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Correlates of vitamin supplement use in the United States: data from the California Teachers Study cohort

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Abstract

Objective: To describe factors associated with vitamin supplement use in a large cohort of adult women.
Methods: California teachers and administrators (n = 133,479) completed a questionnaire on lifestyle factors and medical history. Specific supplement users regularly used at least one specific vitamin supplement in the past year; multivitamin users regularly used a multivitamin; and multivitamin and specific supplement users took a multivitamin and one or more specific supplements. Associations between supplement use and other variables were quantified using means, cross-tabulations, and age-adjusted prevalence odds ratios.
Results: Multivitamin and specific supplement users tended to be older and Caucasian. Compared to non-users, they were also leaner (odds ratio [OR] for BMI ≥ 30 kg/m$^2 = 0.6$ for specific supplement users with or without multivitamins, and OR = 0.7 for multivitamin only users), and were less likely to be current smokers (OR for current smoking = 0.8 for multivitamin plus specific supplement users, OR = 0.9 for specific supplement only users, and OR = 0.7 for multivitamin only users). Specific supplement users (with or without multivitamins) were more likely to use cancer screening tests, eat fruits and vegetables, and exercise than were multivitamin only users or non-users.
Conclusions: A variety of demographic, dietary, and health-related factors were associated with different categories of supplement use.

Introduction

Vitamin and mineral supplements have become an important source of micronutrients for many Americans. In epidemiologic studies, micronutrient intake, including from supplements, has been associated with lower rates of several chronic diseases (*e.g.* calcium with osteoporosis [1], folic acid with neural tube defects and heart disease [2, 3], and antioxidants with cancer and heart disease [4]). However, observational epidemiologic studies of micronutrient intake and disease can be compromised if confounding factors are not taken into account.

On the one hand, failure to measure nutritional supplement use can lead to a considerable misclassification of an individual's intake of micronutrients [5]. On the other, including supplements as a source of micronutrients may introduce confounding by factors related to supplement use. As several recent studies have shown, the act of supplementation itself is associated with a range of variables that are related to cancer and chronic disease [5, 6]. For instance, research has shown that, compared to non-users, supplement users are more likely to be female, white, of high socioeconomic status (SES), non-smokers, moderate drinkers, and have a normal weight; in addition they tend to consume diets that are low in fat and high in micronutrients, to exercise, receive cancer-screening tests, and believe in the diet–cancer connection [6–10]. Some research has suggested that multivitamin supplement use may be associated with a different range of demographic and lifestyle factors compared with specific supplement use. In particular the pattern of specific supplement use has been shown to be more variable across categories of age, race, geographic region, and education compared to multivitamin use [10].

This article describes the demographic and health-related factors associated with multivitamin and specific supplement use in adult women participating in a large prospective cohort study. The purpose of the analysis is to identify variables that may be confounders of the relation between micronutrient consumption and disease.

Materials and methods

The California Teachers Study (CTS) cohort was established in 1995. Participants were recruited through the California State Teachers Retirement System (STRS), a statewide system in which all professional public school employees from grades K-12 and some community colleges participate. A self-administered optically scannable questionnaire was sent to approximately 329,000 active and retired female STRS members. A total of 133,479 women returned the questionnaire, thereby joining the cohort and providing information for future contact. This cohort is followed annually for cancer outcomes via linkage with the population-based statewide cancer registry and biannually via self-administered questionnaires to update exposure information, collect new risk factor data, and obtain information on non-cancer disease occurrence [11].

The self-administered baseline questionnaire collected information on a wide variety of factors believed or hypothesized to be related to breast cancer risk and women's health. These included questions on reproductive and hormonal factors, smoking, general health, and cancer history. Usual dietary intake during the previous year was measured using an early version of the Block 1995 food-frequency questionnaire (FFQ) [12]. Supplement use was assessed through questions on the regular use of multivitamins, as well as several specific antioxidant vitamin and mineral supplements (vitamins A, C, E, and beta-carotene). Frequency, duration, and dose were also assessed.

For our analyses we grouped women into four categories based on their supplement use patterns: multivitamin only users (n = 27,942); specific supplement users with (n = 32,762) or without multivitamins (n = 15,508); and supplement non-users (n = 34,996). Women who reported they took supplements fewer than four times per week (n = 11,199), or who reported taking only selenium or supplements not listed on the questionnaire (n = 11,072), were excluded from the analysis. Multivitamin users, users of specific supplements only, users of both multivitamins and specific supplements, and non-users were compared on a variety of factors. Categories of potential correlates, such as age, race/ethnicity, body mass index, age at menarche, age at first full-term pregnancy, smoking, alcohol consumption, recent strenuous or moderate physical activity, and consumption of fruits and vegetables, were based on *a-priori* groupings. Use of cancer screening tests and selected aspects of medical history were analyzed as dichotomous variables. Women who reported a history of breast or cervical cancer were excluded from the analysis of the related screening test variables as appropriate.

Means and cross-tabulations were used to describe the three categories of supplement users. Prevalence odds ratios were used to compare the three groups of supplement users to non-users. These odds ratios were calculated using unconditional multiple logistic regression, adjusting for age.

Results

Of the 111,208 women included in this analysis, 97,201 (87%) were Caucasian, 2769 (3%) were African-American, 4225 (4%) were Latina, 3750 (3%) were Asian, and 3263 (3%) were of another racial/ethnic background or did not specify their race on the questionnaire. The average age was 55 (standard error [SE], 0.04) and ranged from 22 to 103. Menopausal status could be determined for 87% of women, and of these women 61% were postmenopausal. The average BMI was 25 kg/m^2 (SE 0.02). Over half of the women were lifetime non-smokers (64%) and only 5% said they smoked currently. Among regular supplement users, 37% reported taking a multivitamin only, 20% specific supplements but not a multivitamin, and 43% a multivitamin in combination with specific supplements. Specific supplement users consumed the following: vitamin A, 8%; beta-carotene, 17%; vitamin C, 52%; and vitamin E, 44%.

Tables 1 and 2 describe the demographic and health-related characteristics of the three types of supplement users. Supplement users of all types were older than non-users, tended to be Caucasian, and were leaner than the non-users. Various measures of menstrual history, reproductive factors, and hormone use, all of which are related to the risk of hormone-dependent cancers, were also related to supplement use. We measured several indicators of an overall "healthy" lifestyle. In particular, women who used specific supplements, alone or with a

Table 1. Description of multivitamin users, specific supplement users, and supplement non-users

	Users of both multivitamins and specific supplements (n = 32,762)	Users of specific supplements only (n = 15,508)	Users of multivitamins only (n = 27,942)	Non-users (n = 34,996)
Age (mean, SE)	57.8 (0.07)	59.0 (0.11)	52.9 (0.09)	50.8 (0.08)
Race/ethnicity (%)				
Caucasian	90	88	87	84
African-American	2	3	2	3
Hispanic	2	3	4	6
Asian	3	3	3	4
Other/race not specified	2	2	3	3
BMI (mean, SE)	24.6 (0.03)	24.5 (0.04)	24.8 (0.03)	25.3 (0.03)
Age at menarche (mean, SE)	12.5 (0.01)	12.6 (0.01)	12.5 (0.01)	12.5 (0.01)
Nulliparous (%)	26	27	25	27
Age at first full-term pregnancy, among parous women only (mean, SE)	26.0 (0.03)	26.0 (0.04)	26.8 (0.03)	26.6 (0.03)
Menopausal status (%)				
Pre/Peri	24	21	38	46
Post	63	66	49	43
Unknown	13	13	13	11
Estrogen use, among women 45 years and older (%)	58	58	43	33
Progestin use, among women 45 years and older (%)	34	34	25	19
Smoking (%)				
Never	61	59	66	66
Former	31	32	26	24
Current	5	5	4	6
Alcohol use, non-drinkers (%)	30	29	32	31
Alcohol use, among drinkers (g/day, mean, SE)	11.6 (0.07)	11.9 (0.10)	11.1 (0.08)	11.5 (0.07)
Moderate or strenuous physical activity at least weekly (%)	78	78	67	63
Fruit (3+ servings per day, %)	14	14	11	8
Vegetables (3+ servings per day, %)	13	12	9	8
Ever had a mammogram – women 40 years and over[a] (%)	81	81	69	69
Ever had a breast exam by a health provider[a] (%)	84	82	86	87
Ever had a PAP smear[b] (%)	90	89	90	90
Family history of breast cancer (%)	13	13	12	12

[a] Excludes women who reported a history of breast cancer.
[b] Excludes women who reported a history of cervical cancer.

multivitamin, tended to exercise, eat more fruits and vegetables, and were more likely to have had a mammogram or PAP smear compared to either multivitamin only users or non-users. Supplement users of any type were less likely to be current smokers compared to non-users and were more likely to be postmenopausal and use exogenous estrogen or progestin.

Discussion

Our analysis indicates that multivitamin and specific supplement users in the CTS cohort tended to be older, Caucasian, leaner, and were less likely to be current smokers compared to non-users; these results are consistent with the findings of previous studies [7–10]. The prevalence of supplement use was slightly higher for women in the CTS (58% of the total cohort) compared to women participating in the third National Health and Nutrition Examination Survey (NHANES III) [13]. This national survey found a prevalence of supplement use (as indicated by use in the past month) between 42% and 55% for women, depending on age. In addition, we observed that specific supplement users differed from multivitamin users with respect to many demographic and lifestyle factors, and women who took both specific

Table 2. Association between supplement use and cancer-related variables, adjusted for age

	Users of both multivitamins and specific supplements (n = 32,762)	Users of specific supplements only (n = 15,508)	Users of multi-vitamins only (n = 27,942)
Age (unadjusted)			
<45	1.0	1.0	1.0
45–54	2.1 (2.05–2.23)	2.4 (2.30–2.58)	0.9 (0.91–0.99)
55–64	3.7 (3.51–3.86)	4.4 (4.18–4.74)	1.3 (1.21–1.33)
>64	4.0 (3.83–4.19)	5.1 (4.83–5.44)	1.5 (1.40–1.53)
Race/ethnicity			
Caucasian	1.0	1.0	1.0
African-American	0.7 (0.62–0.76)	0.9 (0.81–1.03)	0.8 (0.76–0.93)
Hispanic	0.5 (0.50–0.60)	0.7 (0.67–0.82)	0.7 (0.66–0.77)
Asian	0.7 (0.66–0.78)	0.8 (0.72–0.90)	0.8 (0.72–0.86)
Other/race not specified	0.9 (0.79–0.96)	1.0 (0.85–1.07)	1.0 (0.91–1.09)
BMI (kg/m^2)			
15.0–19.9	1.0	1.0	1.0
20.0–24.9	0.9 (0.90–1.00)	1.0 (0.92–1.05)	0.9 (0.87–0.96)
25.0–29.9	0.8 (0.71–0.80)	0.8 (0.70–0.81)	0.8 (0.75–0.85)
30.0+	0.6 (0.56–0.64)	0.6 (0.53–0.63)	0.7 (0.64–0.73)
Age at menarche (12 or older *vs* younger)	1.0 (0.95–1.02)	1.0 (0.92–1.01)	1.0 (0.96–1.04)
Nulliparous (*vs* parous)	1.2 (1.16–1.24)	1.2 (1.19–1.30)	0.9 (0.90–0.97)
Age at first full-term pregnancy (among parous)			
<25	1.0	1.0	1.0
25–29	0.9 (0.83–0.91)	0.8 (0.79–0.87)	1.1 (1.01–1.10)
>29	0.8 (0.79–0.87)	0.8 (0.76–0.86)	1.2 (1.14–1.26)
Postmenopausal (*vs* pre/perimenopausal)	1.7 (1.60–1.77)	2.0 (1.84–2.10)	1.2 (1.17–1.30)
Estrogen use, among women age 45 years and older (ever *vs* never)	1.9 (1.81–1.95)	1.7 (1.59–1.75)	1.6 (1.49–1.62)
Progestin use, among women age 45 years and older (ever *vs* never)	1.6 (1.56–1.68)	1.6 (1.51–1.66)	1.4 (1.33–1.44)
Smoking			
Never	1.0	1.0	1.0
Former	1.2 (1.16–1.24)	1.3 (1.21–1.32)	1.0 (0.98–1.06)
Current	0.8 (0.74–0.85)	0.9 (0.81–0.97)	0.7 (0.65–0.76)
Alcohol (g/day)			1.0
Non-user	1.0	1.0	
<5.00 g	1.1 (1.06–1.16)	1.1 (1.06–1.19)	1.0 (0.93–1.03)
5.00–14.99 g	1.1 (1.03–1.12)	1.1 (1.05–1.17)	0.9 (0.90–0.98)
>15 g	1.0 (1.00–1.10)	1.2 (1.11–1.24)	0.8 (0.80–0.89)
Fruit (3+ servings per day *vs* 2 or fewer)	1.7 (1.59–1.76)	1.6 (1.50–1.69)	1.4 (1.30–1.45)
Vegetables (3+ servings per day *vs* 2 or fewer)	1.5 (1.41–1.56)	1.4 (1.35–1.54)	1.2 (1.13–1.27)
Moderate or strenuous physical activity (any *vs* none, per week)	1.6 (1.59–1.71)	1.7 (1.61–1.76)	1.1 (1.07–1.15)
Ever had a mammogram – women 40 years and over[a]	2.0 (1.80–2.15)	1.7 (1.52–1.89)	1.5 (1.33–1.59)
Ever had a breast exam by a health provider[a]	1.8 (1.62–2.04)	1.7 (1.45–1.93)	1.5 (1.37–1.73)
Ever had a PAP smear[b]	1.8 (1.57–2.03)	1.7 (1.43–1.96)	1.4 (1.25–1.61)
Family history of breast cancer	1.1 (1.01–1.11)	1.0 (0.98–1.10)	1.0 (0.92–1.02)

[a] Excludes women who reported a history of breast cancer.
[b] Excludes women who reported a history of cervical cancer.

supplements and multivitamins tended to resemble more closely the specific supplement only users compared to the multivitamin only users. The strongest findings indicated that specific supplement users of any type were more likely to engage in the typically healthy behaviors than were users of multivitamins only or non-users.

To our knowledge this is the first study to examine such a wide range of factors associated with different categories of supplement use. Of the studies that have looked at different categories of supplement use, most have been limited to a description of the prevalence of use and have not addressed the relation between supplementation and lifestyle or other factors. Conversely, the studies that have looked at various behavioral or lifestyle factors associated with supplement use have generally only studied two categories: any use *versus* none. As our findings suggest, both demographic and lifestyle characteristics may differ between groups of supplement users and, in particular, collapsing supplement use categories may obscure important differences between specific supplement users and multivitamin users.

There are four studies that have examined different patterns of supplement use in relation to other variables. Kato, *et al.* studied 486 middle-aged women who were part of the New York University Women's Health Study (NYUWHS) [14]. Their research showed that specific supplement users were more similar to non-users with respect to serum folate and homocysteine as well as dietary folate, leading them to compare multivitamin users to a collapsed category of specific supplement users and non-users in subsequent analyses. Their definition of specific supplement use differed from ours in that they considered women who used both a multivitamin and specific supplements to be multivitamin users. A study by Newman *et al.* examined patterns of supplement use in 435 women participating in the Women's Healthy Eating and Living (WHEL) Study who had a previous diagnosis of breast cancer [15]. The authors found that the factors predicting multivitamin use differed from those predicting use of a variety of specific supplements, each of which were considered separately. For example, multivitamin and mineral use was associated with only BMI, whereas vitamin C was associated with BMI, alcohol consumption, time since diagnosis, education, and age. Gray *et al.* assessed multivitamin and specific supplement use in a random sample of 3939 black elderly and white elderly from urban and rural areas of North Carolina [16]. These authors reported that specific supplement use was associated with being white, female, educated, and urban-born, but it was not clear if they were comparing specific supplement users to non-users or to both non-users and multivitamin users. Finally, Block *et al.* described age, ethnicity, education, and geographic differences between specific supplement users and multivitamin users using data from NHANES I. These authors found, as we did, that multivitamin supplement users more closely resembled non-users than did specific supplement users [10].

Our goal in presenting these results is to describe demographic and lifestyle patterns in different groups of supplement users. As in any epidemiologic study with a large number of subjects and multiple comparisons, the interpretation of what constitutes an important finding should not depend simply on whether the 95% confidence interval includes the null value. Rather, it is the magnitude of the association between supplement use and the other variables (and the precision of these estimates, as conveyed by the confidence intervals) that is the more relevant information. We did not adjust our results to account for the multiple comparisons, a fact which should be borne in mind when interpreting our findings. Although this study includes data on a large number of women, the results may be limited in generalizability to populations with similar characteristics (*i.e.* largely educated, white, California women). In addition, the women who are part of the CTS cohort represent only those who demonstrated an interest in participating in a longitudinal study on breast cancer and women's health; thus they may differ from women in the general population with respect to other factors (such as health-consciousness). Nonetheless, our results are similar to those found in the national NHANES I sample.

Vitamin and mineral supplements are an important source of micronutrients in the diet and should be measured to accurately assess total intake. However, since supplement use is associated with a range of other factors (*e.g.* a diet high in fruits and vegetables, increased physical activity, lower BMI) that may alter an individual's risk for disease in the same direction as supplement use, failure to control for these factors could lead to an overestimate of the effects of micronutrient intake on disease. Thus, when assessing hypotheses related to micronutrient intake, these potential confounding effects and biases need to be addressed in the design of the study, in the analysis, and in the interpretation of the data. Several statistical approaches have been proposed to address the issue of confounding by factors associated with supplement use, and each has its limitations. One method is to conduct stratified analyses, *i.e.* to analyze supplement users separately and compare the results in users to the results in non-users. If the results were similar, many would interpret this as evidence that there is no effect measure modification and would then combine the two groups in an "adjusted" estimate [8]. However, as discussed by Block *et al.* [5], this approach could lead to problems of interpretation if the results between supplement users and non-users were not similar. Another suggested approach is to control for variables in the analysis that are thought to be confounders of the relationship between micronutrient intake and disease by including them in the statistical models. Researchers are more likely to collect data on these variables when they have *a-priori* information regarding the likely confounders related to nutrient intake and the disease of interest. Numerous studies have identified factors that are possible confounders [7–10, 15, 17, 18], but the possibility that an important confounding variable may go unmeasured still exists. In addition, including a large number of covariates in the model may reduce the statistical power to detect an association, even if one exists. To address this problem some researchers have limited their analyses of micronutrient intake and disease risk to an assessment of a dose–response effect among supplement users only [19].

This approach may reduce or eliminate the effect of confounding by extraneous factors, but it also limits the generalizability of the results to the subpopulation who use vitamin or mineral supplements.

In summary, we have identified many correlates of multivitamin and specific supplement use in our cohort study population. By identifying these correlates we have also identified a number of variables that may lead to confounding in analyses of the effect of micronutrient intake on disease risk.

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