Published in final edited form as:

J Am Diet Assoc. 2009 March ; 109(3): 422–429. doi:10.1016/j.jada.2008.11.023.

Supplement use contributes to meeting recommended dietary intakes for calcium, magnesium and vitamin C in four ethnicities of middle-aged and older Americans: The Multi-Ethnic Study of Atherosclerosis

Andrea N. Burnett-Hartman, MPH [Pre-doctoral Research Assistant],

Department of Epidemiology, University of Washington, Seattle, WA, Ph: 206-280-3959, Fax: 206-616-4075, email: anbh@u.washington.edu

Annette L. Fitzpatrick, PhD [Research Assistant Professor],

Department of Epidemiology, University of Washington, Seattle, WA, Ph: 206-897-1903, Fax: 206-616-4075, email: fitzpal@u.washington.edu

Kun Gao, MPH, PhD [Manager],

Global Health Economics, Amgen Inc., Thousand Oaks, CA, Ph: 805-313-6205, Fax: 805-376-1816, email: sgao@amgen.com

Sharon A. Jackson, PhD [Northrop Grumman contractor to the Division of Heart Disease and Stroke Prevention], and

Centers for Disease Control and Prevention, Atlanta, GA, Ph: 770-488-5004, Fax: 770-488-8151, email: erf8@CDC.GOV

Pamela J. Schreiner, MS, PhD [Professor and Director of Graduate Studies]

Division of Epidemiology and Community Health, University of Minnesota, Minneapolis, MN, Ph: 612-626-9097, Fax: 612-624-0315, email: schreiner@epi.umn.edu

Abstract

Background—Low intake of nutrients is associated with poor health outcomes. Therefore, we examined the contribution of dietary supplementation to meeting recommended dietary intakes of calcium, magnesium, potassium and vitamin C in participants of the Multi-Ethnic Study of Atherosclerosis (MESA), a cohort of Caucasian, African-American, Hispanic and Chinese participants ages 45–84 years. We also assessed the prevalence of intakes above Tolerable Upper Intake Levels (ULs).

Methods—At the baseline exam in 2000–01, 2,938 men and 3,299 women completed food-frequency questionnaires and provided information about dietary supplementation. We used relative risk regression to estimate the probability of meeting RDAs or AIs in supplement-users vs. non-users and Fisher's exact tests to compare the proportion of those exceeding ULs between the two groups. RDAs, AIs, and ULs were defined by the National Academy of Sciences Food and Nutrition Board's *Dietary Reference Intakes (DRIs)*.

Corresponding Author: Andrea N. Burnett-Hartman, 334 NW 103rd St, Seattle, WA 98177, Ph: 206-280-3959, Fax: 206-616-4075, email: E-mail: anbh@u.washington.edu.

Author for reader requests: Same as corresponding author

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Results—After adjustment for age and education, the relative risk (RR) of meeting RDAs or AIs in supplement-users vs. nonusers ranged from 1.9 (1.6, 2.3) in Caucasian men to 5.7 (4.1, 8.0) in African American women for calcium, from 2.5 (1.9, 3.3) in Hispanic men to 5.2 (2.4, 11.2) in Chinese men for magnesium, and from 1.4 (1.3, 1.5) in African American women to 2.0 (1.7, 2.2) in Chinese men for vitamin C. The RRs for meeting RDAs for calcium differed significantly by ethnicity ($p<0.021$) and gender ($p<0.001$), by ethnicity for magnesium ($p=0.001$). The RR for each gender/ethnicity strata was close to 1 and did not reach statistical significance at $\alpha=0.05$ for potassium. For calcium, 15% of high-dose supplement-users exceeded the UL compared with only 2.1% of nonusers. For vitamin C, the percentages were 6.6% and 0%, and for magnesium, 35.3% and 0% ($p<0.001$ for all).

Conclusion—Although supplement use is associated with meeting DRI guidelines for calcium, vitamin C and magnesium, many adults are not meeting the DRI guidelines even with the help of dietary supplements, and the effect of supplementation can vary according to ethnicity and gender. However, supplementation was not significantly associated with meeting DRIs for potassium. Also, high-dose supplement use is associated with intakes above ULs for calcium, magnesium and vitamin C.

Keywords

Dietary supplements; micronutrient intake; race; ethnicity; gender

Introduction

Numerous studies point to the fact that many Americans are not getting the proper amounts of micronutrients they need on a daily basis (1-8). This may be most pronounced in older adults due to a decrease in total energy intake with advancing age (9). One study estimates that for some nutrients, older adults consume only 20-33% of the Recommended Daily Allowance (RDA) (10).

RDAs and Adequate Intakes (AIs) are goals established by the Institute of Medicine's Food and Nutrition Board for nutrient intake in individuals. The RDAs are age and gender specific and are set to meet the needs of 97-98% of the people in a group. The AI is set at a level that is thought to meet the needs for 100% of the people in a given group. However, for some nutrients not enough data are available to establish an RDA, so the AI target value is used (11).

When a large percent of the population is not meeting the RDA or AI for a particular nutrient there is cause for concern, and public health intervention should be considered. The United States Department of Agriculture's *Dietary Guidelines for Americans 2005* did an evaluation of micronutrient intake in the United States and identified the following nutrients as being at low levels in the diets of many American adults: calcium, potassium, fiber, magnesium, vitamin A, vitamin C and vitamin E (12). In particular, calcium, magnesium, potassium and vitamin C play essential roles in maintaining health, and it is clear that low intake of important nutrients is associated with poor health outcomes in both chronic and infectious disease (13,14). Low calcium intake has been associated with increased risks for osteoporosis and cardiovascular disease (15,16). Magnesium deficiency is associated with low bone mineral density, high levels of C-reactive protein indicative of systemic inflammation, and an increased risk for the metabolic syndrome (17,18). Potassium has an important role in regulating blood pressure (19), and adequate vitamin C intake is essential to immune function (20).

Based on the above information, it is clear that having low intakes of important nutrients can have negative health impacts. However, there is also concern over extremely high micronutrient intake, and Tolerable Upper Intake Levels (UL) have been set for specific

nutrients. ULs are levels at which the micronutrient could potentially be harmful (11). Excessive calcium intake is associated with kidney stone formation (21), and Vitamin C and supplemental magnesium in excess are associated with diarrhea (21,22). Since chronic excessive intake of potassium has not been observed in healthy individuals, no UL is established for potassium (23).

Many adults take dietary supplements. Approximately 52.7% of people surveyed in the 2000 National Health Interview Survey (NHIS) reported taking vitamin or mineral supplements at some point during the preceding 12 months (24). In older Americans, the proportion was even higher, with 61% of 55-69 year olds and 60% of those 70 years of age and older taking dietary supplements (24).

The high prevalence of dietary supplement use in the United States has increased interest in research evaluating the role of supplements in meeting nutritional requirements. A recent study by Sebastian, et al. found that supplement use significantly increases mean and median intakes of micronutrients in the population (8). However, studies have not addressed the effect of dietary supplements in a multi-ethnic population. Nutrient intake varies according to ethnicity with African Americans tending to have lower intakes of important nutrients, such as calcium, than Caucasians (25). In addition, supplemental intake is different among people with different ethnic backgrounds (8). Therefore, it is important to examine the contribution of supplement use in achieving nutritional goals separately for people of different ethnicities.

This study examines the role of dietary supplementation in meeting recommended dietary intakes in four ethnic groups of middle-aged and older Americans for calcium, magnesium, potassium and vitamin C by analyzing dietary data from the Multi-Ethnic Study of Atherosclerosis (MESA). We chose these nutrients because they were identified among the nutrients of concern by the USDA *Dietary Guidelines for Americans 2005* (12), and the dietary and supplemental intakes of these nutrients are extremely well-characterized in the MESA cohort. In addition, we will examine the association between micronutrient supplementation and prevalence of having intakes that exceed recommended Tolerable Upper Intake Levels (UL) for calcium, magnesium and vitamin C.

Methods

Study population

Data for these analyses are drawn from the MESA study, a prospective cohort study designed to investigate the prevalence, correlates and progression of subclinical cardiovascular disease in individuals without clinical cardiovascular disease. This population-based cohort included 6814 subjects aged 45-84 who were recruited from six different regions in the United States: Forsyth County NC, Northern Manhattan and the Bronx NY, Baltimore City and Baltimore County MD, St. Paul MN, Chicago IL and Los Angeles County CA. Approximately 38% of the MESA participants are Caucasian, 28% are African-American, 22% are Hispanic, and 12% are Asian-American (all of Chinese descent). In addition to the age criteria, participants were excluded from this cohort if they had history of diagnosed clinical CVD, were currently undergoing cancer treatment, were pregnant, had any serious medical condition which would prevent long-term participation in the study, weighed over 300 pounds, had cognitive impairment, were living in a nursing home, were planning to leave the community within five years, or spoke a language other than English, Spanish, Cantonese or Mandarin. Participation rate among those who were screened and eligible to participate was 59.8%.

Data Collection

The current study utilizes data obtained at the baseline MESA visit conducted between August 1, 2000 and July 30, 2002. Institutional review board approval for this study is through the University of Washington and remains current, with the most recent renewal dated March 2008.

Data were collected in a self-administered food-frequency questionnaire (FFQ) that queried the type and frequency of foods typically consumed over the past year. The FFQ administered in this study is a version of the Block FFQ (26). It was originally modified and validated for use in the Insulin Resistance Atherosclerosis Study to include regionally and ethnically diverse foods for Caucasians, African Americans and Hispanics (27). Additional modifications were done for the MESA study to include Chinese foods and cooking practices.

Respondents were also asked about specific dietary supplements taken, frequency of intake, and amount of each micronutrient contained in each of their dietary supplements. Respondents supplied this latter information using labels found on their supplement bottles.

Information from the food-specific portion of the questionnaire was converted to approximate daily intake amounts of the micronutrients in the food using the *DietSys Nutrient Analysis Program* (28), which in turn was used to calculate total food-related micronutrient intake. Similarly, total intake of each micronutrient from dietary supplements was calculated. Total daily intake of specific nutrients was calculated by summing intake from food and dietary supplements. This value was used to classify each participant as meeting the RDA for magnesium and vitamin C, meeting the AI for calcium and potassium, or as exceeding the UL as defined by the National Academy of Sciences Food and Nutrition Board's *Dietary Reference Intakes (DRIs)*. Those who did not take dietary supplements containing the micronutrient of interest were considered supplement non-users for the purposes of this study, and their ability to meet the RDA/AI for that micronutrient was based on food intake alone.

In addition to classifying participants as supplement users and non-users for each nutrient in this study, we split supplement users into multivitamin only users and high-dose supplement users. Supplement users were classified as multivitamin users if they had supplemental intakes greater than zero for all of the following: vitamin A or beta-carotene, vitamin B6, vitamin C, vitamin E, riboflavin, and niacin. In addition, cutoff values were established for high-doses of each nutrient in this study based on the amount of each micronutrient typically found in common multivitamins. For calcium, those taking >200 mg/day or taking a separate calcium supplement and not a multivitamin, were characterized as high-dose calcium users. For vitamin C, the cutoff was >60 mg/day. For magnesium and potassium, the cutoff value was >100mg/day.

Data Analysis

A cross-sectional analysis using STATA 9.2 (StataCorp LP, College Station, TX; release date: April 2006) was conducted to examine the effect of dietary supplements on the estimated daily intake of calcium, vitamin C, potassium, and magnesium. Because meeting the RDA/AI is not a rare outcome in this population, logistic regression analyses resulting in odds ratio estimates would have overestimated the relative risk of meeting the RDA/AI associated with supplement use. Therefore, relative risk regression was used to estimate the probability of meeting the RDA or AI for each micronutrient (comparing those who took supplements containing the micronutrient of interest vs. those who did not) using a generalized linear model with log link, Gaussian error and robust standard error estimates (29). Wald tests were used to test for interactions between gender and supplement use and between race and supplement use. In addition, Fisher's exact tests were performed to compare the proportion of those exceeding the ULs between those who did and did not use supplements for each nutrient except potassium

which does not have a defined UL. Participants who did not complete the food frequency questionnaire were excluded from these analyses.

Results

Of the 6814 participants in the MESA cohort, 6237 (91.5%) completed food frequency questionnaires. Table 1 provides demographics of the study cohort by dietary supplement use. Over half of the population took dietary supplements containing at least one of the following: calcium, magnesium, potassium or vitamin C. Supplement users were more likely to be older, women, Caucasian and college-educated than non-users (chi-square $p < 0.001$ for all). Use of supplements containing calcium and/or vitamin C was most common. Approximately 46% of the population took supplements containing one or both of these micronutrients.

Over all, median dietary intake of calcium, magnesium, potassium and vitamin C was similar between supplement users and non-users among both men and women (table 2). However, there were differences in median dietary intake levels between the different ethnic groups with Chinese Americans tending to have the lowest dietary intakes. This was most apparent in calcium where both Chinese and African Americans had significantly lower dietary intakes of calcium than Caucasians and Hispanics (table 2).

Calcium supplementation increased median calcium intake by 56%, magnesium supplementation increased median magnesium intake by 42%, and potassium supplementation increased median potassium intake by 3% in men. Vitamin C supplementation had the largest effect on median intake in men, ranging from a 160% increase in Chinese men to a 235% increase in African American men (table 2).

For women, the effect of calcium supplementation varied among the different ethnic groups ranging from a 101% increase in median calcium intake among Hispanic women using calcium supplements to a 151% increase in median intake among Chinese women. Magnesium supplementation increased median magnesium intake by 61%, potassium supplementation increased median potassium intake by 5%, and vitamin C supplementation increased median vitamin C intake by 181% in women (table 2).

Study participants were most likely to meet the RDA for vitamin C and least likely to meet the AI for potassium from both food and dietary supplements (figure 1). According to figure 1, 50.9% of calcium supplement users met the AI for calcium with supplementation compared to 16.4% of non-users. The corresponding numbers for magnesium were 49.9% vs. 15.7%, 7.2% vs. 7.1% for potassium, and 98.4% vs. 59.7% for vitamin C. Fisher's exact tests indicated no significant differences for meeting RDAs/AIs through dietary intake alone between users and non-users for calcium, magnesium, and potassium. However, for vitamin C a significantly greater proportion of users than non-users met the RDA through food intake alone.

Table 3 displays the adjusted relative risks (RRs) of meeting the RDA/AI comparing supplement users to non-users for each micronutrient stratified by ethnicity and gender. After adjusting for age and education, the probability of meeting the RDA/AI was significantly greater among supplement users for each micronutrient except for potassium. The RRs for calcium ranged from 1.9 (1.6, 2.3) in Caucasian men to 5.7 (4.1, 8.0) in African American women for calcium. The RRs for magnesium ranged from 2.5 (1.9, 3.3) in Hispanic men to 5.2 (2.4, 11.2) in Chinese men for magnesium. The RRs for potassium were not significantly different from 1 for any race/gender group. The RRs for vitamin C ranged from 1.4 (1.3, 1.5) in African American women to 2.0 (1.7, 2.2) in Chinese men for vitamin C. For calcium, there were significant interactions between ethnicity and supplement use ($p < 0.001$) and between gender and supplement use ($p < 0.001$). In addition, there was a significant interaction between ethnicity and supplement use for magnesium ($p = 0.001$). For calcium, the effect of

supplementation was greater among females than among males, and supplementation had a stronger effect among African American and Chinese ethnicities compared to Caucasians and Hispanics. Neither potassium nor vitamin C had significant interactions between supplement use and ethnicity, nor between supplement use and gender.

Table 4 illustrates the contribution of multivitamins and high-dose dietary supplementation separately for each micronutrient. For calcium, multivitamin use was significantly associated with meeting the AI in Chinese men (RR=3.1; 95% CI=1.5 to 6.4) and African American women (RR=1.9; 95% CI=1.2 to 3.2) but in none of the other gender/ethnic groups. However, high-dose calcium was associated with meeting the AI for calcium in all groups. Both multivitamin and high-dose vitamin use were significantly associated with meeting the RDAs for magnesium and vitamin C for each gender/ethnic group. Multivitamin use was not significantly associated with meeting the AI for potassium in any of the groups. However, high-dose potassium was significantly associated with meeting the AI in African American women (RR=2.7; 95% CI=1.2 to 6.3).

The percent of high-dose supplement users exceeding the UL for calcium, magnesium and vitamin C was significantly higher than the percent of non-users exceeding the UL (Fisher's exact $p < .001$ for all). For calcium, 15.0% of high-dose users exceeded the UL compared to 1.9% of multivitamin users and 2.1% of non-users. For magnesium, 35.3% of high-dose supplement users exceeded the UL compared to 0% of both multivitamin users and non-users. In addition, 6.6% high-dose vitamin C users exceeded the UL compared to 0% of both multivitamin users and non-users.

Discussion

The results of this study support an association between supplement use and meeting RDAs/AIs for calcium, magnesium and vitamin C in this multi-ethnic population of middle-aged and older adults and are consistent with an existing study exploring the impact of supplementation in Americans 51 and older (8). In addition, our results suggest that the association between supplementation and meeting the RDAs/AIs for calcium is stronger for women than for men. Also, Chinese- and African-Americans tend to show the largest effects for calcium supplementation.

Some of this may be explained by differences in dietary intake between ethnicities and genders. Table 2 indicates that median dietary intake for calcium tends to be less in women than in men and in less African Americans and Chinese Americans. Therefore, calcium supplementation in these populations may have a greater impact. In addition, women tended to take a higher dose of supplemental calcium than men (median supplemental intake in women users=600 mg; median supplemental intake in men users=200 mg) making it more likely that women calcium supplement-users would cross the AI threshold than men calcium supplement-users.

The differences in recommended nutritional requirements between men and women along with the differences in dietary habits between the two genders, has prompted some vitamin manufacturers to make multivitamins tailored to each gender. This type of customization may increase the effect of supplements in both men and women and future studies should assess the contribution of these types of vitamins. In addition, more studies analyzing differences in dietary habits between people from different backgrounds can help nutritionists and other health professionals target populations that are most likely to benefit from dietary supplements and tailor other dietary interventions to specific groups.

The most common type of vitamin supplement used in the US population is the multivitamin (30). In this study, we found that multivitamin use was significantly associated with meeting the RDAs for magnesium and vitamin C regardless of gender/ethnic group (table 4). However,

for calcium, multivitamin use was only associated with meeting the AI in two of the eight groups; whereas, high-dose calcium use was associated with meeting the AI in all groups. For potassium, multivitamin use was not associated with meeting the AI for any of the groups. This is partially a reflection the amount of micronutrient typically found in a multivitamin and the proportion of the AI/RDA that amount represents. A typical multivitamin has 60 mg of vitamin C accounting for 80% of the RDA in women and 67% of the RDA in men. On the other hand, a typical multivitamin has 200 mg of calcium (accounting for between 17% and 20% of the AI depending on age) and less than 100mg of potassium (accounting for only 2% of the AI).

It would be ideal if most people could adequately supplement dietary intake of important nutrients by taking a single multivitamin. However, the amount of micronutrients in multivitamins is limited by the size of the tablet. Therefore, consideration is taken when determining the amount of each micronutrient in the multivitamin. Determining ways to reformulate multivitamins to more adequately meet the gaps in nutrition should be considered.

Despite the strong association between supplement use and meeting the RDA/AI for calcium and magnesium, still about half of supplement-users are not meeting the RDA/AI for these important nutrients. Vitamin C is the only micronutrient where supplementation results in close to 100% of supplement-users with intakes meeting or exceeding recommended levels. As previously mentioned, the amount of vitamin C in multivitamins is high in relation to the amount needed to meet the RDA. In addition, baseline dietary intake of vitamin C is relatively high in this population (table 2).

Not surprisingly, supplement users were more likely than non-users to exceed ULs for calcium, magnesium and vitamin C. However, this association was confined to those taking high-dose vitamins and not in those taking multivitamins only. This is of concern for two reasons. First, micronutrient intake that exceeds recommended ULs may lead to poor health outcomes, such as kidney stones (21). Second, many users do not discuss their decision to use supplements with their doctor, and therefore, may not receive advice concerning appropriate use of micronutrient supplementation (24).

Our findings should be interpreted in light of a few limitations. First, we used an FFQ to assess dietary intake. Although FFQs are cost-efficient and allow direct assessment of nutrient intakes, they are prone to bias due to inaccurate recall. However, the FFQ used in this study was validated for use in a multi-ethnic population and any bias found to be similar between different ethnic groups (31). In addition, we did not assess the contribution of antacids to supplemental calcium intake which can be a significant source of supplemental calcium in older populations (32). Therefore, we may have underestimated the contribution of calcium supplementation in this population. Also, due to the nature of our analysis, we were unable to adjust for differences in meeting the RDA/AI through food intake alone between supplement users and non-users. Since we saw little difference in the percent meeting the RDA through dietary intake alone between these groups, any bias from this is minimal and would not change the overall results. In addition, this study examines an outcome (meeting RDAs/AIs) that is a proxy for nutrition in the population, and does not look longitudinally to determine if meeting RDAs/AIs through supplementation will result in better long-term health outcomes. Future studies should evaluate dietary supplementation in relation to cardiovascular disease, disability status and life-expectancy in longitudinal studies. Finally, our analysis of the association between exceeding the ULs for the micronutrients of interest and dietary supplementation is an unadjusted analysis that does not take into account potential confounding variables, such as age and education. However, since zero participants classified as non-users for potassium and vitamin C supplements exceeded the UL, we were unable to do an adjusted regression analysis to examine this relationship.

Despite these limitations, there are several strengths to this study. The large sample size and multiple ethnic groups in this population gave us enough power to examine interactions between supplementation and ethnicity. In addition, the large sample size and detailed dietary questionnaire allowed for a very specific analysis of the micronutrients of interest and dietary supplementation. Therefore, the associations between dietary supplementation and meeting recommended daily intakes for calcium, magnesium and vitamin C are robust and should be reproducible in future studies.

The present study indicates a clear association between meeting RDA/AIs and supplement use for calcium, magnesium and vitamin C. However, even with the assistance of dietary supplements many middle-aged and older Americans are not getting adequate nutrition, and there was no association between supplement use and meeting the AI for potassium. In addition, those taking high-dose vitamin supplements were more likely to exceed the UL for that nutrient. Future studies should explore dietary supplementation along with other methods to improve nutrition in middle-aged and older Americans.

Acknowledgments

This research was supported by contracts N01-HC-95159 through N01-HC-95165 and N01-HC-95169 from the National Heart, Lung, and Blood Institute. The authors thank the other investigators, the staff, and the participants of the MESA study for their valuable contributions. A full list of participating MESA investigators and institutions can be found at <http://www.mesa-nhlbi.org>.

References

1. Ford ES, Mokdad AH. Dietary magnesium intake in a national sample of US adults. *J Nutr* 2003;133:2879–2882. [PubMed: 12949381]
2. Guenther PM, Dodd KW, Reedy J, Krebs-Smith SM. Most Americans eat much less than the recommended amounts of fruits and vegetables. *J Am Diet Assoc* 2006;106:1371–1379. [PubMed: 16963342]
3. Fletcher RH, Fairfield KM. Vitamins for chronic disease prevention in adults: Clinical applications. *JAMA* 2002;287:3127–3129. [PubMed: 12069676]
4. Taylor CA, Hampl JS, Johnston CS. Low intakes of vegetables and fruits, especially citrus fruits, lead to inadequate vitamin C intakes among adults. *Eur J Clin Nutr* 2000;54:573–578. [PubMed: 10918468]
5. Ryan AS, Craig LD, Finn SC. Nutrient intakes and dietary patterns of older Americans: a national study. *J Gerontol* 1992;47:M145–150. [PubMed: 1512429]
6. Ervin RB, Kennedy-Stephenson J. Mineral intakes of elderly adult supplement and non-supplement users in the Third National Health and Nutrition Survey. *J Nutr* 2002;32:3422–3427. [PubMed: 12421862]
7. Cid-Rzafa J, Caulfield LE, Barron Y, West SK. Nutrient intakes and adequacy among an older population on the eastern shore of Maryland: The Salisbury Eye Evaluation. *J Am Diet Assoc* 1999;9:564–571.
8. Sebastian RS, Cleveland LE, Goldman JD, Moshfegh AJ. Older adults who use vitamin/mineral supplements differ from nonusers in nutrient intake adequacy and dietary attitudes. *J Am Diet Assoc* 2007;107:1322–1332. [PubMed: 17659898]
9. Drewnowski A, Shultz JM. Impact of aging on eating behaviors, food choices, nutrition and health status. *J Nutr Health Aging* 2001;5:75–79. [PubMed: 11426286]
10. Wakimoto P, Block G. Dietary intake, dietary patterns, and changes with age: an epidemiological perspective. *J Gerontol A Biol Sci Med Sci* 2001;56:65–80. [PubMed: 11730239]
11. Institute of Medicine, Food and Nutrition Board. Dietary Reference Intakes: Recommended Intakes for Individuals. Washington, DC: National Academies Press; 2004.
12. US Department of Health and Human Services and US Department of Agriculture. Dietary Guidelines for Americans. 2005. Available at: www.healthierus.gov/dietaryguidelines

13. Keusch, G. Nutrition and infection. In: Shils, M.; Olson, JA.; Shike, M., editors. *Modern nutrition in health and disease*. Philadelphia: Lea & Febiger; 1994. p. 1241-1258.
14. Edington J, Winter PD, Coles SJ, Gale CR, Martyn CN. Outcomes of undernutrition in patients in the community with cancer or cardiovascular disease. *Proc Nutr Soc* 1999;58:655–661. [PubMed: 10604199]
15. Nieves JW. Osteoporosis: the role of micronutrients. *Am J Clin Nutr* 2005;81:1232S–1239S. [PubMed: 15883457]
16. Vaskonen T. Dietary minerals and modification of cardiovascular risk factors. *J Nutr Biochem* 2003;14:492–506. [PubMed: 14505811]
17. Ryder KM, Shorr RI, Bush AJ, Kritchevsky SB, Harris T, Stone K, Cauley J, Tylavsky FA. Magnesium intake from food and supplements is associated with bone mineral density in healthy older white subjects. *J Am Geriatr Soc* 2005;53:1875–1880. [PubMed: 16274367]
18. Song Y, Ridker PM, Manson JE, Cook NR, Buring JE, Liu S. Magnesium intake, C-reactive protein, and the prevalence of metabolic syndrome in middle-aged and older US women. *Diabetes Care* 2005;28:1438–1444. [PubMed: 15920065]
19. Whelton PK, He J, Cutler JA, Brancati FL, Appel LJ, Follmann D, Klag MJ. Effects of oral potassium on blood pressure. Meta-analysis of randomized controlled clinical trials. *JAMA* 1997;277:1624–1632. [PubMed: 9168293]
20. Wintergerst ES, Maggini S, Horning DH. Immune-enhancing role of vitamin C and zinc and effect on clinical conditions. *Ann Nutr Metab* 2006;50:85–94. [PubMed: 16373990]
21. Institute of Medicine, Food and Nutrition Board. Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D and fluoride. Washington, DC: National Academies Press; 2000.
22. Institute of Medicine, Food and Nutrition Board. Dietary reference intakes for vitamin C, vitamin E, selenium and carotenoids. Washington, DC: National Academies Press; 2000.
23. Dietary Institute of Medicine, Food and Nutrition Board. Dietary reference intakes: water, potassium, sodium, chloride and sulfate. Washington, DC: National Academies Press; 2004.
24. Fennell D. Determinants of supplement usage. *Prev Med* 2004;39:932–939. [PubMed: 15475026]
25. Fulgoni V 3rd, Nicholls J, Reed A, Buckley R, Kaffer K, Huth P, DiRienzo D, Miller GD. Dairy consumption and related nutrient intake in African-American adults and children in the United States: continuing survey of food intakes by individuals 1994-1996, 1998, and the National Health And Nutrition Examination Survey 1999-2000. *J Am Diet Assoc* 2007;107:256–264. [PubMed: 17258962]
26. Block G, Woods M, Potosky A, Clifford C. Validation of a self-administered diet history questionnaire using multiple diet records. *J Clin Epidemiol* 1990;43:1327–1335. [PubMed: 2254769]
27. Leise AD, Schulz M, Moore CG, Mayer-Davis EJ. Dietary patterns, insulin sensitivity and adiposity in the multi-ethnic Insulin Resistance Atherosclerosis Study population. *Br J Nutr* 2004;92:973–984. [PubMed: 15613260]
28. National Cancer Institute, Applied Research Branch. DietSys. Available at: <http://appliedresearch.cancer.gov/DietSys/materials.html>
29. Lumley, T.; Kronmal, RA.; Ma, S. UW Biostatistics Working Paper Series. University of Washington; 2006. Relative Risk Regression in Medical Research: Models, Contrasts, Estimators and Algorithms. Paper 293. Available at: <http://www.bepress.com/uwbiostat/paper293>
30. Radimer K, Bindewald B, Hughes J, Ervin B, Swanson C, Picciano MF. Dietary supplement use by US adults: data from the National Health and Nutrition Examination Survey, 1999-2000. *Am J Epidemiol* 2004;160:339–349. [PubMed: 15286019]
31. Mayer-Davis EJ, Vitolins MZ, Carmichael SL, Hemphill S, Tsaroucha G, Rushing J, Levin S. Validity and reproducibility of a food frequency interview in a multi-cultural epidemiologic study. *AEP* 1999;9:314–324. [PubMed: 10976858]
32. Radimer KL, Subar AF, Thompson FE. Nonvitamin, nonmineral dietary supplements: Issues and findings from NHANES III. *J Am Diet Assoc* 2000;100:447–454. [PubMed: 10767902]

Figure 1. Percent of supplement-users and non-users meeting the RDA/AI for each micronutrient

Table 1
Descriptive statistics of the study population (N=6237) by supplement use

	Supplement-user ^a N (%)	Non-user N (%)	Chi-square p-value
N (%)	3323 (53)	2914 (47)	
Age			
45-54	820 (46)	947 (54)	<0.001
55-64	924 (54)	799 (46)	
65-74	1051 (57)	791 (43)	
75-84	528 (58)	377 (42)	
Gender			
Men	1348 (46)	1590 (54)	<0.001
Women	1975 (60)	1324 (40)	
Highest Education Level			
No High School Diploma	423 (38)	701 (62)	<0.001
High School Diploma	1523 (53)	1342 (46)	
Bachelor Degree	657 (60)	431 (40)	
Graduate/Professional	717 (62)	435 (38)	
Ethnicity			
Caucasian	1538 (62)	936 (38)	<0.001
African American	760 (47)	855 (53)	
Chinese	441 (56)	349 (44)	
Hispanic	584 (43)	774 (57)	

^aHas supplemental intake of one or more of the following micronutrients: calcium, potassium, magnesium, vitamin C

Note: Approximately 46% of the total study population took supplements containing calcium, 36% took supplements containing magnesium, 30% took supplements containing potassium, 46% took supplements containing vitamin C, and 35% took a multivitamin.

Table 2
Median intakes of specific micronutrients among supplement users and non-users stratified by race and gender

	All Median	Caucasian Median	African American Median	Chinese Median	Hispanic Median
Men					
Calcium (mg/day)					
Non-users	631	722	542	469	720
Users (Diet only)	641	685	558	514	727
Users (Diet +Supplement)	1000	1017	921	955	1066
Magnesium (mg/day)					
Non-users	255	281	236	208	269
Users (Diet only)	265	280	248	233	258
Users (Diet +Supplement)	377	394	371	337	378
Potassium (mg/day)					
Non-users	2628	2862	2542	1968	2738
Users (Diet only)	2703	2822	2412	2317	2723
Users (Diet +Supplement)	2797	2900	2555	2415	2813
Vitamin C (mg/day)					
Non-users	97	94	108	88	104
Users (Diet only)	104	106	105	97	105
Users (Diet +Supplement)	330	334	352	253	335
Women					
Calcium (mg/day)					
Non-users	592	659	534	463	694
Users (Diet only)	578	652	520	432	660
Users (Diet +Supplement)	1320	1551	1066	1085	1327
Magnesium (mg/day)					
Non-users	215	225	206	175	234
Users (Diet only)	216	234	209	181	223
Users (Diet +Supplement)	347	362	360	299	343
Potassium (mg/day)					

	All Median	Caucasian Median	African American Median	Chinese Median	Hispanic Median
Non-users	2232	2302	2188	1709	2397
Users (Diet only)	2208	2357	2218	1873	2237
Users (Diet +Supplement)	2314	2481	2367	1950	2286
Vitamin C (mg/day)					
Non-users	94	85	104	89	94
Users (Diet only)	96	94	111	84	91
Users (Diet +Supplement)	270	278	282	229	259

Note: AI for Calcium is 1,000 mg/day for men and women ages 31-50 years and 1,200 mg/day for men and women ages >50 years. RDA for magnesium is 420 mg/day for men ages >30 years and 320 mg/day for women ages >30 years. AI for potassium is 4,700 mg/day for men and women ages >30 years. RDA for Vitamin C is 90 mg/day for men ages >30 years and 75 mg/day for women ages >30 years.

Table 3

Adjusted^a relative risk (RR) with 95% confidence intervals (95% CI) for meeting RDA/AI based on total intake (including supplementation), comparing supplement users to non-users stratified by ethnicity and gender

	Calcium RR (95% CI)	Magnesium RR (95% CI)	Potassium RR (95% CI)	Vitamin C RR (95% CI)
Men				
Caucasian	1.9 (1.6, 2.3)	3.1 (2.5, 3.9)	0.9 (0.6, 1.4)	1.8 (1.7, 2.0)
African American	2.5 (1.9, 3.4)	3.1 (2.3, 4.2)	1.1 (0.6, 1.9)	1.6 (1.5, 1.8)
Chinese	5.3 (2.8, 9.9)	5.2 (2.4, 11.2)	0.8 (0.1, 7.8)	2.0 (1.7, 2.2)
Hispanic	2.1 (1.6, 1.6)	2.5 (1.9, 3.3)	1.0 (0.6, 1.9)	1.7 (1.6, 1.9)
Women				
Caucasian	3.5 (2.9, 4.3)	3.4 (2.8, 4.0)	1.5 (0.9, 2.5)	1.7 (1.5, 1.8)
African American	5.7 (4.1, 8.0)	3.6 (2.9, 4.4)	1.6 (0.5, 4.7)	1.4 (1.3, 1.5)
Chinese	5.4 (3.1, 8.5)	3.2 (2.2, 4.6)	0.6 (0.1, 4.3)	1.5 (1.4, 1.7)
Hispanic	3.0 (2.4, 3.7)	2.5 (2.1, 3.1)	0.8 (0.4, 1.8)	1.5 (1.4, 1.6)

^a Adjusted for age and education

Table 4

Adjusted^a relative risk (RR) with 95% confidence intervals (95% CI) for meeting RDA/AI among multivitamin users and mega vitamin users stratified by ethnicity and gender

	Caucasian RR (95% CI)	African American RR (95% CI)	Chinese RR (95% CI)	Hispanic RR (95% CI)
Males				
Calcium				
Non-users	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Multivitamin only	1.1 (0.9, 1.4)	1.2 (0.7, 1.9)	3.1 (1.5, 6.4)	1.1 (0.8, 1.7)
High Dose (>200 mg/d)	2.9 (2.4, 3.5)	4.0 (2.9, 5.4)	7.8 (4.1, 14.6)	2.9 (2.3, 3.6)
Magnesium				
Non-users	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Multivitamin only	2.2 (1.7, 2.9)	1.8 (1.2, 2.8)	4.1 (1.9, 8.8)	1.6 (1.1, 2.2)
High Dose (>100 mg/d)	5.7 (4.5, 7.1)	5.0 (3.6, 6.9)	9.7 (4.8, 19.8)	3.9 (3.0, 5.1)
Potassium				
Non-users	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Multivitamin only	0.9 (0.6, 1.4)	1.0 (0.6, 1.8)	1.1 (0.3, 3.3)	0.8 (0.4, 1.4)
High Dose (>100 mg/d)	1.5 (0.8, 2.9)	2.2 (0.9, 5.6)	2.5 (0.3, 18.2)	1.6 (0.6, 4.5)
Vitamin C				
Non-users	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Multivitamin only	1.8 (1.6, 1.9)	1.6 (1.4, 1.7)	1.9 (1.6, 2.2)	1.7 (1.5, 1.8)
High Dose (>60 mg/d)	1.8 (1.7, 2.0)	1.7 (1.5, 1.8)	2.0 (1.7, 2.2)	1.7 (1.5, 1.9)
Females				
Calcium				
Non-users	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Multivitamin only	1.1 (0.8, 1.5)	1.9 (1.2, 3.2)	0.7 (0.2, 2.3)	1.2 (0.8, 1.8)
High Dose (>200 mg/d)	3.9 (3.2, 4.8)	7.5 (5.4, 10.5)	6.6 (3.8, 11.4)	3.6 (2.9, 4.4)
Magnesium				
Non-users	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Multivitamin only	2.3 (1.9, 2.8)	1.9 (1.5, 2.5)	2.0 (1.3, 3.1)	1.7 (1.3, 2.2)
High Dose (>100mg/d)	4.4 (3.7, 5.3)	4.8 (4.0, 5.9)	6.1 (4.1, 8.9)	3.5 (2.9, 4.2)
Potassium				
Non-users	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Multivitamin only	1.1 (0.6, 2.1)	1.2 (0.5, 2.6)	0.3 (0.0, 3.2)	0.9 (0.4, 2.2)
High Dose (>100 mg/d)	2.1 (1.0, 4.6)	2.7 (1.2, 6.3)	<0.1 ^b	1.0 (0.1, 7.1)
Vitamin C				
Non-users	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Multivitamin only	1.6 (1.5, 1.8)	1.3 (1.2, 1.4)	1.5 (1.3, 1.7)	1.5 (1.4, 1.6)
High Dose (>60 mg/d)	1.7 (1.6, 1.8)	1.4 (1.3, 1.5)	1.6 (1.4, 1.8)	1.5 (1.4, 1.7)

^a Adjusted for age and education

^b All high dose supplement users failed to meet the RDA

Note: High dose users had intakes of the specific micronutrient greater than the level typically found in a multivitamin (>200 mg for calcium, >100 mg for magnesium, >100 mg for potassium, >60 mg for vitamin C) or took a separate supplement containing the micronutrient of interest that was not a multivitamin. Multivitamin only users took a multivitamin and did not have supplemental intake of the micronutrient of interest greater than what is typically found in a multivitamin.