful in reducing airway neutrophilia, with clinical impact in asthma control and severity. Early dietary factors could influence on immune programming and atopic march. Nevertheless NHS only provides data on current dietary intake. Recent data shows that certain dietary

Accepted Article

intake behaviors, such as energy dense foods intake and body mass index tend to tracking over the time, and that the consumption of energy-dense foods at young ages is negatively associated with the diet quality of children few years later [37, 38], strengthening the relevance of addressing dietary patterns during pregnancy and early childhood for asthma expression. In addition early feeding practices seems to influence dietary intake of fruits and vegetables in adolescence [39]. Nevertheless, we have no data on dietary intake during pregnancy and childhood, or evidence that dietary patterns in adulthood are exactly the same or reflect the past dietary patterns.

Our study supports the rationale for lifestyle intervention studies in asthma, based on whole dietary patterns that includes fruit, vegetables and fish, such as *Mediterranean* or *prudent healthy* dietary patterns [40], and reduced intake of high energy density/low micronutrient foods, such as “*high fat, sugar and salt*” DP. Moreover, DP approach allows to better understand the interactions between nutrients, foods and meals on asthma, being conceptually easier for dietary recommendations. Incident asthma and poor asthma control are associated with higher medical costs, increased productivity loss, and substantial reduction in quality of life. Therefore, nutritional intervention based on a healthy dietary pattern, adequate body weight maintenance, and regular physical activity could contribute as a low cost public health lifestyle strategy to reduce asthma prevalence and incidence, and improve asthma control management.

In summary, our results suggest a protective association between “*fish, vegetables and fruit*” DP and current and persistent asthma and, conversely, a detrimental association between “*high fat, sugar and salt*” DP and severe

asthma prevalence, independent of other socio-economic and lifestyle factors. These data supports the rational for diet and lifestyle intervention studies in asthma based on whole dietary patterns and physical activity.

Conflict of interest: The authors have no competing interest to disclose.

References

1. Nurmatov, U., G. Devereux, and A. Sheikh, *Nutrients and foods for the primary prevention of asthma and allergy: systematic review and meta-analysis*. J Allergy Clin Immunol, 2011. **127**(3): p. 724-33 e1-30.
2. Barros, R., et al., *Dietary intake of alpha-linolenic acid and low ratio of n-6:n-3 PUFA are associated with decreased exhaled NO and improved asthma control*. Br J Nutr, 2011. **106**(3): p. 441-50.
3. Li, J.J., et al., *Intakes of long-chain omega-3 (n-3) PUFAs and fish in relation to incidence of asthma among American young adults: the CARDIA study*. Am J Clin Nutr, 2013. **97**(1): p. 173-178.
4. Moreno-Macias, H. and I. Romieu, *Effects of antioxidant supplements and nutrients on patients with asthma and allergies*. J Allergy Clin Immunol, 2014. **133**(5): p. 1237-44; quiz 1245.
5. Wood, L.G., et al., *Manipulating antioxidant intake in asthma: a randomized controlled trial*. Am J Clin Nutr, 2012. **96**(3): p. 534-43.
6. Moreira, A., et al., *Pilot study of the effects of n-3 polyunsaturated fatty acids on exhaled nitric oxide in patients with stable asthma*. J Investig Allergol Clin Immunol, 2007. **17**(5): p. 309-13.
7. Barros, R., et al., *Adherence to the Mediterranean diet and fresh fruit intake are associated with improved asthma control*. Allergy, 2008. **63**(7): p. 917-23.
8. Garcia-Marcos, L., et al., *Influence of Mediterranean diet on asthma in children: a systematic review and meta-analysis*. Pediatr Allergy Immunol, 2013. **24**(4): p. 330-8.
9. Tromp, Il, et al., *Dietary patterns and respiratory symptoms in pre-school children: the Generation R Study*. Eur Respir J, 2012. **40**(3): p. 681-9.
10. Takaoka, M. and D. Norback, *Diet among Japanese female university students and asthmatic symptoms, infections, pollen and furry pet allergy*. Respir Med, 2008. **102**(7): p. 1045-54.
11. Varraso, R., et al., *Dietary patterns and asthma in the E3N study*. Eur Respir J, 2009. **33**(1): p. 33-41.
12. Wickens, K., et al., *Fast foods - are they a risk factor for asthma?* Allergy, 2005. **60**(12): p. 1537-1541.

- Accepted Article
13. Ellwood, P., et al., *Do fast foods cause asthma, rhinoconjunctivitis and eczema? Global findings from the International Study of Asthma and Allergies in Childhood (ISAAC) Phase Three*. Thorax, 2013. **68**(4): p. 351-360.
 14. Hooper, R., et al., *Dietary patterns and risk of asthma: results from three countries in European Community Respiratory Health Survey-H*. Brit J Nutr, 2010. **103**(9): p. 1354-1365.
 15. Bakolis, I., et al., *Dietary patterns and adult asthma: population-based case-control study*. Allergy, 2010. **65**(5): p. 606-615.
 16. Instituto Nacional de Estatística IP. *Inquérito Nacional de Saúde 2005/2006* 2009, Instituto Nacional de Saúde Doutor Ricardo Jorge: Lisboa, Portugal. p. 330.
 17. Laires, P.A. and M. Gouveia, *Association of rheumatic diseases with early exit from paid employment in Portugal*. Rheumatology International, 2014. **34**(4): p. 491-502.
 18. World Health Organization, *Obesity: preventing and managing the global epidemic*. WHO Technical Report Series No.894. Geneva (Switzerland), 2000.
 19. Craig, C.L., et al., *International physical activity questionnaire: 12-country reliability and validity*. Med Sci.Sports Exerc., 2003. **35**(8): p. 1381-1395.
 20. Severo, M., et al., *Diagnostic value of patterns of symptoms and signs of heart failure: application of latent class analysis with concomitant variables in a cross-sectional study*. BMJ Open, 2012. **2**(6).
 21. Severo, M., et al., *Assessment of the general public's knowledge about rheumatic diseases: evidence from a Portuguese population-based survey*. BMC Musculoskelet Disord, 2010. **11**: p. 211.
 22. (EFSA), E.F.S.A., *General principles for the collection of national food consumption data in the view of a pan-European dietary survey*. EFSA Journal, 2009. **7**(12): p. 51.
 23. Verlaet, A., et al., *Physical activity in adults with controlled and uncontrolled asthma as compared to healthy adults: a cross-sectional study*. Clin Transl Allergy, 2013. **3**(1): p. 1.
 24. Silva, D., et al., *Physical training improves quality of life both in asthmatic children and their caregivers*. Ann Allergy Asthma Immunol, 2013. **111**(5): p. 427-428.
 25. Lange, N.E., et al., *Maternal dietary pattern during pregnancy is not associated with recurrent wheeze in children*. J Allergy Clin Immunol, 2010. **126**(2): p. 250-5, 255 e1-4.
 26. Miyake, Y., et al., *Maternal dietary patterns during pregnancy and risk of wheeze and eczema in Japanese infants aged 16-24 months: the Osaka Maternal and Child Health Study*. Pediatr Allergy Immunol, 2011. **22**(7): p. 734-41.
 27. Varraso, R., et al., *Assessment of dietary patterns in nutritional epidemiology: principal component analysis compared with confirmatory factor analysis*. American Journal of Clinical Nutrition, 2012. **96**(5): p. 1079-1092.
 28. Bach-Faig, A., et al., *Mediterranean diet pyramid today. Science and cultural updates*. Public Health Nutr, 2011. **14**(12A): p. 2274-84.
 29. Romieu, I., et al., *Maternal fish intake during pregnancy and atopy and asthma in infancy*. Clin Exp Allergy, 2007. **37**(4): p. 518-25.

30. Marinangeli, C.P. and P.J. Jones, *Pulse grain consumption and obesity: effects on energy expenditure, substrate oxidation, body composition, fat deposition and satiety*. Br J Nutr, 2012. **108 Suppl 1**: p. S46-51.
31. Leavy, O., *Diet and airway inflammation*. Nature Reviews Immunology, 2014. **14**(2): p. 64-65.
32. Trompette, A., et al., *Gut microbiota metabolism of dietary fiber influences allergic airway disease and hematopoiesis*. Nat Med, 2014. **20**(2): p. 159-166.
33. Shai, I., et al., *Weight loss with a low-carbohydrate, Mediterranean, or low-fat diet*. N Engl J Med, 2008. **359**(3): p. 229-41.
34. Sofi, F., et al., *Accruing evidence on benefits of adherence to the Mediterranean diet on health: an updated systematic review and meta-analysis*. Am J Clin Nutr, 2010. **92**(5): p. 1189-96.
35. Kastorini, C.M., et al., *The effect of Mediterranean diet on metabolic syndrome and its components: a meta-analysis of 50 studies and 534,906 individuals*. J Am Coll Cardiol, 2011. **57**(11): p. 1299-313.
36. Wood, L.G., M.L. Garg, and P.G. Gibson, *A high-fat challenge increases airway inflammation and impairs bronchodilator recovery in asthma*. J Allergy Clin Immunol, 2011. **127**(5): p. 1133-40.
37. Vilela, S., et al., *The influence of socioeconomic factors and family context on energy-dense food consumption among 2-year-old children*. Eur J Clin Nutr, 2015. **69**(1): p. 47-54.
38. Durao, C., et al., *Evaluating the effect of energy-dense foods consumption on preschool children's body mass index: a prospective analysis from 2 to 4 years of age*. Eur J Nutr, 2014.
39. de Lauzon-Guillain, B., et al., *The influence of early feeding practices on fruit and vegetable intake among preschool children in 4 European birth cohorts*. Am J Clin Nutr, 2013. **98**(3): p. 804-12.
40. Sherzai, A., et al., *Stroke, food groups, and dietary patterns: a systematic review*. Nutr Rev, 2012. **70**(8): p. 423-35.

Figure 1. Association between dietary patterns and asthma prevalence, incidence and control

Figure legend:

Unconditional logistic regression models adjusted for gender, age, bmi, education, family income, proxy reporting information and smoking. DP: Dietary patterns; aOR: adjusted Odds Ratio; p-value ≤ 0.05

Tables and figures

Table 1. Characteristics of participants

	Total (n = 32644)
Gender, female (%)	52.4
Age (%)	
20 – 39 y	37.8
40 – 64 y	40.5
65 – 84 y	19.8
≥ 85 y	1.9
Education (%)	
None	12.7
1 st cycle	34.1
2 nd and 3 rd cycles	27.8
High school	12.2
College	13.1
Family income (%)	
≤ 500 /month	23.7
501 – 1200 /month	44.1
1201 - 2000 /month	20.0
> 2000 /month	12.2
Proxy reporting information (%)	29.8
Asthma prevalence (%)	
Ever asthma	5.3
Incident asthma	0.2
Current asthma	3.5
Current medicated asthma	3.0
Current severe asthma	1.4
BMI Classes (%)	
Underweight and normal weight	46.4
Overweight	37.6
Obesity classes I and II	15.2
Obesity class III	0.8
Level of Physical activity* (%)	
Low	39.0
Moderate	46.1
Hight	14.9
Smoking (%)	
Current smoker	21.4
Past smoker	16.8

Data presented as proportions (%), and sample weighted pond 1; *Level of physical activity (pond 4)

Table 2. Standardized loadings for the 5-factor latent trait model (LTM) with the food items intake

LTM						
Food-items	5-factors Model					
	Total n=32644	Z1 (r)	Z2 (r)	Z3 (r)	Z4 (r)	Z5 (r)
Meals						
Milk, cheese and yogurt	85.7%	0.58	0.05	-0.04	0.0.	0.28
Vegetable soup	69.0%	0.26	0.53	-0.02	0.03	-0.04
Bread and cereal products	94.2%	0.02	0.44	0.00	-0.01	0.35
Meat*	76.6%	-	-	-	-	-
Fish	49.8%	-0.02	-0.06	0.00	0.44	-0.02
Potatoes, rice and pasta	87.5%	-0.08	0.12	0.09	0.21	0.23
Pulses	22.6%	-0.04	0.43	0.23	0.01	0.01
Vegetables	69.9%	0.16	-0.01	0.01	0.54	0.00
Fruit	81.9%	0.22	0.07	-0.05	0.45	0.14
Pastry, chocolates or sweet dessert	23.7%	-0.06	0.00	0.37	0.06	0.46
Snacks						
Fruit	41.2%	0.48	0.05	0.15	0.17	-0.20
Bread or sandwiches*	43.8%	-	-	-	-	-
Milk, cheese and yogurt	36.8%	0.70	-0.11	0.23	-0.01	-0.04
Juices	10.1%	0.16	-0.02	0.57	0.00	0.06
Soft drinks	4.4%	0.02	0.09	0.65	-0.11	0.02
Pastry, chocolates or sweet desserts	10.0%	0.03	-0.16	0.56	-0.02	0.40
Other candies	3.1%	0.04	-0.17	0.63	-0.04	0.15
Salty snacks	3.0%	-0.19	0.00	0.71	0.22	-0.04
Chips	1.3%	0.02	0.05	0.92	0.00	-0.02
Alcoholic beverages	10.6%	-0.41	0.04	0.39	0.05	-0.13

LTM: Latent trait model. *Food-items removed from the LTM analysis. Five factors (Z) were identified by latent trait model ($r > 0.35$): factor 1 (positive correlated with milk and dairy products, fruit and negative with alcoholic beverages in snacks); factor 2 (positive correlated with vegetable soup, bread, pulses); factor 3 (positive correlated with pastry, chocolate and sweet desserts, other candies, salty snacks, chips, fruit juices, soft drinks and alcoholic beverages at snack); factor 4 (positive correlated with fish, vegetables and fruit at meals); and factor 5 (positive correlated with pastry, chocolate and sweet desserts).

Table 3. Association between dietary patterns and asthma prevalence, incidence and control

Dietary Patterns	Ever Asthma		Current Asthma		Current Medicated Asthma		Current Severe Asthma		Incident Asthma	
	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)	p
"Dairy and fruit" DP	0.94 (0.86; 1.02)	0.147	0.96 (0.86; 1.06)	0.412	0.99 (0.89; 1.11)	0.901	0.85 (0.71; 1.01)	0.061	1.21 (0.70; 2.09)	0.501
"Soup and starchy foods" DP	0.95 (0.83; 1.08)	0.404	1.01 (0.87; 1.18)	0.882	1.02 (0.87; 1.20)	0.773	0.87 (0.68; 1.12)	0.282	1.81 (0.79; 4.17)	0.163
"High fat, sugar and salt" DP	1.13 (1.03; 1.24)	0.010	1.10 (0.98; 1.23)	0.094	1.05 (0.93; 1.19)	0.405	1.23 (1.03; 1.48)	0.024	1.14 (0.63; 2.06)	0.659
"Fish, fruit and vegetables" DP	0.92 (0.82; 1.05)	0.218	0.84 (0.73; 0.98)	<0.001	0.84 (0.72; 0.98)	0.030	0.88 (0.68; 1.12)	0.308	0.79 (0.36; 1.73)	0.552
"Sugary and fatty foods" DP	1.01 (0.90; 1.13)	0.889	1.01 (0.89; 1.16)	0.844	1.06 (0.92; 1.22)	0.444	0.96 (0.77; 1.19)	0.695	0.82 (0.40; 1.72)	0.607

Unconditional logistic regression models adjusted for gender, age, BMI, education, family income, proxy reporting information and smoking. DP: Dietary patterns; aOR: adjusted Odds Ratio; p-value ≤ 0.05

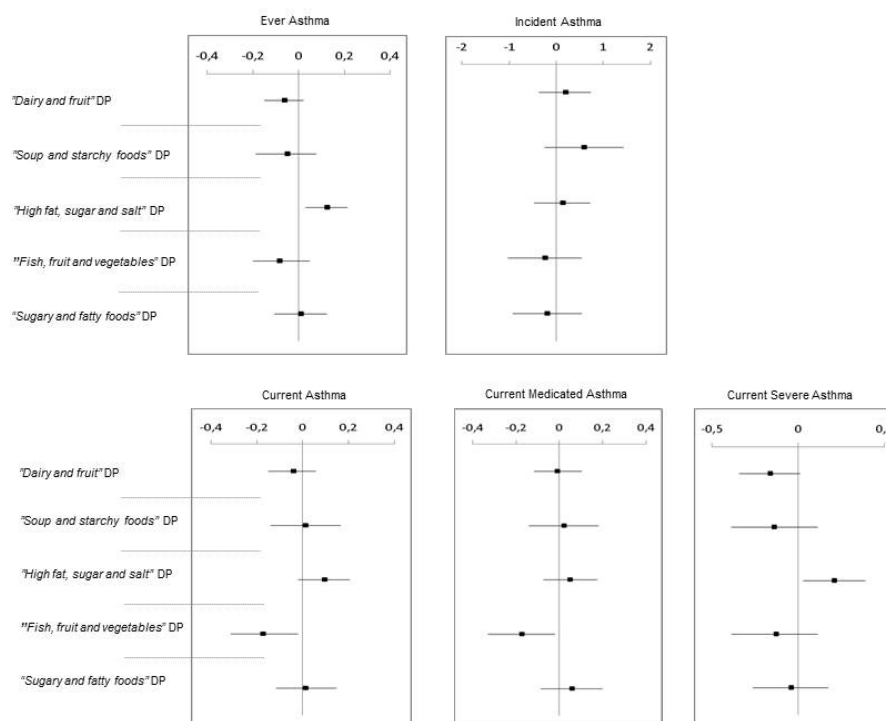


Figure1. Association between dietary patterns and asthma prevalence, incidence and control

Unconditional logistic regression models adjusted for gender, age, bmi, education, family income, proxy reporting information and smoking. DP: Dietary patterns; aOR: adjusted Odds Ratio; p-value ≤ 0.05 .