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Use of Dietary Supplements Improved Diet Quality But Not Cardiovascular and Nutritional Biomarkers in Socioeconomically Diverse African American and White Adults

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ABSTRACT

Knowledge of the contribution of supplements to overall nutritional health is limited. The research objectives were to describe motivations for use of dietary supplements by African Americans and Whites examined in the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study and to determine if supplements provided beneficial effects to micronutrient diet quality and nutritional and cardiovascular biomarkers. The majority of the HANDLS study population were smokers, overweight or obese, and self-reported their health as poor to good. The top two reasons for their supplement use were to supplement the diet and to improve overall health. Micronutrient intake was calculated from two 24-hour recalls and a supplement questionnaire. Diet quality was assessed by the Mean Adequacy Ratio (MAR) [Maximum score = 100] derived from the Nutrient Adequacy Ratio (NAR) for 17 micronutrients. The MAR score for nonusers was 73.12, for supplement users based on diet alone was 74.89, and for food and supplements was 86.61. Dietary supplements significantly increased each NAR score and MAR score. However, there were no significant differences between the population proportions with inadequate or excessive blood levels for any biomarkers examined. Nutrition education programs and intervention strategies addressing dietary supplement intake might lead to healthier food choices and may improve the health of this population.

KEYWORDS
Diet quality; dietary supplements; supplement use

Introduction

Dietary supplement intake is common in the United States (1). From 2003 to 2006, 53% of the United States population consumed at least one dietary supplement (2). Most reports based on national nutritional surveys indicate a greater percentage of Whites, women, nonsmokers, older adults, and people with higher education and income are likely to take dietary supplements

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compared to African Americans and Hispanics, men, and persons with lower socioeconomic status (2–6). Knowledge of dietary supplement intake is important due to its impact on total nutrient intake and the relationship of diet and health.

Our knowledge about the efficacy of dietary supplement use for disease prevention, management or treatment and the complex interrelationships of social, psychological, and economic determinants that motivate supplement choices in nutrient-replete populations is limited (6, 7). The Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) prospective study, was designed to explore the relationships between race and socioeconomic status (SES) with risk for developing cardiovascular and cerebrovascular diseases and cognitive changes (8). The study included socioeconomically diverse urban populations of African American and White adults. Previous analyses of baseline dietary recall data of HANDLS study participants indicated that many of the micronutrients were consumed in less than adequate amounts by these adults (9). Although dietary supplement use was not assessed at baseline (Wave 1) in an effort to minimize respondent burden, a dietary supplement questionnaire was administered at a following study visit (Wave 3).

The purpose of this study was to (1) describe dietary supplement intake of study participants by age and race; (2) identify the reasons or motivations for dietary supplement intake; and (3) determine if dietary supplement intake impacts diet quality and cardiovascular and nutritional biomarkers.

Methods

Background on Wave 3 of the HANDLS study

At baseline, 3720 African American and White participants were drawn from 13 predetermined neighborhoods in Baltimore City between August 2004 and March 2009 (Wave 1). Of these participants, 2,468 were reexamined in Wave 3 between June 2009 and July 2013 (See Consort Figure 1). Wave 3 of the HANDLS study consisted of two phases. The first phase was conducted on the Mobile Research Vehicles. This phase consisted of the first dietary recall, a physical examination, cognitive evaluation, a variety of physiological assessments, physical performance, and bone density and laboratory measurements. The second phase, completed four to ten days later, included the second dietary recall and dietary supplement questionnaire. The protocol and a complete listing of the examinations can be found on the HANDLS study website (http://handls.nih.gov/).

This study was conducted according to the Declaration of Helsinki guidelines and all procedures were approved by the Institutional Review Boards at National Institute on Environmental Health Sciences and University of

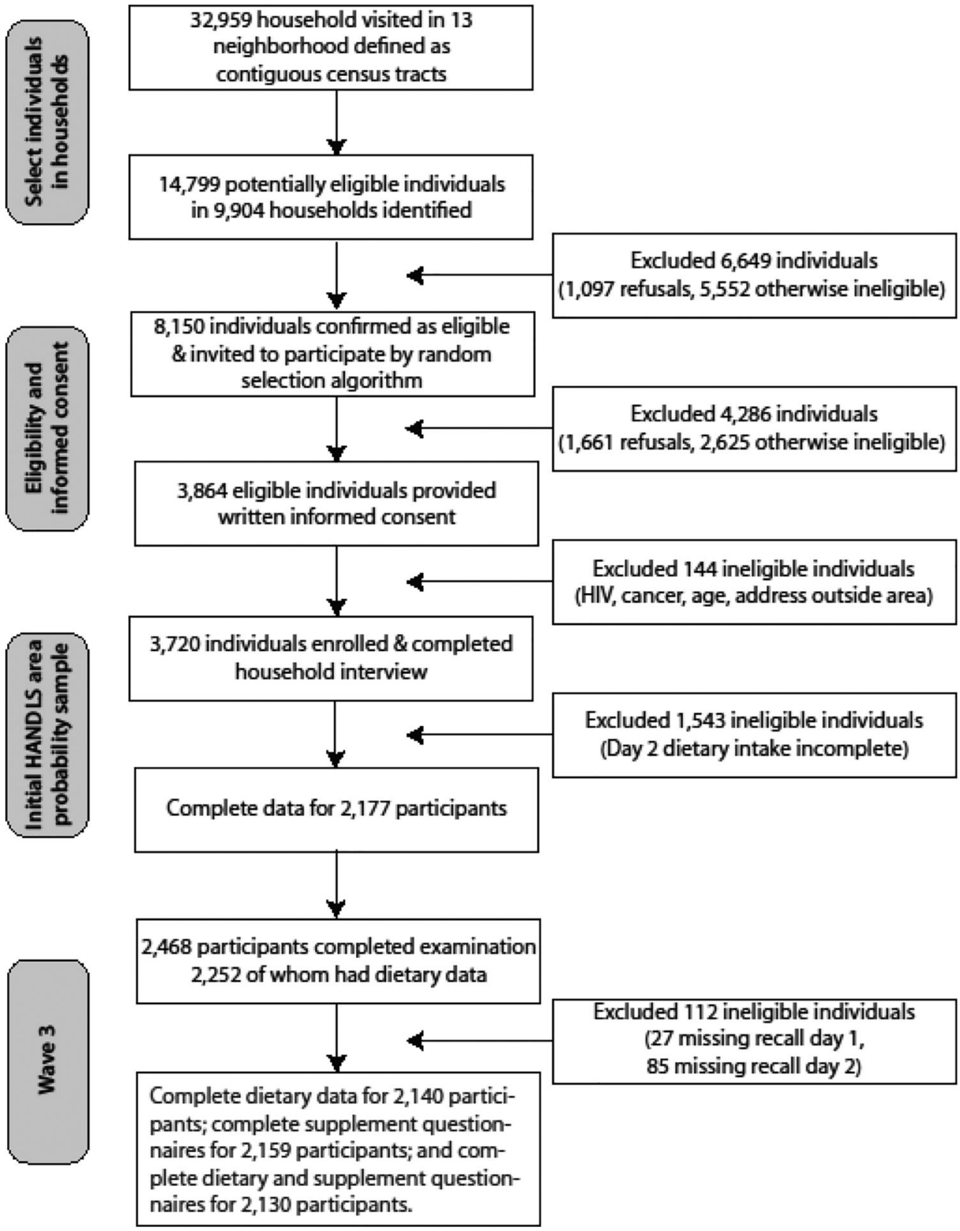

Figure 1. Sample recruitment and eligibility.

Delaware. Written informed consent was obtained from all Wave 3 HANDLS study participants, all of whom were compensated monetarily.

Dietary intake method

The United States Department of Agriculture (USDA) Automated Multiple Pass Method was used to collect 24-hour dietary recalls (10). Measurement aids such as measuring cups, spoons, ruler, and the USDA Food Model Booklet—a book containing illustrated 2-dimensional guides—were used to assist participants in estimating accurate quantities of foods and beverages consumed (11). The first 24-hour dietary recall was administered in-person and the second recall was completed by phone. Trained interviewers conducted both recalls. The dietary recalls were coded using Survey Net software to generate nutrient intakes by matching foods consumed with codes in the Food and Nutrient Database for Dietary Studies version 5.0 (12).

Dietary supplement questionnaire

The HANDLS dietary supplement questionnaire was adapted from the 2007 NHANES instrument (13). Study participants were asked to have their supplement bottles available during their interview. Detailed information was collected about over-the-counter (OTC) vitamin and mineral supplements, antacids, prescription supplements, and botanicals. For each supplement reported, participants were asked to provide information about dosage (strength and frequency), length of time the supplement was consumed, reason(s) for supplement use and how recently supplement was consumed, and if taken seasonally, how many days per week or months per year.

A HANDLS study dietary supplement database was developed by trained nutritionists and registered dietitians based on the supplements reported. Nutrient quantities were obtained from detailed information on the supplement product labels or the manufacturer's website. When detailed information was not available, a default nutrient profile was derived from the most frequently reported products. For this study, OTC supplements included multivitamin and mineral supplements as well as single vitamins and minerals. Although botanicals were reported by participants, these products were not included in this analysis. For this study, users of dietary supplements were defined as those who reported currently taking an OTC supplement, antacid, and/or prescribed supplement. Nonusers were defined as those individuals who reported not taking any OTC supplement, antacid, or prescribed supplement.

The dietary supplement database consisted of four files which were integrated and used to derive the intake of each nutrient consumed. Serving size and nutrient content of supplements were obtained from product and manufacture labels. Total micronutrient intake and average time of intake were based on the dietary supplement questionnaire. A detailed description of the steps used to calculate the nutrients from supplements can be found on the HANDLS study website (13).

The questionnaire had 26 possible motivations for taking dietary supplements. Prior to analysis, the reasons for use were condensed into 16 categories based on related themes. For example, physician recommended supplement intake included diagnosis of anemia, marginal or deficient vitamin status, and gastric bypass surgery. Motivation for women's health included prenatal vitamins and minerals and menopause supplements. The original and shortened list of motivations can be found on the HANDLS study website.

Diet quality measure

Individual nutrient-based diet quality of supplement intake was compared to the Recommended Dietary Allowance (RDA) based on participant's age and sex (9, 14). Micronutrients evaluated included calcium, magnesium, selenium, phosphorus, vitamin A, vitamin C, vitamin D, vitamin E, vitamins B_6 and B_{12}, folate, iron, thiamin, riboflavin, niacin, copper, and zinc. An adjustment of an additional 35 mg vitamin C was applied to the RDA for participants who were current smokers (15).

To determine the nutrient adequacy ratio (NAR), the following formula was used: NAR = [Subject's daily intake of nutrient]/[RDA of nutrient]. The NAR of each nutrient was converted to a percent, and percentages greater than 100 were truncated to 100 (9, 16). The mean adequacy ratio (MAR), a measure of total quality of the diet, was calculated using the following formula: MAR = [Sum of all 17 nutrient NARs]/17 (9, 16). To determine the MAR score based on food and beverage intake plus dietary supplements (MAR-S), the daily amount of nutrients provided by supplements reported by the participants was calculated and added to each recall NAR score.

Blood biomarkers

Fasting venous blood specimens were collected from participants during their Mobile Research Vehicle visit and analyzed at the Nichols Institute of Quest Diagnostics, Inc. (Chantilly, VA, USA). The analyses of cardiovascular and nutrition related biomarkers included albumin (g/L), magnesium (mg/dL), iron (mcg/dL), ferritin (ng/mL), hemoglobin (g/dL), folate (ng/mL), vitamin B-12 (pg/mL), triglycerides (mg/dL), total cholesterol (mg/dL), and HDL-cholesterol (mg/dL). Serum total cholesterol, HDL-cholesterol, triglycerides, albumin, magnesium, and iron were assessed using a spectrophotometer (Olympus 5400, Olympus, Melville, NY, USA). Serum ferritin was measured using a standard chemiluminescence immunoassay. Hemoglobin A1C was assessed by high performance liquid chromatography. Serum folate and vitamin B-12 were measured using enzyme immunoassay.

Statistical analysis

All analyses were conducted using Stata release 13.0, with the exception of the NAR and MAR analyses, which were conducted with SPSS version 22. The use of different software programs reflects the collaborative efforts of two institutions, however comparable results were derived from regression models and identical results for all other analyses. The relationship of supplement use with demographics, smoking status, socioeconomic status, and health-related conditions was assessed with two-sided independent sample *t*-test for continuous variables or chi-square tests for categorical variables (Table 1). Additionally, adjusted differences in means were estimated using multiple linear regression models that controlled for demographics, smoking status, socioeconomic status, and health-related conditions (Table 1). Among supplement users, the relationship of age (<50 y vs. ≥50 y) with demographics, smoking status, socioeconomic status, health-related conditions, over the counter supplement use, antacid use, and prescription supplement use was

Table 1. HANDLS study participant characteristics by dietary supplement use: Means, proportions and adjusted odds ratios.

Characteristics	n	Nonusers (n = 1075)	Supplement users (n = 1084)	OR (95% CI)
Age at baseline, years X ± SEM	2159	47.0 ± 0.3	50.0 ± 0.3‡	1.03‡ (1.03;1.06)
Age at follow-up, years X ± SEM	2159	51.7 ± 0.3	54.6 ± 0.3‡	—
Race, % ± SEM	2159‡			
White	828	33.7 ± 1.4	43.0 ± 1.5	1.00
African American	1331	66.3 ± 1.4	57.0 ± 1.5	0.66† (0.50;0.86)
Sex, % ± SEM	2159‡			
Women	1272	54.1 ± 1.5	63.7 ± 1.5	1.00
Men	887	45.9 ± 1.5	36.3 ± 1.5	0.68† (0.52;0.89)
Marital status, % ± SEM	1630			
Single	451	30.3 ± 1.6	25.0 ± 1.5‡	1.00
Married	533	31.1 ± 1.6	34.3 ± 1.7	0.95 (0.67;1.34)
Partnered	210	13.3 ± 1.2	12.4 ± 1.2	1.23 (0.79;1.92)
Divorced	192	10.3 ± 1.1	13.2 ± 1.2	0.97 (0.67;1.50)
Separated	93	5.9 ± 0.8	5.5 ± 0.8	1.74 (0.95;3.17)
Widowed	87	4.7 ± 0.7	6.0 ± 0.8	1.04 (0.56;1.92)
Never married	64	4.3 ± 0.7	3.6 ± 0.6	0.78 (0.37;1.63)
Education, years X ± SEM	2117	12.2 ± 0.1	13.0 ± 0.1‡	1.01 (0.99;1.04)
Literacy, % ± SEM	2117			
<High School	464	26.1 ± 1.4	17.7 ± 1.2‡	1.00
High School	325	16.6 ± 1.1	14.1 ± 1.1	1.02 (0.66;1.56)
Post-High School	587	27.7 ± 1.4	27.8 ± 1.4	1.01 (0.68;1.48)
College and higher	741	29.6 ± 1.4	40.3 ± 1.5‡	1.38 (0.94;2.02)
Smoking status	1615			
Current Smoker, % ± SEM	685	51.0 ± 1.8	34.4 ± 1.6‡	0.65† (0.49;0.86)
Socioeconomic status	2159			
Income < 125% FPG, % ± SEM	866	45.0 ± 1.5	35.2 ± 1.5‡	0.72* (0.54;0.95)
BMI, kg/m^2, X ± SEM	2151	30.2 ± 0.2	31.1 ± 0.2†	1.00 (0.98;1.02)
Self-reported health status, % ± SE	1682			
Poor/Fair	438	3.5 ± 0.6	3.3 ± 0.6	1.00
Good	671	39.9 ± 1.7	39.9 ± 1.7	0.96 (0.70;1.32)
Very good/Excellent	573	27.7 ± 1.5	26.9 ± 1.5	0.90 (0.64;2.75)

Note. HANDLS, Healthy Aging in Neighborhoods of Diversity across the Life Span; OR, Odds Ratio; FPG, Federal Poverty Guidelines.

Odds Ratios were multivariate adjusted for all characteristics with one exception. Only Age at baseline was added in the model to avoid multi-collinearity with Age at follow-up. Sample size for multiple regression analyses equaled 1079 which reflects missing data on all covariates included in the model.

Significance level: *significant at $p < 0.05$; †significant at $p < 0.01$; ‡significant at $p < 0.001$.

assessed with two-sided independent sample t-test for continuous variables or chi-square tests for categorical variables (Table 2). The same approach was used to assess the relationship of race (African American vs. White) within each of the two age groups (<50 y vs. ≥50 y) (Table 2). Post-hoc tests were also conducted to compare proportions using a two-sided independent samples t-test for proportions.

Reasons for use of dietary supplements among users were closely examined and the distributions were compared across age group and race using chi-square tests (Table 3). Binary variables (yes/no) were created per supplement and per individual denoting the precoded reason for use.

To examine the impact of dietary supplements on nutrient intakes, the NAR and MAR scores based on food intake alone, and NAR-S and MAR-S scores based on food and supplement intake were compared between supplement users and nonusers (Table 4). Adjusted differences in means were estimated using multiple linear regression models (ANCOVA) controlled for age, sex, race, poverty status, smoking, and total energy intake (kcal).

The relationship between supplement use and serum biomarkers were assessed using a two-sided independent sample t-test comparing means for each of the 11 biomarkers considered. Moreover, adjusted differences in means were estimated using multiple linear regression models that controlled for demographics, smoking status, socioeconomic status, and health-related conditions. A sensitivity analysis was also conducted controlling for smoking status, HIV positive antibody, hepatitis B surface antigen, and hepatitis C positive antibody. In addition to assessing the mean of biomarkers, categorical outcome variables that reflect values outside reference ranges that may affect health risk were also constructed. The association between supplement use and categorical outcomes were examined by comparing proportions and conducting a bivariate logistic regression model with supplement use as the sole predictor. Multiple logistic regression models were also carried out adjusting for demographic variables (age, sex, race, and economic status), and current smoking status, HIV positive antibody status, hepatitis B surface antigen, and hepatitis C antibody status. Type I error was set at 0.05 in all analyses to assess significance of associations.

Results

Participant characteristics

Of the 2159 HANDLS study participants who completed the Wave 3 dietary supplement questionnaire, 1084 participants reported using dietary supplements. Based on t-tests and chi-square analyses, there were significant differences between supplement users and nonusers with respect to age, sex, race, single marital status, literacy, income, body mass index (BMI), smoking status and

Table 2. Characteristics of HANDLS study participants who use nutritional supplements by age and race.

	Age <50 years		Age ≥50 years		Age comparisons
	African American (n = 316) X ± SEM	White (n = 220) X ± SEM	African American (n = 302) X ± SEM	White (n = 246) X ± SEM	<50 v ≥ 50 years *P*
Age at baseline, years,	42.7 ± 0.3	42.5 ± 0.4	57.1 ± 0.3	57.5 ± 0.3	**<0.001**
Age at follow-up, years	47.4 ± 0.3	47.0 ± 0.3	61.8 ± 0.3	61.9 ± 0.3	**<0.001**
Sex, % women	63.0 ± 2.7	64.5 ± 3.2	66.9 ± 2.7	59.8 ± 3.1	0.982
Marital status, %	(N = 230)	(N = 185)	(N = 206)	(N = 195)	
Single	34.8 ± 3.1	22.2 ± 3.1†	21.8 ± 2.9	19.5 ± 2.8	**0.005**
Married	24.3 ± 2.8	39.5 ± 3.6†	31.6 ± 3.2	44.1 ± 3.6†	**0.048**
Partnered	13.0 ± 2.2	18.9 ± 2.9	7.3 ± 1.8	10.8 ± 2.2	**0.004**
Divorced	8.3 ± 1.8	10.3 ± 2.2	20.4 ± 2.8	14.4 ± 2.5	**<0.001**
Separated	10.0 ± 2.0	3.8 ± 1.4*	5.8 ± 1.6	1.5 ± 0.9*	**0.029**
Widowed	2.6 ± 1.1	3.8 ± 1.4	10.7 ± 2.2	7.2 ± 1.9	**<0.001**
Never married	7.0 ± 1.7	1.6 ± 0.9†	2.4 ± 1.1	2.6 ± 1.1	0.108
Education,	(n = 316)	(n = 213)	(n = 302)	(n = 234)	
Years	12.5 ± 0.2	13.4 ± 0.3‡	12.7 ± 0.2	13.6 ± 0.4*	0.350
Smoking Status	(n = 218)	(n = 186)	(n = 227)	(n = 203)	
Current smoker, %	47.7 ± 3.4	37.1 ± 3.6*	33.0 ± 3.3	20.7 ± 2.7†	**<0.001**
Literacy, %	(N = 306)	(N = 215)	(N = 295)	(N = 245)	
<High School	21.2 ± 2.3	13.0 ± 2.3*	23.7 ± 2.5	10.2 ± 1.9‡	0.912
High School	19.3 ± 2.3	8.4 ± 1.9‡	18.0 ± 2.2	8.2 ± 1.8‡	0.556
Post-High School	29.7 ± 2.6	19.1 ± 2.7†	34.6 ± 2.8	24.9 ± 2.8*	0.078
College and higher	29.7 ± 2.6	59.5 ± 3.4‡	23.7 ± 2.5	56.7 ± 3.2‡	0.269
Socioeconomic status	(n = 316)	(n = 220)	(n = 302)	(n = 246)	
<125% FPG, %	46.2 ± 2.8	30.9 ± 3.1‡	35.1 ± 2.8	25.2 ± 2.8*	**0.001**

(*Continued*)

Table 2. Continued.

	Age <50 years		Age ≥50 years		Age comparisons
	African American (n = 316) X ± SEM	White (n = 220) X ± SEM	African American (n = 302) X ± SEM	White (n = 246) X ± SEM	<50 v ≥ 50 years *P*
BMI, kg/m^2	31.6 ± 0.5	31.1 ± 0.5	31.0 ± 0.4	30.7 ± 0.5	0.319
Self-reported health status, %	(n = 235)	(n = 196)	(n = 203)	(n = 211)	
Poor/Fair	26.0 ± 2.9	26.5 ± 3.1	26.6 ± 3.1	25.6 ± 3.0	0.965
Good	39.6 ± 3.2	37.8 ± 3.5	44.3 ± 3.5	37.9 ± 3.3	0.492
Very good/Excellent	34.5 ± 3.1	35.7 ± 3.4	29.1 ± 3.2	36.5 ± 3.3	0.503
Characteristics of Supplement Usage					
Over the counter supplements					
Users of OTC supplements, n	246	177	242	203	0.346
Number OTC supplements for users	1.71 ± 0.08	2.26 ± 0.15‡	1.95 ± 0.10	3.20 ± 0.24‡	**<0.001**
Length OTC supplement taken, y	(N = 242)	(N = 174)	(N = 238)	(N = 199)	**<0.001**
	2.4 ± 0.3	3.4 ± 0.4*	3.5 ± 0.4	5.8 ± 0.6‡	
Antacids					
Users of Antacids, n	58	54	48	49	0.183
Number of Antacids for users	1.03 ± 0.02	1.04 ± 0.03	1.02 ± 0.04	1.04 ± 0.03	0.867
Length Antacids taken, y	(N = 52)	(N = 50)	(N = 48)	(N = 48)	0.533
	1.4 ± 0.3	3.9 ± 1.1*	2.5 ± 0.5	4.0 ± 0.8	
Prescription(RNX) supplements					
Users of RNX supplements, n	67	28*	60	48*	0.569
Number of RNX supplements for users	1.06 ± 0.03	1.11 ± 0.08*	1.20 ± 0.07	1.30 ± 0.13	**0.0256**
Length RXN supplement taken, y	(N = 63)	(N = 26)	(N = 60)	(N = 28)	0.0952
	1.3 ± 0.3	2.4 ± 0.7	2.2 ± 0.5	2.9 ± 0.8	

y, Average years supplement(s) taken as elicited by participants.
Note. HANDLS, Healthy Aging in Neighborhoods of Diversity across the Life Span; FPG, Federal Poverty Guidelines; BMI, Body Mass Index; OTC, Over-The-Counter.
Significance level: *significant at $p < 0.05$; †significant at $p < 0.01$; ‡significant at $p < 0.001$.

Table 3. Reported reasons for use of dietary supplements by Wave 3 HANDLS study participants.

	All users	Age <50 years		Age ≥50 years		Age comparisons
Reasons	(n = 1084)	African American (n = 316)	White (n = 220)	African American (n = 302)	White (n = 246)	P < 50 v ≥ 50 y
To supplement diet	20.5 ± 1.2	18.4 ± 2.2	24.1 ± 2.9	19.5 ± 2.3	21.1 ± 2.6	0.85
To improve overall health	20.3 ± 1.2	23.4 ± 2.4	12.7 ± 2.3†	21.2 ± 2.3	22.0 ± 2.6	0.31
Doctor recommended	20.3 ± 1.2	20.3 ± 2.3	23.6 ± 2.9	17.2 ± 2.2	21.1 ± 2.6	0.28
For acid reflux, GERD	17.4 ± 1.2	17.1 ± 2.1	22.7 ± 2.8	14.9 ± 2.1	16.3 ± 2.4	0.09
For bone health	16.6 ± 1.1	11.1 ± 1.8	8.6 ± 1.9	22.5 ± 2.4	23.6 ± 2.7	**<0.001**
To maintain health (stay healthy)	15.6 ± 1.1	10.4 ± 1.7	20.9 ± 2.7‡	11.3 ± 1.8	22.8 ± 2.7‡	0.45
For enhance energy	13.2 ± 1.0	16.5 ± 2.1	11.8 ± 2.2	12.3 ± 1.9	11.4 ± 2.0	0.19
For heart health	11.3 ± 1.0	7.3 ± 1.5	10.0 ± 2.0	9.9 ± 1.7	19.1 ± 2.5†	**0.003**
To boost immunity, to prevent colds	8.4 ± 0.8	5.1 ± 1.2	10.0 ± 2.0*	8.9 ± 1.6	10.6 ± 2.0	0.13
For gastrointestinal health	7.3 ± 0.8	5.1 ± 1.2	6.8 ± 1.7	6.0 ± 1.4	12.2 ± 2.1†	0.06
For healthy joints, prevent arthritis	6.0 ± 0.7	2.2 ± 0.8	6.8 ± 1.7†	5.3 ± 1.3	11.0 ± 2.0*	**0.009**
For women's health	3.5 ± 0.6	1.9 ± 0.8	6.8 ± 1.7†	2.3 ± 0.9	4.1 ± 1.3	0.47
For mental health	1.5 ± 0.4	0.6 ± 0.4	1.8 ± 0.9	1.7 ± 0.7	2.0 ± 0.9	0.34
For eye health	1.4 ± 0.4	0.0 ± 0.0	1.4 ± 0.8*	1.0 ± 0.6	3.7 ± 1.2*	**0.022**
For men's health	1.2 ± 0.3	0.9 ± 0.5	0.0 ± 0.0	1.7 ± 0.7	2.0 ± 0.9	0.06

Note. HANDLS, Healthy Aging in Neighborhoods of Diversity across the Life Span; GERD, Gastroesophageal reflux disease.
Significance level: *significant at $p < 0.05$; †significant at $p < 0.01$; ‡significant at $p < 0.001$.

Table 4. Comparison of dietary quality based on diet alone (NAR and MAR) and diet with supplements (NAR-S and MAR-S) of Wave 3 HANDLS study participants by usage of dietary supplements (DS).

	NAR DS nonusers	NAR DS users	NAR-S	Comparison of NAR DS nonusers vs DS users			Comparison of NAR vs NAR-S DS users		
Nutrient	Mean ± SEM	Mean ± SEM	Mean ± SEM	*b*	SEM	*p*	*b*	SEM	*p*
Vitamin A	55.06 ± 0.78	61.21 ± 0.82	80.44 ± 0.84	4.60	1.20	**<0.001**	18.10	2.40	**<0.001**
Vitamin C	36.83 ± 1.04	43.77 ± 1.14	60.09 ± 1.32	3.90	1.50	**0.010**	20.10	2.60	**<0.001**
Vitamin D	24.63 ± 0.59	24.37 ± 0.63	72.97 ± 1.06	–0.10	1.40	0.894	47.70	3.30	**<0.001**
Vitamin E	43.46 ± 0.63	45.95 ± 0.69	76.56 ± 0.97	2.60	0.80	**0.002**	31.70	2.90	**<0.001**
Vitamin B_6	82.61 ± 0.59	83.20 ± 0.60	92.67 ± 0.48	1.50	0.90	0.072	9.80	1.50	**<0.001**
Vitamin B_{12}	85.30 ± 0.60	85.38 ± 0.62	94.35 ± 0.45	–0.20	0.90	0.795	8.30	1.60	**<0.001**
Folate	80.25 ± 0.61	80.40 ± 0.65	91.33 ± 0.52	<.001	0.90	0.995	11.10	1.60	**<0.001**
Thiamin	85.72 ± 0.54	86.26 ± 0.57	93.70 ± 0.45	0.30	0.80	0.711	7.90	1.30	**<0.001**
Riboflavin	89.78 ± 0.46	91.14 ± 0.47	96.06 ± 0.33	0.80	0.70	0.204	4.60	1.10	**<0.001**
Niacin	90.99 ± 0.43	91.33 ± 0.45	96.01 ± 0.34	0.60	0.60	0.364	5.00	1.00	**<0.001**
Calcium	66.85 ± 0.73	67.30 ± 0.74	81.56 ± 0.68	1.30	1.00	0.182	15.80	1.60	**<0.001**
Copper	85.35 ± 0.51	87.63 ± 0.51	88.53 ± 0.49	2.30	0.70	**0.001**	1.30	0.20	**<0.001**
Iron	85.38 ± 0.61	86.35 ± 0.63	91.93 ± 0.53	<0.001	0.80	0.959	4.70	1.30	**<0.001**
Magnesium	63.19 ± 0.60	66.80 ± 0.66	74.46 ± 0.67	2.20	0.80	**0.004**	8.60	1.10	**<0.001**
Phosphorus	93.48 ± 0.38	94.39 ± 0.38	94.66 ± 0.37	0.90	0.60	0.091	0.40	0.10	**0.003**
Selenium	93.99 ± 0.39	94.67 ± 0.38	96.46 ± 0.31	1.00	0.60	0.086	1.30	0.60	**0.031**
Zinc	80.16 ± 0.59	82.03 ± 0.59	90.51 ± 0.51	1.10	0.80	0.154	9.10	1.30	**<0.001**
	MAR	**MAR**	**MAR-S**						
	73.12 ± 0.43	74.89 ± 0.44	86.61 ± 0.41	1.39	0.531	**0.009**	12.00	0.962	**<0.001**

Note. HANDLS, Healthy Aging in Neighborhoods of Diversity across the Life Span; DS, Dietary Supplement; NAR, Nutrient Adequacy Ratio based on diet; NAR-S, Nutrient Adequacy Ratio based on diet plus supplements; MAR, Mean Adequacy Ratio based on diet; MAR-S, Mean Adequacy Ratio based on diet plus supplements; SEM, Standard Error of Mean. Regression coefficients from multiple linear regression were adjusted for age, sex, race, poverty status, smoking and energy.

education, but not self-reported health status (Table 1). When multiple logistic regression was used to evaluate characteristic differences between supplement users and nonusers, the multivariable adjusted odds ratios were significant for age, sex, race, income, and smoking status (Table 1). Compared to nonusers, supplement users were more likely to be older, female, White, have higher incomes (>125% of the Federal poverty guidelines (FPG), and not currently smoke.

As shown in Table 2, there were 536 HANDLS study participants younger than 50 years (316 African Americans, 220 Whites) and 548 participants, 50 years and older (302 African Americans, 246 Whites) who reported taking dietary supplements. A comparison of demographic characteristics revealed that the older age group was comprised of significantly fewer current smokers and fewer individuals with incomes below 125% of the FPG ($p < 0.001$).

Within these two age groups, there were several characteristics that differed significantly by race (Table 2). Among those younger than 50 years, more African Americans were single, separated or never married while more Whites were married. Among those 50 years or older, significantly more Whites were married while more African Americans of similar age were separated. Regardless of age, significantly more African Americans smoked, had incomes less than 125% of the FPG, lower literacy scores, and less years of education compared to Whites, whereas, gender, BMI and self-reported health status did not differ by race in either age group.

As illustrated in Table 2, regardless of age there was no difference in the number of OTC supplement or antacid users by race; however, significantly more African Americans reported taking prescription dietary supplements compared to Whites. The mean number of OTC supplements was significantly higher for Whites compared to African Americans for both age groups; however, the mean number of antacids taken daily was approximately one and did not differ by race or age. The average length of time for using OTC was significantly longer for White compared to African American participants for both age groups (Table 2). The mean length of time reported for antacid usage was less than that of OTC supplements, ranging from 1.4 to 4.0 years. Significant differences in antacid usage were found only between the younger age group with Whites reporting a mean time of 3.9 years compared to 1.4 years for African Americans. There were no differences in length of time prescription supplements were used by age (Table 2).

Reasons for supplement use

Based on the frequency of responses, the three most common reasons why participants reported using dietary supplements were “to supplement the diet” because they felt they did not get enough nutrients from food, “to improve overall health,” and “doctor recommended” (Table 3). Some motivations for taking dietary supplements differed by age. A higher percentage of reported use of dietary supplements for site-specific reasons namely bone, heart, joints, and eye health was found for participants 50 years and older compared to participants younger than 50 years (Table 3).

Selected reasons also differed by race. The reported use of dietary supplements "to improve overall health" was significantly more frequent among African American participants younger than 50 years while the motivation to use supplements "to boost immunity" and "for women's health" was significantly more frequent among White participants younger than 50 years. In both age groups, a higher percentage of White participants reported using dietary supplements "to maintain health," "for healthy joints and to prevent arthritis," and "for eye health" compared to African American participants.

Nutrient intake and diet quality by supplement usage

Among dietary supplement users, there were racial differences in both age groups with respect to selected nutrients provided by supplements. For the adults younger than 50 years, the intakes of omega-3 fatty acids and riboflavin were significantly higher among White supplement users compared to African American supplement users (Omega-3 fatty acids: Whites 61.2 ± 24.1 mg vs. African Americans 18.4 ± 5.4 mg, $p = 0.043$; Riboflavin: Whites 8.5 ± 2.6 mg vs. African Americans 3.4 ± 0.7 mg, $p = 0.030$). In contrast, iron intakes from supplements were significantly higher for African Americans (27.2 ± 5.1 mg) who reported taking supplements compared to Whites (12.1 ± 1.9 mg) ($p = 0.018$). For adults older than 50 years, intakes from supplements for calcium, magnesium, niacin, thiamin, and riboflavin were significantly higher for Whites compared to African Americans (Calcium: Whites 429.8 ± 43.4 mg vs. African Americans 317.5 ± 24.2 mg, $p = 0.018$; Magnesium: Whites 78.9 ± 19.5 mg vs. African Americans 36.4 ± 4.0 mg, $p = 0.019$; Niacin: Whites 36.8 ± 10.7 mg vs. African Americans 10.7 ± 1.0 mg, $p = 0.008$; Thiamin: Whites 13.6 ± 2.4 mg vs. African Americans 4.0 ± 1.0 mg, $p < 0.001$; Riboflavin Whites 7.3 ± 1.3 mg vs African Americans 2.4 ± 0.5 mg, $p < 0.001$).

The use of dietary supplements significantly improved the NAR scores for all the micronutrients with the MAR score increasing by approximately 12 points above the score for diet alone for supplement users (Table 4). The mean NAR scores based on food intake alone for vitamins A, C and E, magnesium and copper of people using dietary supplements were significantly higher than the NAR scores for nonusers of dietary supplements (Table 4).

Cardiovascular and nutrition related biomarkers

The comparison of dietary supplement use with biomarkers revealed there were no differences in the proportion of at risk participants among dietary supplement users and nonusers (Table 5). Participants who reported use of

Table 5. Percent (SEM) of Wave 3 HANDLS study participants with inadequate nutritional biomarkers by supplement use.

	DS nonusers		DS users		DS users vs. DS nonusers		
Nutritional biomarkers	n	% ± SEM	n	% ± SEM	OR	(95%CI)	P
Serum albumin, <3.4 g/L	1055	0.95 ± 0.30	1066	0.94 ± 0.30	0.75	(0.23;2.47)	0.64
Serum cholesterol,>200 or < 160 mg/dL	1055	60.00 ± 1.51	1065	60.09 ± 1.50	0.92	(0.74;1.15)	0.48
Serum triglycerides,>150 mg/dL	1055	23.70 ± 1.31	1065	23.76 ± 1.30	0.97	(0.75;1.25)	0.83
Serum HDL-C, <40 mg/dL men, <50 mg/dL women	1054	6.74 ± 0.77	1065	6.48 ± 0.75	0.89	(0.57;1.39)	0.61
Cholesterol/HDL-C ratio, >3.5 to 1	1054	44.69 ± 1.53	1065	41.13 ± 1.51	0.90	(0.72;1.12)	0.36
Serum magnesium, <1.7 mg/dL	1054	4.55 ± 0.64	1065	7.42 ± 0.80	1.18	(0.76;1.84)	0.46
Hemoglobin, <12 g/dL females, <13 g/dL for men	1061	24.51 ± 1.32	1058	29.02 ± 1.40	1.15	(0.85;1.54)	0.37
Serum iron, <60 mcg/dL	1053	15.48 ± 1.12	1063	14.02 ± 1.07	1.12	(0.82;1.53)	0.48
Serum ferritin, <12 ng/mL	1054	5.79 ± 0.72	1063	5.27 ± 0.69	1.06	(0.67;1.69)	0.80
Serum folate, <3.0 ng/mL	949	0.63 ± 0.26	751	0.53 ± 0.27	2.57	(0.41;16.24)	0.32
Serum Vitamin B_{12}, <200pg/mL	1052	2.19 ± 0.45	1051	2.28 ± 0.46	1.04	(0.50;2.14)	0.92

Note. HANDLS, Healthy Aging in Neighborhoods of Diversity across the Life Span; SEM, Standard Error of Mean; OR, Odds Ratio; HDL-C, High Density Lipoprotein Cholesterol; DS, Dietary Supplement.

Regression coefficients from multiple linear regression were adjusted for age, sex, race, poverty status, smoking status, hepatitis B surface antigen, hepatitis positive antibody, and HIV positive.

dietary supplements (OTC, antacids, or prescribed supplements) had significantly higher levels of serum albumin (4.36 ± 0.01 vs. 4.33 ± 0.01, $p < 0.05$), HDL-cholesterol, (57.81 ± 0.57 vs. 55.86 ± 0.61, $p < 0.05$), folate, (13.91 ± 0.20 vs. 11.99 ± 0.16, $p < 0.001$), and Vitamin B_{12} (512.20 ± 8.13 vs. 426.07 ± 5.91, $p < 0.001$), and lower levels of serum ferritin (130.57 ± 5.39 vs. 158.00 ± 7.30, $p < 0.01$) than participants who did not report supplement use. The odds ratios were significant for serum folate, vitamin B_{12}, and ferritin (folate:b = 1.52 ± 0.30, $p < 0.001$; vitamin B_{12}:b = 76.64 ± 11.34, $p < 0.001$; ferritin:b = -36.17 ± 10.40, $p = 0.001$)

Discussion

The usage of dietary supplements among HANDLS study participants was consistent with reports of US populations examined in the National Health and Nutrition Examination Surveys (2) and slightly lower than the Council for Responsible Nutrition (CRN) consumer surveys of supplement use which ranged from 64% to 69% of US adults (17). Similar to findings reported by other researchers, middle-aged persons were more likely to use dietary supplements compared to younger aged adults (1, 17, 18). In addition, women compared to men and non-Latino Whites compared to non-Latino Blacks were more likely to report use of dietary supplements (1, 17, 18).

Often, an association between healthy lifestyles and use of dietary supplements has been reported (18–20). However, one in three HANDLS study participants who reported using dietary supplements were smokers and the mean BMI of users was approximately 31 kg/m^2. Further, one in four users of dietary supplements reported their health status as poor/fair. Thus, participants may rely on supplements to counter the effects of poor diet and lifestyle choices.

In fact, "to supplement the diet" was the primary motivation reported by HANDLS study participants. This reason was second in the CRN surveys 2007–2011and fourth in the NHANES 2007–2010 (17). The improvement of overall health, the top motivation reported in NHANES and the CRN surveys (7, 17) was the second most commonly reported reason for HANDLS study participants. The motivations for use of dietary supplements for older HANDLS participants were the same as those reported by Bailey and colleagues from adults examined in 2007–2010 NHANES (7). It should be noted that Bailey and colleagues defined older adults as persons 60 years and older. Additionally, Bailey and colleagues reported that 23% of supplement products were used based on recommendations by health care providers, similar to the 20% found in this study (7).

Usage of dietary supplements contributed to improving diet quality, assessed by the MAR score based on 17 micronutrients, suggesting the top motivation for use achieved the intended outcome. Although usage of dietary supplements may be advantageous for the HANDLS study population, intakes of vitamin C were still low. This finding was similar to that reported by Wallace and associates, who observed that among multivitamin/mineral users in the US population there was a low percentage with intakes of vitamins A, C, D, and E, and magnesium and calcium less than recommended. However, the reductions were not extremely dramatic (1).

Even though improvement in MAR score was observed with supplement use, the percent of HANDLS study participants with inadequate cardiovascular and nutrition related biomarkers did not differ between nonusers and users. Thus these biomarkers did not support better health status for users. Further, this evidence appears to indicate that supplement use did not match the second motivation reported by users, namely improvement in overall health. Use of dietary supplements appeared to result in higher levels of serum folate and vitamin B_{12} for supplement users compared to nonusers. Yet, these higher values did not translate into significantly fewer individuals having deficient levels. Serum ferritin, which can be affected by inflammation and infection, was significantly higher in nonusers compared to users even after adjusting for HIV positive antibody, hepatitis B surface antigen, and hepatitis C positive antibody. C-reactive protein (CRP), a marker for inflammation, was not measured in wave 3, but baseline CRP was found to be extremely high (21) and might explain this finding.

Expert nutrition organizations like the Academy of Nutrition and Dietetics and the Food and Nutrition Board of the Institute of Medicine recommend obtaining essential micronutrients from diet. However, sometimes even balanced, well-planned diets may result in nutrient shortfalls. Minimal, if any, risk is associated with the ingestion of a multivitamin/mineral dietary supplement consisting of 10 or more vitamins and minerals at levels recommended for healthy people (1, 22). In fact, there may be small benefits for reduced risk of cancer and nuclear cataracts (22, 23). The SENECA (Survey in Europe on Nutrition and the Elderly, a Concerted Action) study found that dietary supplement use was associated with a mortality differential in older adult smokers and nonsmokers (24). In nonsmokers, dietary supplement use provided no evidence of a beneficial effect on the risk of mortality during a 10-year follow-up among SENECA's participants; however, supplement use was associated with a higher risk of mortality in smokers. Smokers and former smokers should also be aware of a risk of taking dietary supplements with large amounts of vitamin A, since studies have shown this vitamin to be associated with increased risk of lung cancer (22). Given the high prevalence of smokers in the HANDLS study, it seems that a prudent approach would be to educate participants on nutrient-dense food selections and money management focused on food purchases, as well as on the effects of smoking on nutrition and the need to enroll in smoking cessation programs.

Strengths of this research include the relatively large, socioeconomically diverse population not typically examined in nutrition studies, and the capture of seasonal and long-term use of OTC supplements, antacids, and prescribed supplements. A limitation of this study was that the estimates relied on self-reported data for both nutrients from foods and supplements. It was assumed that reported nutrient intakes from food and beverage sources on the 24-hour recalls were unbiased and that self-reported dietary supplement intake reflected true long-term intake patterns. Additionally, estimates of vitamins and minerals contributed by dietary supplements depended on the label declarations rather than analytical values and default values were only used when no information on the supplement was available. The sample size for antacid and prescription supplement users was small thus future studies with larger samples should attempt to replicate the findings of this study.

In conclusion, micronutrient sufficiency appears not to be achieved through food in the HANDLS study population. Nutrient-dense foods are the preferred method for obtaining recommended intakes of vitamins and minerals. Nevertheless, dietary supplements can contribute to increased numbers of individuals achieving the recommended intakes with minimal risk of exceeding the tolerable upper intake levels for micronutrients.

Take away points

- Approximately half of socioeconomically diverse urban African American and White adults in the HANDLS study reported use of OTC, antacid, and/or prescribed dietary supplements.
- The use of dietary supplements improved diet quality measured by the Mean Adequacy Ratio based on 17 micronutrients.
- The only significantly different nutritional biomarkers were serum folate and vitamin B_{12}, with users of dietary supplements having higher mean values compared to nonusers.

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