

The Impact of Lifestyle Characteristics on Carotenoid Intake in the United States: The 1987 National Health Interview Survey

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Objectives. This study compared mean carotenoid intake in the United States by demographic and lifestyle variables to identify potential high-risk subgroups for disease.

Methods. Adults 18 to 99 years of age (n = 22 080) completed a food frequency questionnaire in the 1987 National Health Interview Survey, and mean carotenoid intakes were estimated.

Results. Carotenoid intakes were lower among Whites (vs Blacks), current smokers (vs nonsmokers), nondrinkers (vs drinkers), adults 18 to 39 years of age (vs those 40 to 69 years of age), frequent restaurant consumers (vs those who ate at home), and less educated (vs college-educated) persons.

Conclusions. The benefits of a carotenoid-rich diet should be communicated to high-risk subgroups. (*Am J Public Health.* 1997;87:268–271)

Introduction

Consumption of select foods, especially carotenoid-rich fruits and vegetables, may reduce the risk of certain cancers and cardiovascular disease.^{1,2} Specific carotenoids found in human plasma play an essential role in normal epithelial cell differentiation and maintenance³ and have antioxidative capacities that make them potentially important components in cancer prevention.⁴ Initially, beta carotene was thought to have the strongest antioxidative capability; however, newer findings indicate that other carotenoids, such as lycopene, have a greater capacity to quench singlet oxygen.⁵ The greatest antioxidative benefits may be achieved when multiple carotenoids are present in the diet.⁶

The 1987 National Health Interview Survey (NHIS) collected dietary data on a representative sample of the adult US population.⁷ The 1993 US Department of Agriculture–National Cancer Institute (USDA–NCI) carotenoid food composition database provides values on five specific carotenoids (alpha carotene, beta carotene, beta cryptoxanthin, lutein, and lycopene).^{8,9} In this study, carotenoid values from the 1993 USDA–NCI database were linked to the 1987 NHIS food frequency questionnaire to describe the estimated mean specific and total carotenoid intake in the US population. The objective was to compare specific and total mean carotenoid intake across a nationally representative sample by demographic and lifestyle characteristics and identify subgroups with lower carotenoid intake that may be at higher risk of disease.

Methods

NHIS

In 1987, the NHIS included the NCI Epidemiology Study Supplement with questions about cancer risk factors and

dietary intake.⁷ A stratified multistage cluster design was used to select a representative sample of households within the 48 contiguous US states. The sample population (n = 20 080) included resident, noninstitutionalized civilians of the United States, 18 to 99 years of age.¹⁰ Experienced Census Bureau interviewers collected data by in-home interviews conducted with one randomly selected adult 18 years old or older per household. Telephone interviews were conducted if respondents were not at home after repeated efforts. The overall eligible household response rate was 82%.⁷ Dietary data were collected between January 1 and December 31, 1987, by means of a semiquantitative 60-item food frequency questionnaire administered once to the randomly selected adult in each household. Individuals were asked to report their usual frequency of intake and portion size for specific food items during the past year. The 60 items were selected to include foods that were the major contributors to nutrient intake in the 24-hour dietary recalls from the 1976 through 1980 National Health and Nutrition Examination Survey (NHANES II).¹⁰ Since the food frequency questionnaire provided a relative measure of intake rather than an individual's absolute quantitative intake, the reported estimated mean carotenoid intake was used for comparison among demographic subgroups only.

Approximately 6% of the 22 080 completed food frequency questionnaires were excluded as a result of errors in coding, interview, or response.¹⁰ Further details describing the methods and collec-

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This paper was accepted May 3, 1996.

TABLE 1—Multiple Linear Regression Analysis: Adjusted Mean Carotenoid Intakes (mg/d) and Standard Errors for Adults (n = 16 317) in the 1987 National Health Interview Survey

	Alpha Carotene	Beta Carotene	Beta Cryptoxanthin	Lutein	Lycopene	Total
Total sample	0.29 ± 0.003	2.61 ± 0.02	0.027 ± 0.001	2.14 ± 0.03	2.07 ± 0.02	7.15 ± 0.06
Race						
White	0.30 ± 0.003	2.54 ± 0.03	0.026 ± 0.001	1.84 ± 0.02	2.08 ± 0.02	6.88 ± 0.06
Black	0.27 ± 0.008**	3.31 ± 0.09***	0.034 ± 0.001***	3.72 ± 0.11***	1.96 ± 0.04*	9.30 ± 0.22***
Smoking ^a						
Never	0.31 ± 0.004	2.66 ± 0.03	0.030 ± 0.001	2.11 ± 0.03	2.12 ± 0.02	7.22 ± 0.07
Former	0.31 ± 0.005	2.75 ± 0.04	0.029 ± 0.001	2.29 ± 0.04**	2.11 ± 0.03	7.49 ± 0.09
Current	0.28 ± 0.007***	2.46 ± 0.05***	0.022 ± 0.001***	2.08 ± 0.05	1.97 ± 0.03*	6.81 ± 0.12***
Alcohol ^b (drinks per week)						
Never	0.28 ± 0.005	2.67 ± 0.05	0.026 ± 0.001	2.14 ± 0.04	1.96 ± 0.03	7.08 ± 0.09
1–6	0.30 ± 0.004	2.56 ± 0.03	0.027 ± 0.001	2.08 ± 0.03**	2.05 ± 0.02	7.02 ± 0.07
7+	0.32 ± 0.007**	2.70 ± 0.06*	0.028 ± 0.001	2.30 ± 0.07	2.25 ± 0.04***	7.59 ± 0.14**
Restaurant meals per week						
Never	0.32 ± 0.007	2.74 ± 0.06	0.030 ± 0.001	2.32 ± 0.05	2.14 ± 0.03	7.55 ± 0.12
1+	0.29 ± 0.003***	2.58 ± 0.03*	0.026 ± 0.001***	2.09 ± 0.03***	2.05 ± 0.02*	7.04 ± 0.06**
Age, y						
18–39	0.28 ± 0.004	2.34 ± 0.03	0.025 ± 0.001	1.94 ± 0.03	2.05 ± 0.03	6.64 ± 0.07
40–69	0.32 ± 0.005***	2.97 ± 0.05***	0.029 ± 0.001***	2.39 ± 0.04***	2.09 ± 0.03	7.80 ± 0.09***
Gender						
Male	0.30 ± 0.004	2.57 ± 0.03	0.027 ± 0.001	2.09 ± 0.03	2.09 ± 0.02	7.03 ± 0.08
Female	0.29 ± 0.004	2.71 ± 0.03***	0.026 ± 0.001	2.19 ± 0.04*	2.05 ± 0.02	7.27 ± 0.07*
Education, y ^c						
0–8	0.26 ± 0.010	2.59 ± 0.12	0.026 ± 0.002	1.97 ± 0.09	2.05 ± 0.07	6.91 ± 0.24
9–12	0.28 ± 0.004	2.47 ± 0.03	0.027 ± 0.001	2.00 ± 0.03	2.00 ± 0.03	6.79 ± 0.07
13+	0.33 ± 0.005***	2.80 ± 0.04	0.028 ± 0.001	2.33 ± 0.04***	2.15 ± 0.02	7.63 ± 0.08***
Per capita income, \$ ^d						
0–9 999	0.30 ± 0.005	2.57 ± 0.05	0.026 ± 0.001	2.06 ± 0.04	2.08 ± 0.02	7.04 ± 0.09
10 000–19 000	0.30 ± 0.005	2.66 ± 0.04	0.028 ± 0.001	2.20 ± 0.04*	2.05 ± 0.03	7.23 ± 0.09
20 000–39 000	0.30 ± 0.008	2.70 ± 0.06	0.028 ± 0.001	2.25 ± 0.06*	2.08 ± 0.04	7.35 ± 0.13
40 000–49 000	0.28 ± 0.022	2.57 ± 0.20	0.024 ± 0.002	2.36 ± 0.18	2.16 ± 0.17	7.39 ± 0.48
50 000+	0.28 ± 0.032	2.42 ± 0.16	0.028 ± 0.003	2.12 ± 0.15	1.93 ± 0.14	6.78 ± 0.40

Note. Shown are adjusted least square's means between the indicated level of the independent variable and the baseline comparison level. Variables of adjustment include age, race, smoking, drinking, restaurant meals, gender, education, per capita income, body mass index, and season.

^aComparison among never vs current or former smokers.

^bComparison among never vs all other drinking groups.

^cComparison among 0–8 years vs 9–12 or 13+ years of education.

^dComparison among lowest vs all other income groups.

* $P < .05$; ** $P < .005$; *** $P < .0001$.

tion process have been reported elsewhere.¹⁰ This analysis focused on Black and White individuals (n = 16 317); Hispanics and other minorities were excluded because of small sample sizes and/or difficulty in reporting ethnic-specific foods or omission of these foods from the food frequency questionnaire.

Estimation of Dietary Carotenoid Intake

Each carotenoid-rich food item in the food frequency questionnaire was linked to the same item in the USDA–NCI carotenoid food composition database to determine specific carotenoid content (alpha carotene, beta carotene, beta crypto-

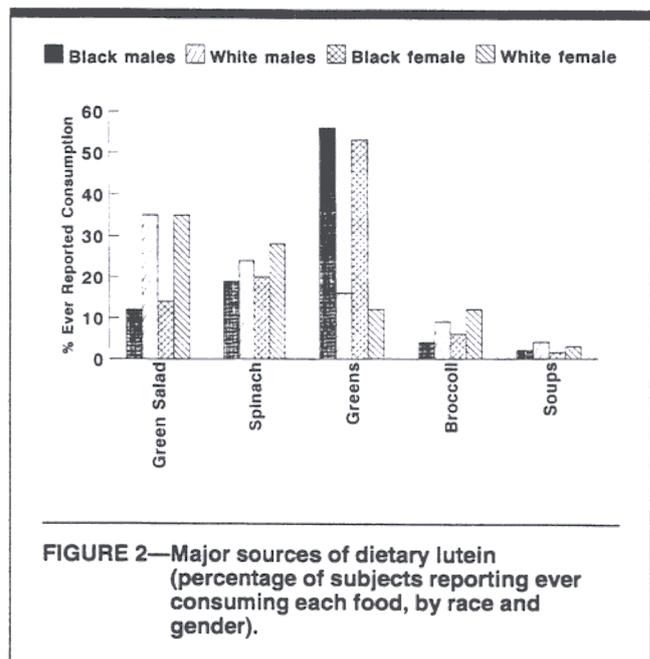
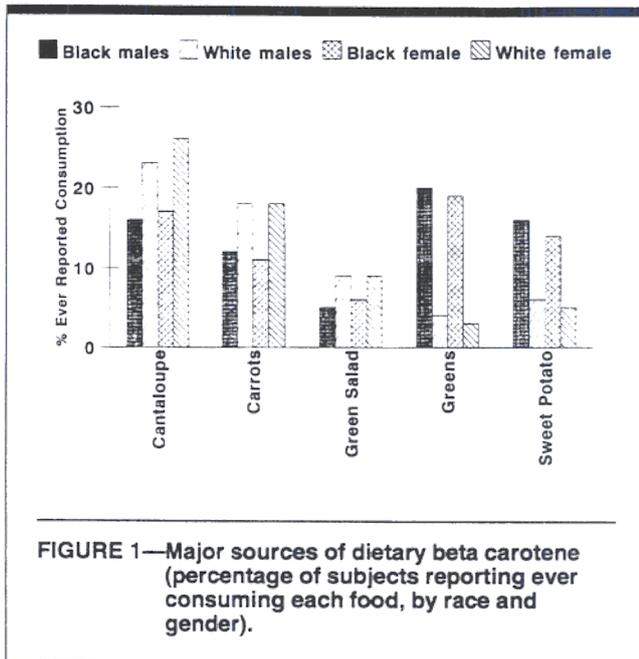
xanthin, lutein plus zeaxanthin, and lycopene).⁸ For each carotenoid-rich food item, the frequency of intake of a set of foods representing that item was calculated via the 24-hour recalls in NHANES II and weighted to reflect appropriate age- and sex-specific US subpopulations. The specific carotenoid value for each food in the questionnaire item was multiplied by this weighted frequency from NHANES II. Next, the respondent's reported frequency of intake during the past year and reported portion size were multiplied by the weighted individual carotenoid values for each food item. Then the respondent's item-specific carotenoid intakes over the year were averaged to provide an esti-

mated mean daily dietary intake (milligrams per day). Total carotenoid intake was estimated from the sum of the five specific carotenoid intakes.¹¹

Statistical Analysis

Since the survey was based on a complex sample design, all analyses were computed with observations weighted by sample weights and with standard errors estimated by taking account of the stratification, clustering, and weighting of the sample selection. The SUDAAN software package (version 6.0; Research Triangle Park, NC) was used in conducting analyses.

The analyses involved estimating unadjusted mean carotenoid intakes by



demographic and lifestyle variables and then fitting multiple linear regression models with the mean individual carotenoid intakes as the dependent variable.

Continuous variables were grouped into categories: age (18 through 29, 30 through 39, 40 through 49, 50 through 59, 60 through 69 years), education (0 through 8, 9 through 12, 13+ years), body mass index (17 through 27, 28 through 32, 33 through 68 kg/m²), per capita income (\$0 through \$9999, \$10 000 through \$19 999, \$20 000 through \$39 999, \$40 000 through \$49 999, \$50 000+), number of restaurant meals (0 per week, 1+ per week), alcohol consumption (0, 1 through 6, 7+ drinks per week), and cigarette smoking (never, former, current). The categorical variables of race, gender, and season (winter was classified as January through March; spring, as April through June; summer, as July through September; and fall, as October through December) were also analyzed. Self-reported weight and height were used to estimate body mass index (kg/m²). The age groupings were merged into larger categories (18 through 39, 40 through 69 years) because some cell sizes for Blacks were too small (<25 per cell).

Adjusted mean carotenoid values were calculated for each demographic and lifestyle variable in the fitted regression model. The adjusted mean was computed by taking a weighted average (using the sample weights) over the predicted values of the observations derived from the regression model; each observation was assigned to the category for which the

mean was being computed. These adjusted means were analogous to the least squares means in SAS, except the sample weights were used in the computation. The standard errors for the adjusted means were computed by combining the variances and covariances of the coefficients in the regression model. Unless otherwise indicated, all reported significant differences are at the $P < .05$ level (two-sided).

Results

Adjusted mean carotenoid intakes are provided in Table 1. Blacks consumed more beta carotene (31%), beta cryptoxanthin (33%), lutein (92%), and total carotenoids (35%) than Whites. In contrast, Whites consumed more lycopene (6%) and beta carotene (10%) than Blacks. These differences were associated with consumption variations in specific fruits and vegetables. Figures 1 and 2 present the five most frequently consumed dietary sources of beta carotene and lutein by race and gender. Overall, Blacks reported consuming dark leafy greens (mustard, kale, collards) and sweet potato more frequently than Whites.

Current smokers consumed significantly less alpha carotene (8%), beta carotene (7%), beta cryptoxanthin (26%), and lycopene (7%) and fewer total carotenoids (7%) than nonsmokers. In contrast, former smokers consumed higher amounts of carotenoids than nonsmokers, but only lutein (9%) intake was significantly higher.

In comparison with never drinkers, alcohol drinkers, especially those consuming seven or more drinks per week, had significantly higher alpha carotene (11%), lycopene (15%), and total carotenoid (7%) intakes (primarily in the form of tomatoes, pizza, and tomato-based pasta dishes). The effect of the interactions between drinking and smoking on mean carotenoid intakes was not statistically significant (data not shown).

Overall, persons eating at home had significantly higher alpha carotene (8%), beta carotene (6%), beta cryptoxanthin (15%), lutein (10%), lycopene (4%), and total carotenoid (7%) intakes than regular restaurant meal consumers (one or more meals per week).

Older adults (40 to 69 years of age) had significantly higher alpha carotene (13%), beta carotene (27%), beta cryptoxanthin (16%), lutein (23%), and total carotenoid (18%) intakes than adults 18 to 39 years of age.

Differences in mean carotenoid intake appeared by gender, women consuming higher amounts of beta carotene (7%), lutein (5%), and total carotenoids (4%) than men. There were no significant gender-specific interactions in the model.

College-educated individuals (i.e., those with 13+ years of education) had significantly higher mean alpha carotene (22%), lutein (18%), and total carotenoid (10%) intakes than those with 12 or fewer years of education. Except for lutein, mean carotenoid intake did not statistically differ by per capita income. Finally,

mean total and specific carotenoid intakes were not statistically different by season or by body mass index (data not shown).

Discussion

The adjusted mean carotenoid intake in the US population differed by race, age, years of education, smoking status, drinking status, and frequency of restaurant meals. Overall, Blacks had higher beta carotene, beta cryptoxanthin, lutein, and total carotenoid intakes than Whites. Blacks reported a higher frequency of consumption of green leafy vegetables and sweet potatoes, which contributed to their overall higher carotenoid intakes than Whites.

In comparison with Whites, Blacks had a higher prevalence of heavy alcohol use and current smoking, characteristics that induce increased oxidative stress.¹¹ Perhaps the heavier drinking and smoking habits of Blacks contribute to an increased cancer risk and outweigh the potential benefits of their higher carotenoid intake.¹²⁻¹⁴ Alternatively, the race-specific differences in carotenoid intake may not translate into biologically meaningful higher carotenoid concentrations in plasma and tissue.¹¹ Further investigation is needed to clarify this issue.

Current smokers consumed lower amounts of specific and total carotenoids than nonsmokers. Smokers have been reported to consume fewer calories, have lower body weights, drink more alcohol and coffee, and have lower serum carotenoid levels than nonsmokers.¹⁵⁻¹⁷ Thus, adjustment for dietary carotenoid intake needs to be entered into the smoking-plasma carotenoid association.

Individuals who ate at home had higher specific and total carotenoid intakes than those having one or more restaurant meals per week. No details of restaurant type were provided in the NHIS questionnaire.⁷ Further research is needed to determine whether differences in carotenoid intake by restaurant use represent a marker of a lifestyle related to lower carotenoid intake or whether such differences are a direct result of the type of restaurant meal consumed.¹⁸

College-educated persons had higher mean alpha carotene, lycopene, and total carotenoid intakes than those with less education. These results were in accord with expectations if education is considered a proxy for nutrition knowledge. Individuals with greater nutritional awareness tend to consume a more nutritionally balanced diet.¹⁹

Carotenoid intake did not differ significantly by season, which may reflect the availability of fresh fruits and vegetables throughout the year in US markets and, especially the availability of foods, such as carrots, rich in beta carotene.

The food frequency questionnaire is a primary tool of dietary assessment in nutrition epidemiology that minimizes intraindividual variation in diet by assessing usual consumption over a period of time.²⁰ The food frequency questionnaire is an attractive option for collecting dietary data in large populations because of its adequate test-retest reliability and low respondent burden²⁰; however, limitations exist.²¹ Response bias, along with the limited number of items included in a food frequency questionnaire, may lead to limitations, especially among specific ethnic groups.²¹ The NHIS food frequency questionnaire was pretested for validity and administered by trained Census Bureau staff to improve accuracy of data collection and reduce potential bias.¹⁰

In summary, this analysis using the USDA-NCI carotenoid nutrient database provides the first available estimate of mean daily carotenoid intake by demographic and lifestyle characteristics in a nationally representative sample. Race-specific differences were the largest, with intake in Blacks exceeding that in Whites. Lower carotenoid intake also occurred among smokers, nondrinkers, those with lower education levels, and those who regularly ate meals in restaurants. The benefits of a carotenoid-rich diet should be communicated to individuals in high-risk groups. □

Acknowledgments

We extend our gratitude to Timothy W. Marr and Lisa L. Kahle of Information Management Services, Silver Spring, Md, for their assistance with the NHANES II data and the USDA-NCI Carotenoid Food Composition database.

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