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Plant-based and vegetarian diets are associated with reduced obstructive sleep apnoea risk

Yohannes Adama Melaku[1,2*], Lijun Zhao[3], Robert Adams[1], Danny J. Eckert[1]

[1]FHMRI Sleep Health (Adelaide Institute for Sleep Health), College of Medicine and Public Health, Flinders University, Bedford Park, South Australia, Adelaide, Australia
[2]Cancer Epidemiology Division, Cancer Council Victoria, Victoria, Melbourne, Australia
[3]Adelaide Medical School, Faculty of Health and Medical Science, The University of Adelaide

***Corresponding Author:**
Dr Yohannes Adama Melaku
yohannes.melaku@flinders.edu.au;
Mark Oliphant Building, L2, 5 Laffer Drive
Bedford Park 5042, South Australia, Australia
Phone number: +61 8 74219746; Adelaide, Australia

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Take home message
While a healthy plant-based dietary index (PDI) is linked to a reduced risk of obstructive sleep apnea (OSA), an unhealthy PDI increases the risk. These associations vary between males and females. Further longitudinal studies are warranted.

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Yohannes Adama Melaku: Conceived the study, analysed the data and wrote the first draft
Lijun Zhao: Wrote the first draft and critically reviewed the manuscript
Danny Eckert: Overall supervision, conceived the study and critically reviewed the draft
Robert Adams: Overall supervision, cconceived the study and critically reviewed the draft

Abstract

Introduction: Obstructive sleep apnea (OSA) and obesity commonly coexist. Weight loss and exercise are recommended management options for OSA. However, most of the current evidence on diet and OSA is focused on calorie restriction rather than diet quality.

Aim: To determine the association of plant-based dietary indices (PDI) with OSA risk.

Methods: Cross-sectional data from 14,210 participants of the National Health and Nutrition Examination Survey who provided dietary information using the 24-hour recall method were used. PDI– including healthy (hPDI), unhealthy (uPDI) and pro-vegetarian diet index (PVDI) – were determined. OSA risk was determined using the STOP-BANG questionnaire. Logistic regression was used to determine the relationship between dietary indices and OSA risk.

Results: Higher adherence to PDI (odds ratio $[OR]_{Q5\ vs.\ Q1}$=0.81; 95% confidence interval (CI): 0.66-1.00), hPDI (OR=0.83; 95% CI: 0.69-1.01) and PVDI (OR=0.84; 95% CI: 0.68-1.05) was inversely associated with OSA risk, whereas a higher consumption of unhealthy plant-based diet (OR=1.22; 95% CI: 1.00-1.49) was positively associated with OSA. Sex differences in estimates were observed for PDI in males (OR=0.71; 95% CI: 0.56-0.90) versus females (OR=0.93; 95% CI: 0.68-1.28), hPDI in males (OR=0.90; 95% CI: 0.68-1.18) versus females (OR=0.77; 95% CI: 0.54-1.09), and uPDI in males (OR=1.13; 95% CI: 0.89-1.44) versus in females (OR=1.42; 95% CI: 1.03-1.97) but not for PVDI.

Conclusions: Higher adherence to a healthy PDI is associated with reduced OSA risk, while an unhealthy plant-based diet has a positive association. The magnitude of these associations differed by sex. Further longitudinal studies are warranted.

Key words: sleep disordered breathing, healthy diet, lifestyle, weight loss.

Introduction

Almost one billion people worldwide are estimated to have obstructive sleep apnea (OSA) [1], a condition that triples the risk of cardiometabolic diseases [2], such as cardiovascular disease (CVD) [3], diabetes [4] and mortality [5]. The primary predictor of OSA is obesity, especially central obesity [6]. Effective treatment to reduce OSA severity includes lifestyle modifications, such as weight loss through exercise and diet [7, 8].

Most dietary intervention studies focused on OSA have emphasized weight reduction via caloric restriction and specific dietary elements [8-10], rather than holistic dietary patterns. In addition, a considerable portion of research in this domain is derived from secondary evaluations of randomized clinical trials. For instance, the Positive Pressure Long-term Efficacy Study (APPLES study) identified associations between certain dietary constituents, such as protein and total fat, and OSA [11, 12]. Another longitudinal investigation involving OSA patients showed links between diet inflammatory properties and sleep metrics [13]. Although these studies have focused on the influence of specific dietary elements, dietary patterns based on plant-based diets may have potential effect on OSA risk via different mechanisms, including reduced inflammation and adiposity [14-16]. Thus, considering overall adherence to a plant-based diet and investigating its association with OSA risk is crucial to design appropriate control and prevention strategies.

Despite considerable variation among studies, healthy plant-based diets, defined by a low frequency of animal food consumption, have been shown to reduce the risk of developing CVD [17], obesity [15, 18], and type 2 diabetes [19]. High quality nutrients in plant-based diets is one of the factors for reduced risk of these metabolic conditions [20] through weight loss [18], enhanced glycemic control [18], better blood pressure regulation [21], improved lipid profiles, diminished low-grade inflammation [22] and a healthier gut microbiota [23]. However, certain plant-based diets characterized by refined grains, high sugar and salt content are associated with adverse outcomes and as such, may be considered “unhealthy” [24].

In a randomized clinical trial of 89 overweight or obese men with moderate to severe OSA, an 8-week interdisciplinary weight loss and lifestyle intervention (including healthy dietary intervention) reduced OSA severity [25]. Similarly, a clinical trial found a clinically meaningful decrease of ~4 points on the Epworth Sleepiness Scale (ESS) after switching from a standard Western diet to a whole-food plant-based diet for 21 days in 14 OSA patients [26]. However, no population-based studies have examined the association of plant-based and vegetarian diets with OSA risk. In this study, we determined a plant-based dietary index (PDI), healthy PDI (hPDI), unhealthy PDI (uPDI), and a pro-vegetarian diet index (PVDI) [19, 27, 28] to investigate their associations with OSA risk.

Methods

Study design and population

Data from the National Health and Nutrition Survey (NHANES) were used. NHANES is an ongoing study that gathers nationally representative data in the United States. The data can be accessed through the National Center for Health Statistics website, where users can download the datasets [29]. Data were obtained through interviews, medical assessments, and laboratory investigations. For this study, we utilized data from four cycles of the NHANES study (2005-2008 & 2015-2018), which included a total of 39,722 participants. Data from 14,210 participants were used for analysis (**Figure 1**). The National Center for Health Statistics Ethics Review Board granted ethical clearance for the NHANES study [30]. Additional ethical approval for this specific study was obtained from the Flinders University Human Research Ethics Committee (6547).

Assessment dietary intake

Dietary data were collected in each cycle of NHANES using a 24-recall method. A more detailed description of the methods can be found elsewhere [31]. Briefly, the US Department of Agriculture's (USDA) Automated Multiple-Pass Method was used to collect dietary data over two days (first face-to-face and second via telephone) for the 2005-2007 and 2015-2018 cycles. For this study, we only used dietary data collected during the face-to-face interview on

the first day. The micro- and macronutrient contents of the food were determined using the USDA Food and Nutrient Database for Dietary Studies (FNDDS) [31]. Additionally, the participants' data was linked to the USDA's Food Patterns Equivalents Database, which disaggregates foods and beverages into 37 USDA Food Patterns components [32].

Plant-based dietary index (PDI) and pro-vegetarian dietary index (PVDI)

We calculated 4 plant-based diet indices (PDI, hPDI, uPDI, and PVDI). A detailed description of the calculation of each diet index has been provided in previous studies [19, 27, 28]. Briefly, 18 food groups for the PDI, hPDI, and uPDI and 12 food groups for PVDI (**Supplementary Table 1**) were used. These food groups were categorized as healthy plant foods (whole grains, fruits, vegetables, nuts, legumes, tea and coffee), less-healthy plant foods (refined grains, potatoes, sugar-sweetened beverages, sweets and desserts, salty foods), and animal foods (animal fat, dairy, eggs, fish or seafood, meat, miscellaneous animal foods) for the PDI, hPDI, and uPDI. Plant foods (grains, fruits, vegetables, nuts, legumes, potatoes) and animal foods (animal fat, dairy, eggs, fish or seafood, meat) were used for PVDI.

The 18 food groups were divided into deciles of consumption, and each decile was assigned a score between 1 and 10. For PDI, participants received a score of 10 for each plant food group for which they were above the highest decile of consumption, a score of 9 for which they were above the second highest decile but below the highest decile, and so on, with a score of 1 for consumption below the lowest decile (positive scores). On the other hand, participants received a score of 1 for each animal food group for which they were above the highest decile of consumption and so on (reverse scores). For hPDI, positive scores were given to healthy plant food groups, and reverse scores to less healthy plant food groups and animal food groups. For PVDI, we used the same approach as hPDI. For uPDI, positive scores were given to less healthy plant food groups, and reverse scores to healthy plant food groups and animal food groups. The 18 food group scores for an individual were summed to obtain the indices, with a possible score range of 18 (lowest possible score) to 180 (highest possible score). The indices were analysed as quintiles, with energy intake adjusted in our models.

Sleep apnea risk

The STOP-BANG tool (Snoring, Tired, Observed (Snort), Pressure (blood pressure), Body mass index (BMI), Age, Neck, Gender) was used to assess the risk of sleep apnea [33]. **Supplementary Table 2** provides details on the assessment methods, the scoring criteria and frequency. More detailed explanation of how questions from NHANES were used, scores were constructed, and review of sensitivity and specificity of the STOP-BANG tool can be found in our previous work [16, 34]. As there were no data on neck circumference, waist circumference was used as a substitute. Neck and waist circumference are highly and significantly correlated (r= 0.64) [35]. The STOP-BANG score ranges from 0 to 8, with scores of 2 or lower considered low risk, scores of 3 to 4 considered intermediate risk, and scores of 5 or higher considered high risk. In addition, a score of 2 or higher AND meeting one of the following criteria – male gender, BMI >35, or waist circumference >102 cm for males or >88 cm for females – was considered high risk [33]. High versus low/intermediate OSA risk category was used in the main analysis. Sensitivity analysis based on OSA50 and STOP was described in the **supplementary Method**.

Covariates

Various sociodemographic characteristics (age, sex, race, marital status, income), behavioral factors (smoking, physical activity, sleep duration, and alcohol consumption), and chronic conditions (CVD, cancer, and diabetes) were taken into account in our analyses. **Supplementary Table 3** provides details on the assessment methods and units used for each variable.

Statistical analysis

Our analyses accounted for the complex survey design using NHANES-assigned weights, population sampling units, and strata. To summarize categorical and continuous variables, we used frequency, mean (SD), and median (interquartile range). We used generalized linear regression with binomial family and link function to determine the association of dietary indices

with OSA. Four models were developed: model 1 adjusted for sociodemographic characteristics (sex, age, race, marital status, education, and income) and energy intake; model 2 additionally adjusted for smoking, physical activity, and alcohol consumption; model 3 additionally adjusted for CVD, cancer, and diabetes; and model 4 additionally adjusted for sleep duration. As some of the covariates could mediate rather than confound the association of diet and OSA, the model-based approach provided more insight into how these variables affected the estimates with and without their inclusion. We also used restricted cubic splines (3 knot) to determine the association of PDI, hPDI, uPDI, and PVDI (as continuous variables) with OSA. We determined the significance for non-linearity using the likelihood ratio test. All analyses were performed using STATA 16.0 and R (R Foundation for Statistical Computing; Vienna, Austria). We conducted several sensitivity analyses to further explore the association between diet and OSA risk (**Supplementary method**).

Results

Participant characteristics

Half (49.4%) of participants were male. Insufficient physical activity was reported by 32.8% of the participants, while 20.5% were current smokers. The prevalence of snoring was 28.5%. Based on the STOP-BANG score, 50.5% of participants had intermediate to severe risk of sleep apnea, while 25.1% were classified as high risk (**Table 1**). The mean (SD) of the dietary constructs are provided in **Table 1**, while the distribution of dietary indices is presented in **Supplementary Figure 1**.

Association of PDI and PVDI with sleep apnea risk

Participants in the fifth (highest) quintile of PDI had 19% lower odds (OR=0.81; 95% CI: 0.66-1.00) of sleep apnea risk compared to those in the first quintile (p for trend = .008). Participants in the fifth quintile of hPDI had 17% lower odds (OR=0.83; 95% CI: 0.69-1.01) of sleep apnea risk, while those in the fifth quintile of uPDI had 22% higher odds (OR=1.22; 95% CI: 1.00-1.49) of sleep apnea risk, compared to those in the first quintile. We also found that higher adherence of the Pro-vegetarian diet (higher PVDI) was associated with a lower risk of OSA (**Table 2)**.

Non-linearity test on the association between the dietary constructs and OSA risk was not significant (**Figure 2**).

Association of PDI and PVDI with sleep apnea risk by sex

Differences in estimates were observed for PDI (OR=0.71; 95% CI: 0.56-0.90 in males versus OR=0.93; 95% CI: 0.68-1.28 in females), hPDI (OR=0.90; 95% CI: 0.68-1.18 in males versus OR=0.77; 95% CI: 0.54-1.09 in females), and uPDI (OR=1.13; 95% CI: 0.89-1.44 in males versus OR=1.42; 95% CI: 1.03-1.97 in females) but not for PVDI (**Table 3)**.

Non-linear tests on the associations between the dietary constructs and OSA risk with respect to sex were not significant (**Figure 3**).

Sensitivity analyses

The results reveal significant inverse associations of PDI, hPDI, and PVDI with both STOP and STOP-BANG scores (as count), while positive associations were found with uPDI **(The supplementary tables 4 and 5)**. The use of intermediate and high-risk STOP-BANG scores to indicate OSA-risk did not alter the findings (**Supplementary Table 6**). However, when self-reported doctor diagnosed OSA was used (**Supplementary Table 7**), the associations of different dietary indices with OSA (N=6998) had wider confidence intervals. With the exception of reported snort, the other components of STOP-BANG (Snore, Tiredness, Hypertension, BMI and waist circumference) were found to have inverse associations with PDI, hPDI, and PVDI. Conversely, uPDI showed positive associations with STOP-BANG components (**Supplementary Table 8**). The results of the associations between dietary indices and sleep apnea remained consistent when the OSA50 tool was used to determine apnea risk (**Supplementary Table 9**).

Discussion

Our findings demonstrate the role of plant-based dietary indices in influencing OSA risk. Specifically, participants with the highest adherence to a general and healthy plant-based diet (PDI and hPDI, respectively) have markedly reduced odds of OSA risk compared to their counterparts with the lowest adherence. Conversely, high adherence to uPDI is associated with increased odds of OSA risk. The association with PVDI further supports the potential protective role of certain vegetarian-leaning dietary patterns. A sex difference is observed regarding hPDI and uPDI; females exhibit decreased odds of OSA risk associated with higher adherence to hPDI, whereas they show increased odds of OSA risk with uPDI, a trend not

observed in males. Overall PDI is primarily associate with reduced odds of OSA risk in males, not females. This suggests potential sex-specific mechanisms or susceptibilities that warrant further exploration.

Limitation of the study

There are limitations that should be considered when interpreting our results. The cross-sectional nature of the study prevents us from inferring causality between dietary indices and OSA risk. Moreover, the reliance on 24-hour recall data for dietary information may not be indicative of typical consumption patterns and might introduce recall biases. Although the STOP-BANG criteria employed to assess OSA is not the standard diagnostic tool, it has been well validated and widely accepted as a risk tool, and has high sensitivity [33, 36]. We also used OSA-50 as a sensitivity analysis to check the robustness of findings. Additionally, we used the individual components of STOP-BANG to determine associations with PBD.

Comparison with other studies

Although there are a handful of studies that have evaluated associations between overall diet quality and OSA [13, 16, 37-41], there are no previous studies that have examined the association between plant-based diet and OSA risk. However, studies have shown that plant-based diets are associated with lower risk of obesity [15, 26, 42], a major cause of OSA. Other dietary patterns derived based on overall dietary behaviour have also been associated with OSA risk. For instance, a Mexican survey showed that people with high adherence to 'industrialised dietary pattern' (high in sugar-sweetened beverages, fast foods, and alcohol, coffee or tea) were more likely to experience daytime symptoms and OSA compared with the traditional pattern (high in legumes and tortilla) [41]. A pre-post pilot clinical trial found a reduced daytime sleepiness after switching from a standard Western diet to a whole-food plant-based diet only for 3 weeks in patients with OSA [26]. In three prospective US cohorts [38], while higher diet quality (higher Alternate Healthy Eating Index scores) was associated with lower risk of OSA, and higher dietary inflammatory potential was associated with increased risk of OSA. Similar findings were also reported in the US [16, 40].

Previous studies also showed the distribution of macronutrients intake associate with the some of the individual components of STOP-BANG questionnaire. For instance, in an iso-caloric substitution analysis, substitution of fat and carbohydrate with protein was inversely associated with excessive daytime sleepiness (EDS), substitution of protein with fat and carbohydrate was positively associated with EDS [37]. *Bove et al* also found that a diet high in fat had twice severity of OSA in overweight patients [39]. A cross-sectional analysis of APPLES study showed that participants with severe sleep disordered breathing, indicated as respiratory disturbance index consumed a diet that was higher in cholesterol, protein, total fat, and total saturated fatty acids [12].

Our findings reveal sex-based differences in the association between plant-based dietary indices and OSA risk. Consistent with the current study, in our previous findings, we observed a sex difference in OSA risk based on a healthy lifestyle (diet, exercise, smoking, alcohol consumption, and body mass index), which demonstrated a stronger association between a healthy lifestyle and OSA in females [16]. The observed sex-specific associations warrant further exploration. Potential underlying biological mechanisms or external behavioral factors might account for these differences. For instance, during menopause, hormonal changes, specifically the decline in estrogen levels, may contribute to an increased risk of OSA via the sexual hormone receptors (i.e., estradiol and progesterone) in the carotid body [43]. The majority of unhealthy plant-based foods, such as refined grains, potatoes, sugar sweetened beverages and sweets and desserts, have very high non-complex carbohydrates, thereby increase the energy imbalance. Alternatively, avoiding uPDI and intaking hPDI, especially phytoestrogen-rich legumes (especially soy) and legume-derived foods [44], may alleviate the risk of OSA in postmenopausal women.

Potential mechanisms

The effect of a healthy plant-based diet on OSA could be attributed to reduced inflammation and a lower risk of obesity. The anti-inflammatory effect of hPDI on OSA could be partially related to various anti-inflammatory components such as high levels of antioxidant nutrients

like vitamin C and E, high levels of B-vitamins, and low levels of detrimental dietary factors (e.g., nitrates and nitrites) [14-16, 20]. A meta-analysis of 18 observational studies indicated that vegetarianism is associated with lower serum concentrations of high-sensitivity C-reactive protein [22]. In our previous studies, we also found that an anti-inflammatory diet, a healthy diet, or the consumption of healthy plant-based foods were all linked to a decreased risk of developing obesity [15, 16].

Furthermore, plant-based diets that are low in fat and high in fiber have the potential to positively alter the microbial composition of the intestine, shifting the microbiome environment towards beneficial bacteria like *Prevotella* and *Bacteroides*, while reducing the presence of *Firmicutes* [45]. Imbalances in the gut microbiota in turn have also been associated with conditions such as obesity, cardiovascular disease, and depression [46, 47]. Available evidence suggests there is a bidirectional relationship between OSA and the composition of the microbiota [47]. In animal models, sleep fragmentation and intermittent hypoxemia alter the gut microbiome composition and reduce intestinal epithelial barrier integrity, which promotes insulin resistance and systemic inflammation [48, 49]. This evidence may suggest that changes in the gut microbiome might predispose individuals to the development of OSA or sleep disruption. In summary, one of the potential mechanisms through which healthy plant-based diet could benefit OSA patients could be due to modifications in the gut microbiome [45].

Conclusions

The evidence presented in this study highlights the significant influence of plant-based diets on OSA risk, with particular emphasis on the protective role of diets like the healthy plant-based diet. Such findings prompt consideration for re-evaluation of dietary recommendations, to a shift towards emphasizing healthy plant-based diets that are rich in anti-inflammatory components and antioxidant nutrients and low in harmful dietary factors. These diets not only influence OSA risk but also have the potential to modulate other pathophysiological mechanisms, possibly affecting various other health conditions, from obesity to cardiovascular

diseases. Furthermore, the distinct sex-specific patterns observed call for more personalized dietary interventions. Additional research with longitudinal data is crucial to substantiate these new findings, particularly focusing on how plant-based diets affect sleep apnea risk, especially in the context of maintained body weight.

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Table 1: Characteristics of study participants

Characteristics	Proportion (%)		Characteristics	Proportion (%)
Male	49.4		**Cancer**	9.7
Education			**CVD**	7.7
			High blood	
Less Than High School	13.5		**pressure**	32.6
School Diploma				
(including GED)	24.7		**Obese**	16.1
More Than High School	61.8		**Snored**	28.5
Income			**Snort**	5.6
Under $20,0000	15.3		**Tired**	30.5
			High waist	
$20,000-$34,999	18.5		**circumference**	56.0
			Self-reported	
			doctor-diagnosed	
			sleep apnea	
$35,000-$54,999	17.8		**(n=6998)**	4.9
$55,000-$74,999	12.5		**STOP score**	
$75,000 and above	35.9		0	37.0
Marital status			1	36.9
Married/living with				
partner	66.8		2	19.2
Widowed	4.5		3	5.6
Divorced	9.5		4	1.2
Separated	2.3		**STOP-BANG score**	
Never married	16.9		0	7.3
Race			1	21.4
Mexican American	8.1		2	21.8
Other Hispanic	4.9		3	20.6
Non-Hispanic White	69.2		4	16.2
Non-Hispanic Black	10.3		5	8.3
Physical activity level			6	3.3
Insufficient	32.8		7	0.8
Adequate	11.3		8	0.2
More than adequate	56.0		**Sleep apnea risk (STOP-BANG)**	
Smoking			Low	50.5
Never	54.4		Intermediate	24.4
Ex-smoker	25.1		High	25.1
Smoker	20.5		**Sleep apnea risk (OSA50)**	
Unhealthy lifestyle score			Low risk	57.8%
0-1	21.4		High risk	42.2%
2	36.9		**PDI, mean (SD)[1]**	94.5(14.5)
3	32.1		**uPDI, mean (SD)[1]**	108.9(17.3)
4	9.6		**hPDI, mean (SD)[1]**	105.7(16.2)
Diabetes	12.6		**PVDI, mean (SD)[1]**	63.7(11.4)

[1] Dietary indices and corresponding mean and SD values. CVD – Cardiovascular Disease; GED - General Educational Development; PDI - Plant-based Dietary Index; PVDI – Pro-Vegetarian Dietary Index; hPDI – healthy PDI; uPDI – Unhealthy PDI; STOP-BANG - Snoring, Tired, Observed (Snort), Pressure (blood pressure), Body mass index (BMI), Age, Neck, Gender;

Table 2: Association between diet and high risk of sleep apnea* (N = 14, 210)

Models	Odds ratio (95% CI)					P for trend
	Q1	Q2	Q3	Q4	Q5	
Overall PDI						
Model 1	1.00	1.02(0.84-1.24)	0.90(0.73-1.13)	0.80(0.64-0.99)	0.77(0.63-0.93)	<0.001
Model 2	1.00	1.02(0.84-1.24)	0.92(0.74-1.15)	0.82(0.66-1.02)	0.80(0.65-0.98)	0.003
Model 3	1.00	1.01(0.83-1.23)	0.91(0.73-1.14)	0.82(0.66-1.02)	0.81(0.65-0.99)	0.006
Model 4	1.00	1.01(0.83-1.22)	0.92(0.73-1.15)	0.83(0.66-1.03)	0.81(0.66-1.00)	0.008
Healthy PDI						
Model 1	1.00	1.01(0.84-1.20)	0.85(0.72-1.02)	0.93(0.77-1.13)	0.77(0.63-0.94)	0.007
Model 2	1.00	1.00(0.84-1.20)	0.86(0.72-1.02)	0.95(0.78-1.15)	0.80(0.65-0.97)	0.018
Model 3	1.00	1.02(0.85-1.22)	0.87(0.72-1.04)	0.95(0.77-1.16)	0.81(0.67-0.99)	0.023
Model 4	1.00	1.03(0.86-1.23)	0.87(0.73-1.05)	0.96(0.79-1.18)	0.83(0.69-1.01)	0.042
Unhealthy PDI						
Model 1	1.00	1.17(0.97-1.41)	1.28(1.05-1.55)	1.42(1.13-1.77)	1.36(1.11-1.66)	0.001
Model 2	1.00	1.14(0.94-1.38)	1.21(1.00-1.48)	1.34(1.06-1.69)	1.27(1.03-1.55)	0.010
Model 3	1.00	1.13(0.93-1.37)	1.24(1.01-1.52)	1.33(1.05-1.69)	1.25(1.02-1.53)	0.010
Model 4	1.00	1.11(0.92-1.34)	1.21(0.99-1.48)	1.32(1.04-1.67)	1.22(1.00-1.49)	0.016
Pro-vegetarian diet						
Model 1	1.00	0.91(0.73-1.13)	0.89(0.74-1.07)	0.82(0.67-1.00)	0.76(0.61-0.94)	0.005
Model 2	1.00	0.93(0.75-1.16)	0.92(0.76-1.11)	0.87(0.71-1.06)	0.82(0.66-1.01)	0.043
Model 3	1.00	0.94(0.76-1.18)	0.92(0.76-1.13)	0.88(0.71-1.08)	0.83(0.66-1.03)	0.069
Model 4	1.00	0.95(0.76-1.18)	0.93(0.76-1.13)	0.89(0.72-1.11)	0.84(0.68-1.05)	0.099

Model 1 was adjusted for sex, age, race, marital status, education, income and energy intake
Model 2 was additionally adjusted for smoking, physical activity and alcohol consumption
Model 3 was additionally adjusted for cardiovascular disease, cancer and diabetes
Model 4 was additionally adjusted for sleep duration
Q5 indicates higher adherence (higher consumption) to specific dietary construct and vice versa for Q1.
*Sleep apnea was based on STOP-BANG (Snoring, Tired, Observed (Snort), Pressure (blood pressure), Body mass index (BMI), Age, Neck, Gender) tool. Only high risk OSA cases were included (overall prevalence=27.5%)

Table 3: Association between diet and high risk of sleep apnea* in males (N = 7,257) and females (N = 6,953)

Models	Odds ratio (95% CI)					P for trend
	Q1	Q2	Q3	Q4	Q5	
Male						
Overall PDI						
Model 1	1.00	0.90(0.69-1.17)	0.95(0.72-1.27)	0.84(0.64-1.11)	0.66(0.53-0.83)	0.0010
Model 2	1.00	0.91(0.70-1.19)	0.98(0.73-1.31)	0.87(0.66-1.15)	0.70(0.55-0.89)	0.0080
Model 3	1.00	0.91(0.70-1.19)	0.95(0.71-1.28)	0.87(0.66-1.15)	0.70(0.55-0.89)	0.0080
Model 4	1.00	0.91(0.70-1.19)	0.95(0.71-1.28)	0.87(0.65-1.15)	0.71(0.56-0.90)	0.0100
Healthy PDI						
Model 1	1.00	1.08(0.82-1.44)	0.99(0.81-1.21)	0.89(0.68-1.16)	0.87(0.66-1.14)	0.096
Model 2	1.00	1.08(0.82-1.44)	0.99(0.81-1.22)	0.88(0.67-1.15)	0.87(0.67-1.14)	0.090
Model 3	1.00	1.10(0.82-1.46)	1.01(0.82-1.24)	0.88(0.68-1.15)	0.87(0.66-1.15)	0.096
Model 4	1.00	1.10(0.83-1.46)	1.02(0.83-1.25)	0.89(0.69-1.16)	0.90(0.68-1.18)	0.144
Unhealthy PDI						
Model 1	1.00	1.23(0.97-1.56)	1.24(0.94-1.64)	1.22(0.92-1.60)	1.23(0.96-1.57)	0.127
Model 2	1.00	1.20(0.94-1.52)	1.19(0.91-1.57)	1.16(0.86-1.55)	1.17(0.91-1.49)	0.284
Model 3	1.00	1.18(0.93-1.51)	1.23(0.93-1.64)	1.17(0.86-1.58)	1.17(0.92-1.49)	0.247
Model 4	1.00	1.15(0.91-1.46)	1.21(0.91-1.60)	1.15(0.85-1.56)	1.13(0.89-1.44)	0.317
Pro-vegetarian diet						
Model 1	1.00	0.81(0.62-1.07)	0.93(0.73-1.18)	0.85(0.65-1.11)	0.68(0.52-0.89)	0.017
Model 2	1.00	0.83(0.62-1.11)	0.96(0.75-1.23)	0.89(0.68-1.17)	0.73(0.55-0.96)	0.075
Model 3	1.00	0.83(0.62-1.11)	0.95(0.75-1.22)	0.89(0.68-1.18)	0.72(0.54-0.96)	0.077
Model 4	1.00	0.84(0.63-1.13)	0.96(0.74-1.22)	0.92(0.70-1.22)	0.74(0.56-0.99)	0.125
Female						
Overall PDI						
Model 1	1.00	1.07(0.82-1.40)	0.81(0.62-1.06)	0.69(0.51-0.94)	0.85(0.62-1.16)	0.031
Model 2	1.00	1.08(0.83-1.39)	0.82(0.64-1.07)	0.72(0.54-0.97)	0.88(0.65-1.19)	0.057
Model 3	1.00	1.08(0.83-1.41)	0.86(0.67-1.12)	0.76(0.57-1.01)	0.93(0.68-1.28)	0.163
Model 4	1.00	1.08(0.83-1.41)	0.87(0.67-1.13)	0.76(0.57-1.02)	0.93(0.68-1.28)	0.169
Healthy PDI						
Model 1	1.00	0.86(0.64-1.14)	0.89(0.66-1.20)	0.85(0.62-1.16)	0.67(0.48-0.95)	0.022
Model 2	1.00	0.86(0.65-1.15)	0.91(0.67-1.23)	0.88(0.64-1.21)	0.73(0.52-1.03)	0.077
Model 3	1.00	0.86(0.64-1.15)	0.91(0.66-1.25)	0.88(0.64-1.21)	0.76(0.53-1.08)	0.117
Model 4	1.00	0.86(0.64-1.15)	0.91(0.66-1.25)	0.89(0.65-1.22)	0.77(0.54-1.09)	0.145
Unhealthy PDI						
Model 1	1.00	1.29(0.99-1.67)	1.53(1.14-2.06)	1.70(1.30-2.23)	1.63(1.18-2.24)	<0.001
Model 2	1.00	1.24(0.95-1.62)	1.45(1.07-1.95)	1.57(1.19-2.08)	1.48(1.07-2.06)	0.005
Model 3	1.00	1.26(0.96-1.66)	1.42(1.05-1.91)	1.53(1.16-2.01)	1.44(1.04-1.99)	0.009
Model 4	1.00	1.25(0.96-1.65)	1.40(1.05-1.88)	1.52(1.15-2.00)	1.42(1.03-1.97)	0.010
Pro-vegetarian diet						
Model 1	1.00	0.79(0.64-0.98)	0.73(0.56-0.94)	0.74(0.63-0.88)	0.69(0.53-0.89)	0.008
Model 2	1.00	0.79(0.64-0.98)	0.73(0.57-0.95)	0.76(0.65-0.91)	0.74(0.57-0.97)	0.041
Model 3	1.00	0.80(0.64-0.99)	0.74(0.57-0.97)	0.78(0.65-0.92)	0.73(0.55-0.96)	0.038
Model 4	1.00	0.81(0.65-1.01)	0.75(0.57-0.99)	0.80(0.67-0.95)	0.75(0.56-1.00)	0.068

Model 1 was adjusted for age, race, marital status, education, income and energy intake
Model 2 was additionally adjusted for smoking, physical activity and alcohol consumption
Model 3 was additionally adjusted for cardiovascular disease, cancer and diabetes
Model 4 was additionally adjusted for sleep duration (hour)
Q5 indicates higher adherence (higher consumption) to specific dietary construct and vice versa for Q1. *Sleep apnea was based on STOP-BANG (Snoring, Tired, Observed (Snort), Pressure (blood pressure), Body mass index (BMI), Age, Neck, Gender) tool. Only high risk OSA cases were included (prevalence in males= 31.5%; females=23.4%)
Sleep apnea was based on STOP-BANG (Snoring, Tired, Observed (Snort), Pressure (blood pressure), Body mass index (BMI), Age, Neck, Gender) tool.

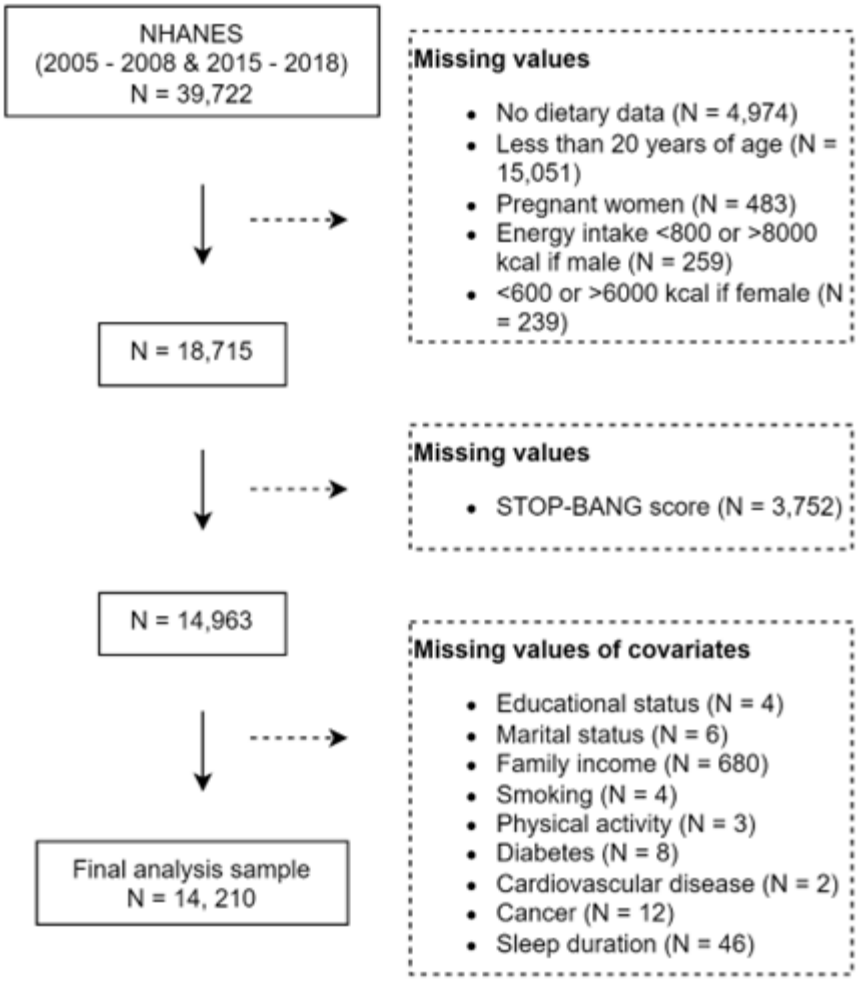

NHANES
(2005 - 2008 & 2015 - 2018)
N = 39,722
Missing values
No dietary data (N = 4,974)
Less than 20 years of age (N = 15,051)
Pregnant women (N = 483)
Energy intake <800 or >8000 kcal if male (N = 259)
<600 or >6000 kcal if female (N = 239)
N = 18,715
Missing values
STOP-BANG score (N = 3,752)
N = 14,963
Missing values of covariates
Educational status (N = 4)
Marital status (N = 6)
Family income (N = 680)
Smoking (N = 4)
Physical activity (N = 3)
Diabetes (N = 8)
Cardiovascular disease (N = 2)
Cancer (N = 12)
Sleep duration (N = 46)
Final analysis sample
N = 14, 210

Figure 1

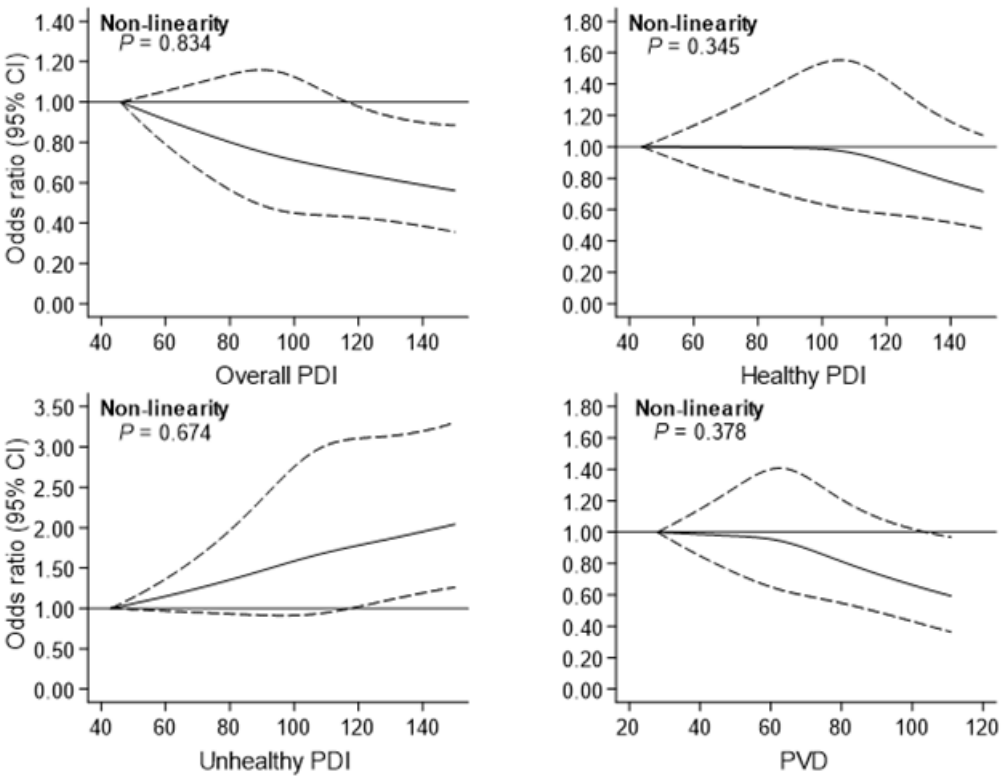

Non-linearity
P = 0.834
Odds ratio (95% CI)
Overall PDI
Non-linearity
P = 0.345
Healthy PDI
Non-linearity
P = 0.674
Odds ratio (95% CI)
Unhealthy PDI
Non-linearity
P = 0.378
PVD

Figure 2

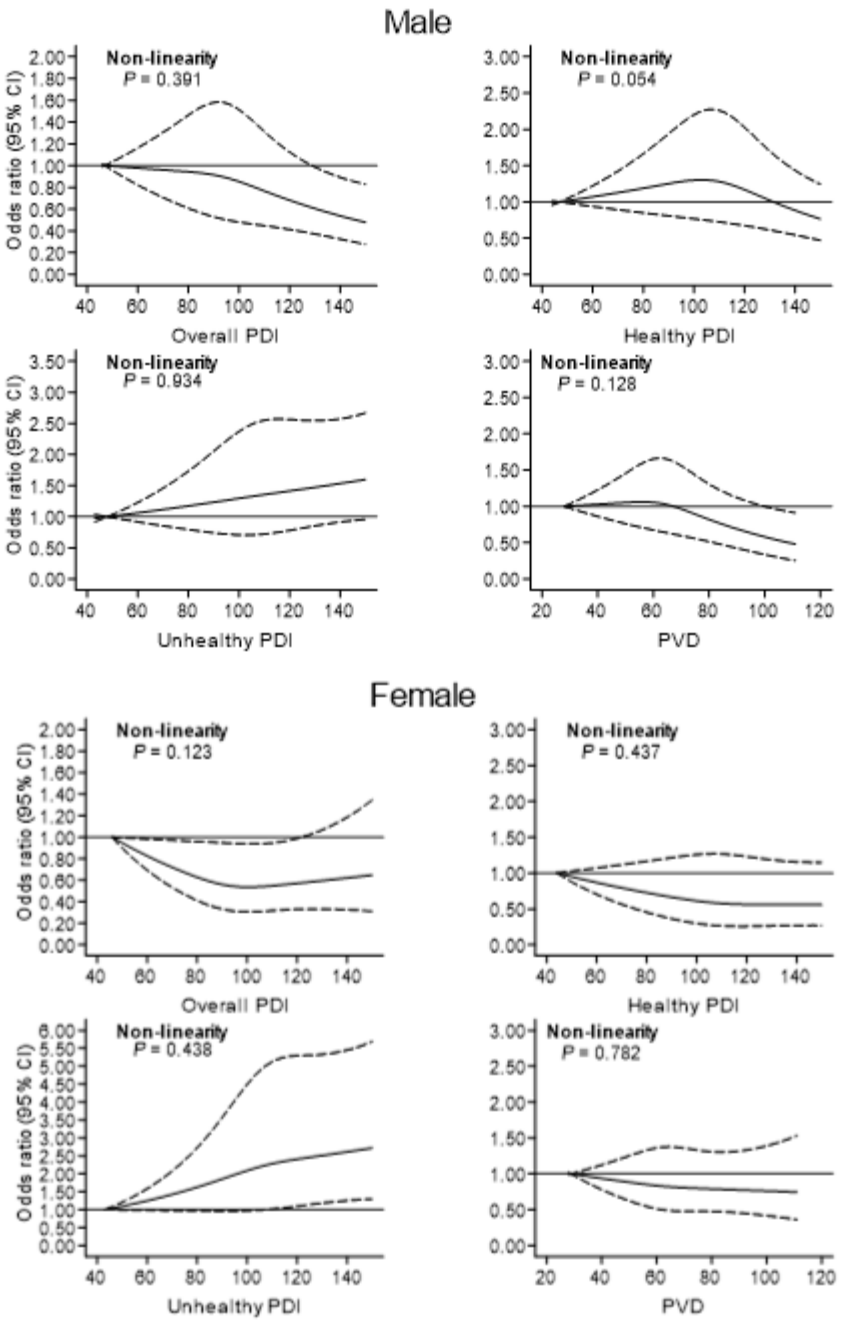

Male
Non-linearity
P = 0.391
Odds ratio (95% CI)
Overall PDI
Non-linearity
P = 0.054
Healthy PDI
Non-linearity
P = 0.934
Unhealthy PDI
Non-linearity
P = 0.128
PVD
Female
Non-linearity
P = 0.123
Overall PDI
Non-linearity
P = 0.437
Healthy PDI
Non-linearity
P = 0.438
Unhealthy PDI
Non-linearity
P = 0.782
PVD

Figure 3

Supplementary method

Sensitivity analyses

Definition of OSA

The sensitivity analysis also utilized the OSA50 tool [1], which consists of 4 components: waist circumference (waist circumference >102 cm if male OR >88 cm if female; 3 points), snoring (3 points), stop breathing (2 points), and age (≥50 years, 2 points). The score ranges from 0 to 10, and those with scores above 5 were considered to be in the high-risk sleep apnea group. Using a cut-off score of ≥5, the screening questionnaire had a sensitivity of 100% and a specificity of 29% [1]. Furthermore, the STOP score (high-risk sub-criteria without BMI, age, waist circumference or gender) ≥ 2 was used to define increased risk of OSA [2].

Statistical analysis

First, we used the STOP-BANG and STOP scores as count outcome variables and applied a Poisson regression model with a logit link function to calculate incidence rate ratios. Second, we combined the intermediate and high-risk groups in the STOP-BANG score as the outcome variable. Third, we used self-reported doctor-diagnosed OSA as the outcome to assess the association between diet and sleep apnea. However, this analysis was limited to the 2005-2008 waves, with a sample size of 6,998. Fourth, we examined the association between diet and each of the STOP-BANG components (Snoring, Tiredness, Snort (Observed apnea), Hypertension, Body Mass Index, and waist circumference). Finally, we used the OSA50 tool to define OSA risk.

Supplementary results

Supplementary Table 1. Scoring system and classification of food items in the NHANES[1]

Food groups	PDI	hPDI	uPDI	Pro-vegetarian
Healthy plant foods				
Food group	**Used in the calculation**			
Whole grains	Yes	Yes	Yes (reverse)	Yes[2]
Fruits	Yes	Yes	Yes (reverse)	Yes
Vegetables	Yes	Yes	Yes (reverse)	Yes
Nuts	Yes	Yes	Yes (reverse)	Yes
Legumes	Yes	Yes	Yes (reverse)	Yes
Tea and coffee	Yes	Yes	Yes (reverse)	Not scored
Less healthy plant foods				
Refined grains	Yes	Yes (reverse)	Yes	Yes[2]
Potatoes	Yes	Yes (reverse)	Yes	Yes
Sugar sweetened beverages	Yes	Yes (reverse)	Yes	Not scored
Sweets and desserts	Yes	Yes (reverse)	Yes	Not scored
Salty food group	Yes	Yes (reverse)	Yes	Not scored
Animal foods				
Animal fat	Yes (reverse)	Yes (reverse)	Yes (reverse)	Yes (reverse)
Dairy	Yes (reverse)	Yes (reverse)	Yes (reverse)	Yes (reverse)
Eggs	Yes (reverse)	Yes (reverse)	Yes (reverse)	Yes (reverse)
Fish or seafood	Yes (reverse)	Yes (reverse)	Yes (reverse)	Yes (reverse)
Meat	Yes (reverse)	Yes (reverse)	Yes (reverse)	Yes (reverse)
Miscellaneous animal foods	Yes (reverse)	Yes (reverse)	Yes (reverse)	Not scored

[1] The PDI, hPDI, and uPDI categorized good groups to “healthy plant foods,” “less healthy plant foods,” and “animal foods.” The PVDI categorized food groups into “plant foods” and “animal foods.” Positive indicates that higher intakes received higher scores. Reverse indicates that higher intakes received lower scores.

[2] Whole grains and refined grains were aggregated to “grains” food group in the PVDI.

PDI, overall plant-based diet index; hPDI, healthful plant-based diet index; uPDI, unhealthful plant-based diet index. PVDI, pro-vegetarian dietary index

Supplementary Table 2. STOP-BANG components and scoring system 2005-2008 & 2015-2018[1]

STOP-BANG score	Questions/measurements	Response/category	Criteria	Total sample (n=14,210)
Snoring	In the past 12 months, how often did you snore while you were sleeping?	Never Rarely - 1-2 nights a week Occasionally - 3-4 nights a week Frequently - 5 or more nights a week	Never Rarely - 1-2 nights a week Occasionally - 3-4 nights a week = 0	9,894
			Frequently - 5 or more nights a week = 1	4,316
Tired/sleepiness	Over the last 2 weeks, how often have you been bothered by the following problems feeling tired or having little energy? OR	Not at all Several days More than half the days Nearly every day	Not at all Several days = 0	11,853
			More than half the days Nearly every day = 0	2,248
	In the past month, how often did you feel excessively or overly sleepy during the day?	Never Rarely - 1 time a month Sometimes - 2-4 times a month Often- 5-15 times a month Almost always - 16-30 times a month	Never Rarely - 1 time a month Sometimes - 2-4 times a month Often- 5-15 times a month = 0	11,084
			Almost always - 16-30 times a month = 1	3,122
Observed (Snort)	In the past 12 months, how often did you snort, gasp, or stop breathing while you were asleep?	Never Rarely - 1-2 nights a week Occasionally - 3-4 nights a week Frequently - 5 or more nights a week	Never Rarely - 1-2 nights a week Occasionally - 3-4 nights a week = 0	13,366
			Frequently - 5 or more nights a week = 1	844
Pressure (blood pressure)	Measured systolic blood pressure OR diastolic blood pressure	Diastolic blood pressure (DBP) < 90 mmHg AND Systolic blood pressure (SBP) < 140 mmHg	Diastolic blood pressure (DBP) < 90 mmHg AND Systolic blood pressure (SBP) < 140 mmHg = 0	11370
		DBP ≥ 90 mmHg SBP ≥ 140 mmHg	DBP ≥ 90 mmHg SBP ≥ 140 mmHg = 1	2,840
	Because of your high blood pressure/hypertension, have you ever been told to . . . take prescribed medicine?	No Yes	No = 0	4,348
			Yes = 1	589
STOP score range			0-4	
Body mass index (BMI, kg/m^2)	Measured weight (kg) and height (m)	BMI ≤ 35 kg/m2	BMI ≤ 35 kg/m2 = 0	11,808

		BMI >45 kg/m2	BMI >45 kg/m2 = 1	2,402
Age	Self-reported age in years	≤50 years >50 years	≤50 years=0	7,517
			>50 years = 1	6,693
Neck (we used waist circumference as a proxy for neck circumference)	Measured waist coreference	≤102 cm if male OR ≤88 if female >102 cm if male OR >88 if female	≤102 cm if male OR ≤88 if female = 0	6,132
			>102 cm if male OR >88 if female = 1	8,078
Gender	Self-reported	Male Female	Female = 0	7,257
			Male = 1	6,953
STOP-BANG score range			0-8	
STOP-BANG score			Low risk - 0-2	6,497
			Intermediate risk - 3-4	3,801
			High risk - ≥5 OR STOP≥2 + male OR STOP≥2 + BMI > 35 OR STOP≥2 + waist > 102 cm if male OR >88 cm if female	3,912

[1] The STOP-BANG (Snoring, Tired, Observed (Snort), Pressure (blood pressure), Body mass index (BMI), Age, Neck, Gender) Score.

Supplementary Table 3: Covariate assessment methods and categories/unites[1]

Variable name	Assessment methods	Categories/unit
Socio-demographic		
Age	Self-reported	years
Sex	Self-reported	Male/female
Race	Self-reported	Mexican American/ Other Hispanic/ Non-Hispanic White/ Non-Hispanic Black
Marital status	Self-reported	Married/living with partner/Widowed/Divorced/Separated/Never married
Income	Self-reported (family income)	Under $20,0000/ $20,000-$34,999/ $35,000-$54,999/ $55,000-$74,999/ $75,000 and above
Behavioural factors		
Smoking	Self-reported Smoking status was categorised as never, former (smoked > 100 cigarettes in lifetime but does not currently smoke), and current (smoked > 100 cigarettes in lifetime and smokes currently).	Never/ex-smoker/smoker
Physical activity	Self-reported Levels of physical activity were assessed and scored using the validated Global Physical Activity Questionnaire Analysis (GPAQ [3]. Specifically, the number of minutes that participants spent each week doing moderate to vigorous activities requiring at least 4 metabolic equivalent units (MET) per hour were estimated [4]. Insufficient (<600 MET-minute per week)/moderate ≥600 & <1200 MET-minute per week)/sufficient (≥1200 MET-minute per week)	Insufficient (600 MET-minute per week)/moderate ≥600 & <1200 MET-minute per week)/sufficient (≥1200 MET-minute per week)
Alcohol consumption	Self-reported based on 24-hour dietary recall	Grams
Sleep duration	Self-reported How much sleep {do you/does SP} usually get at night on weekdays or workdays?	Hours
Chronic conditions		
Cardiovascular health	Self-reported	Yes/no
Cancer	Self-reported	Yes/no
Hypertension	Measured (SBP ≥140 or DBP ≥90 mm Hg) or use of anti-hypertensive	Yes/no
Diabetes	Diabetes was defined as having at least one of the following: fasting plasma glucose ≥126 mg/dL, random plasma glucose of ≥200 mg/dL in the presence of symptoms, 2-hour plasma glucose during the 75-g oral glucose tolerance test (OGTT) ≥ 200 mg/dL, and/or HbA1c ≥ 6.5% (39, 40). In addition, subjects that gave a positive response to any of the following questions were classified as diabetic: “Are you taking insulin?,” “Did a doctor tell you, you have diabetes?,” “Do you take pills to lower blood sugar?”	Yes/no

[1] SBP, systolic blood pressure,; DBP, diastolic blood pressure.

Supplementary Table 4: Association between diet and STOP-BANG score* (as count variable)

		Incidence rate ratio (95% CI)					
	Models	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**P for trend**
Plant-based dietary index (PDI)							
Overall PDI							
	Model 4	1.00	0.98(0.95-1.01)	0.92(0.89-0.96)	0.91(0.88-0.94)	0.87(0.84-0.91)	<0.001
Healthy PDI							
	Model 4	1.00	0.97(0.94-1.01)	0.95(0.92-0.99)	0.96(0.92-0.99)	0.91(0.88-0.94)	<0.001
Unhealthy PDI							
	Model 4	1.00	1.04(1.00-1.07)	1.07(1.02-1.11)	1.09(1.04-1.14)	1.08(1.04-1.13)	<0.001
Pro-vegetarian diet index							
	Model 4	1.00	0.99(0.96-1.03)	0.95(0.92-0.99)	0.93(0.89-0.97)	0.90(0.86-0.94)	<0.001

Model 4 was adjusted for sex, age, race, marital status, education, income, smoking, physical activity, alcohol consumption, cardiovascular disease, cancer, diabetes, sleep duration, energy intake

Q5 indicates higher adherence (higher consumption) to specific dietary construct and vice versa for Q1.
*Sleep apnea was based on STOP-BANG (Snoring, Tired, Observed (Snort), Pressure (blood pressure), Body mass index (BMI), Age, Neck, Gender) tool.
PDI, overall plant-based diet index; hPDI, healthful plant-based diet index; uPDI, unhealthful plant-based diet index. PVDI, pro-vegetarian dietary index

Supplementary Table 5: Association between diet and STOP score* (as count variable)

		Incidence rate ratio (95% CI)					
	Models	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**P for trend**
Plant-based dietary index (PDI)							
Overall PDI							
	Model 4	1.00	1.02(0.95-1.08)	0.94(0.88-1.01)	0.91(0.85-0.97)	0.90(0.83-0.96)	<0.001
Healthy PDI							
	Model 4	1.00	0.96(0.89-1.03)	0.92(0.86-0.98)	0.93(0.87-1.00)	0.86(0.81-0.92)	<0.001
Unhealthy PDI							
	Model 4	1.00	1.08(1.00-1.17)	1.11(1.03-1.20)	1.14(1.05-1.24)	1.15(1.08-1.24)	<0.001
Pro-vegetarian diet index							
	Model 4	1.00	1.02(0.95-1.09)	0.95(0.90-1.00)	0.91(0.85-0.99)	0.91(0.84-0.98)	0.001

Model 4 was adjusted for sex, age, race, marital status, education, income, smoking, physical activity, alcohol consumption, cardiovascular disease, cancer, diabetes, sleep duration, energy intake
Q5 indicates higher adherence (higher consumption) to specific dietary construct and vice versa for Q1.
*Sleep apnea was based on STOP (Snoring, Tired, Observed (Snort), Pressure (blood pressure)).
PDI, overall plant-based diet index; hPDI, healthful plant-based diet index; uPDI, unhealthful plant-based diet index. PVDI, pro-vegetarian dietary index

Supplementary Table 6: Association between diet and sleep apnea risk* (intermediate and high risk) on STOP-BANG score

	Odds ratio (95% CI)					
Models	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**P for trend**
Plant-based dietary index (PDI)						
Overall PDI						
Model 4	1.00	1.03(0.88-1.22)	0.79(0.66-0.96)	0.73(0.60-0.89)	0.61(0.51-0.73)	<0.001
Healthy PDI						
Model 4	1.00	0.79(0.66-0.94)	0.74(0.61-0.91)	0.79(0.66-0.94)	0.63(0.50-0.80)	<0.001
Unhealthy PDI						
Model 4	1.00	1.11(0.93-1.32)	1.27(1.05-1.54)	1.28(1.07-1.53)	1.39(1.15-1.68)	0.001
Pro-vegetarian diet index						
Model 4	1.00	1.04(0.86-1.25)	0.83(0.68-1.01)	0.81(0.67-0.98)	0.68(0.57-0.81)	<0.001

Model 4 was adjusted for sex, age, race, marital status, education, income, smoking, physical activity, alcohol consumption, cardiovascular disease, cancer, diabetes, sleep duration, energy intake
Q5 indicates higher adherence (higher consumption) to specific dietary construct and vice versa for Q1.
*Sleep apnea was based on STOP-BANG (Snoring, Tired, Observed (Snort), Pressure (blood pressure), Body mass index (BMI), Age, Neck, Gender) tool.
PDI, overall plant-based diet index; hPDI, healthful plant-based diet index; uPDI, unhealthful plant-based diet index. PVDI, pro-vegetarian dietary index

Supplementary Table 7: Association between diet and self-reported doctor-diagnosed sleep apnea (N= 6,998)

		Prevalence ratio (95% CI)					
	Models	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**P for trend**
Plant-based dietary index (PDI)							
Overall PDI							
	Model 4	1.00	0.99(0.58-1.70)	0.81(0.56-1.18)	0.77(0.50-1.18)	0.82(0.50-1.35)	0.174
Healthy PDI							
	Model 4	1.00	1.10(0.79-1.54)	1.10(0.75-1.61)	1.02(0.60-1.73)	0.75(0.45-1.24)	0.346
Unhealthy PDI							
	Model 4	1.00	0.92(0.62-1.36)	1.20(0.86-1.68)	0.95(0.61-1.48)	1.12(0.78-1.61)	0.503
Pro-vegetarian diet index							
	Model 4	1.00	0.89(0.64-1.22)	0.84(0.61-1.15)	0.83(0.58-1.19)	0.67(0.40-1.13)	0.118

Model 4 was adjusted for sex, age, race, marital status, education, income, smoking, physical activity, alcohol consumption, cardiovascular disease, cancer, diabetes, sleep duration, energy intake
Q5 indicates higher adherence (higher consumption) to specific dietary construct and vice versa for Q1.
PDI, overall plant-based diet index; hPDI, healthful plant-based diet index; uPDI, unhealthful plant-based diet index. PVDI, pro-vegetarian dietary index

Supplementary Table 8: Association between diet and components of STOP-BANG*

	Odds ratio (95% CI)					
Models	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**P for trend**
Plant-based dietary index (PDI)						
Overall PDI						
Snore	1.00	1.01(0.83-1.23)	0.98(0.84-1.15)	0.87(0.74-1.03)	0.97(0.82-1.14)	0.238
Tired	1.00	1.13(0.97-1.30)	1.04(0.86-1.25)	0.87(0.75-1.01)	0.91(0.76-1.09)	0.017
Snort	1.00	1.06(0.77-1.46)	0.87(0.64-1.18)	1.13(0.79-1.63)	1.07(0.75-1.54)	0.635
Hypertension	1.00	1.02(0.84-1.23)	0.84(0.71-0.99)	0.88(0.70-1.10)	0.79(0.64-0.99)	0.02
BMI > 35	1.00	0.75(0.62-0.90)	0.64(0.52-0.78)	0.60(0.50-0.72)	0.45(0.37-0.55)	<0.001
Waist circumference (>102 if male and >88 if female)	1.00	0.90(0.77-1.05)	0.71(0.60-0.85)	0.72(0.62-0.85)	0.50(0.42-0.60)	<0.001
Healthy PDI						
Snore	1.00	0.95(0.80-1.13)	1.04(0.89-1.22)	0.86(0.72-1.02)	0.79(0.66-0.94)	0.006
Tired	1.00	0.97(0.83-1.13)	0.91(0.78-1.06)	0.99(0.84-1.17)	0.80(0.69-0.92)	0.019
Snort	1.00	1.00(0.70-1.42)	0.81(0.59-1.11)	0.70(0.47-1.05)	0.85(0.60-1.21)	0.06
Hypertension	1.00	0.91(0.78-1.06)	0.74(0.62-0.89)	0.98(0.78-1.22)	0.88(0.72-1.08)	0.548
BMI > 35	1.00	0.88(0.71-1.08)	0.96(0.76-1.22)	0.91(0.72-1.16)	0.69(0.54-0.89)	0.022
Waist circumference (>102 if male and >88 if female)	1.00	0.97(0.83-1.13)	0.86(0.75-0.99)	0.84(0.71-0.98)	0.68(0.56-0.82)	<0.001
Unhealthy PDI						
Snore	1.00	1.21(1.01-1.45)	1.15(0.98-1.36)	1.31(1.10-1.55)	1.30(1.12-1.50)	0.001
Tired	1.00	1.02(0.84-1.24)	1.10(0.88-1.37)	1.14(0.91-1.43)	1.13(0.95-1.33)	0.089
Snort	1.00	1.35(0.96-1.90)	1.48(1.08-2.02)	1.31(0.94-1.83)	1.14(0.80-1.64)	0.369
Hypertension	1.00	1.09(0.91-1.31)	1.15(0.92-1.44)	1.07(0.84-1.35)	1.22(0.99-1.49)	0.139
BMI > 35	1.00	1.08(0.90-1.29)	1.26(1.02-1.56)	1.51(1.21-1.89)	1.49(1.20-1.86)	<0.001
Waist circumference (>102 if male and >88 if female)	1.00	1.06(0.89-1.24)	1.18(1.01-1.39)	1.23(1.01-1.50)	1.26(1.06-1.49)	0.003
Pro-vegetarian diet index						
Snore	1.00	1.02(0.87-1.20)	0.92(0.79-1.06)	0.85(0.72-1.00)	0.90(0.76-1.06)	0.041
Tired	1.00	1.06(0.90-1.25)	0.91(0.78-1.07)	0.90(0.77-1.06)	0.89(0.75-1.06)	0.021
Snort	1.00	0.97(0.70-1.36)	1.07(0.78-1.47)	1.02(0.74-1.41)	0.98(0.62-1.55)	0.976
Hypertension	1.00	1.06(0.88-1.29)	0.95(0.80-1.11)	0.90(0.73-1.12)	0.91(0.72-1.15)	0.21

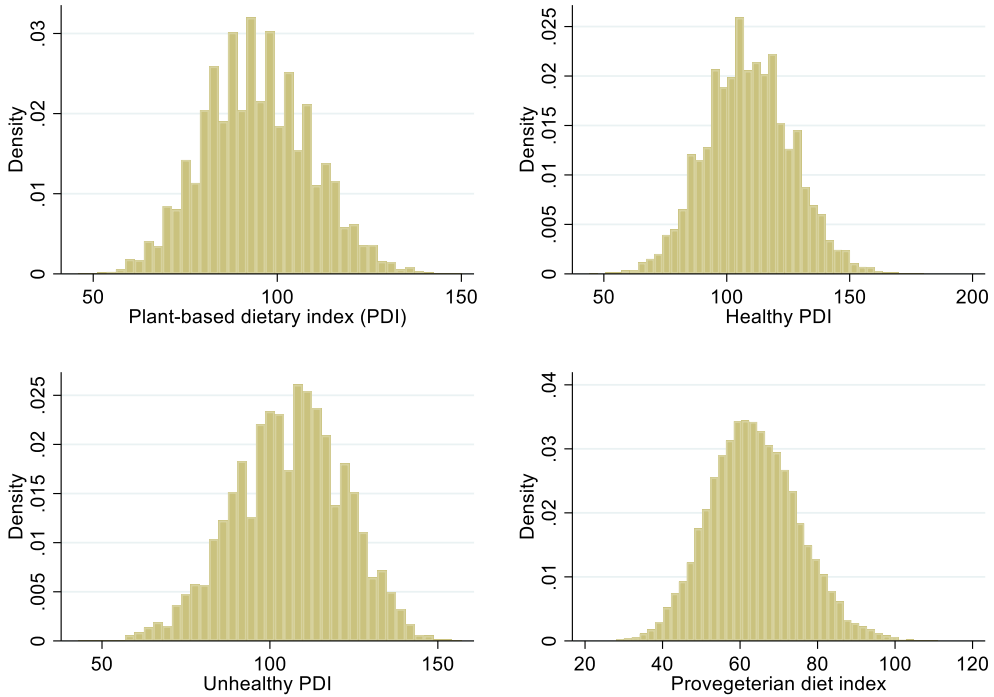
	BMI > 35	1.00	0.80(0.67-0.95)	0.81(0.66-0.99)	0.67(0.52-0.86)	0.57(0.45-0.71)	<0.001
	Waist circumference (>102 if male and >88 if female)	1.00	0.94(0.78-1.13)	0.85(0.72-1.02)	0.74(0.63-0.88)	0.58(0.49-0.69)	<0.001

Model 4 was adjusted for sex, age, race, marital status, education, income, smoking, physical activity, alcohol consumption, cardiovascular disease, cancer, diabetes, sleep duration, energy intake
Except for body mass index and waist circumference models, all were adjusted for body mass index.
Q5 indicates higher adherence (higher consumption) to specific dietary construct and vice versa for Q1.
* STOP-BANG (Snoring, Tired, Observed (Snort), Pressure (blood pressure), Body mass index (BMI), Age, Neck, Gender) tool.
PDI, overall plant-based diet index; hPDI, healthful plant-based diet index; uPDI, unhealthful plant-based diet index. PVDI, pro-vegetarian dietary index

Supplementary Table 9: Association between diet and sleep apnea risk*

	Odds ratio (95% CI)					
Models	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**P for trend**
Plant-based dietary index (PDI)						
Overall PDI						
Model 4	1.00	1.01(0.85-1.20)	0.80(0.66-0.97)	0.82(0.69-0.97)	0.65(0.52-0.80)	<0.001
Healthy PDI						
Model 4	1.00	0.91(0.75-1.09)	0.84(0.71-0.99)	0.79(0.65-0.96)	0.70(0.59-0.83)	<0.001
Unhealthy PDI						
Model 4	1.00	1.09(0.93-1.28)	1.15(0.96-1.37)	1.24(1.05-1.48)	1.13(0.94-1.35)	0.065
Pro-vegetarian diet index						
Model 4	1.00	1.04(0.87-1.25)	0.86(0.72-1.03)	0.79(0.64-0.97)	0.71(0.59-0.84)	<0.001

Model 4 was adjusted for sex, age, race, marital status, education, income, smoking, physical activity, alcohol consumption, cardiovascular disease, cancer, diabetes, sleep duration, energy intake
Q5 indicates higher adherence (higher consumption) to specific dietary construct and vice versa for Q1.
*Sleep apnea was based on OSA-50 tool (≥5 score was considered high risk OSA).
PDI, overall plant-based diet index; hPDI, healthful plant-based diet index; uPDI, unhealthful plant-based diet index. PVDI, pro-vegetarian dietary index



Supplementary Figure 1. Distribution of Plant-based dietary index (PDI), healthy PDI, unhealthy PDI, and pro-vegetation diet

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