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VALIDATION OF AN ANTIOXIDANT NUTRIENT QUESTIONIARE IN WHITES AND AFRICAN AMERICANS

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Abstract

High antioxidant intakes are inversely related to risk for many diseases. However, there is no comprehensive instrument that captures consumption of antioxidant nutrients from both foods and dietary supplements. This report examines the validity of a newly developed questionnaire assessing self-reported dietary and supplemental intakes of antioxidant nutrients (carotenoids, vitamin C, and vitamin E). Between March and December 2005, participants (n=164), 20–45 years, completed the new 92-item antioxidant nutrient questionnaire, a demographic/health questionnaire, four 24-hour dietary recalls, a dietary supplement inventory, and provided semi-fasting blood samples that were analyzed for plasma antioxidant levels. Data analyses included descriptive statistics, correlation coefficients, and linear regression. The mean age of participants was 31.9 years, 51% were African American, and 52% were female. Median antioxidant intakes from the questionnaire and mean of the four recalls were generally comparable. Adjusted Pearson's correlations of questionnaire- and recall-derived intakes ranged from r=0.06–0.56; correlations for the questionnaire and biomarkers ranged from r=0.10–0.33. Agreement rates for classification of intakes from the questionnaire and recalls into the same/adjacent quartiles were 65–89%; misclassification to the opposite quartile was rare (0–12%). For most nutrients, there were linear trends of increasing plasma concentrations with higher questionnaire-derived intakes ($p<0.01$). Correlations of supplement use between the questionnaire and a supplement inventory were r=0.33–0.84. The new antioxidant nutrient questionnaire demonstrated good validity for collecting self-reported antioxidant nutrient intakes from foods and supplements in both whites and African Americans. The study also underscores the importance of examining the performance characteristics of dietary assessment instruments separately in different population subgroups.

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Keywords

antioxidants; African Americans; biomarkers; questionnaires; validity; whites

INTRODUCTION

The accuracy of diet and disease associations is largely dependent upon the quality of dietary exposure assessment. However, assessing dietary intake in free-living populations poses several challenges. The strengths and limitations of various self-report dietary assessment methods have been extensively reviewed (1–4). Also, although biologically-based assessments of nutritional status are optimal, biomarkers are not always feasible or practical for widespread use in population-based investigations (1,2,5). Therefore, there is a continual need for new and improved methods and instruments to accurately capture self-reported diet.

Consumption of plant foods, such as fruits, vegetables, and whole grains are inversely associated with incidence of many diseases (7). Antioxidants, present in foods as vitamins, minerals, polyphenols, etc., are believed to be among the bioactive compounds in these foods that are beneficial to health, and include vitamins A, C, and E, β-carotene, lycopene, and the mineral selenium (5,6,7). Despite considerable interest in studies of antioxidants and disease, it does not appear that any instrument(s) have been developed specifically to assess antioxidant nutrient intakes from both foods and dietary supplements.

This report describes the development and validation of a newly developed antioxidant nutrient questionnaire modeled after the semi-quantitative food frequency questionnaire (FFQ) (1,2, 8). It has the advantages of the FFQ (e.g., lower cost, suitability for lower literacy populations), but is targeted solely at antioxidant nutrients that can be reasonably captured by self-report (i.e., carotenoids, vitamin C, and vitamin E). The objectives were to 1) develop and test the relative validity of the new antioxidant nutrient questionnaire by comparison to multiple 24-hour dietary recalls and nutrient biomarkers, and 2) examine whether validity differs by race (whites and African Americans). Based on the published literature, this is the first dietary instrument aimed at assessing self-reported antioxidant nutrient exposure that has been validated in both whites and African Americans.

MATERIALS AND METHODS

Study design and participants

Data are from the DIet, Supplements, and Health (DISH) Study, which enrolled 168 generally healthy whites and African Americans in North Carolina from March–December 2005. Details on the DISH study design have been published (9). Eligible participants were years, generally healthy, free of chronic diseases (i.e., cancer, diabetes, heart disease), and fluent in English. Because oxidative stress was one of the study outcomes, current smokers and self-reported obese persons (BMI $\geq 30 kg/m^2$) were ineligible. 191 respondents met eligibility requirements, 168 (88.0%) were enrolled, and 164 (85.9%) completed the study. The study was approved by the University of North Carolina-Chapel Hill (UNC-CH) Institutional Review Board and all participants provided signed informed consent.

Data collection

Participants completed four unannounced telephone-administered 24-hour dietary recalls and a 12 page self-administered questionnaire. During a one-time visit to the UNC-CH General Clinical Research Center, they had their height, weight, and waist circumference measured, provided semi-fasting (≥6 hours) blood samples, and participated in a dietary supplement

inventory. Diabetics and current smokers (based on hemoglobin A1c and serum cotinine, respectively) were excluded. Participants received a $100 incentive.

Antioxidant Nutrient Questionnaire—The 92-item self-administered questionnaire was modeled after the semi-quantitative FFQ and was designed to capture *usual* dietary and supplemental intakes of carotenoids, vitamin C, and vitamin E (Appendix). It includes more than 80 foods that either are natural sources of carotenoids, vitamins A, C, and E (e.g., fruits, vegetables) or fortified sources (e.g., cold cereals). The food items were selected based on the most commonly consumed antioxidant-rich foods among whites and African Americans using NHANES data (10); the published literature (1,5,10,11); and consensus among five white and African American nutritionists. Participants reported how often they ate each food *in the past month*: ≤once/month, once/month, two-three/month, one-two/week, three-four/week, one/day, or two/day and recorded whether they usually consumed a small, medium, or large amount (a medium serving size was shown as a reference). Nutrient analyses were performed by the Fred Hutchinson Cancer Research Center Nutrition Assessment Shared Resource using Nutrition Data System (NDS).

Dietary supplement use was collected separately from the food portion using a closed-ended format that quantified self-reported use (frequency and dose) of antioxidant nutrients *in the past month*. Supplements assessed include multivitamins and single and multi-nutrient formulations of β-carotene and vitamins A, C, and E. Participants reported the usual frequency of use (days per week) and typical dose (amount per day) for the single supplements. Daily intake of each nutrient was calculated as " days/week × dose/day/7" (12).

Dietary Recalls—Four unannounced telephone-administered 24-hour dietary recalls were conducted by trained nutritionists (who were unaware of the study design or hypotheses) using a computerized multiple pass approach (13) with the NDS software (version 5.0.35, 2006, University of Minnesota, Minneapolis) over a *one month period*. Two recalls each were conducted on weekdays and weekend days to adequately capture dietary variability over four weeks. The questionnaire and recalls captured the same (one month) time frame.

Dietary supplement inventory—Participants were instructed to bring the bottles for all vitamin and mineral supplement(s) taken *during the past month* to the in-person interview. For each supplement, a trained nutritionist recorded the brand name, type (multivitamin, single-, multi-nutrient), usual frequency and amount of use, number of pills taken each time, and amount of *each* "nutrient" per pill. This open-ended approach has been shown to be more valid than self-administered questionnaires (12,14). Average daily nutrient intake from the inventory was calculated as week × number of pills taken each time × dose/pill/7 (11), summed across all supplements containing that nutrient. Nutrients were converted into activity units: 1 IU of vitamin A = 0.3μg retinol and 3.6μg β-carotene; 1 IU of vitamin E = 0.45mg α-tocopherol (15).

Plasma nutrients—Semi-fasting (≥6 hours) blood samples protected from heat and light were analyzed for plasma concentrations of carotenoids, retinols, tocopherols, cholesterol, and vitamin C (using plasma preserved with metaphosphoric acid). The assays were performed by Craft Technologies Inc. (Wilson, NC) using standard methods (16). Quality control samples and 10% duplicates were included in each batch Samples were stored at −80ºC and analyzed within one year, within guidelines for storage stability (17).

Participant characteristics—In addition to the antioxidant questionnaire, the 12-page instrument also collected information on physical activity, medical history, smoking, alcohol use, and demographic characteristics. Self-reported and interviewer-measured height and weight were used to compute BMI (kg/m^2) (18). The 12-page questionnaire was pilot-tested

in a small convenience sample (n=10) and the feedback was used make the necessary modifications.

Statistical Analyses

Analyses were performed using SAS (version 9.2, 2002–2003, SAS Institute Inc., Cary, NC). Descriptive statistics (percentages and means) were calculated for all variables. White-African American comparisons were based on t-tests and chi-squared tests (for dichotomous and categorical variables, respectively).

Validity was assessed using various approaches. For each dietary assessment method (questionnaire, recalls, and biomarkers), median, 25^{th}, and 75^{th} percentile values of each nutrient were calculated separately for whites and African Americans. Also, Spearman's and Pearson's correlation coefficients, partialled for covariates (age, sex, education, BMI, and for fat-soluble vitamins, plasma cholesterol) were computed for each of the three possible pairs of dietary assessment methods: questionnaire/recalls, questionnaire/biomarkers, and recalls/biomarkers, for each nutrient, separately by race. To correct for within-person variation for the recalls which has multiple data-points, de-attenuated correlations, (i.e., corrected for measurement error) were computed as described by Rosner and Willett (19).

Race-specific degree of agreement in quartile distribution (same, adjacent, one quartile apart, and opposite) between the questionnaire and recalls was calculated. Race-specific agreement between supplemental intakes from the questionnaire and the inventory were assessed by comparing the proportion of non-supplement users and computing adjusted Spearman's correlation coefficients and their 95% confidence intervals. Finally, linear regression examined associations of the biomarkers with 1) intakes from the questionnaire and recalls and 2) multivitamin use, controlling for covariates. Adjusting for oxidative stress (measured by the Comet assay) did not alter the results. Log transformations of the right-skewed self-reported dietary and biomarker data improved their normality. All tests were two-sided; statistical significance was set a $p \leq 0.05$.

RESULTS AND DISCUSSION

The mean age of whites was 32.5 years (7.9 SD) and 52% were female. African Americans were 30.9 years (7.9 SD) on average and 53% were female. Whites had higher educational levels, physical activity, and alcohol consumption than African Americans, all $p<0.05$. African Americans were more likely than whites to report no supplement use (48% *vs*. 64%, respectively), $p>0.05$. There were no appreciable racial differences by marital status, income, self-rated health status, or county of residence (data not shown).

Median antioxidant nutrient intakes from the questionnaire, the average of four recalls, and nutrient biomarkers, stratified by race, are given in Table 1. Median intakes from the questionnaire and recalls were generally comparable, with differences typically between 10–30%. Exceptions among whites were α-carotene, vitamin C, and α-tocopherol, and among African Americans, β-carotene, α-carotene, and α-tocopherol.

Pearson's correlations of antioxidant nutrient intakes from the questionnaire, recalls, and biomarkers, adjusted for age, sex, education, BMI, and except for vitamin C, total plasma cholesterol, are given in Table 2. Associations among the different methods were modest, with generally higher correlations in whites than in African Americans. In whites, correlations of the questionnaire with the mean of four recalls ranged from r=0.17 (lycopene) to r=0.56 (β-carotene); those between the questionnaire and biomarkers ranged from r=0.12 (lycopene) to r=0.33 (β-carotene), and for the recalls and biomarkers, r=0.08 (lycopene) to r=0.31 (lutein + zeaxanthin). In African Americans, the corresponding values were r=0.06 (α-carotene) to

r=0.51 (lutein + zeaxanthin) for the questionnaire and recalls; *r*=0.10 (vitamin C) to *r*=0.33 (β-cryptoxanthin) for the questionnaire and biomarkers, and *r*=0.12 (retinols) to *r*=0.48 (lutein + zeaxanthin) for the recalls and biomarkers. Deattenuation of the correlation coefficients between the questionnaire and the recalls resulted in generally stronger associations, but did not change the results appreciably (data not shown). Also, recall-derived intakes for all nutrients and biomarker concentrations, except lycopene, increased linearly with higher questionnaire-derived intakes, all *p* for trend<0.001 (data not shown).

The degree of agreement in quartile distributions of antioxidant nutrient intakes between the questionnaire and mean of the recalls showed agreement rates for classification into the same or adjacent quartiles of 65–89%; misclassification to the opposite quartile was rare (0–12 percent)(data not shown). Lutein + zeaxanthin, β-cryptoxanthin, β-carotene, retinol, and vitamin C were most likely to be classified in the same or adjacent quartile; total α-tocopherol (9% in whites) and lycopene (12% in African Americans) were most often in the opposite quartile. Agreement was generally higher for whites than African Americans.

Comparisons of antioxidant intakes from dietary supplements only from the questionnaire and the supplement inventory, by race, are given in Table 3. Respondents were slightly more likely to be classified as non-users on the questionnaire relative to the inventory. Spearman's correlations of supplement use between the questionnaire and inventory were highest for vitamin E for both whites (*r*=0.81) and African Americans (*r*=0.84), and lowest for β-carotene in whites (*r*=0.33) and Vitamin C in African Americans (*r*=0.66). After excluding single supplement users of β-carotene and vitamins A, C, and E, there were trends of increasing biomarker concentrations of these nutrients with increasing multivitamin use (*p* for trend ≤0.05), demonstrating the validity of self-reported multivitamin use. For example, plasma α-tocopherol among multivitamin non-users was 7.74 μmol/L compared to 9.84 μmol/L for frequent multivitamin users (≥5 days/week) (data not shown).

The new antioxidant nutrient questionnaire performed reasonably well compared to the dietary recalls. Median antioxidant nutrient intake estimates by both methods were generally comparable, adjusted Pearson's correlations were modest (*r*=0.17–0.56 in whites and *r*=0.11–0.51 in African Americans), and agreement rates for classification into the same or adjacent quartiles were high (generally >70%). These results are similar to other published studies that have examined the validity of antioxidant nutrient estimates from FFQs relative to recalls (20–24). For example, the FFQ-recall correlations for carotenoids reported here (*r*=0.11–0.56) are similar to those among control participants in the Women's Healthy Eating and Living (WHEL) Study (*r*=0.36–0.48) (21). Correlation coefficients for African Americans in the present study were slightly higher than those in the Black Women's Health Study (24) for vitamin C (*r*=0.37 *vs.* *r*=0.23) and vitamin E (*r*=0.30 *vs.* *r*=0.08).

There was good agreement for intakes from the new questionnaire compared to biomarkers, and the associations were comparable (and sometimes stronger) to the recalls, which underscores the new instrument's validity. Correlation coefficients for questionnaire- and biomarker-derived intakes ranged from *r*=0.12–0.33 (whites) and *r*=0.10–0.33 (African Americans), similar to other studies (21,25–29). For example, in the Chicago Health and Aging Project (CHAP) validation study (28), correlations were *r* =0.14 (n=30 whites) and *r* =0.18 (n=29 African Americans) for dietary vitamin C, and *r* =0.15 and *r* =0.10, respectively, in the present study.

Given the high prevalence of supplement use and its sizeable contribution to nutrient intakes in the United States (6,30,31) it is important to evaluate the validity of self-reported use of antioxidant supplements. Respondents tended to self-classify more often as non-users of specific supplements, whereas the supplement inventory identified them as users. It is

conceivable that respondents did not remember using certain supplements or were not able to appropriately classify their supplement type in the questionnaire and therefore did not report them; whereas, the trained nutritionist accurately classified and documented the supplements during the in-person interview. Also, possibly, some participants may have begun using supplements in the 1–2 weeks between completion of the questionnaire and the in-person interview. Associations (Spearman's correlations) of supplement use between the questionnaire and inventory were strong, ranging from 0.84 for vitamin E (African Americans) to 0.33 for β-carotene (Whites). Also, biomarker values of the antioxidant nutrients increased with more frequent multivitamin use. The associations reported here for supplement use relative to the inventory and biomarkers are comparable to those in the published literature (12,14). Overall, the questionnaire appears to adequately capture supplemental antioxidant intakes relative to criterion measures.

Validity tended to be superior in whites than in African Americans. Overall, associations among the three methods were stronger and classification of intakes into the same/adjacent quartiles was more frequent in whites. These findings are analogous to the few other studies that have compared the validity of self-reported antioxidant intakes in both whites and African Americans using the same instrument. For example, in the CHAP validation study (28), the validity of the modified Harvard FFQ relative to multiple dietary recalls and biomarkers was generally better for whites than African Americans. Results were similar in a study of white, African American, and Hispanic females (n=186) examining the validity of a modified NCI Health and Habits History questionnaire relative to eight 24-hour recalls (32). The stronger questionnaire-biomarker associations in whites may be due to their (non-statistically significant) higher supplement use, as supplement use increases nutrient biomarker concentrations (1,5,12,20,33). It is worth-noting, however, that the validity of some carotenoids (e.g., lutein + zeaxanthin), was consistently higher in African Americans.

This study has some limitations. Self-reported dietary data, particularly from FFQs, are not precise and are subject to both random and systematic bias (1), and nutrient-specific FFQs may result in over-reporting of intake. Correlated errors between FFQs and recalls might result in an overestimation of the true associations, and results were not adjusted for total energy intake. Blood measures reflect concentrations at a single time point and the analyses could not control for differences absorption and metabolism. In particular, blood vitamin C is not an optimal biomarker because vitamin C is under tight homeostatic control (1,5). Also, another reason why the concentrations of vitamin C in this report, as well as the corresponding correlation coefficients, are lower than in other studies may be related to vitamin C deterioration during storage (34,35). Sample size limitations precluded stratification by both race and sex. Finally, generalizability may be limited because the study population consisted of healthy volunteers.

CONCLUSIONS

This is one the first studies to validate self-reported dietary and supplemental antioxidant nutrient intakes by comparison to a superior self-report method (multiple dietary recalls), a detailed supplement inventory (for supplement use), and more rigorously, to biomarkers in both whites and African Americans. The new questionnaire generally provided valid measures of self-reported antioxidant nutrient intakes from foods and supplements, although associations were somewhat stronger in whites. The study highlights the importance of examining the performance characteristics of dietary assessment instruments separately in different population subgroups. Future studies should evaluate both the reproducibility and validity of other antioxidants, use multiple methods, and include diverse populations.

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APPENDIX. Newly Developed Antioxidant Nutrient Questionnaire

In the next section, we are interested in the foods that you have eaten in the past month. The list below may not include all the foods you typically eat; please only answer for the specific foods mentioned. Unless specified otherwise, assume each item represents all forms of that food (i.e., fresh, frozen, cooked, or canned). For example, “cherries” would include fresh and raw cherries as well as cherry filling in a pie. For each of the following foods, mark the column to show how often you ate each food in the past month. Mark your usual amount (serving size) as small, medium, or large (for those foods not consumed, leave the amount blank).

- A small serving is about one-half (½) the medium serving size or less.
- A large serving is about one-and-a-half (1½) times the medium serving size or more.

HOW OFTEN DID YOU EAT THESE FOODS IN THE PAST MONTH?

	Not in the last month	1 per month	2–3 per month	1–2 per week	3–4 per week	5–6 per week	
FRUITS							
Example: *Rice*	○	○	○	○	○	•	
Apples, applesauce	○	○	○	○	○	○	
Apricots	○	○	○	○	○	○	
Bananas	○	○	○	○	○	○	
Cantaloupe	○	○	○	○	○	○	
Cherries	○	○	○	○	○	○	
Grapefruit	○	○	○	○	○	○	
Grapes	○	○	○	○	○	○	
Honeydew melon	○	○	○	○	○	○	
Kiwi	○	○	○	○	○	○	
Limes or lemons	○	○	○	○	○	○	
Mango	○	○	○	○	○	○	
Nectarines	○	○	○	○	○	○	
Oranges	○	○	○	○	○	○	
Papaya	○	○	○	○	○	○	
Peaches	○	○	○	○	○	○	
Pears	○	○	○	○	○	○	
Pineapple	○	○	○	○	○	○	
Plums	○	○	○	○	○	○	
Raisins	○	○	○	○	○	○	
Strawberries	○	○	○	○	○	○	

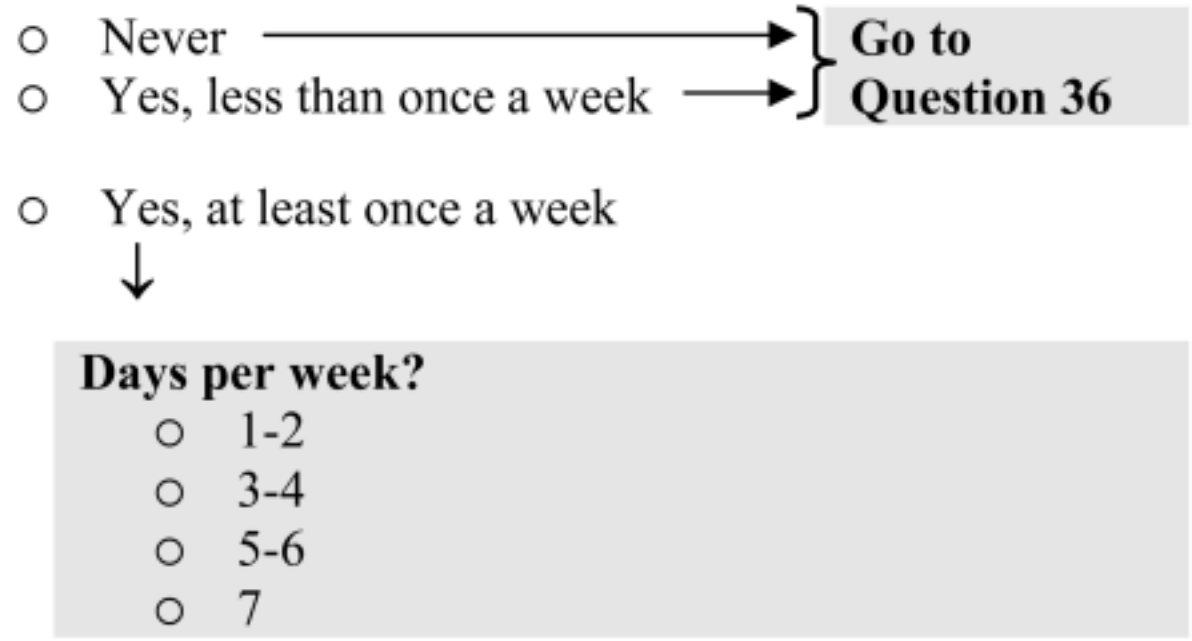
	Not in the last month	1 per month	2–3 per month	1–2 per week	3–4 per week	5–6 per week	
Berries (Excluding strawberries)	○	○	○	○	○	○	
Tangerines	○	○	○	○	○	○	
Watermelon	○	○	○	○	○	○	
VEGETABLES							
Avocado	○	○	○	○	○	○	
Broccoli	○	○	○	○	○	○	
Brussel sprouts	○	○	○	○	○	○	
Cabbage	○	○	○	○	○	○	
Carrots	○	○	○	○	○	○	
Cauliflower	○	○	○	○	○	○	
Celery	○	○	○	○	○	○	
Coleslaw	○	○	○	○	○	○	
Corn	○	○	○	○	○	○	
Greens (Swiss chard, kale, collard, turnip, or mustard greens)	○	○	○	○	○	○	
Spinach (cooked)	○	○	○	○	○	○	
Spinach (raw)	○	○	○	○	○	○	
Fresh tomatoes	○	○	○	○	○	○	
Green beans	○	○	○	○	○	○	
Green peas	○	○	○	○	○	○	
Green pepper	○	○	○	○	○	○	
Green salad (iceberg lettuce only)	○	○	○	○	○	○	
Green salad (romaine or leaf lettuce)	○	○	○	○	○	○	
Jalapeno, sweet red, or chili peppers	○	○	○	○	○	○	
Mixed vegetables (frozen or canned)	○	○	○	○	○	○	
Onions and leeks	○	○	○	○	○	○	
Summer squash or zucchini	○	○	○	○	○	○	
Sweet potatoes or yams	○	○	○	○	○	○	
CEREALS, GRAINS, NUTS, AND SNACKS							
Almonds	○	○	○	○	○	○	
Peanuts	○	○	○	○	○	○	
Other nuts (e.g., Brazil, pistachio)	○	○	○	○	○	○	
Peanut butter	○	○	○	○	○	○	
Cold cereal, fortified (e.g., Raisin Bran®	○	○	○	○	○	○	

	Not in the last month	1 per month	2–3 per month	1–2 per week	3–4 per week	5–6 per week	
Oatmeal (fortified, instant)	○	○	○	○	○	○	
Whole wheat bread or rolls (enriched)	○	○	○	○	○	○	
MEATS, EGGS, AND DAIRY PRODUCTS							
Liver (beef or chicken)	○	○	○	○	○	○	
Fish	○	○	○	○	○	○	
Cheese (excluding cottage and cream cheese)	○	○	○	○	○	○	
Cottage cheese	○	○	○	○	○	○	
Cream cheese	○	○	○	○	○	○	
Eggs, whole	○	○	○	○	○	○	
Fat-free milk	○	○	○	○	○	○	
Reduced-fat milk	○	○	○	○	○	○	
Whole milk	○	○	○	○	○	○	
Soy milk	○	○	○	○	○	○	
MIXED DISHES AND SOUPS							
Chili	○	○	○	○	○	○	
Macaroni and cheese	○	○	○	○	○	○	
Minestrone	○	○	○	○	○	○	
Pizza	○	○	○	○	○	○	
Spaghetti, lasagna, and other pasta with tomato sauce	○	○	○	○	○	○	
Stews with tomatoes	○	○	○	○	○	○	
Tomato soup	○	○	○	○	○	○	
Vegetable soup	○	○	○	○	○	○	
SAUCES, CONDIMENTS, AND OILS							
Butter or margarine	○	○	○	○	○	○	
Mayonnaise, including low-fat	○	○	○	○	○	○	
Ketchup	○	○	○	○	○	○	
Tomato sauce (excluding pasta sauce)	○	○	○	○	○	○	
Salsa	○	○	○	○	○	○	
Olive oil	○	○	○	○	○	○	
Safflower or corn oil	○	○	○	○	○	○	
Soybean oil	○	○	○	○	○	○	
Wheat germ oil	○	○	○	○	○	○	
BEVERAGES							
Apple juice or cider	○	○	○	○	○	○	
Carrot juice	○	○	○	○	○	○	

	Not in the last month	**1 per month**	**2–3 per month**	**1–2 per week**	**3–4 per week**	**5–6 per week**	
Cranberry juice (or Cran-blend juice)	○	○	○	○	○	○	
Grapefruit juice	○	○	○	○	○	○	
Fruit punch or lemonade	○	○	○	○	○	○	
Orange juice, unfortified	○	○	○	○	○	○	
Orange juice (Vitamin C-fortified)	○	○	○	○	○	○	
Orange juice (Fortified, other)	○	○	○	○	○	○	
Pineapple juice	○	○	○	○	○	○	
Tea (Iced or Hot)	○	○	○	○	○	○	
Tomato juice or V-8	○	○	○	○	○	○	
Red Wine	○	○	○	○	○	○	
Please answer these two important questions.							
	Never or less than once per week	**1–2 per week**	**3–4 per week**	**5–6 per week**	**1 per day**	**2 per day**	
In summary, how often did you eat vegetables in the past month, not counting potatoes, salad, or beans?	○	○	○	○	○	○	
In summary, how often did you eat fruits in the past month, not counting juices?	○	○	○	○	○	○	

MULTIVITAMINS

35. In the past month, did you take a MULTIVITAMIN?



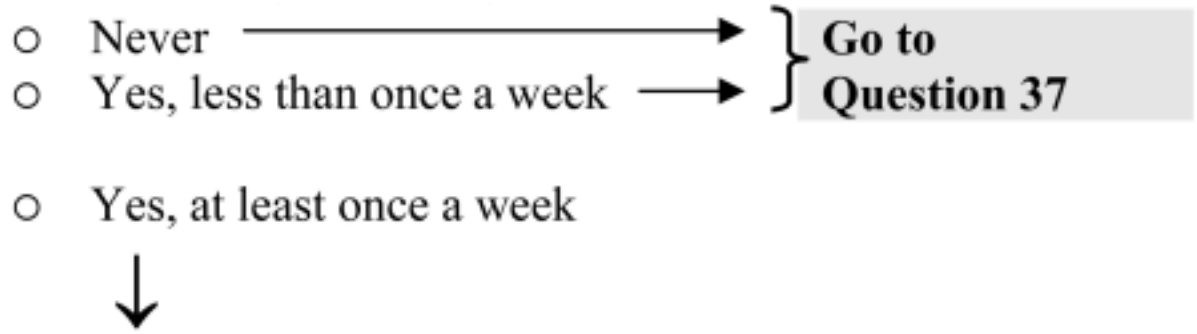
What brand of MULTIVITAMIN do you take now? *Mark only one.*

- Centrum®
- Centrum® Performance
- Central Vite® (Rite Aid)
- NatureMade® Multivitamin with minerals
- One-A Day® Maximum with minerals
- Kirkland Multivitamin with minerals
- GNC Solo-Day®
- Theragran-M ® with minerals
- Theragran ® (no minerals)
- Other brand (Specify exact brand and type)

MULTIVITAMINS contain 10 or more vitamins and/or minerals. An example is Centrum®.

SINGLE SUPPLEMENTS AND MIXTURES (not including multivitamins)

36. In the past month, have you taken any vitamin or mineral supplements other than a multivitamin? *Include vitamins, minerals, and mixtures.*



Please indicate which vitamins or minerals are (were) in your supplements. Do NOT include multivitamins. *If you have the bottles, please look at the labels.*

	Days taken per week in the past month	Closest amount per day	Years taken
Vitamin A			
◦ Yes →	◦1–2	◦ 5000 IU	◦ <1
◦No	◦3–4	◦ 7500 IU	◦ 1–2
↓	◦5–6	◦ 10,000 IU	◦ 3–4
	◦7	◦ 15,000 IU	◦ 5+
		◦ 20,000 IU	◦ Don't know
		◦ Don't know	
Beta-carotene			
◦ Yes →	◦ 1–2	◦ 5000 IU	◦ <1
◦ No	◦ 3–4	◦ 7500 IU	◦ 1–2
↓	◦ 5–6	◦ 10,000 IU	◦ 3–4
	◦ 7	◦ 15,000 IU	◦ 5+
		◦ 20,000 IU	◦ Don't know
		◦ Don't know	
Vitamin C			
◦ Yes →	◦ 1–2	◦ 60 mg	◦ <1
◦No	◦ 3–4	◦ 100 mg	◦ 1–2
↓	◦ 5–6	◦ 250 mg	◦ 3–4
	◦ 7	◦ 500 mg	◦ 5+
		◦ 1000 mg	◦ Don't know
		◦ 1500 mg	
		◦ Don't know	
Vitamin E			
◦ **Yes →**	◦1–2	◦ 30 IU	◦ <1
◦**No**	◦3–4	◦ 100 IU	◦1–2
	◦5–6	◦200 IU	◦3–4

	Days taken per week in the past month	Closest amount per day	Years taken
	◦7	◦400 IU ◦600 IU ◦800 IU ◦ Don’t know	◦5+ ◦ Don’t know

TABLE 1

Comparison of antioxidant nutrient intakes from the antioxidant nutrient questionnaire and mean of four 24-hour dietary recalls among whites and African Americans in North Carolina (n=164) [a]

Nutrient Intakes (per day)	Whites (n=81)			African Americans (n=83)		
	Median (25^{th}–75^{th} percentile)			Median (25^{th}–75^{th} percentile)		
	FFQ	Dietary recalls [b]	Biomarkers	FFQ	Dietary recalls	Biomarkers
Dietary alpha-carotene (μg)	3625	2937	0.190	2865	2151	0.133
Plasma beta-carotene (μmol/L)	(2168–6168)	(1708–4488)	(0.131–0.302)	(1267–5490)	(988, 4072)	(0.094–0.233)
Dietary alpha-carotene (μg)	617	305	0.051	242	175	0.031
Plasma alpha-carotene (μmol/L)	(296–976)	(122–718)	(0.028–0.085)	(96–714)	(70, 419)	(0.019–0.046)
Dietary beta-cryptoxanthin (μg)	194	164	0.091	125	140	0.094
Plasma beta-cryptoxanthin (μmol/L)	(85–327)	(76–294)	(0.062–0.119)	(68–379)	(39–297)	(0.058–0.135)
Dietary lutein + zeaxanthin (μg)	3034	2411	0.128	1936	1631	0.114
Plasma lutein + zeaxanthin (μmol/L)	(1607–4843)	(1201–3694)	(0.096–0.166)	(1057–3982)	(934–2907)	(0.089–0.141)
Dietary lycopene (μg)	4343	4890	0.392	3970	3241	0.402
Plasma lycopene (μmol/L)	(2986–7654)	(2868–10446)	(0.295–0.476)	(2258–7916)	(1219–6129)	(0.311–0.549)
Dietary total alpha-tocopherol (mg)	12.8	9.7	9.7	7.6	6.9	7.4
Plasma alpha-tocopherol (μmol/L)	(7.3–17.8)	(6.5, 13.6)	(8.0, 11.7)	(3.8, 12.5)	(5.1, 9.3)	(6.0–9.0)
Dietary vitamin C (mg)	145	105	9.06	110	90	8.19
Plasma vitamin C (μmol/L)	(86–202)	(73–158)	(7.01–9.87)	(58–217)	(54–135)	(6.59–9.69)

[a] Whites (n=81) and African Americans (n=83)

[b] Mean of four dietary recalls

TABLE 2

Adjusted [a] Pearson's correlations of antioxidant nutrient intakes from the antioxidant questionnaire, mean of four 24-hour dietary recalls[2], and nutrient biomarkers among whites and African Americans in North Carolina (n=164)

	Antioxidant nutrient questionnaire and dietary recalls [b]		Antioxidant nutrient questionnaire and biomarkers		Dietary recalls and biomarkers	
Nutrient (per day)	**Whites (n=81)**	**African Americans (n=83)**	**Whites (n=81)**	**African Americans (n=83)**	**Whites (n=81)**	**African Americans (n=83)**
Beta-carotene	0.56****	0.44****	0.33**	0.27*	0.24*	0.24*
Alpha-carotene	0.48***	0.06	0.31**	0.31**	0.19	0.13
Beta-Cryptoxanthin	0.27*	0.34***	0.28**	0.33**	0.14	0.43****
Lutein + Zeaxanthin	0.49****	0.51****	0.24*	0.32**	0.31**	0.48****
Lycopene	0.17	0.11	0.12	0.11	0.08	0.28**
Retinols	0.17	0.12	0.12	0.23*	0.14	0.12
Total alpha-tocopherol	0.29**	0.30**	0.15	0.12	0.19	0.14
Vitamin C or ascorbic acid	0.45****	0.37***	0.15	0.10	0.20	0.17

**** **NOTE:** p≤0.0001,

*** p≤0.001,

** p≤0.01,

* p≤0.05

[a] Adjusted for age, sex, education, body mass index, and, except for Vitamin C, total plasma cholesterol

[b] Average of four 24-dietary recalls

TABLE 3

Comparison of antioxidant intakes from dietary supplements only from the antioxidant questionnaire and a dietary supplement inventory among whites and African Americans in North Carolina (n=164)

Supplement Use [a] (per day)	Distributions (%) of non-users[b] in whites (n=81)		Distributions (%) of non-users[b] in African Americans (n=83)		Spearman's correlations (p value) between the questionnaire and the supplement inventory [f]	
	FFQ[†]	Supplement Inventory [c]	FFQ	Supplement Inventory [c]	Whites (n=81)	African Americans (n=83)
Vitamin A (IU) [d]	64	63	73	70	0.81 (<0.0001)	0.83 (<0.0001)
Beta-carotene (IU) [d]	75	63	81	70	0.33 (0.003)	0.66 (<0.0001)
Vitamin C (mg)	60	56	72	67	0.79 (<0.0001)	0.80 (<0.0001)
Vitamin E (IU) [e]	60	57	73	70	0.81 (<0.0001)	0.84 (<0.0001)

[a] Includes intakes from multivitamins and single supplements

[b] Average current daily supplemental intake from the FFQ computed as: days per week × dose per day/7 (days)

[c] Average current daily supplemental intake from supplement inventory calculated as: frequency of use × number of pills taken each time × dose per pill/7 (days)

[d] 1 IU vitamin A = 0.3 mcg retinol and 0.6 mcg β-carotene

[e] 1 IU vitamin E = 0.45 mg α-tocopherol

[f] Adjusted for age, sex, race, education, body mass index, and, except for Vitamin C, total plasma cholesterol.