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Food and Beverage Consumption and Food Addiction Among Women in the Nurses' Health Studies

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Abstract

Background and Aims—Previous studies have not addressed a fundamental component of a food addiction disorder: the compulsive relationship between eating and potentially positively reinforcing foods. We aimed to evaluate the association between food consumption and food addiction.

Design, Setting, and Participants—We conducted cross-sectional analyses merging data from the Nurses' Health Study(n=58,625) and Nurses' Health Study II (n=65,063), two prospective cohort studies of female nurses in the United States.

Measurements—Diet was assessed in 2006–2007 using a food frequency questionnaire, and food addiction was assessed in 2008–2009 using the Modified Yale Food Addiction Scale.

Findings—The prevalence of food addiction was 5.4%. The odds of food addiction were strongest among nurses consuming 5+ servings/week (compared with <1 serving/month) of hamburgers (MVOR 4.08; 95% CI, 2.66–6.25), French fries (MVOR, 2.37; 95% CI, 1.59–3.51) and pizza(MVOR, 2.49; 95% CI, 1.67–3.69). Consumption of red/processed meat, low/no fat snacks/desserts, and low calorie beverages was positively associated with food addiction, while consumption of refined grains, sugar-sweetened beverages and fruit and vegetables was inversely associated with food addiction.

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Conclusions—This epidemiologic study is the largest to examine food consumption and food addiction. Food addiction was positively associated with consumption of many hypothesized positively reinforcing foods that include a combination of carbohydrates and fats such as snacks/desserts, "fast foods" and candy bars. However, it was inversely or not associated with certain sweet foods, refined grains, and sugar-sweetened beverages, which is consistent with literature suggesting that carbohydrates (without other ingredients) are less associated with food addiction. Longitudinal analyses will help untangle the temporal order between food consumption and food addiction, as some relationships in our analyses were difficult to interpret due to the cross-sectional design.

Keywords

Food addiction; feeding behavior; epidemiology; diet; nutrition; eating; fast foods; psychology

Introduction[1]

In 1956, physician and researcher Theron Randolph introduced the construct of food addiction, theorizing that certain foods had "addictive" potential(1). Since then, the concept of food addiction has existed predominantly in popular culture. Self-help books such as *A Substance Called Food* (1989)(2) and *Food Junkies: The Truth about Food Addiction* (2012)(3), and self-help groups such as Food Addicts Anonymous, Overeaters Anonymous, and Food Addicts in Recovery Anonymous, were created for and by individuals who self-identify as food addicts and compulsive eaters. It is hypothesized that highly palatable foods full of fat, salt, and sugar might be linked to addictive-like eating (4, 5), overeating, and obesity.(6) However, food addiction has not been classified by the Diagnostic Statistical Manual of Mental Disorders (DSM) as a mental disorder, or more specifically, as a substance -use disorder, and scientific evidence (7–11)has only recently emerged on the construct of food addiction.

Since 2009, when researchers first validated a food addiction tool to measure food addiction in humans(12), more than fifty peer -reviewed scientific papers have examined the prevalence of food addiction, the reliability and validity of food addiction scales, and potential correlates of the condition in several populations. Recent findings suggest that the prevalence of food addiction in the general population ranges from 5 to 10%(9, 13, 14), that food addiction is distinct from other related disorders such as binge eating disorder(15, 16), and that it is positively associated with body mass index (BMI)(13, 17, 18), binge eating behaviors (16, 19), depression (16, 19), food cravings(20, 21) and impulsivity(20).

This body of research, however, has largely not addressed what is central to a food addiction disorder—the compulsive relationship between eating and specific foods that fail to perform a necessary biological function (22). Currently, it is unclear whether certain types of foods are positively reinforcing, and therefore core to the internal dysfunction of food addiction. Evidence from animal studies support a biological basis for the food addiction construct,

[1] *Abbreviations:* BMI, body mass index; CI, Confidence Interval; DSM, Diagnostic Statistical Manual of Mental Disorders; FFQ, Food Frequency Questionnaire; mYFAS, modified Yale Food Addiction Scale; NHS, Nurses' Health Study; NHSII, Nurses' Health Study II; OR, Odds Ratio.

demonstrating similarities to models of drug addiction (4, 23–34). In these studies, animals that consume large quantities of sugar and foods high in sugar and/or fat over time exhibit dependency symptoms such as tolerance (a need for markedly increased amounts of palatable food to achieve a desired effect) (35–41)and withdrawal (chattering teeth, forepaw tremor, and head shakes when deprived of sugar) (35, 42). In addition, one study observed that animals continue to eat palatable foods despite experiencing adverse consequences (e.g., an electric shock) (23). These animal studies suggest that consumption of certain types of foods may be positively reinforcing and associated with addictive eating behaviors.

Recent studies in humans (18, 43–45)examined the relationship between food consumption and food addiction. This research has focused primarily on the relationship between food addiction and nutrients; overall, results have been heterogeneous. Among 652 adults in Canada (18)food addiction was not associated with carbohydrate consumption, yet a positive association was observed with protein and fat intake. When limited to 116 overweight/obese individuals (43), food addicted compared with non-food addicted participants consumed statistically significantly more grams per day of sugar and saturated, *trans,* and monounsaturated fats than food addiction non-obese subjects. A study (44) in Australia found that among 462 adults, food addiction symptom scores were positively associated with percent of energy from energy-dense, nutrient-poor foods (e.g., candy, baked sweet products); however, sugar and carbohydrate intake were not associated with food addiction diagnosis. In another study among 70 children in the United States, food addiction symptom count was only positively associated with dinner calorie intake.(45)Using the two largest epidemiologic studies to date, we extend this preliminary research by examining the association between consumption of hypothesized potentially reinforcing foods and food addiction in over 120,000 women.

Methods

Study Populations

The Nurses' Health Study (NHS)and Nurses' Health Study II (NHSII) are prospective cohort studies conducted in the United States. Beginning in 1976, 121,700 female registered nurses, married and 30–55 years old were enrolled into NHS(46). NHSII began in 1989, enrolling 116,430 nurses who were 25–42 years old at baseline. Every two years participants receive questionnaires about their demographics, medical history and lifestyle, and response rates have been at least 90%. The Human Research Committees of Brigham and Women's Hospital and Massachusetts Eye and Ear Infirmary approved the studies(46). The current analyses used diet data collected in 2006 (NHS) and 2007 (NHSII) and food addiction data collected in 2008 (NHS) and 2009 (NHSII). As food addiction was only measured once in each cohort, our analyses were cross-sectional.

Ascertainment of Food and Beverage Items and Food Groups

The NHS first collected dietary information in the 1980, 1984, and 1986 follow-up questionnaires, and every four years since. The NHSII first collected diet information in 1991, and every four years since(47). In our cross-sectional analyses, we examined average consumption of food sand beverages from the 2006 NHS and 2007 NHSII 131-item food frequency questionnaire(FFQ). The FFQ is a primary tool for measuring nutrient and food intake in epidemiologic studies and has been shown to have good reliability and validity(48, 49).

For each food and beverage item, participants selected from nine response options ranging from never or <1/month to 6+ servings/day for frequency of intake. Of the 131 items, we identified 39 potentially positively reinforcing food items from published animal(23, 50) and human research (12, 34, 51, 52)on food addiction and binge eating, discussions with food addiction investigators, and published reports of individuals identifying as food addicts and compulsive overeaters (2, 53). These foods included, but are not limited to, hamburgers (12, 51, 52), French fries(12, 52), milk chocolate(12, 23, 50–52), pasta (12, 51), and sugar-sweetened beverages(12, 51, 52). We also examined consumption of several fruits and vegetables as a contrast to positively reinforcing foods(51, 52). We created nine food groups (red/processed meats, snacks, sweets and desserts, refined grains, fruits and vegetables, no/low fat snacks and sweets, no/low fat dairy, low calorie beverages, and sugar-sweetened beverages) by merging consumption of over 85 individual food items into groups based on previous epidemiologic studies that have used these food groups to study nutrition and disease(54, 55).

Ascertainment of Food Addiction

We assessed food addiction using a modified version of the Yale Food Addiction Scale (mYFAS)(Supplemental Table 1) in the NHS2008 and NHSII2009 questionnaires. The mYFAS has nine of 25 items in the original Yale Food Addiction Scale. There is one item for each of the seven diagnostic symptoms for eating-related substance dependence as defined by the DSM-IV, and two items assess impairment and distress (Supplemental Table 2). A participant meets criteria for food addiction if she has three or more of seven substance-use dependence symptoms and experiences impairment or distress in the past year (13). Previous research has shown that food addiction diagnosis as measured by the mYFAS has marginal to good internal reliability in college students (α=0.75) (13)and in a community-based sample (α=0.63 to 0.84) (56), and substantial test-retest reliability (K=0.73, 95% CI, 0.48–0.88) over a two-week period in a community-based sample (56). Although the long-term stability of the mYFAS has not been examined, a recent study (57)found that food addiction diagnosis measured by the Yale Food Addiction Scale had moderate stability (K=0.50, 95% CI, 0.23–0.77) over an 18-month period. In the current study, 1,461 (2.5%) of NHS and 5,194 (8.0%) of NHSII met the criteria for food addiction.

Exclusions

After excluding women who did not fill out questionnaires on diet or food addiction in 2006 and 2008 or 2007 and 2009, we excluded women who were missing entire sections of the FFQ (n=654), did not provide sufficient food addiction information (n=3,634), were missing calorie intake (n=3,945) or smoking (n=585), or had extreme values for other covariates (n=23). Nurses who responded to the food addiction items on the questionnaire were slightly older (~ 4 years) than those who did not respond. However, we did not observe differences by calorie intake, alcohol and smoking habits or depression scores for this same comparison.

After these exclusions, our final sample included 123,688 women, which was over 93% of the available cohort.

Statistical Analysis

We examined frequency distributions for categorical variables and means for continuous variables to compare differences in possible food addiction risk factors (e.g., depression) stratified by food addiction status and cohort. We estimated odds ratios (OR) and 95% confidence intervals (CI)using age -and multivariable -adjusted logistic regression to determine whether food and beverage item intake based on categories of servings (<1/month, 1–3/month, 1/week, 2–4/week and ≥5–6/week) and food groups based on servings/day were associated with food addiction status. Our first multivariable models were adjusted for age, alcohol consumption, current smoking, depression, and total energy intake. Our second multivariable models were additionally adjusted for all food items or food groups in the corresponding table. Because we hypothesized that BMI changes could occur as a consequence of reinforcing food intake and simultaneously a consequence of food addiction, BMI could act as a collider and conditioning on it could introduce collider bias(58). For example, if bacon intake increases BMI and food addiction also increases BMI, then conditioning on BMI could induce a false negative association between bacon and food addiction. Thus our main analyses were not adjusted for BMI.

To test for a linear trend in the odds of food addiction with increasing consumption of each food item, we included a continuous variable with values corresponding to each category of consumption (0–4). The coefficient of the continuous term was evaluated using the Wald test; we considered *P* values <0.05 as statistically significant. We also examined interaction between food group consumption and depression, alcohol consumption, current smoking status, BMI, and diabetes. To test for multiplicative interaction, we evaluated the coefficient for the cross-product term representing the main effect for food group consumption (servings/day, continuous) and the stratification factor(binary)using the Wald test. We additionally calculated ORs for the association between food group and food addiction within each stratification factor.

As we assumed that the biological effects of food intake on food addiction were similar between cohorts, we merged NHS and NHSII for our main analyses and examined the heterogeneity of associations using the Q statistic(a standard statistical test used for harmonizing data to determine the presence of between-study heterogeneity and whether combining data is justified)(59). Overall we observed little heterogeneity by cohort; we present results for food groups stratified by cohort in Supplemental Table 3.

We performed statistical analyses using SAS version 9.3 (SAS Institute Inc, Cary, NC).

Results

The majority of women in both cohorts were married, Caucasian, non-smokers, and non-heavy drinkers (Table 1). Approximately 63% to 66% of obese nurses (BMI kg/m^2≥30) met criteria for food addiction. Women with depression or who consumed a higher number of calories were more likely to be classified with food addiction, whereas women who were older, smoked or drank alcohol were less likely.

In Table 2, we examined associations (reported as ORs (95% CIs))between consumption of potentially positively reinforcing foods and beverages and food addiction. After controlling for confounders(multivariable model a), we observed the highest odds of food addiction for nurses who reported foods typically consumed as fast foods 5+/week compared with <1/ month: hamburgers 4.08 (2.66–6.25), French fries2.37 (1.59–3.51), and pizza2.49 (1.67–3.69); all P’s for trend <0.0001. Bacon, beef as a main dish, popcorn, lean hamburgers, potato/corn chips, popcorn, pretzels, candy bars, candy without chocolate, milk chocolate, white bread, and butter consumption was also positively and significantly associated with food addiction (ORs ranged from 1.13 for pretzels to 1.95 for candy bars). Crackers, cake, store-bought cookies, doughnuts, ice cream, pie, sweet rolls/coffee cakes, pasta, and white potato intake was not associated with food addiction. We observed inverse associations between dark chocolate, homemade cookies, white rice and full fat cheese consumption and food addiction. In addition, when we compared nurses consuming sugar-sweetened beverages 5+/week to <1/month, we observed a strong inverse association with food addiction (0.56 (0.52–0.61)); in contrast, we found a strong positive association between low calorie beverage consumption and food addiction (2.38 (2.24–2.54)). After additionally controlling for all food items in the table, the positive significant associations for hamburgers, candy bars, milk chocolate, butter, pizza, and low calorie beverages remained. Inverse associations were attenuated, but remained significant.

Analyses of two additional FFQ items were consistent with the “fast food” findings: compared with nurses who ate fried food <1/week the odds of food addiction were almost 3-fold for nurses who ate fried food outside the home 4+/week and for nurses consuming fried food at home daily.

With the exception of no/low fat cookies and water, consumption of all no/low fat snacks and sweets, artificial sugar, and low calorie beverages had significant, positive associations with food addiction (Table 3, multivariable model a). For example, compared with nurses consuming <1/month, we observed the strongest odds of food addiction for those consuming 5+/week of caffeinated low calorie beverages(2.21 (2.07–2.35)), decaffeinated low calorie beverages (2.00 (1.86–2.14)), artificial sweetener(excluding Splenda) (1.71 (1.60–1.83)), and Splenda (1.76 (1.65–1.87)).

Consumption of all fruits, vegetables, and legumes had no or inverse associations with food addiction with the exception of string beans (Table 4, multivariable model a). Compared with nurses consuming <1/month, we observed the lowest odds of food addiction for those consuming corn(0.57 (0.43–0.76)) and grapes (0.70 (0.61–0.80)) 5+/week.

Our food group analyses corroborated our food item analyses (Figure 1). For every serving/day increase of red/processed meats, women had a 31% increased odds of food addiction (95% CI, 1.25–1.37). Similarly, for every serving/day increase of low/no fat snacks and desserts, low calorie beverages, and (regular) snacks, women’s odds of food addiction increased by 36% (95% CI, 1.27–1.45), 27% (95% CI, 1.25–1.29), and 13% (95%

CI, 1.09–1.18), respectively. There were no strong associations between sweets and desserts, refined grains, fruits and vegetables, and low/no fat dairy intake and food addiction. However, for every serving/day increase of sugar-sweetened beverage consumption, women had a 26% decreased odds of food addiction (95% CI, 0.70, 0.78). Results were similar when we additionally controlled for all food groups and examined intake by food group quartiles and the 90th versus 10th percentiles of consumption.

To address the ambiguity of the temporal relationship between food group intake, BMI, and food addiction, we conducted sensitivity analyses in which we additionally controlled for BMI (Supplemental Table 3). Overall, the direction of the associations remained the same. However, the associations between red/processed meat and refined grains consumption and food addiction became inverse. The consequences of controlling for BMI may have introduced bias.

As seen in Supplemental Table 3, a few of the p-values for the test for between studies heterogeneity were statistically significant. In the NHSII cohort, with every increase in servings/day of dessert, women were 12% more likely to have food addiction. We did not see this effect in the NHS cohort, the older cohort. Although statistically significant between studies heterogeneity was observed for the food groups of low/no fat snacks and desserts, low calorie-beverages and sugar-sweetened beverages, risk estimates were in the same direction, although the magnitude of the risk was slightly stronger in one cohort. For example, the effect on food addiction for drinking low calorie beverages among women in NHS was slightly stronger (OR 1.33 (1.28–1.39)) than among women in NHSII (OR 1.25 (1.23–1.27)). In addition, food item consumption-heterogeneity analyses (data not shown) were similar to the food group analyses in that there were no qualitatively meaningful differences between cohorts.

Overall, there were few statistically significant interactions between food addiction and food group consumption by depression, smoking, alcohol, BMI or diabetes (Supplemental Table 3). We found qualitatively and statistically significant interactions between red/processed meat consumption and smoking (p=0.04) and BMI (p=0.05), fruit and vegetable intake and BMI (p<0.001), low/no fat snack and dessert consumption and diabetes (p=0.02), and low/no fat dairy intake and smoking (p=0.001). In subgroup analyses, non-smokers and overweight nurses had increased odds of food addiction with increased red/processed meat intake, while smokers and non-overweight nurses did not, and smokers had increased odds of food addiction with increased low/no fat dairy intake while non-smokers had decreased odds. Overweight nurses had lower odds of food addiction with increased fruit and vegetable intake while non-overweight nurses did not, and non-diabetic nurses had increased odds of food addiction with increased low/no fat snack and dessert consumption while diabetics did not. There were other statistically significant interactions between food group consumption and certain stratification factors; however, further subgroup analyses revealed only marginal differences in the magnitude, but not the direction of the ORs.

Discussion

Our study was the first to examine the relationship between food and beverage consumption and food addiction. Intake of many positively reinforcing foods (e.g., pizza) was positively associated with food addiction. We also found strong positive associations between no/low fat and artificially sweetened food and low calorie beverage intake and food addiction. Yet, we found no association between food addiction and consumption of certain sweet food items (e.g., cake and ice cream) and refined grains (e.g., pasta and white potato), foods that are similarly metabolized into sugar. We also found inverse associations with homemade cookies, dark chocolate, white rice, full fat cheese, and sugar-sweetened beverage intake, all of which contradict the basic science model of drugs of abuse(60, 61).

Previous human studies have examined food addiction and food cravings, liking, snacking, and consumption (18, 20, 21, 34, 44, 62–68). Our findings support prior studies observing positive associations between food addiction and fatty food liking(62), processed food liking (62), percent of diet from fat(18, 67), consumption of fat (67), and sweet snacking (20, 21). Our results were also consistent with studies finding no association between food addiction and sugar and carbohydrate consumption,(44)percent of diet from carbohydrates (18, 67), sugar cravings (62, 66), pleasantness ratings of a milkshake (34, 63), reported problems with foods containing mostly sugar without fats or protein (68) and sugar liking(62). However, our results were not consistent with prior work suggesting a positive association between food addiction and starchy food cravings(66). Some of these findings contradict previous animal research, which has supported a model of "sugar addiction"(42, 60).

There are a few possible explanations for our findings. First, people meeting criteria for food addiction may not be addicted to sugar in isolation as has been observed in rat studies; rather, the combination of sugar, fat and salt and/or processing level may create the positively reinforcing quality of foods that leads to the most addictive eating(52, 68). Some of our findings support this 'combination' theory: certain fatty sweet foods (e.g., candy bars) had strong associations with food addiction, and in our study, consumption of "fast foods"—hamburgers, French fries, and pizza—had the highest odds of food addiction.

Our findings suggest that women with food addiction drink fewer sugar-sweetened beverages and more low calorie beverages than those without food addiction. One possible explanation is reverse causation—people with food addiction may replace their sugar-sweetened beverage and sweet food consumption with "diet" beverages, artificially sweetened foods, and no/low fat foods (69). Recent animal studies have supported the addictive nature of artificially sweetened foods; these studies show that the intense sweetness of artificial sweeteners may surpass the reward of cocaine (70) and may produce sucrose-like rewarding effects and withdrawal (71). As prospective analyses have shown positive associations between sugar-sweetened beverage consumption and long-term weight gain(72) and between BMI and food addiction (13), our inverse association between sugar-sweetened beverage consumption and food addiction is likely non-causal. Due to the cross-sectional nature of our analyses, we could not test whether positively reinforcing food intake(collected in 2006 and 2007) causes food addiction (collected in 2008 and 2009)or conclude that drinking these beverages influences one's risk of food addiction. However, we used diet data collected before food addiction, so the direction of potential causality would be correct.

The assessment of diet using the FFQ could have led to exposure misclassification (73). Nurses with unusual diets or who eat foods not assessed by the FFQ may appear to eat fewer positively reinforcing foods. It is also possible that women with food addiction may underreport consumption of certain types of positively reinforcing foods, as research suggests that BMI and underreporting are positively associated(74). The FFQ may not adequately capture binge eating behavior patterns (eating large amounts of food within a short period of time). People with food addiction may generally avoid eating the foods for which we found no or inverse associations (e.g., cake, ice cream); however, these foods may be consumed predominantly during less frequent binge episodes(51). In addition, eating patterns for certain foods(e.g., cake, ice cream) may be affected by seasonality and cultural norms, which may make it more difficult to estimate one's average consumption over the past year; or these foods may appear in a lower intake category due to episodes of binge eating occurring only a few times per year. While these potential sources of error could have biased our effect estimates towards the null, the FFQ is a valid method for assessing long term dietary intake (49).

Our analyses revealed unexpected findings regarding the lack of comorbidity of addictions —i.e., nurses who drank alcohol and smoked cigarettes were less likely to have a food addiction diagnosis. Substance-related disorders involving alcohol, illicit drugs, and nicotine are often comorbid. For example, one study(75) found that the odds of lifetime drug dependence were 15.75 times higher (95% CI 9.59–25.86) among women with lifetime alcohol dependence compared with women without. However, researchers have hypothesized an inverse relationship between current food addiction and current substance-related disorders(76–78). As food and alcohol or food and cigarettes may compete for the same neurotransmitters (e.g., dopamine) in the brain, people with a susceptibility to addictive behavior may not abuse more than one of these substances concurrently. Thus, while lifetime comorbidity may be expected, we expected inverse relationships between current food addiction and current other substance-related disorders. Our data supported this hypothesis: compared with women without food addiction, we found a lower prevalence of substance use (i.e., cigarette smoking and alcohol consumption) among women with food addiction.

Unknown or unmeasured factors may have confounded the relationship between diet and food addiction. For example, we did not account for diet intake at younger ages, which may influence both current food intake and food addiction. In addition, the inverse associations between food addiction and consumption of certain sweet foods, refined grains, and sugar-sweetened beverages could partly be due to confounding by dieting. Women with food addiction may be more likely to diet (79)(as are women with weight concerns and those who engage in binge eating behaviors (80)). Women who engage in dieting behaviors often avoid sugar-sweetened beverages and many sugary sweets, and instead eat no/low fat and artificially sweetened foods(81, 82). Although people typically consume no/low fat and artificially sweetened foods to lose weight, research suggests that overweight individuals who drink non-caloric beverages compensate by consuming additional calories from solid food (83). As we only had dieting behavior information in NHSII, we conducted a sensitivity analysis controlling for dieting in our models; results from this sensitivity analysis were similar to our main models. Overall, we accounted for a wide variety of potential confounders in our analyses, and our adjustment for variables was more comprehensive than most previous food addiction studies.

In addition, we examined a large number of associations, and some of the statistically significant associations may be due to chance. For example, we found some statistically significant p-values for the test for between studies heterogeneity when we examined the association between food group consumption and food addiction by cohort. While certain ORs for food group consumption and food addiction were quantitatively different between cohorts, effect estimates were similar and almost exclusively in the same direction, thus not qualitatively different. Most importantly, there was not a consistent pattern suggesting that food consumption and food addiction would be biologically different between the two cohorts. However, due to the cross-sectional nature of our study and concern about multiple comparisons, these results require replication, especially within different age groups.

Although the NHS cohorts provide an extremely rich source of data, the generalizability of our findings may be limited, as the cohorts are comprised of middle to older-aged female nurses, most of whom are Caucasian. Thus, our findings may not be generalizable to younger individuals, people with a different socioeconomic status, men or non-white populations. However, this study was conducted using the largest cohort to date in over 120,000 women; as most previous studies on food addiction have been conducted in small samples of overweight individuals, our study should be more generalizable to the general public.

Despite these potential limitations, our study has a number of strengths. The NHS cohorts have biennial response rates of 90%, which limits potential selection bias. The large sample size provides ample power to detect main effects and control for many confounders simultaneously. The prospective design also allows for continuous updating of exposures and outcomes, which limits potential misclassification and increases the validity of measures.

This paper was the first to examine the relationship between food consumption and food addiction in a large epidemiologic study. Our analyses make fundamental contributions to assessing the relationship between a new, potentially important addiction and the positively reinforcing substances at play. While our research supported many previously suspected foods as being positively associated with food addiction, some findings did not corroborate a model of sugar addiction. Clinical implications of our results will rely on replication of these findings in prospective studies and whether mental health professionals determine that food addiction is a valid psychiatric diagnosis(84). Longitudinal analyses should further investigate the temporal order between food consumption and food addiction, as some of the relationships examined in the current study were difficult to interpret due to the cross-sectional design.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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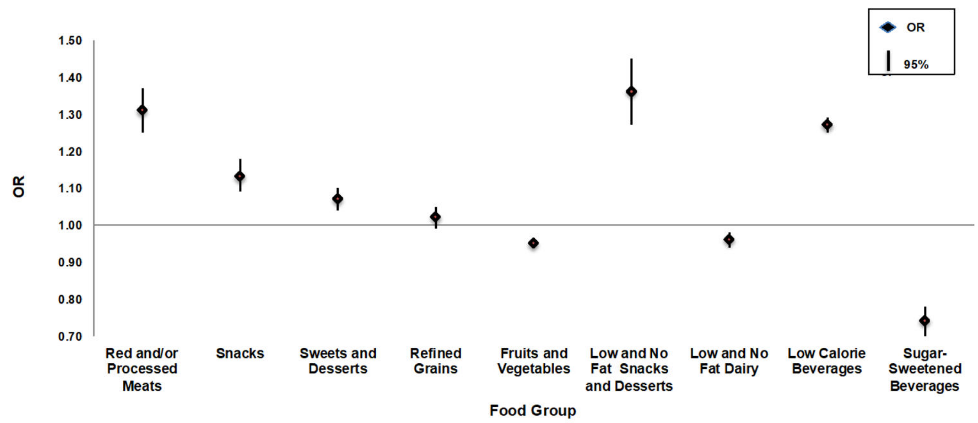

Figure 1.

ORs and 95% CIs For Food Group [a] Consumption (Servings per Day, 2006–2007) and Food Addiction (2008–2009) Among Nurses in the NHS Cohorts (n = 123,688)

Abbreviations: CI = Confidence Intervals; OR = Odds Ratio; NHS = Nurses' Health Study

Analyses were adjusted for age (continuous), total energy intake (continuous calories in kcal), alcohol (non-drinkers (reference), >0–15 and >15 grams/day), current smoking (no current smoking (reference), 1–14 and ≥15 cigarettes/day), and physician diagnosis of depression (no (reference), yes)

[a]The following foods were included in each food group: *Red/Processed Meats:* Beef or pork hot dogs. Chicken or turkey hot dogs, Bacon (2 slices), Salami, bologna, or other processed meat sandwiches. Other processed meats, e.g., sausage, kielbasa, etc. (2 oz. or 2 small links), Hamburger Lean or extra lean. Hamburger regular, Beef, pork, or lamb as a sandwich or mixed dish, e.g., stew, casserole, lasagna, etc., Pork as a main dish, e.g., ham or chops (4–6 oz.), Beef or lamb as a main dish, e.g., steak, roast (4–6 oz.); *Snacks*; Crackers, Popcorn, Potato chips or com/tortilla chips. Pretzels, and French fries; *Sweets and Desserts:* Cake, Candy bars. Candy without chocolate. Homemade Cookies or brownies, Store-bought Cookies or brownies, Dark chocolate. Doughnuts, Milk chocolate, Pie, Ice cream. Homemade sweet roll, coffee cake, or other pastry, and Store-bought sweet roll, coffee cake, or other pastry; *Refined Grains:* White bread, English muffins, bagels or rolls, Muffins or biscuits. White rice. Pasta, Pancakes or waflles. Crackers, Pretzels, Tortillas; *Fruits and Vegetables* Apples, apple juice, bananas, grapes, avocados, apricots, blueberries, cantaloupe, grapefruit, other juice, oranges, orange juice, orange juice with calcium, peaches, prunes, prune juice, strawberries, tomatos, tomato juice, tomato sauce, string beans, broccoli, cabbage/coleslaw, cauliflower, brussel sprouts, raw carrots, cooked carrots, corn, mixed vegetables, peas, eggplant, squash, yams, cooked spinach, raw spinach, kale, iceburg lettuce, red leaf lettuce, celery, onions; *Low and No Fat Sweets and Snacks.* Frozen yogurt, sherbet or low-fat ice cream. Cookies fat free or reduced fat Popcorn fat free or light. Sweet roll, coffee cake or other pastry fat free or reduced fat; *Low and No Fat Dairy.* Skim milk, 1 or 2% milk, Low-carb, artificially sweetened or plain flavored yogurt. Low or no fat cottage cheese. Low or no fat other cheese; *Low Calories Beverages:* Low-calorie beverage with caffeine and Other low-calorie beverage without caffeine; *Sugar-Sweetened Beverages:*

Carbonated beverage with caffeine and sugar, Carbonated beverage with sugar, Other sugared beverages

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Table 1

Characteristics of Nurses in the Nurses' Health Studies in 2008 and 2009 (n = 123,688)

		NHS (n = 58,625)		NHSII (n = 65,063)	
		Food Addiction, No. (%)			
		Yes	No	Yes	No
Food Addiction	No		57,164 (97.5)		59,869 (92.0)
	Yes	1,461 (2.5)		5,194 (8.0)	
Age (years)	45–59			4,266 (82.1)	48,263 (80.6)
	60–74	1,133 (77.5)	32,307 (56.5)	928 (17.9)	11,606 (19.4)
	75–87	328 (22.5)	24,857 (43.5)		
Martial Status[a]	Never married			397 (7.8)	2,898 (5.0)
	Separated/divorced	172 (12.0)	4,133 (7.3)	811 (16.0)	7,270 (12.4)
	Widowed	310 (21.7)	16,440 (29.0)	146 (2.9)	1,725 (3.0)
	Married	950 (66.3)	36,140 (63.7)	3,710 (73.3)	46,678 (79.7)
Race/Ethnicity	Other/Unknown	77 (5.3)	3,397 (5.9)	158 (3.0)	1,793 (3.0)
	African American	9 (0.6)	552 (1.0)	38 (0.7)	659 (1.10)
	Hispanic	6 (0.4)	330 (0.6)	60 (1.2)	779 (1.3)
	Asian	2 (0.1)	399 (0.7)	23 (0.4)	827 (1.4)
	Caucasian	1,367 (93.6)	52,486 (91.8)	4,915 (94.6)	55,811 (93.2)
Current Smoking (cig/day)	0	1,415 (96.9)	54,215 (94.8)	4,978 (95.8)	56,264 (94.0)
	1–14	30 (2.1)	1,724 (3.0)	125 (2.4)	2,022 (3.4)
	15+	16 (1.1)	1,225 (2.1)	91 (1.8)	1,583 (2.6)
Alcohol Consumption (g/day)	0	752 (51.5)	24,975 (43.7)	2,145 (41.3)	19,816 (33.1)
	> 0–15	584 (40.0)	24,041 (42.1)	2,605 (50.2)	32,007 (53.5)
	> 15	125 (8.6)	8,148 (14.3)	444 (8.6)	8,046 (13.4)
Depression (physician diagnosis)	No	1,173 (80.3)	53,388 (93.4)	3,273 (63.0)	50,247 (83.9)
	Yes	288 (19.7)	3,776 (6.6)	1,921 (37.0)	9,622 (16.1)

		NHS (n = 58,625)		NHSII (n = 65,063)	
		Food Addiction, No. (%)			
		Yes	**No**	**Yes**	**No**
Body Mass Index[a] (kg/m^2)	<=24.9	136 (9.4)	26,187 (46.4)	484 (9.4)	26,228 (44.2)
	25–29.9	400 (27.7)	18,859 (33.4)	1,283 (24.9)	18,152 (30.6)
	30+	906 (62.8)	11,382 (20.2)	3,382 (65.7)	14,917 (25.2)
Mean Calories (kcal/day)[b] (SD)		1,773.1 (579.9)	1,648.7 (532.3)	1,882.3 (596.5)	1,802.8 (554.1)

Abbreviations: cig = cigarettes; g = grams; kcal = kilocalories; kg = kilograms; m = meters; NHS = Nurses' Health Study; SD = standard deviation

[a]Frequencies do not add up to column totals due to missing data; 1,908 missing marital status; 1,372 missing body mass index

[b]This information was collected from 2006 and 2007 food frequency questionnaires

Table 2

Odds Ratios and 95% Confidence Intervals for Consumption of Potentially Positively Reinforcing Foods and Beverages (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II (n = 123,688)

		OR (95% CI)					
		Number of Servings					
Food Item		**<1/month**	**1–3/month**	**1/week**	**2–4/week**	**≥5–6/week**	P_{trend} *
		Processed and Red Meats					
Bacon	No. of cases	2938	2340	993	318	66	
	Age-adjusted	1.00	1.01 (0.96–1.07)	1.10 (1.02–1.18)	1.19 (1.06–1.35)	1.62 (1.25–2.10)	<0.001
	Multivariable[a]	1.00	1.01 (0.95–1.07)	1.08 (1.00–1.16)	1.13 (1.00–1.28)	1.56 (1.20–2.03)	0.001
	Multivariable[b]	1.00	0.95 (0.89–1.01)	0.96 (0.88–1.04)	0.93 (0.82–1.06)	1.12 (0.86–1.47)	0.16
Hamburgers	No. of cases	3461	1688	1164	310	32	
	Age-adjusted	1.00	1.19 (1.12–1.27)	1.59 (1.49–1.71)	2.27 (2.01–2.57)	5.76 (3.83–8.67)	<0.001
	Multivariable[a]	1.00	1.15 (1.08–1.23)	1.46 (1.36–1.57)	1.83 (1.61–2.08)	4.08 (2.66–6.25)	<0.001
	Multivariable[b]	1.00	1.13 (1.06–1.21)	1.33 (1.23–1.44)	1.51 (1.32–1.74)	3.21 (2.02–5.09)	<0.001
Hamburgers (lean)	No. of cases	1843	2140	2045	599	28	
	Age-adjusted	1.00	0.94 (0.89–1.01)	1.18 (1.10–1.25)	1.58 (1.44–1.74)	2.13 (1.43–3.19)	<0.001
	Multivariable[a]	1.00	0.96 (0.90–1.02)	1.12 (1.04–1.19)	1.34 (1.21–1.48)	1.62 (1.07–2.44)	<0.001
	Multivariable[b]	1.00	1.02 (0.95–1.09)	1.12 (1.04–1.20)	1.27 (1.15–1.42)	1.10 (0.71–1.70)	<0.001
Beef as a Main Dish	No. of cases	1267	2030	2299	1001	58	
	Age-adjusted	1.00	0.96 (0.89–1.03)	1.01 (0.94–1.08)	1.22 (1.12–1.33)	1.77 (1.34–2.35)	<0.001
	Multivariable[a]	1.00	0.97 (0.90–1.04)	1.01 (0.94–1.09)	1.15 (1.05–1.26)	1.54 (1.16–2.06)	0.001
	Multivariable[b]	1.00	0.94 (0.87–1.01)	0.94 (0.87–1.02)	1.02 (0.92–1.12)	1.14 (0.84–1.54)	0.85
		Snacks					
Crackers	No. of cases	1494	1734	1450	1289	688	
	Age-adjusted	1.00	0.89 (0.83–0.95)	0.94 (0.87–1.02)	0.94 (0.87–1.01)	1.16 (1.06–1.27)	0.04

Food Item		OR (95% CI)					
		Number of Servings					
		<1/month	1–3/month	1/week	2–4/week	≥5–6/week	P_{trend}*
		Processed and Red Meats					
	Multivariable[a]	1.00	0.89 (0.83–0.96)	0.94 (0.87–1.01)	0.90 (0.83–0.98)	1.06 (0.96–1.17)	0.98
	Multivariable[b]	1.00	0.89 (0.82–0.96)	0.92 (0.85–1.00)	0.88 (0.81–0.96)	1.01 (0.91–1.12)	0.24
French fries	No. of cases	2882	2332	1076	331	34	
	Age-adjusted	1.00	1.11 (1.04–1.17)	1.37 (1.28–1.48)	1.91 (1.69–2.16)	3.41 (2.33–4.98)	<0.001
	Multivariable[a]	1.00	1.07 (1.01–1.13)	1.25 (1.16–1.35)	1.53 (1.34–1.74)	2.37 (1.59–3.51)	<0.001
	Multivariable[b]	1.00	0.97 (0.91–1.04)	1.01 (0.92–1.10)	1.04 (0.90–1.20)	1.14 (0.74–1.74)	0.77
Popcorn	No. of cases	4202	1512	644	233	64	
	Age-adjusted	1.00	1.05 (0.99–1.11)	1.28 (1.17–1.40)	1.39 (1.21–1.59)	1.78 (1.37–2.31)	<0.001
	Multivariable[a]	1.00	1.00 (0.94–1.06)	1.19 (1.09–1.30)	1.21 (1.05–1.39)	1.45 (1.11–1.89)	<0.001
	Multivariable[b]	1.00	0.99 (0.93–1.06)	1.14 (1.04–1.25)	1.15 (1.00–1.33)	1.28 (0.97–1.68)	0.003
Potato/corn chips	No. of cases	1876	2158	1443	948	230	
	Age-adjusted	1.00	1.02 (0.95–1.08)	1.09 (1.02–1.17)	1.22 (1.12–1.33)	1.53 (1.32–1.77)	<0.001
	Multivariable[a]	1.00	1.02 (0.95–1.09)	1.08 (1.00–1.16)	1.14 (1.05–1.25)	1.38 (1.19–1.61)	<0.001
	Multivariable[b]	1.00	0.99 (0.93–1.07)	0.98 (0.90–1.07)	1.00 (0.91–1.10)	1.13 (0.97–1.33)	0.77
Pretzels		2851	1940	917	639	308	
	Age-adjusted	1.00	1.02 (0.96–1.08)	1.07 (0.99–1.15)	1.11 (1.02–1.21)	1.19 (1.06–1.35)	<0.001
	Multivariable[a]	1.00	1.02 (0.96–1.08)	1.08 (0.99–1.16)	1.09 (1.00–1.20)	1.13 (1.00–1.28)	0.005
	Multivariable[b]	1.00	0.99 (0.93–1.05)	1.00 (0.92–1.09)	1.03 (0.93–1.13)	1.02 (0.90–1.17)	0.85
		Sweets and Desserts					
Cake	No. of cases	2965	2821	686	165	18	
	Age-adjusted	1.00	1.12 (1.06–1.18)	1.37 (1.26–1.49)	1.57 (1.33–1.85)	1.37 (0.85–2.22)	<0.001
	Multivariable[a]	1.00	1.04 (0.98–1.10)	1.19 (1.09–1.30)	1.24 (1.05–1.47)	1.12 (0.69–1.82)	0.001

Food Item		OR (95% CI)					
		Number of Servings					
		<1/month	1–3/month	1/week	2–4/week	≥5–6/week	P_{trend}*
		Processed and Red Meats					
	Multivariable[b]	1.00	1.10 (1.03–1.17)	1.21 (1.08–1.35)	1.29 (1.07–1.56)	0.99 (0.59–1.67)	<0.001
Candy bar	No. of cases	3647	1957	725	258	68	
	Age-adjusted	1.00	1.32 (1.25–1.40)	1.74 (1.60–1.90)	2.08 (1.82–2.37)	2.32 (1.80–3.00)	<0.001
	Multivariable[a]	1.00	1.24 (1.17–1.32)	1.55 (1.43–1.70)	1.74 (1.51–2.00)	1.95 (1.50–2.54)	<0.001
	Multivariable[b]	1.00	1.16 (1.09–1.24)	1.33 (1.20–1.46)	1.41 (1.22–1.64)	1.61 (1.22–2.14)	<0.001
Candy without chocolate	No. of cases	3588	1819	678	368	202	
	Age-adjusted	1.00	1.21 (1.14–1.28)	1.35 (1.24–1.47)	1.44 (1.29–1.61)	1.50 (1.29–1.74)	<0.001
	Multivariable[a]	1.00	1.15 (1.08–1.22)	1.24 (1.14–1.35)	1.27 (1.14–1.43)	1.28 (1.10–1.49)	<0.001
	Multivariable[b]	1.00	1.10 (1.03–1.17)	1.08 (0.98–1.18)	1.12 (1.00–1.27)	1.12 (0.96–1.31)	0.006
Dark chocolate	No. of cases	3501	1692	803	422	237	
	Age-adjusted	1.00	1.01 (0.95–1.08)	1.01 (0.94–1.10)	0.98 (0.88–1.09)	0.90 (0.79–1.03)	0.37
	Multivariable[a]	1.00	0.98 (0.92–1.04)	0.95 (0.88–1.03)	0.88 (0.79–0.98)	0.77 (0.67–0.89)	<0.001
	Multivariable[b]	1.00	1.00 (0.94–1.07)	0.91 (0.83–0.99)	0.88 (0.79–0.99)	0.80 (0.69–0.93)	<0.001
Milk chocolate	No. of cases	2135	2164	1265	736	355	
	Age-adjusted	1.00	1.21 (1.13–1.28)	1.49 (1.39–1.60)	1.75 (1.60–1.91)	2.05 (1.82–2.31)	<0.001
	Multivariable[a]	1.00	1.16 (1.09–1.24)	1.37 (1.27–1.47)	1.54 (1.40–1.68)	1.69 (1.49–1.91)	<0.001
	Multivariable[b]	1.00	1.12 (1.05–1.20)	1.24 (1.14–1.35)	1.34 (1.21–1.48)	1.43 (1.25–1.63)	<0.001
Cookies (homemade)	No. of cases	3143	2192	817	362	141	
	Age-adjusted	1.00	0.82 (0.78–0.87)	0.91 (0.84–0.99)	0.83 (0.74–0.93)	0.89 (0.75–1.06)	<0.001
	Multivariable[a]	1.00	0.79 (0.75–0.84)	0.83 (0.76–0.90)	0.74 (0.66–0.83)	0.75 (0.63–0.90)	<0.001
	Multivariable[b]	1.00	0.81 (0.76–0.86)	0.77 (0.71–0.85)	0.76 (0.67–0.85)	0.79 (0.66–0.95)	<0.001
Cookies (store)	No. of cases	2916	1819	970	618	332	

		OR (95% CI)					
		Number of Servings					
Food Item		**<1/month**	**1–3/month**	**1/week**	**2–4/week**	**≥5–6/week**	P_{trend}*
			Processed and Red Meats				
	Age-adjusted	1.00	1.07 (1.01–1.14)	1.36 (1.26–1.47)	1.15 (1.05–1.26)	1.19 (1.06–1.34)	<0.001
	Multivariable[a]	1.00	1.02 (0.96–1.09)	1.23 (1.14–1.33)	1.02 (0.93–1.11)	1.00 (0.89–1.13)	0.06
	Multivariable[b]	1.00	1.00 (0.93–1.06)	1.13 (1.03–1.23)	0.91 (0.82–1.00)	0.90 (0.79–1.02)	0.23
Doughnuts	No. of cases	4335	1765	425	108	22	
	Age-adjusted	1.00	1.24 (1.17–1.31)	1.51 (1.36–1.67)	1.65 (1.35–2.01)	1.96 (1.26–3.05)	<0.001
	Multivariable[a]	1.00	1.15 (1.08–1.22)	1.31 (1.18–1.46)	1.32 (1.07–1.62)	1.49 (0.95–2.34)	<0.001
	Multivariable[b]	1.00	1.06 (1.00–1.14)	1.09 (0.97–1.23)	1.01 (0.81–1.26)	1.01 (0.63–1.62)	0.08
Ice cream	No. of cases	2854	2280	794	596	131	
	Age-adjusted	1.00	1.00 (0.94–1.05)	1.05 (0.96–1.13)	1.24 (1.13–1.36)	1.28 (1.07–1.54)	<0.001
	Multivariable[a]	1.00	0.95 (0.90–1.01)	0.92 (0.84–1.00)	1.01 (0.92–1.11)	0.94 (0.78–1.13)	0.26
	Multivariable[b]	1.00	0.94 (0.88–1.00)	0.88 (0.80–0.96)	0.95 (0.86–1.05)	0.86 (0.71–1.05)	0.004
Pie	No. of cases	3893	2289	403	61	9	
	Age-adjusted	1.00	0.99 (0.94–1.04)	1.24 (1.12–1.38)	1.38 (1.06–1.79)	2.73 (1.35–5.51)	0.002
	Multivariable[a]	1.00	0.91 (0.86–0.96)	1.04 (0.93–1.16)	1.02 (0.78–1.33)	1.94 (0.94–4.01)	0.20
	Multivariable[b]	1.00	0.90 (0.84–0.96)	0.94 (0.82–1.07)	0.94 (0.71–1.26)	1.91 (0.86–4.23)	0.006
Sweet roll/coffee cake (homemade)	No. of cases	5263	1124	224	37	7	
	Age-adjusted	1.00	0.92 (0.87–0.99)	0.97 (0.84–1.11)	0.94 (0.67–1.31)	1.16 (0.54–2.51)	0.08
	Multivariable[a]	1.00	0.87 (0.81–0.93)	0.85 (0.74–0.98)	0.79 (0.57–1.11)	0.94 (0.43–2.05)	<0.001
	Multivariable[b]	1.00	0.92 (0.85–0.99)	0.78 (0.67–0.92)	0.74 (0.52–1.04)	0.96 (0.44–2.12)	<0.001
Sweet roll/coffee cake (store)	No. of cases	4158	1784	534	156	23	
	Age-adjusted	1.00	1.15 (1.09–1.22)	1.48 (1.34–1.62)	1.82 (1.54–2.15)	1.43 (0.93–2.19)	<0.001
	Multivariable[a]	1.00	1.08 (1.02–1.14)	1.28 (1.16–1.41)	1.45 (1.22–1.72)	1.11 (0.72–1.71)	<0.001

Food Item		OR (95% CI)					
		Number of Servings					
		<1/month	1–3/month	1/week	2–4/week	≥5–6/week	P_{trend}*
Processed and Red Meats							
	Multivariable[b]	1.00	1.08 (1.01–1.15)	1.24 (1.11–1.39)	1.37 (1.14–1.65)	0.97 (0.62–1.53)	<0.001
Refined Grains							
Pasta	No. of cases	547	1857	2665	1441	145	
	Age-adjusted	1.00	0.82 (0.74–0.90)	0.77 (0.70–0.85)	0.79 (0.71–0.87)	1.10 (0.90–1.33)	0.01
	Multivariable[a]	1.00	0.82 (0.74–0.91)	0.74 (0.67–0.82)	0.69 (0.62–0.77)	0.88 (0.72–1.08)	<0.001
	Multivariable[b]	1.00	0.86 (0.77–0.95)	0.80 (0.71–0.89)	0.75 (0.67–0.85)	0.92 (0.74–1.13)	<0.001
White bread	No. of cases	2885	1320	754	971	725	
	Age-adjusted	1.00	1.11 (1.04–1.19)	1.05 (0.96–1.14)	1.10 (1.02–1.18)	1.28 (1.18–1.39)	<0.001
	Multivariable[a]	1.00	1.11 (1.03–1.18)	1.03 (0.94–1.12)	1.05 (0.97–1.13)	1.13 (1.03–1.23)	0.02
	Multivariable[b]	1.00	1.12 (1.04–1.20)	1.02 (0.93–1.11)	1.04 (0.96–1.13)	1.06 (0.96–1.16)	0.37
White Potato	No. of cases	730	1965	2177	1557	226	
	Age-adjusted	1.00	0.96 (0.87–1.04)	0.95 (0.87–1.03)	0.93 (0.85–1.01)	1.16 (1.00–1.36)	0.71
	Multivariable[a]	1.00	0.93 (0.85–1.01)	0.88 (0.80–0.96)	0.79 (0.72–0.87)	0.91 (0.77–1.06)	<0.001
	Multivariable[b]	1.00	0.99 (0.90–1.09)	0.92 (0.84–1.02)	0.82 (0.74–0.91)	0.89 (0.75–1.05)	<0.001
White rice	No. of cases	2376	2721	1206	327	25	
	Age-adjusted	1.00	0.91 (0.86–0.96)	0.90 (0.84–0.97)	0.85 (0.75–0.95)	0.54 (0.36–0.81)	<0.001
	Multivariable[a]	1.00	0.88 (0.83–0.93)	0.84 (0.78–0.90)	0.72 (0.64–0.82)	0.46 (0.31–0.69)	<0.001
	Multivariable[b]	1.00	0.90 (0.84–0.96)	0.89 (0.82–0.97)	0.77 (0.68–0.88)	0.51 (0.34–0.78)	<0.001
Other							
Butter	No. of cases	2807	1110	639	1062	1037	
	Age-adjusted	1.00	1.04 (0.96–1.11)	0.98 (0.90–1.08)	1.02 (0.95–1.10)	1.16 (1.08–1.25)	0.002
	Multivariable[a]	1.00	1.07 (0.99–1.15)	1.02 (0.94–1.12)	1.06 (0.98–1.14)	1.13 (1.05–1.22)	0.004

Food Item		OR (95% CI)					
		Number of Servings					
		<1/month	1–3/month	1/week	2–4/week	≥5–6/week	P_{trend}*
Processed and Red Meats							
	Multivariable[b]	1.00	1.12 (1.04–1.20)	1.10 (1.00–1.20)	1.17 (1.08–1.26)	1.26 (1.16–1.37)	<0.001
Cheese (full fat)	No. of cases	2512	282	523	988	2350	
	Age-adjusted	1.00	0.80 (0.71–0.91)	0.86 (0.78–0.95)	0.86 (0.80–0.93)	0.93 (0.87–0.98)	0.006
	Multivariable[a]	1.00	0.85 (0.75–0.97)	0.90 (0.82–0.99)	0.90 (0.83–0.97)	0.90 (0.85–0.96)	0.001
	Multivariable[b]	1.00	0.88 (0.77–1.01)	0.92 (0.83–1.02)	0.91 (0.84–0.99)	0.90 (0.84–0.96)	<0.001
Pizza	No. of cases	1293	2843	2104	380	35	
	Age-adjusted	1.00	1.09 (1.02–1.17)	1.28 (1.19–1.38)	1.87 (1.65–2.11)	3.59 (2.46–5.25)	<0.001
	Multivariable[a]	1.00	1.07 (1.00–1.15)	1.19 (1.10–1.29)	1.51 (1.33–1.72)	2.49 (1.67–3.69)	<0.001
	Multivariable[b]	1.00	1.07 (1.00–1.16)	1.11 (1.02–1.21)	1.27 (1.11–1.46)	1.90 (1.26–2.88)	0.001
Beverages							
Sugar-Sweetened Beverages	No. of cases	4281	774	446	364	790	
	Age-adjusted	1.00	0.73 (0.68–0.79)	0.68 (0.62–0.75)	0.72 (0.64–0.80)	0.69 (0.64–0.74)	<0.001
	Multivariable[a]	1.00	0.70 (0.64–0.76)	0.63 (0.57–0.70)	0.65 (0.58–0.73)	0.56 (0.52–0.61)	<0.001
	Multivariable[b]	1.00	0.75 (0.69–0.82)	0.69 (0.62–0.76)	0.71 (0.63–0.80)	0.63 (0.57–0.69)	<0.001
Low Calorie Beverages	No. of cases	1540	463	500	544	3608	
	Age-adjusted	1.00	1.34 (1.20–1.49)	1.58 (1.42–1.75)	1.60 (1.44–1.76)	2.47 (2.32–2.63)	<0.001
	Multivariable[a]	1.00	1.37 (1.23–1.53)	1.59 (1.43–1.77)	1.63 (1.47–1.81)	2.38 (2.24–2.54)	<0.001
	Multivariable[b]	1.00	1.31 (1.17–1.46)	1.48 (1.33–1.65)	1.46 (1.32–1.62)	1.93 (1.80–2.07)	<0.001

Abbreviations: CI = Confidence Interval; NHS = Nurses' Health Study; OR = Odds Ratio

[a]Adjusted for age (continuous), total energy intake (continuous calories in kcal), alcohol (non-drinkers (reference), >0–15 and >15 grams/day), current smoking (no current smoking (reference), 1–14 and ≥15 cigarettes/day), and physician diagnosis of depression (no (reference), yes)

[b]Additionally adjusted for food items in table

*P for trend was calculated by including a continuous variable with values corresponding to each category of consumption (i.e., 0–4); multivariable model b included continuous variables for all food items simultaneously

Low Calorie Beverages: Low-calorie beverage with caffeine and Other low-calorie beverage without caffeine

Sugar-Sweetened Beverages: Carbonated beverage with caffeine and sugar, Carbonated beverage with sugar, Other sugared beverages

Table 3

Odds Ratios and 95% Confidence Intervals for Consumption of Low or No Fat and/or No Sugar Foods and Beverages (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II (n = 123,688)

		OR (95% CI)					
		Number of Servings					
Food Item		**<1/month**	**1–3/month**	**1/week**	**2–4/week**	**≥5–6/week**	P_{trend}*
Low and No Fat Snacks							
Popcorn (fat free)	No. of cases	3403	1694	881	492	185	
	Age-adjusted	1.00	1.21 (1.14–1.29)	1.45 (1.34–1.56)	1.76 (1.59–1.94)	2.23 (1.91–2.62)	<0.001
	Multivariable[a]	1.00	1.19 (1.12–1.26)	1.38 (1.28–1.49)	1.65 (1.49–1.83)	2.04 (1.73–2.40)	<0.001
	Multivariable[b]	1.00	1.06 (0.99–1.13)	1.17 (1.08–1.27)	1.36 (1.23–1.51)	1.58 (1.34–1.87)	<0.001
Low and No Fat Sweets and Desserts							
Cookies (no/low fat)	No. of cases	4978	946	377	244	110	
	Age-adjusted	1.00	1.15 (1.07–1.24)	1.39 (1.24–1.55)	1.27 (1.11–1.45)	1.21 (0.99–1.47)	<0.001
	Multivariable[a]	1.00	1.11 (1.03–1.19)	1.31 (1.17–1.46)	1.19 (1.04–1.36)	1.08 (0.89–1.32)	<0.001
	Multivariable[b]	1.00	0.94 (0.87–1.02)	1.08 (0.96–1.21)	1.00 (0.87–1.15)	0.94 (0.76–1.15)	0.78
Sherbet/frozen yogurt	No. of cases	3341	1835	643	624	212	
	Age-adjusted	1.00	1.11 (1.05–1.18)	1.13 (1.04–1.24)	1.31 (1.20–1.43)	1.43 (1.24–1.65)	<0.001
	Multivariable[a]	1.00	1.07 (1.01–1.14)	1.06 (0.97–1.15)	1.17 (1.07–1.28)	1.16 (1.00–1.35)	<0.001
	Multivariable[b]	1.00	0.96 (0.90–1.02)	0.88 (0.81–0.97)	0.97 (0.89–1.07)	0.96 (0.83–1.12)	0.10
Sweet roll/coffee cake (no/low fat)	No. of cases	5681	744	168	48	14	
	Age-adjusted	1.00	1.29 (1.20–1.40)	1.46 (1.24–1.71)	1.66 (1.23–2.24)	2.57 (1.46–4.50)	<0.001
	Multivariable[a]	1.00	1.21 (1.11–1.31)	1.28 (1.09–1.51)	1.35 (0.99–1.83)	2.16 (1.22–3.85)	<0.001
	Multivariable[b]	1.00	1.06 (0.98–1.16)	1.08 (0.91–1.27)	1.12 (0.82–1.53)	1.73 (0.95–3.13)	0.06
Artificial Sweeteners							

		OR (95% CI)					
		Number of Servings					
Food Item		**<1/month**	**1–3/month**	**1/week**	**2–4/week**	**≥5–6/week**	P_{trend}*
*Artificial Sweetener**	No. of cases	4024	545	365	413	1308	
	Age-adjusted	1.00	1.51 (1.38–1.66)	1.67 (1.49–1.87)	1.59 (1.43–1.77)	1.81 (1.70–1.94)	<0.001
	Multivariable[a]	1.00	1.46 (1.33–1.61)	1.56 (1.40–1.75)	1.51 (1.35–1.68)	1.71 (1.60–1.83)	<0.001
	Multivariable[b]	1.00	1.15 (1.04–1.27)	1.17 (1.04–1.32)	1.15 (1.03–1.29)	1.38 (1.29–1.48)	<0.001
Splenda	No. of cases	3301	625	418	601	1710	
	Age-adjusted	1.00	1.52 (1.39–1.66)	1.72 (1.55–1.91)	1.85 (1.69–2.03)	1.91 (1.80–2.03)	<0.001
	Multivariable[a]	1.00	1.46 (1.33–1.60)	1.65 (1.48–1.84)	1.76 (1.60–1.93)	1.76 (1.65–1.87)	<0.001
	Multivariable[b]	1.00	1.25 (1.14–1.37)	1.37 (1.23–1.53)	1.47 (1.33–1.62)	1.45 (1.36–1.54)	<0.001
Low Calorie Beverages							
Low-calorie beverage with caffeine	No. of cases	2261	801	533	827	2233	
	Age-adjusted	1.00	1.47 (1.36–1.60)	1.58 (1.43–1.74)	1.71 (1.57–1.86)	2.30 (2.16–2.45)	<0.001
	Multivariable[a]	1.00	1.49 (1.37–1.62)	1.58 (1.43–1.75)	1.71 (1.57–1.86)	2.21 (2.07–2.35)	<0.001
	Multivariable[b]	1.00	1.28 (1.17–1.40)	1.30 (1.17–1.44)	1.38 (1.27–1.51)	1.76 (1.65–1.89)	<0.001
Other low-calorie beverage without caffeine	No. of cases	3287	872	546	705	1245	
	Age-adjusted	1.00	1.31 (1.21–1.41)	1.46 (1.33–1.61)	1.63 (1.50–1.78)	2.14 (2.00–2.30)	<0.001
	Multivariable[a]	1.00	1.27 (1.17–1.37)	1.44 (1.31–1.59)	1.60 (1.47–1.74)	2.00 (1.86–2.14)	<0.001
	Multivariable[b]	1.00	1.03 (0.95–1.12)	1.12 (1.01–1.24)	1.25 (1.15–1.38)	1.48 (1.38–1.60)	<0.001
Water	No. of cases	432	246	245	431	5301	
	Age-adjusted	1.00	1.02 (0.87–1.20)	1.03 (0.87–1.21)	0.85 (0.74–0.97)	0.88 (0.80–0.98)	0.001
	Multivariable[a]	1.00	0.98 (0.83–1.16)	0.99 (0.84–1.17)	0.84 (0.73–0.97)	0.87 (0.79–0.97)	0.002
	Multivariable[b]	1.00	0.95 (0.80–1.12)	0.94 (0.80–1.12)	0.81 (0.70–0.93)	0.90 (0.81–1.00)	0.04

Abbreviations: CI = Confidence Interval; NHS = Nurses' Health Study; OR = Odds Ratio

*All other artificial sugar except Splenda

[a]Adjusted for age (continuous), total energy intake (continuous calories in kcal), alcohol (non-drinkers (reference), >0–15 and >15 grams/day), current smoking (no current smoking (reference), 1–14 and ≥15 cigarettes/day), and physician diagnosis of depression (no (reference), yes)

[b]Additionally adjusted for food items in table

[*]P for trend was calculated by including a continuous variable with values corresponding to each category of consumption (i.e., 0–4); multivariable model b included continuous variables for all food items simultaneously

Table 4

Odds Ratios and 95% Confidence Intervals for Consumption of Fruits, Vegetables, and Legumes (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II (n = 123,688)

		OR (95% CI)					
		Number of Servings					
Food Item		**<1/month**	**1–3/month**	**1/week**	**2–4/week**	**≥5–6/week**	P_{trend}*
Apples	No. of cases	933	1819	1377	1707	819	
	Age-adjusted	1.00	1.01 (0.93–1.09)	0.94 (0.86–1.02)	0.93 (0.86–1.01)	0.99 (0.89–1.09)	0.13
	Multivariable[a]	1.00	0.98 (0.90–1.06)	0.88 (0.81–0.96)	0.85 (0.78–0.93)	0.85 (0.77–0.94)	<0.001
	Multivariable[b]	1.00	1.06 (0.97–1.15)	1.00 (0.92–1.10)	0.98 (0.90–1.07)	0.94 (0.85–1.05)	0.03
Avocado	No. of cases	4516	1418	494	195	32	
	Age-adjusted	1.00	0.96 (0.90–1.02)	0.85 (0.77–0.93)	0.77 (0.67–0.90)	0.74 (0.52–1.06)	<0.001
	Multivariable[a]	1.00	0.97 (0.91–1.03)	0.85 (0.77–0.94)	0.77 (0.66–0.89)	0.70 (0.49–1.01)	<0.001
	Multivariable[b]	1.00	0.98 (0.92–1.05)	0.88 (0.80–0.97)	0.78 (0.67–0.90)	0.69 (0.48–0.99)	<0.001
Broccoli	No. of cases	692	1698	2329	1625	311	
	Age-adjusted	1.00	0.84 (0.76–0.92)	0.85 (0.78–0.93)	0.84 (0.77–0.92)	0.97 (0.85–1.12)	0.22
	Multivariable[a]	1.00	0.87 (0.79–0.95)	0.88 (0.80–0.96)	0.83 (0.76–0.92)	0.94 (0.82–1.09)	0.04
	Multivariable[b]	1.00	0.94 (0.85–1.03)	1.01 (0.91–1.11)	0.96 (0.87–1.06)	1.00 (0.86–1.15)	0.68
Corn	No. of cases	1406	2579	1944	673	53	
	Age-adjusted	1.00	0.83 (0.77–0.89)	0.75 (0.70–0.81)	0.77 (0.70–0.84)	0.75 (0.57–1.00)	<0.001
	Multivariable[a]	1.00	0.80 (0.75–0.86)	0.69 (0.64–0.74)	0.64 (0.58–0.71)	0.57 (0.43–0.76)	<0.001
	Multivariable[b]	1.00	0.85 (0.79–0.91)	0.75 (0.69–0.81)	0.70 (0.63–0.77)	0.58 (0.44–0.78)	<0.001
Grapes	No. of cases	2993	2026	800	588	248	
	Age-adjusted	1.00	0.83 (0.78–0.88)	0.75 (0.70–0.82)	0.73 (0.67–0.80)	0.83 (0.73–0.95)	<0.001
	Multivariable[a]	1.00	0.79 (0.74–0.84)	0.69 (0.64–0.75)	0.65 (0.59–0.71)	0.70 (0.61–0.80)	<0.001
	Multivariable[b]	1.00	0.82 (0.77–0.87)	0.73 (0.67–0.80)	0.69 (0.62–0.75)	0.72 (0.63–0.83)	<0.001

		OR (95% CI)					
		Number of Servings					
Food Item		**<1/month**	**1–3/month**	**1/week**	**2–4/week**	**≥5–6/week**	P_{trend}*
Peas	No. of cases	2561	2140	1480	427	47	
	Age-adjusted	1.00	0.85 (0.80–0.90)	0.84 (0.79–0.90)	0.75 (0.67–0.83)	0.97 (0.72–1.30)	<0.001
	Multivariable[a]	1.00	0.82 (0.77–0.87)	0.77 (0.72–0.83)	0.64 (0.57–0.71)	0.77 (0.57–1.05)	<0.001
	Multivariable[b]	1.00	0.88 (0.82–0.93)	0.85 (0.79–0.91)	0.69 (0.62–0.78)	0.78 (0.57–1.07)	<0.001
String beans	No. of cases	1128	1885	2188	1270	184	
	Age-adjusted	1.00	0.82 (0.76–0.89)	0.85 (0.79–0.91)	0.94 (0.87–1.02)	1.40 (1.19–1.65)	0.20
	Multivariable[a]	1.00	0.83 (0.77–0.90)	0.83 (0.77–0.90)	0.87 (0.80–0.95)	1.22 (1.03–1.44)	0.23
	Multivariable[b]	1.00	0.90 (0.83–0.97)	0.95 (0.88–1.03)	1.03 (0.94–1.13)	1.38 (1.16–1.65)	0.008

Abbreviations: CI = Confidence Interval; NHS = Nurses' Health Study; OR = Odds Ratio

[a] Adjusted for age (continuous), total energy intake (continuous calories in kcal), alcohol (non-drinkers (reference), >0–15 and >15 grams/day), current smoking (no current smoking (reference), 1–14 and ≥15 cigarettes/day), and physician diagnosis of depression (no (reference), yes)

[b] Additionally adjusted for food items in table

[*] P for trend was calculated by including a continuous variable with values corresponding to each category of consumption (i.e., 0–4); multivariable model b included continuous variables for all food items simultaneously