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Racial/Ethnic disparities in association between dietary quality and incident diabetes in postmenopausal women in the United States: The Women's Health Initiative 1993- 2005

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Abstract

Objective—To examine the association of dietary quality and risk of incident diabetes overall and by race/ethnicity among postmenopausal women enrolled in the Women's Health Initiative (WHI).

Research Methods & Procedures—The WHI recruited 161,808 postmenopausal women between 1993 and 1998, and followed them until 2005. Incident diabetes was determined annually over an average of 7.6 years from enrollment. At baseline, all participants completed a Food Frequency Questionnaire (FFQ). Dietary quality was assessed by the Alternate Healthy Eating Index, (AHEI) calculated from the baseline FFQ responses.

Results—There were 10,307 incident cases of self-reported treated diabetes over 1,172,761 person-years of follow-up. Most participants did not meet the AHEI dietary goals; i.e., only 0.1% of women met or exceeded the recommended consumption of vegetables, and few (17.3%) met or exceeded the recommended level for total fiber. After adjusting for potential confounders, women in the highest quintile of the AHEI score were 24% less likely to develop diabetes relative to women in the lowest quintile of AHEI [hazard ratio (HR) = 0.76 (95% CI: 0.70-0.82)]. This association was observed in Whites [HR= 0.74 (95% CI: 0.68-0.82)] and Hispanics [HR= 0.68 (95% CI: 0.46-0.99)] but not in Blacks [HR= 0.85 (95% CI: 0.69-1.05)] or Asians [HR= 0.88 (95% CI: 0.57-1.38)].

Conclusion—These findings support a protective role of healthful eating choices in reducing the risk of developing diabetes, after adjusting for other lifestyle factors, in White and Hispanic postmenopausal women. Future studies are needed to investigate the relationship between dietary quality and risk of diabetes among Blacks and Asians in relationship to other lifestyle factors.

Keywords

Dietary quality; diabetes; postmenopausal women; women's health; epidemiology

Introduction

It is widely believed that diet plays an important role in the development of diabetes in postmenopausal women; however, the specific dietary factors and overall dietary quality that may contribute to an increased risk of diabetes among individual racial and ethnic groups is an area deserving of deeper inquiry. Several studies have found differences of dietary intake by race and ethnicity(1-3). Using data from the Third National Health and Nutrition Examination Survey (NHANES III), Bird and colleagues found that Whites consumed significantly more combined servings of fruit and vegetables than did either Blacks or Mexican Americans. Specifically, Whites averaged 4.90 ± 3.53 servings of fruit and vegetables/day, compared with 4.57 ± 3.40 servings/day for Mexican Americans and 3.99 ± 3.38 servings/day for Blacks(1). In terms of dietary quality, data from the Continuing Survey of Food Intake found that Whites had the highest average Healthy Eating Index (HEI) score, followed by Hispanics and other races/ethnicities, while Blacks had the lowest HEI scores(3). Further, disparities in diabetes incidence in postmenopausal women among racial/ethnic groups have suggested that lifestyle variability, including but not limited to dietary quality, may be primary factors(4). Few studies have been large or diverse enough to allow for the assessment of an association of dietary quality with diabetes risk among individual racial/ethnic groups, with particular attention to women (5).

To explore the effect of dietary quality on diabetes risk among postmenopausal women, we evaluated the risk of diabetes by using the Alternate Healthy Eating Index (AHEI), developed to improve upon the Healthy Eating Index (HEI) in assessing diet-chronic disease associations, particularly cardiovascular disease. The HEI measured adherence to the 1995 USDA Food Pyramid dietary guidelines(6). In contrast to the traditional paradigm in nutritional epidemiology which focuses on diabetes risk in relation to a single or a selected few nutrients, and current clinical approaches that focus on carbohydrate(7), indices of dietary quality combine several important food groups, nutrients and dietary factors. The AHEI includes consumption of fruit, vegetables, nuts and legumes, ratio of white to red meat, cereal fiber, *trans*-fat, ratio of polyunsaturated fat to saturated fat (P:S), alcohol, and multivitamin use. We selected the AHEI for our study of diabetes considering that cardiovascular disease and diabetes share a number of risk factors.

Four large prospective studies examined the association between dietary factors and the risk of diabetes in women (2-5). Firstly, the Nurses' Health Study, a 14-year follow-up study of 84,204 women aged 34-59 years showed that intakes of total fat, saturated and monounsaturated fatty acid are not associated with risk of diabetes in women, while the intake of trans fatty acid increases and polyunsaturated fatty acids reduces risk (3). Secondly, Liu and colleagues examined the association between intake of dairy foods and the incident of diabetes in 37,183 women who participated in the Women's Health Study. An average of 10 years follow-up later, they found a moderate inverse association between dairy consumption, especially low-fat dairy consumption, and incident diabetes (2). Thirdly, a 6-year follow-up study of 35,988 Iowa women, aged 55-69 years, support a protective role for grains (particularly whole grains), cereal fiber, and dietary magnesium in the development of diabetes in older women. However, intake of total carbohydrate, refined grains, fruit and vegetables, and soluble fiber and the glycemic index were unrelated to diabetes risk (4). Finally, lower overall dietary quality scores, as measured by the AHEI predicted increased risk for diabetes using data from 80,029 women aged 38–63 years in the Nurses' Health Study who were followed from 1984 to 2002 (5). To our knowledge, no study has examined the association between dietary quality as assessed by the AHEI and risk of diabetes by race/ethnicity.

The purpose of this study was to examine the overall association of dietary quality and the risk of incident diabetes by race/ethnicity using the multiethnic cohort of postmenopausal women from the Women's Health Initiative (WHI) Study. We hypothesized that the associations between dietary quality and risk of diabetes would differ among race/ethnicity groups.

Methods

Participants

The WHI began in 1992, and was established across 40 sites in the United States, enrolling a total of 161,808 women between 1993 and 1998. A total of 93,676 women were enrolled into an observational study (WHI-OS) and 68,132 into three clinical trials (WHI-CT)(8). The WHI-CT included: the Dietary Modification (DM) Trial, the Hormone Trials (HT, estrogen-alone or estrogen plus progestin) and the Calcium Vitamin D (CaD) Trial. The WHI eligibility criteria included: postmenopausal women aged 50 to 79 years, ability to complete study visits, and an expected survival and local residency for at least 3 years. Exclusion criteria for the WHI included current alcoholism, drug dependency, dementia, or other conditions that would limit full participation in the study. An average of 7.6 years of follow-up occurred by March 2005 when all WHI trials were completed the WHI shifted to being an observational study. After exclusion for missing data and prevalent cases of diabetes at baseline, data from a total of 154,493 women were included in this investigation.

Dietary assessment and dietary quality index calculation

At baseline, all WHI participants completed a validated food frequency questionnaire (FFQ) developed for the WHI to estimate average daily nutrient intake over the three-month period prior to enrollment(9). Dietary quality, assessed by AHEI(10, 11), was computed based on food items and nutrients derived from the FFQ, including: 1) fruit, 2) vegetables, 3) nuts and legumes, 4) ratio of white to red meat, 5) cereal fiber, 6) *trans*-fat, 7) ratio of polyunsaturated fat to saturated fat (P:S), 8) alcohol, and 9) multivitamin use from the current supplements inventory(12). In this study, AHEI scores were computed for each participant at baseline according to the guidelines described in MuCullough et al. (2002), with one exception: total dietary fiber was substituted for cereal fiber, as cereal fiber was not assessed by the WHI FFQ. There is precedent for this substitution in the WHI study(13). Higher AHEI scores are indicative of a better quality diet. Detailed methodology has been described elsewhere(14, 15).

Identification of diabetes

Participants were asked at baseline whether a physician had ever told them that they had “sugar diabetes” or “high blood sugar” when they were not pregnant. Women who self-reported “yes” to this question at baseline were excluded from this investigation. At each semi-annual (WHI-CT) or annual contact (WHI-OS), all participants were asked, “Since the date given on the front of this form, has a doctor prescribed for the first time any of the following pills or treatments?” Choices included “pills for diabetes” and “insulin shots for diabetes.” Thus, only incident treated diabetes was ascertained, and this was defined as a self-report of a new physician diagnosis of diabetes treated with oral drugs or insulin(16, 17). The accuracy of self-reported diabetes in the WHI trials has been assessed using medication and laboratory data, and self-reported diabetes was found to be valid(18).

Covariates

Demographic and health history data were self-reported at baseline and included age, race/ethnicity, education level, cigarette smoking status, family history of diabetes, and hormone therapy use. The metabolic equivalents (METs) of different categories of recreational physical activity were computed, with detailed methodology described elsewhere (19).

WHI certified staff conducted baseline measures of height using a fixed stadiometer, weight by a calibrated balance-beam scale, and waist circumference. Body mass index [BMI=weight(kg)/height(m)^2] was computed from measured height and weight.

Statistical analyses

Cox proportional hazard models were used to estimate the hazard ratios (HR) and associated 95% confidence intervals (CIs) of incident diabetes corresponding to each baseline AHEI score quintile compared with the lowest quintile. Results from three sets of models are reported: Model 1- unadjusted model including only the AHEI score as the covariate; Model 2 – including the AHEI score, adjusting for age, race/ethnicity, and BMI, and Model 3 – multivariable model including the AHEI score, adjusting for all potentially confounding variables (age, race/ethnicity, education, cigarette smoking, BMI, waist/hip ratio, physical activity, daily energy intake, family history of diabetes, study arm, and hormone therapy use). The dependent variable was time to self-reported incident diabetes. Time to event (incident diabetes) was calculated as the interval between enrollment date and the earliest of the following: 1) date of annual medical history update when new diabetes was ascertained (positive outcome); and 2) date of last annual medical update during which diabetes status was ascertained (censorship). We also conducted the analyses by race/ethnicity focusing on four major racial/ethnic groups available in the WHI, namely Whites, Blacks, Hispanics, and Asians. Two AHEI score quintile variables were created by using the overall sample and race/ethnicity specific subgroups. Since there were no appreciable differences in the distributions of AHEI scores between race/ethnicity subgroups, we presented results using AHEI quintiles derived from the overall dataset.

In addition, we evaluated the associations between individual components of AHEI and risk of diabetes using Cox proportional hazards models. In these models, the levels of each nutrient component were categorized as a binary variable based on recommended intake as in a previous WHI publication(13). Similar to the overall analysis for the AHEI score, we also conducted the analyses within race/ethnicity subgroups. All analyses were performed using SAS (version 9.2; SAS Institute Inc., Cary, NC), with results $P<0.05$ (2-tailed) considered statistically significant.

Results

Baseline characteristics (Table 1)

At baseline, the average age of the 154,493 women with evaluable data was 63 years. The racial/ethnic distribution was: 83.7% Whites (n=128,998), 8.3% Blacks (n=12,820), 3.9% Hispanics (n=6,009), and 2.6% Asians (n=3,940). 30.9% of participants had a family history of diabetes. 40.1% had completed at least some college education. The prevalence of current smoking was 7%. Compared to Whites, Blacks and Hispanics tended to have more diabetes risk factors, while Asians tended to have fewer.

AHEI and component scores (Table 2)

The overall average AHEI score at baseline was 38.2 (SD =11.1) out of a possible maximum score of 87.5. Dietary quality average was the highest among Asians (40.6±11.6), followed by Whites (38.6±11.0), Blacks (34.7±11.1), and Hispanics (34.5±10.2). The mean AHEI scores were statistically different between racial/ethnic groups ($p<0.05$). Most participants did not achieve recommended United States Department of Agriculture (20) dietary goals: average daily consumption of vegetables was 1.28 servings (0.1% of Whites met or exceeded recommended consumption of vegetables of 5 servings/day, 0.5% of Hispanics, 0.2% of Blacks and 0.4% of Asians); fruit was 1.52 servings (1.9% of Whites met or exceeded recommended consumption of 4 servings/day, 3.0% of Hispanics, 3.7% of Blacks and 2.1% of Asians); nut and vegetable protein was 0.41 servings (10.4% of White women met or exceeded recommended consumption of 1 servings/day, 5.7% of Hispanics, 9.5% of Blacks and 26.4% of Asians); 8.0% of women met the recommended ratio of white to red meat consumption of 4 (7.1% of Whites, 8.8% of Hispanics, 16.2% of Blacks and 8.9% of Asians); 17.3% met recommendations for total fiber intake of 22 g/day(17.9% of Whites, 16.5% of Hispanics, 13.2% of Blacks and 12.8% of Asians); 0.98% met recommendations for trans fat intake of <0.5% total energy (0.9% of Whites, 1.5% of Hispanics, 0.9% of Blacks and 2.3% of Asians); 7.8% met recommendations for polyunsaturated to saturated fat ratio (P:S) of ≥ 1 (6.8% of Whites, 10.1% of Hispanics, 11.5% of Blacks and 23.4% of Asians); 20.3% met criteria for moderate alcohol consumption (22.5% of Whites, 9.5% of

Hispanics, 8.2% of Blacks and 5.6% of Asians); and 39.38% women took multivitamins (7.1% of Whites, 8.8% of Hispanics, 16.2% of Blacks and 8.9% of Asians).

Average daily energy intake was the highest among Asians (1,625 kcal, with 53% from carbohydrate, 31% from fat, and 16% from protein), followed by Hispanics (1638 kcal, with 51% from carbohydrate, 33% from fat, and 16% from protein), Whites (1632 kcal, with 50% from carbohydrate, 32% from fat, and 17% from protein) and lowest among Blacks (1602 kcal, with 50% from carbohydrate, 34% from fat, and 16% from protein). Average daily sodium intake from each racial/ethnic group exceeded the recommended intake of <2300mg/day (sodium intake was highest in Whites, follow by Hispanics, Blacks and Asians).

Incident diabetes and AHEI score at baseline (Table 3)

There were 10,307 incident cases of self-reported diabetes over 1,172,760 person-years of follow up. In the multivariable Cox proportional hazards model (Model 3), women in the highest quintile of baseline AHEI scores (median score=53.0) had a HR of 0.76 for diabetes (95% CI: 0.70-0.82) when compared to women in the lowest quintile (median=24.1). The cumulative incidence rates of diabetes from lowest to highest AHEI quintile at baseline were 9.41%, 7.53%, 6.56%, 5.45% and 4.41%, respectively.

In subgroup analyses according to race/ethnicity, unadjusted analyses showed significantly lower diabetes risk among White, Black, and Hispanic women in the highest AHEI quintile when compared to women in the lowest AHEI quintile, while no significant association was observed among Asians. After multivariable adjustments, Whites and Hispanics in the highest quintile of baseline AHEI scores had a significantly lower risk of diabetes (multivariable adjusted HR= 0.74; 95% CI: 0.68-0.82 for Whites, and HR=0.68: 95% CI: 0.46-0.99 for Hispanics), while associations among Blacks and Asians were not significant.

Individual AHEI components at baseline and incident diabetes (Table 4)

After adjusting for potential confounders in a multivariable Cox proportional hazards model, women with a higher intake ratio of white to red meat had a significantly reduced risk of incident diabetes (HR=0.89; 95% CI: 0.84-0.94). Similar protective effects were observed among women with a lower intake of energy of trans fat (HR=0.81; 95% CI: 0.75-0.87), a lower consumption of alcohol, averaging 0.5–1.5 drinks/day (HR=0.68; 95% CI: 0.64-0.72.

When examined by race/ethnicity, AHEI diabetes protective factors had different effects with respect to diabetes risk across each race/ethnicity groups. White women had a decreased diabetes risk with lower trans fat and saturated fat intake, and a moderate consumption of alcohol; Black women showed evidence of decreased risk if they had a higher intake ratio of white to red meat, a lower trans fat intake, and a lower intake of dairy foods; Hispanic women exhibited diabetes risk reduction with a higher intake ratio of white to red meat and a moderate consumption of alcohol; while for Asian women we did not find any significant protective changes in AHEI component factors to prevent diabetes.

Discussion

Examining data derived from over one million person-years of observation in postmenopausal women participating in the WHI, we found that higher AHEI dietary quality at baseline predicted overall a lower risk of developing diabetes. Analyses by race/ethnicity showed this association was demonstrated among Whites and Hispanics, not among Blacks and Asians. However, we observed that certain dietary components are stronger predictors of increased diabetes risk than others. In particular, lower white to red meat ratio, and higher energy from trans fat can significantly increase diabetes risk. It is interesting that the ratio of white to red meat (a component of the AHEI) would be important, since it may indicate either a decrease in saturated fat or an effect of substitution of a leaner animal protein, and our sample does not distinguish those who might be following a vegetarian lifestyle. Dietary quality scores attempt to capture overall dietary patterns, in addition to their individual nutrients.

Our findings support Fung and colleagues' results showing that lower overall dietary quality scores predicted increased risk for diabetes in a pre- and postmenopausal cohort of predominantly white women(21). In another study that used the Mediterranean diet score (rMED, an index similar to the AHEI score) and data from European countries, a higher dietary quality score was also found to be associated with decreased risk of diabetes among men and women(22). In a recent study, the Health Professionals Follow-Up Study used five indexes to assess diabetes risk in men: Healthy Eating Index (HEI) 2005, Alternate HEI (AHEI), the Recommended Food Score, alternative Mediterranean Diet (aMED) Score, and Dietary Approaches to Stop Hypertension (DASH) Score, finding that lower dietary quality scores in all five indexes predicted increased risk for diabetes(23). These results are consistent with our findings. However, they did not assess how the association may differ by race/ethnicity.

Several studies have found differences in dietary intake by race/ethnicity (1, 2). Our analysis suggested that Asians' dietary quality was among the best compared to Whites, Blacks, and Hispanics, and from this baseline, diabetes risk among Asians and Blacks appears to be much less sensitive to dietary quality score change differences. Better dietary quality among Asians, in particular, may be related to their traditional dietary habits. A recent study of Chinese women in the U.S. found that acculturation did not affect their overall dietary quality, despite their exposure to highly processed foods(24). The fact that we found Asian women in the WHI to have a healthier dietary quality at baseline may not be the reason for their lowered diabetes risk, since our analysis may be less reliable due to the proportionately smaller sample size of Asians, and the modifying effects on diabetes of other factors such as weight, waist circumference, and socioeconomic status.

Our study has several strengths. The WHI includes a large, racially diverse sample of women, and employs a prospective design that enables an examination of developing diabetes with detailed information on a comprehensive range of diabetes risk factors. We have identified three dietary components that significantly impact the risk of diabetes among postmenopausal women—white to red meat ratio, *trans* fat, and alcohol.

Several limitations of our study are worth noting. First, diabetes incidence data may have been incomplete due to self-report. However, previous WHI studies have found concordance between medication inventories and fasting glucose measurements in determining diabetes in the WHI(18). In addition, the WHI cannot absolutely eliminate inclusion of women with type 1 diabetes, although women who reported diabetes at baseline were excluded from the current study and type 2 diabetes represents the vast majority of all diabetes in older adults(16-18). Although excellent and cost-efficient in evaluating broad dietary patterns, the FFQ is limited in its ability to assess absolute nutrient intake and is subject to a variety of biases, especially energy intake(25, 26), and is related to well-known response sets such as social desirability in women(27, 28). While these biases can produce errors in self-reports of total energy intake, we note that the main driver of such differences is under-reporting of energy dense foods, especially among overweight and obese women(26, 28). In addition, AHEI was developed in a predominately White population and may not be all suitable for other ethnic groups.

In conclusion, consumption of a higher AHEI dietary quality diet was found to be associated with decreased risk for diabetes. However, this association was only found among White and Hispanic postmenopausal women. Future studies are needed to investigate the relationship between dietary quality and risk of diabetes among Blacks and Asians in relationship to other lifestyle factors.

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References

1. Dubowitz T, Heron M, Bird CE, et al. Neighborhood socioeconomic status and fruit and vegetable intake among whites, blacks, and Mexican Americans in the United States. Am J Clin Nutr. 2008; 87:1883–91. [PubMed: 18541581]
2. Donin AS, Nightingale CM, Owen CG, et al. Ethnic differences in blood lipids and dietary intake between UK children of black African, black Caribbean, South Asian, and white European origin: the Child Heart and Health Study in England (CHASE). Am J Clin Nutr. 2010; 92:776–83. [PubMed: 20739425]
3. Forshee RA, Storey ML. Demographics, not beverage consumption, is associated with diet quality. Int J Food Sci Nutr. 2006; 57:494–511. [PubMed: 17162328]
4. Ma Y, Hebert JR, Manson JE, et al. Determinants of Racial/Ethnic Disparities in Incidence of Diabetes in Postmenopausal Women in the U.S.: The Women's Health Initiative 1993-2009. Diabetes Care. 2012; 35:2226–34. [PubMed: 22833490]
5. Hu FB. Globalization of Diabetes: The role of diet, lifestyle, and genes. Diabetes Care. 2011; 34:1249–57. [PubMed: 21617109]

6. Kennedy ET, Ohls J, Carlson S, Fleming K. The Healthy Eating Index: design and applications. J Am Diet Assoc. 1995; 95:1103–8. [PubMed: 7560680]
7. Standards of medical care in diabetes--2010. Diabetes Care. 2010; 33(1):S11–61. [PubMed: 20042772]
8. Design of the Women's Health Initiative clinical trial and observational study. The Women's Health Initiative Study Group. Control Clin Trials. 1998; 19:61–109. [PubMed: 9492970]
9. Patterson RE, Kristal AR, Tinker LF, Carter RA, Bolton MP, Agurs-Collins T. Measurement characteristics of the Women's Health Initiative food frequency questionnaire. Ann Epidemiol. 1999; 9:178–87. [PubMed: 10192650]
10. McCullough ML, Willett WC. Evaluating adherence to recommended diets in adults: the Alternate Healthy Eating Index. Public Health Nutr. 2006; 9:152–7. [PubMed: 16512963]
11. McCullough ML, Feskanich D, Stampfer MJ, et al. Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. Am J Clin Nutr. 2002; 76:1261–71. [PubMed: 12450892]
12. Patterson RE, Levy L, Tinker LF, Kristal AR. Evaluation of a simplified vitamin supplement inventory developed for the Women's Health Initiative. Public Health Nutr. 1999; 2:273–6. [PubMed: 10512561]
13. Belin RJ, Greenland P, Allison M, et al. Diet quality and the risk of cardiovascular disease: the Women's Health Initiative (WHI). Am J Clin Nutr. 2011; 94:49–57. [PubMed: 21613562]
14. Ma Y, Pagoto S, Griffith J, et al. A Dietary Quality Comparison of Popular Weight Loss Plans. J Am Diet Assoc. 2007; 107:1786–1791. [PubMed: 17904938]
15. Ma Y, Li W, Olendzki B, et al. Dietary Quality One-Year after Diagnosis of Coronary Heart Disease. J Am Diet Assoc. 2008; 108:240–246. [PubMed: 18237571]
16. de Boer IH, Tinker LF, Connelly S, et al. Calcium plus vitamin D supplementation and the risk of incident diabetes in the Women's Health Initiative. Diabetes Care. 2008; 31:701–7. [PubMed: 18235052]
17. Tinker LF, Bonds DE, Margolis KL, et al. Low-fat dietary pattern and risk of treated diabetes mellitus in postmenopausal women: the Women's Health Initiative randomized controlled dietary modification trial. Arch Intern Med. 2008; 168:1500–11. [PubMed: 18663162]
18. Margolis K, Qi L, Brzyski R, et al. Validity of Diabetes Self-Reports in the Women's Health Initiative: Comparison with Medication Inventories and Fasting Glucose Measurements. Clinical Trials. 2008; 5(3):240–247. [PubMed: 18559413]
19. McTiernan A, Kooperberg C, White E, et al. Recreational physical activity and the risk of breast cancer in postmenopausal women: the Women's Health Initiative Cohort Study. JAMA. 2003; 290:1331–6. [PubMed: 12966124]
20. McGuire, S. Adv Nutr. 7th. Vol. 2. Washington, DC: U.S. Government Printing Office, January 2011; 2011. U.S. Department of Agriculture and U.S. Department of Health and Human Services, Dietary Guidelines for Americans, 2010; p. 293-4.
21. Fung TT, McCullough M, van Dam RM, Hu FB. A prospective study of overall diet quality and risk of type 2 diabetes in women. Diabetes Care. 2007; 30:1753–7. [PubMed: 17429059]
22. Mediterranean Diet and Type 2 Diabetes Risk in the European Prospective Investigation Into Cancer and Nutrition (EPIC) Study: The InterAct project. Diabetes Care. 2011
23. de Koning L, Chiuve SE, Fung TT, Willett WC, Rimm EB, Hu FB. Diet-quality scores and the risk of type 2 diabetes in men. Diabetes Care. 2011; 34:1150–6. [PubMed: 21464460]
24. Liu A, Berhane Z, Tseng M. Improved dietary variety and adequacy but lower dietary moderation with acculturation in Chinese women in the United States. J Am Diet Assoc. 2010; 110:457–62. [PubMed: 20184998]
25. Kristal AR, Potter JD. Not the time to abandon the food frequency questionnaire: counterpoint. Cancer Epidemiol Biomarkers Prev. 2006; 15:1759–60. [PubMed: 17021349]
26. Neuhouser ML, Tinker L, Shaw PA, et al. Use of Recovery Biomarkers to Calibrate Nutrient Consumption Self-Reports in the Women's Health Initiative. Am J Epidemiol. 2008
27. Tooze JA, Subar AF, Thompson FE, Troiano R, Schatzkin A, Kipnis V. Psychosocial predictors of energy underreporting in a large doubly labeled water study. Am J Clin Nutr. 2004; 79:795–804. [PubMed: 15113717]

28. Hebert J, Ebbeling C, Matthews C, et al. Systematic Errors in Middle-Aged Women's Estimates of Energy Intake: Comparing Three Self-Report Measures to Total Energy Expenditure from Doubly Labeled Water. Ann Epidemiol. 2002; 12:577–586. [PubMed: 12495831]

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Table 1

Baseline characteristics of study participants, Women's Health Initiative 1993-2005 (N=154,493)

Characteristic	Asian	Black	Hispanic	White	Overall
No. (%) Continuous variable (Mean±SD)	3,940(2.6)	12,820(8.3)	6,009(3.9)	128,998(83.7)	154,493
Age (years)	62.9±7.5	61.4±7.1	60.1±6.8	63.5±6.8	63.2±7.3
Body mass index (kg/m^2)	24.6±4.5	30.906.6	28.9±5.7	27.5±5.6	27.8±5.8
Body weight (kg)	59.4±12.6	82.0±18.8	71.8±15.8	72.6±16.1	73.0±16.6
Waist circumference (cm)	78.1±10.4	90.9±13.8	86.4±12.7	85.6±13.4	85.9±13.5
Physical activity (MET-hours/week)[1]	13.2±14.0	9.8±13.0	10.6±13.8	13.0±13.8	12.6±13.8
Categorical variable – n (%) Education					
<High school	192(4.9)	1,415(11.2)	1,609(27.3)	4303(3.4)	7,753(5.1)
High school/GED	598(15.3)	1,738(13.7)	952(16.1)	22,317(17.4)	26,092(17.0)
>High school, <4 year college	1,367(35.0)	4,922(38.9)	2,073(35.1)	48,520(37.9)	58,000(37.8)
≥4 year college	1,753(44.8)	4,588(36.2)	1,266(21.5)	53,024(41.4)	61,492(40.1)
Smoking status					
Never	2,819(72.0)	6,221(49.5)	3,724(63.3)	63,515(49.8)	77,712(51.0)
Former	941(24.0)	4,876(38.5)	1,724(29.6)	55,566(43.6)	64,156(42.1)
Current	157(4.0)	1,465(11.6)	418(7.2)	8,387(6.6)	10,637(7.0)
Hormone therapy use last 3 months					
Never	1,088(28.0)	5,841(46.4)	2,327(39.8)	39,191(31.4)	49,395(32.9)
Former	811(20.8)	3,173(25.2)	1,298(22.2)	28,664(22.9)	34,613(23.1)
Current	1,994(51.2)	3,587(28.5)	2,221(38.0)	57,150(45.7)	65,992(44.0)
Family history of diabetes					
Yes	1,371(34.9)	5,547(43.6)	2,432(41.1)	37,274(29.0)	47,545(31.0)
No	2,275(58.0)	5,863(46.1)	3,120(52.7)	86,261(67.2)	99,077(64.5)

[1] Total physical activity energy expenditure

Table 2

Alternate healthy eating index (AHEI), components, and selected nutrient scores at baseline among postmenopausal women participated in the Women's Health Initiative 1993-2005

	Score	Intake	% of Subjects with maximum score[a]
Overall (n=154,493)			
	Mean±SD	Mean±SD	
Total AHEI score	38.2±11.1		
Component of AHEI			
Vegetables (servings/day)	2.6±1.4	1.3±0.	0.1
Fruits (servings/day)	3.8±2.3	1.5±1.0	2.1
Nuts and soy protein (servings/day)	3.2±3.4	0.4±0.6	10.6
Ratio of white to red meat	3.0±2.8	2.0±10.6	8.0
Total dietary fiber (g/day)	6.8±2.4	15.9±7.1	17.3
Trans fat (% of calories)	5.1±2.7	2.3±1.1	1.0
Polyunsaturated to saturated fat ratio	6.1±2.1	0.7±0.2	7.8
Alcohol intake (servings/day)	3.3±4.1	0.4±0.8	20.3
Multivitamin use(n (%))[b]	4.5±2.4	60,831 (39.4)	39.4
Selected Nutrient Scores			
Total caloric intake (kcal/day)		1,625±712	
Nutrition composition			
Carbohydrate (% of calories)		50.4±9.4	
Fat (% of calories)		32.5±8.4	
Protein (% of calories)		16.7±3.2	
Other important nutrients			
Saturated fat (% of calories)		10.8±3.3	
Monounsaturated fat (% of calories)		12.4±3.5	
n-3 Fatty acids (g/day)		6.8±2.2	
Sodium (mg/day)[c]		2,710.5±1,274.5	
Dairy foods (servings/day)[d]		2.6±2.2	
Glycemic load		97.4±44.1	
Glycemic index		52.4±3.8	
White (n=128,998)			
Total AHEI score	38.6±11.0		
Component of AHEI			
Vegetables (servings/day)	2.6±1.38	1.3±0.7	0.1
Fruits (servings/day)	3.8±2.32	1.5±1.0	1.9
Nuts and soy protein (servings/day)	3.2±3.42	0.4±0.6	10.4
Ratio of white to red meat	2.9±2.73	1.8±8.3	7.1
Total dietary fiber (g/day)	6.9±2.33	16.2±6.9	17.9

	Score	Intake	% of Subjects with maximum score[a]
Overall (n=154,493)			
Trans fat (% of calories)	5.1±2.68	2.3±1.1	1.0
Polyunsaturated to saturated fat ratio	6.0±2.11	0.7±0.2	6.8
Alcohol intake (servings/day)	3.6±4.16	0.4±0.8	22.5
Multivitamin use(n (%))[b]	4.6±2.46	53,495(41.5)	41.5
Selected Nutrient Scores			
Total caloric intake (kcal/day)		1632±658	
Nutrition composition			
Carbohydrate (% of calories)		50.2±9.3	
Fat (% of calories)		32.3±8.6	
Protein (% of calories)		16.8±3.1	
Other important nutrients			
Saturated fat (% of calories)		10.9±3.4	
Monounsaturated fat (% of calories)		12.2±3.5	
n-3 Fatty acids (g/day)		6.7±2.1	
Sodium (mg/day)[c]		2732.2±1177.8	
Dairy foods (servings/day)[d]		2.2±2.2	
Glycemic load		97.5±41.3	
Glycemic index		52.3±3.7	
Black (n=12,820)			
Total AHEI score	34.7±11.1		
Component of AHEI			
Vegetables (servings/day)	2.1±1.4	1.1±0.7	0.2
Fruits (servings/day)	3.6±2.5	1.5±1.1	3.7
Nuts and soy protein (servings/day)	2.8±3.4	0.4±0.7	9.5
Ratio of white to red meat	4.2±3.3	3.9±20.7	16.2
Total dietary fiber (g/day)	5.9±2.6	13.9±8.0	13.2
Trans fat (% of calories)	4.2±2.2	2.7±1.2	0.9
Polyunsaturated to saturated fat ratio	6.6±2.1	0.7±0.2	11.5
Alcohol intake (servings/day)	1.7±3.1	0.2±0.6	8.2
Multivitamin use(n (%))[b]	3.8±2.2	3304(25.8)	25.8
Selected Nutrient Scores			
Total caloric intake (kcal/day)		1602±990	
Nutrition composition			
Carbohydrate (% of calories)		50.4±9.8	
Fat (% of calories)		34.5±8.4	
Protein (% of calories)		15.7±3.5	
Other important nutrients			
Saturated fat (% of calories)		10.1±3.1	

	Score	Intake	% of Subjects with maximum score[a]
Overall (n=154,493)			
Monounsaturated fat (% of calories)		13.3±3.6	
n-3 Fatty acids (g/day)		7.5±2.3	
Sodium (mg/day)[c]		2602.9±1748.4	
Dairy foods (servings/day)[d]		1.6±1.9	
Glycemic load		99.1±59.7	
Glycemic index		54.0±4.0	
Hispanic (n=6,009)			
Total AHEI score	34.5±10.2		
Component of AHEI			
Vegetables (servings/day)	2.4±1.6	1.2±0.8	0.5
Fruits (servings/day)	3.4±2.5	1.4±1.1	3.0
Nuts and soy protein (servings/day)	1.9±2.8	0.2±0.5	5.7
Ratio of white to red meat	3.0±3.0	2.4±19.1	8.8
Total dietary fiber (g/day)	6.3±2.6	15.1±8.9	16.5
Trans fat (% of calories)	5.6±2.4	2.1±1.0	1.5
Polyunsaturated to saturated fat ratio	6.2±2.2	0.7±0.3	10.1
Alcohol intake (servings/day)	2.0±3.3	0.2±0.6	9.5
Multivitamin use(n (%))[b]	3.9±2.2	1654(27.5)	22.5
Selected Nutrient Scores			
Total caloric intake (kcal/day)		1638±980	
Nutrition composition			
Carbohydrate (% of calories)		50.6±9.7	
Fat (% of calories)		33.4±8.5	
Protein (% of calories)		16.4±3.5	
Other important nutrients			
Saturated fat (% of calories)		10.8±3.1	
Monounsaturated fat (% of calories)		12.8±3.7	
n-3 Fatty acids (g/day)		7.0±2.7	
Sodium (mg/day)[c]		2665.6±1770.2	
Dairy foods (servings/day)[d]		2.3±2.3	
Glycemic load		97.7±57.6	
Glycemic index		52.0±4.0	
Asian (n=3,940)			
Total AHEI score	40.6±11.6		
Component of AHEI			
Vegetables (servings/day)	2.7±1.5	1.3±0.8	0.4
Fruits (servings/day)	3.6±2.3	1.5±1.0	2.1

	Score	Intake	% of Subjects with maximum score[a]
Overall (n=154,493)			
Nuts and soy protein (servings/day)	5.4±3.5	0.7±0.8	26.5
Ratio of white to red meat	3.3±2.8	2.2±12.4	8.9
Total dietary fiber (g/day)	6.3±0.8	14.5±6.9	12.8
Trans fat (% of calories)	6.3±2.3	1.8±0.8	2.4
Polyunsaturated to saturated fat ratio	7.5±2.1	0.8±0.3	23.4
Alcohol intake (servings/day)	1.2±2.7	0.1±0.4	5.6
Multivitamin use(n (%))[b]	4.3±2.4	1438(36.5)	36.5
Selected Nutrient Scores			
Total caloric intake (kcal/day)		1454±689	
Nutrition composition			
Carbohydrate (% of calories)		53.4±9.3	
Fat (% of calories)		31.2±8.1	
Protein (% of calories)		16.3±3.1	
Other important nutrients			
Saturated fat (% of calories)		9.2±2.9	
Monounsaturated fat (% of calories)		12.1±3.5	
n-3 Fatty acids (g/day)		7.3±2.4	
Sodium (mg/day)[c]		2445.2±1250.2	
Dairy foods (servings/day)[d]		1.5±1.7	
Glycemic load		91.8±42.4	
Glycemic index		52.2±3.1	

[a]Except the duration of vitamin use, component of AHEI intakes were scored proportionately between 0 and 10. Intake criteria for maximum score of 10:Vegetables is 5 servings/day, Fruits is 4 servings/day, Nuts and soy protein is 1 servings/day, Ratio of white to red meat is 4, Total dietary fiber is 22 g/day, Trans fat is ≤0.5% of calories, Polyunsaturated to saturated fat ratio is ≥1, Alcohol intake is 0.5-1.5 servings/day for women, Multivitamin use is ≥5year.

[b]For multivitamin use, the minimum score was 2.5 and the maximum score was 7.5.

[c]Recommended values for Sodium is 2300 mg/day

[d]Dairy foods contain milks and dairy products (e.g., cheese, yogurt).

Table 3

Hazard ratios and 95% confidence intervals (CI) for incident diabetes according to quintile of the Alternate Healthy Eating Index (AHEI) score measured at baseline, in the Women's Health Initiative 1993-2005.

	Quintile 1	Quintile2	Quintile 3	Quintile 4	Quintile 5
Overall (n=154,493)					
Median AHEI score	24.05	31.64	37.65	43.82	53.00
New onset of diabetes	2,906	2,327	2,027	1,684	1,363
No. per quintile	30,898	30,900	30,897	30,899	30,899
Cumulative incidence rate (%)	9.41	7.53	6.56	5.45	4.41
Unadjusted hazard ratios and 95% CI	1	0.79(0.75-0.83)	0.68(0.64-0.72)	0.56(0.53-0.60)	0.46(0.43-0.49)
Age, race, and body mass index adjusted hazard ratios and 95% CI					
Multivariable adjusted hazard ratios and 95% CI[a]	1	0.92(0.87-0.98)	0.88(0.82-0.93)	0.80(0.74-0.86)	0.76(0.70-0.82)
Whites (n=128,998)					
Median AHEI score	24.54	32.23	38.16	44.26	53.34
New onset of diabetes	1935	1657	1491	1251	1063
No. per quintile	23,892	25,340	26,088	26,646	27,032
Cumulative incidence rate (%)	8.10	6.54	5.72	4.69	3.93
Unadjusted hazard ratios and 95% CI	1	0.80(0.75-0.86)	0.70(0.65-0.74)	0.57(0.53-0.61)	0.48(0.45-0.52)
Multivariable adjusted hazard ratios and 95% CI[b]	1	0.90(0.84-0.97)	0.84(0.78-0.91)	0.75(0.69-0.82)	0.74(0.68-0.82)
Blacks (n=12,820)					
Median AHEI score	21.21	29.26	33.64	40.10	49.80
New onset of diabetes	610	388	288	240	156
No. per quintile	4,084	2,750	2,329	1,963	1,694
Cumulative incidence rate (%)	14.94	14.11	12.37	12.23	9.21
Unadjusted hazard ratios and 95% CI	1	0.95(0.84-1.08)	0.82(0.71-0.94)	0.81(0.70-0.94)	0.62(0.52-0.73)
Multivariable adjusted hazard ratios and 95% CI[b]	1	1.03(0.90-1.20)	1.01(0.86-1.19)	1.01 (0.85-1.21)	0.85(0.69-1.05)
Hispanics (n=6,009)					
Median AHEI score	22.23	28.32	33.50	39.09	48.28
New onset of diabetes	237	177	143	75	41

	Quintile 1	Quintile2	Quintile 3	Quintile 4	Quintile 5
Overall (n=154,493)					
No. per quintile	1,800	1,509	1,154	893	653
Cumulative incidence rate (%)	13.17	11.73	12.39	8.40	6.28
Unadjusted hazard ratios and 95% CI	1	0.87(0.72-1.06)	0.89(0.72-1.10)	0.60(0.47-0.78)	0.44(0.31-0.61)
Multivariable adjusted hazard ratios and 95% CI[b]	1	0.98(0.79-1.23)	0.97(0.75-1.24)	0.70(0.52-0.96)	0.68(0.46-0.99)
Asians (n=3,940)					
Median AHEI score	27.09	34.27	40.22	46.17	54.87
New onset of diabetes	51	59	58	81	76
No. per quintile	522	728	770	893	1,027
Cumulative incidence rate (%)	9.77	8.10	7.53	9.07	7.40
Unadjusted hazard ratios and 95% CI	1	0.78(0.54-1.14)	0.74(0.51-1.08)	0.92(0.65-1.30)	0.72(0.51-1.03)
Multivariable adjusted hazard ratios and 95% CI[b]	1	1.02(0.68-1.53)	0.91(0.60-1.39)	1.24(0.82-1.87)	0.88(0.57-1.38)

[a] Hazard ratios were estimated using Cox proportional hazards models adjusted for age, race, education, cigarette smoking, body mass index, waist/hip ratio, physical activity, log (daily energy intake), family history of diabetes, study arms and hormone therapy use.

[b] Hazard ratios were estimated using Cox proportional hazards models adjusted for age, education, cigarette smoking, body mass index, waist/hip ratio, physical activity, log (daily energy intake), family history of diabetes, study arms and hormone therapy use.

Table 4

Hazard ratios and 95% confidence intervals (CI) of incident diabetes based on Alternate Healthy Eating Index(AHEI) construct components baseline, in the Women's Health Initiative 1993-2005.

	Total number	No. of new onset of diabetes(%)	Unadjusted hazard Ratios and 95% CI	Multivariable adjusted hazard ratios and 95% CI[a]
Overall (n=154,493)				
Vegetables (servings/day)				
<3.01	150,462	10,006(6.65)	1	1
≥3.01	3,740	279(7.46)	1.14(1.02-1.29)	1.10(0.96-1.26)
Fruits (servings/day)				
<2.57	132,340	9,004(6.80)	1	1
≥2.57	21,862	1,281(5.86)	0.87(0.82-0.93)	0.99(0.93-1.06)
Nuts & soy protein (servings/day)				
<0.28	91,842	6,335(6.90)	1	1
≥0.28	62,360	3,950(6.33)	0.91(0.88-0.95)	1.02(0.97-1.06)
White to red meat ratio				
<1.71	119,820	8,357(6.97)	1	1
≥1.71	34,382	1,928(5.61)	0.81(0.77-0.85)	0.89(0.84-0.94)
Trans fat (% energy)				
>1.25	129,949	9,274(7.14)	1	1
≤1.25	24,253	1,011(4.17)	0.59(0.55-0.63)	0.81(0.75-0.87)
Total fiber (grams/day)				
<13.14	60,317	4,314(7.15)	1	1
≥13.14	93,885	5,971(6.36)	0.87(0.84-0.90)	0.98(0.93-1.04)
Polyunsaturated to saturated fat ratio				
<0.77	113,811	75,99(6.68)	1	1
≥0.77	40,391	2,686(6.65)	1.00(0.95-1.04)	1.04(0.99-1.09)
Alcohol (servings/day)				
<0.23/>1.59	112,012	8,621(7.70)	1	1
0.23-1.59	42,190	1,664(3.95)	0.49(0.47-0.52)	0.68(0.64-0.72)
Duration of multivitamin use (years)				
<5	93,660	6,743(7.20)	1	1
≥5	60,831	3,564(5.86)	0.83(0.80-0.86)	0.98(0.94-1.03)
Dairy foods (servings/day)				
<3	108,086	7,231(6.69)	1	1
≥3	46,116	3,054(6.62)	0.98(0.94-1.02)	1.03(0.98-1.08)
Glycemic load				
≤82.21	61,683	3,982(6.46)	1	1
>82.21	92,516	6,303(6.81)	1.04(1.00-1.08)	0.96(0.90-1.02)
Glycemic index				
≤51.56	61,732	3,604(5.84)	1	1

	Total number	No. of new onset of diabetes(%)	Unadjusted hazard Ratios and 95% CI	Multivariable adjusted hazard ratios and 95% CI[a]
Overall (n=154,493)				
>51.56	92,470	6,681(7.23)	1.23(1.19-1.29)	1.00(0.95-1.04)
Whites (n=128,998)				
Vegetables (servings/day)				
<3.01	125,728	7,186(5.72)	1	1
≥3.01	3,019	194(6.43)	1.14(0.99-1.32)	1.15(0.98-1.35)
Fruits (servings/day)				
<2.57	110,398	6,475(5.87)	1	1
≥2.57	18,349	905(4.93)	0.85(0.80-0.91)	0.97(0.90-1.05)
Nuts & soy protein (servings/day)				
<0.28	75,690	4,398(5.81)	1	1
≥0.28	53,057	2,982(5.62)	0.97(0.92-1.01)	1.01(0.96-1.07)
White to red meat ratio				
<1.71	102,012	6,203(6.08)	1	1
≥1.71	26,735	1,177(4.40)	0.73(0.68-0.77)	0.93(0.87-1.00)
Trans fat (% energy)				
>1.25	108,363	6,646(6.13)	1	1
≤1.25	20,384	734(3.60)	0.59(0.55-0.64)	0.81(0.74-0.88)
Total fiber (grams/day)				
<13.14	47,257	2,794(5.91)	1	1
≥13.14	81,490	4,586(5.63)	0.94(0.89-0.98)	0.97(0.91-1.03)
Polyunsaturated to saturated fat ratio				
<0.77	97,432	5,631(5.78)	1	1
≥0.77	31,315	1,749(5.59)	0.96(0.91-1.02)	1.09(1.02-1.15)
Alcohol (servings/day)				
<0.23/>1.59	90,166	6,003(6.66)	1	1
0.23-1.59	38,581	1,377(3.57)	0.52(0.49-0.55)	0.67(0.63-0.71)
Duration of multivitamin use (years)				
<5	75,502	4,568(6.05)	1	1
≥5	53,495	2,829(5.29)	0.90(0.86-0.94)	0.99(0.94-1.04)
Dairy foods (servings/day)				
<3	86,920	4,842(5.57)	1	1
≥3	41,827	2,538(6.07)	1.09(1.04-1.14)	1.01(0.95-1.07)
Glycemic load				
≤82.21	50,008	2,683(5.37)	1	1
>82.21	78,739	4,697(5.97)	1.09(1.04-1.15)	0.97(0.91-1.04)
Glycemic index				
≤51.56	53,197	2,676(5.03)	1	1
>51.56	75,550	4,704(6.23)	1.23(1.17-1.29)	1.01(0.96-1.06)

	Total number	No. of new onset of diabetes(%)	Unadjusted hazard Ratios and 95% CI	Multivariable adjusted hazard ratios and 95% CI[a]
Overall (n=154,493)				
Blacks (n=12,820)				
Vegetables (servings/day)				
<3.01	12,524	1,645(13.13)	1	1
≥3.01	280	32(11.43)	0.90(0.63-1.27)	0.80(0.53-1.22)
Fruits (servings/day)				
<2.57	10,951	1,448(13.22)	1	1
≥2.57	1,853	229(12.36)	0.95(0.82-1.09)	1.05(0.90-1.24)
Nuts & soy protein (servings/day)				
<0.28	8,625	1,170(13.57)	1	1
≥0.28	4,179	507(12.13)	0.89(0.80-0.99)	0.96(0.85-1.08)
White to red meat ratio				
<1.71	8,148	1,152(14.14)	1	1
≥1.71	4,656	525(11.28)	0.79(0.71-0.88)	0.85(0.76-0.96)
Trans fat (% energy)				
>1.25	11,654	1,588(13.63)	1	1
≤1.25	1,150	89(7.74)	0.56(0.45-0.70)	0.72(0.57-0.92)
Total fiber (grams/day)				
<13.14	6,999	941(13.44)	1	1
≥13.14	5,805	736(12.68)	0.95(0.86-1.05)	1.02(0.89-1.16)
Polyunsaturated to saturated fat ratio				
<0.77	8,350	1,160(13.89)	1	1
≥0.77	4,454	517(11.61)	0.83(0.75-0.92)	0.94(0.84-1.06)
Alcohol (servings/day)				
<0.23/>1.59	11,118	1,500(13.49)	1	1
0.23-1.59	1,686	177(10.50)	0.75(0.64-0.88)	0.90(0.76-1.06)
Duration of multivitamin use (years)				
<5	9,515	1,288(13.54)	1	1
≥5	3,304	394(11.92)	0.89(0.79-0.99)	0.97(0.86-1.10)
Dairy foods (servings/day)				
<3	11,100	1,424(12.83)	1	1
≥3	1,704	253(14.85)	1.19(1.04-1.36)	1.19(1.01-1.41)
Glycemic load				
≤82.21	5,794	749(12.93)	1	1
>82.21	7,010	928(13.24)	1.03(0.94-1.14)	0.88(0.75-1.02)
Glycemic index				
≤51.56	3,244	399(12.30)	1	1
>51.56	9,560	1,278(13.37)	1.08(0.96-1.20)	0.94(0.83-1.07)
Hispanics (n=6,009)				

	Total number	No. of new onset of diabetes(%)	Unadjusted hazard Ratios and 95% CI	Multivariable adjusted hazard ratios and 95% CI[a]
Overall (n=154,493)				
Vegetables (servings/day)				
<3.01	5,789	644(11.12)	1	1
≥3.01	206	29(14.08)	1.26(0.87-1.83)	1.41(0.89-2.24)
Fruits (servings/day)				
<2.57	5,197	601(11.56)	1	1
≥2.57	798	72(9.02)	0.79(0.62-1.00)	0.98(0.74-1.29)
Nuts & soy protein (servings/day)				
<0.28	4,639	535(11.53)	1	1
≥0.28	1,356	138(10.18)	0.86(0.71-1.04)	0.93(0.75-1.16)
White to red meat ratio				
<1.71	4,623	564(12.20)	1	1
≥1.71	1,372	109(7.94)	0.63(0.52-0.78)	0.68(0.53-0.86)
Trans fat (% energy)				
>1.25	4,893	587(12.00)	1	1
≤1.25	1,102	86(7.80)	0.64(0.51-0.80)	0.85(0.66-1.10)
Total fiber (grams/day)				
<13.14	2,900	321(11.07)	1	1
≥13.14	3,095	352(11.37)	0.98(0.84-1.14)	1.02(0.82-1.27)
Polyunsaturated to saturated fat ratio				
<0.77	4,303	483(11.22)	1	1
≥0.77	1,692	190(11.23)	1.00(0.84-1.18)	0.99(0.82-1.20)
Alcohol (servings/day)				
<0.23/>1.59	5,011	615(12.27)	1	1
0.23-1.59	984	58(5.89)	0.45(0.34-0.59)	0.55(0.41-0.75)
Duration of multivitamin use (years)				
<5	4,355	504(11.57)	1	1
≥5	1,654	169(10.22)	0.86(0.72-1.03)	1.01(0.83-1.23)
Dairy foods (servings/day)				
<3	4,519	497(11.00)	1	1
≥3	1,476	176(11.92)	1.07(0.90-1.27)	1.13(0.91-1.41)
Glycemic load				
≤82.21	2,797	310(11.08)	1	1
>82.21	3,198	363(11.35)	0.99(0.85-1.16)	1.01(0.79-1.29)
Glycemic index				
≤51.56	2,650	315(11.89)	1	1
>51.56	3,345	358(10.70)	0.90(0.78-1.05)	0.90(0.76-1.07)
Asians (n=3,940)				
Vegetables (servings/day)				

	Total number	No. of new onset of diabetes(%)	Unadjusted hazard Ratios and 95% CI	Multivariable adjusted hazard ratios and 95% CI[a]
Overall (n=154,493)				
<3.01	3,793	309(8.15)	1	1
≥3.01	142	16(11.27)	1.40(0.85-2.31)	0.97(0.53-1.79)
Fruits (servings/day)				
<2.57	3,433	277(8.07)	1	1
≥2.57	502	48(9.56)	1.22(0.90-1.66)	1.14(0.80-1.62)
Nuts & soy protein (servings/day)				
<0.28	1,250	93(7.44)	1	1
≥0.28	2,685	232(8.64)	1.17(0.92-1.49)	1.19(0.90-1.57)
White to red meat ratio				
<1.71	2,967	248(8.36)	1	1
≥1.71	968	77(7.95)	0.96(0.74-1.24)	1.07(0.80-1.43)
Trans fat (% energy)				
>1.25	2,844	251(8.83)	1	1
≤1.25	1,091	74(6.78)	0.76(0.59-0.99)	1.00(0.74-1.35)
Total fiber (grams/day)				
<13.14	1,921	149(7.76)	1	1
≥13.14	2,014	176(8.74)	1.12(0.90-1.39)	0.96(0.72-1.29)
Polyunsaturated to saturated fat ratio				
<0.77	1,838	157(8.54)	1	1
≥0.77	2,097	168(8.01)	0.93(0.75-1.16)	1.00(0.79-1.26)
Alcohol (servings/day)				
<0.23/>1.59	3,564	306(8.59)	1	1
0.23-1.59	371	19(5.12)	0.57(0.36-0.91)	0.69(0.42-1.16)
Duration of multivitamin use (years)				
<5	2,502	226(9.03)	1	1
≥5	1,438	99(6.88)	0.74(0.59-0.94)	0.84(0.66-1.09)
Dairy foods (servings/day)				
<3	3,482	286(8.21)	1	1
≥3	453	39(8.61)	1.08(0.77-1.51)	1.08(0.75-1.56)
Glycemic load				
≤82.21	1,833	133(7.26)	1	1
>82.21	2,102	192(9.13)	1.27(1.02-1.58)	0.92(0.65-1.29)
Glycemic index				
≤51.56	1,529	124(8.11)	1	1
>51.56	2,406	201(8.35)	1.03(0.82-1.29)	0.89(0.70-1.14)

[a]Hazard ratios were estimated using Cox proportional hazards models adjusted for age, education, cigarette smoking, BMI, waist/hip ratio, physical activity, log (daily energy intake), family history of diabetes, study arms and hormone therapy use.