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Association of Dietary Supplement Use with Specific Micronutrient Intakes among Middle-Aged American Men and Women: The INTERMAP Study

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ABSTRACT

Objective To assess dietary supplement use and its association with micronutrient intakes and adequacy among 2,195 US men and women aged 40 to 59 years from eight diverse population samples surveyed by the International Population Study on Macronutrients and Blood Pressure. **Design** Four 24-hour dietary recalls were collected, including information on dietary supplements. The Nutrition Data System (NDS) was used for nutrient analyses. Supplements not in NDS were classified separately (non-NDS). Intake of non-NDS supplements was documented. Participants were classified as not supplement users and supplement users, subclassified—due to concerns about nutritional value—as users of NDS supplements only (mostly vitamins and minerals) and users of non-NDS supplements (eg, botanicals, animal products, and enzymes). To assess effects of supplement use on micronu-

trient intake and adequacy, mean intakes from supplements, foods, and foods plus supplements were compared with Dietary Reference Intakes.

Participants Two thousand one hundred ninety-five US participants; 1,136 used supplements.

Statistical analyses χ^2 tests, multivariate logistic regression, and means were used to assess differences in and factors related to supplement use and to determine dietary adequacy.

Results Supplement use was more common among women, older participants, more educated participants, and Asian Americans. Body mass index and current cigarette smoking were significantly and inversely associated with supplement use; past smoking and education were significantly and positively associated with supplement use. Intake from foods plus supplements was considerably higher than from foods alone for vitamins A, C, and E; niacin; folate; and iron.

Conclusions Supplement use is common among middle-aged Americans and sizably increases daily intakes of several micronutrients. These data underscore the importance of dietary supplement assessment.

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Approximately 40% of Americans consume dietary supplements (1). Reports from the Third National Health and Nutrition Examination Survey indicate that supplement users are more likely to be children between the ages of 1 and 5 years and middle-aged and older adults (2). From 1994 to 2000, sales of supplements grew by 80% to an estimated \$15.7 billion (3). Most studies on dietary supplements have focused on populations from specific geographic areas or used instruments with predetermined lists of supplements, thereby limiting scope of supplement intake assessment (4-8). National nutrition monitoring surveys, like the Continuing Survey of Food Intakes by Individuals have been criticized for placing little emphasis on consumer use of dietary supplements (9).

Reasons for supplement use include a wish to decrease susceptibility to disease, improve personal health, and avoid dietary deficiencies (10,11). Although some studies found that people using supplements generally have high total intakes of vitamins and minerals compared to non-users of supplements, this has not been reported consistently (12-14).

It is also unclear what the patterns of supplement intake are by age, sex, ethnicity, socioeconomic status, lifestyle traits, and biomedical traits (eg, smoking, body mass index [BMI], and blood pressure). Although national surveys have documented supplement use among some minority groups, others have not been represented.

With Dietary Reference Intakes (DRIs) now established for many nutrients, nutritional adequacy is being viewed in a fresh light (15). The DRIs define not only Adequate Intake (AI) levels but also Estimated Average Requirements (EARs), Recommended Dietary Allowances, and Upper Limits (ULs) for many nutrients, maximum daily intakes deemed safe (unlikely to increase risk of adverse effects) (16-20). Little information is available about the relations between dietary supplement use and nutrient intake and adequacy/excess in middle-aged US adults. Also, little information is available on intake of the wide range of supplements of varying nutritional merit being purchased and ingested by Americans.

This report uses data from the International Population Study on Macronutrients and Blood Pressure (INTERMAP) to focus on two issues: use of vitamin-mineral and other supplements by middle-aged US men and women aged 40 to 59 years of diverse ethnic, socioeconomic, geographic, lifestyle, and biomedical backgrounds from eight population samples nationwide, and the influence of supplement use on total intakes and adequacy/excess.

METHODS

INTERMAP is an international, cross-sectional epidemiologic study of 4,680 men and women aged 40 to 59 years from 17 diverse population samples surveyed in 1997 to 1999 in Japan, the People's Republic of China, the United Kingdom, and the United States (about 275 persons per sample) (21). The general aim is to clarify influences of multiple nutrients on blood pressure over and above established effects of sodium, potassium, alcohol, and BMI (21). Four in-depth, 24-hour dietary recalls were completed during a 3- to 6-week period, with collection of detailed data on all foods, beverages, and dietary supplements consumed (22). All procedures were conducted in accordance with INTERMAP protocols approved by the institutional review boards at each center and informed signed consents were received from all participants. This report focuses on dietary supplement intake among US participants. In the United States there were 2,195 participants (1,102 men and 1,093 women) from eight samples diverse in location, ethnicity, and socioeconomic status.

All dietary supplement data were obtained during dietary data collection. During the 24-hour dietary recall, all reported foods/beverages and selected supplements (mostly vitamins and minerals) were directly computerized by the interviewer using the Nutrition Data System (NDS) (version 29, 1996, Nutrition Coordinating Center, University of Minnesota, Minneapolis). Intake by each participant of 104 nutrients from foods/beverages was

computed (22). Of the four 24-hour dietary recalls, two were done on consecutive days and then another two on consecutive days approximately 3 weeks later (window of 2 to 6 weeks). One recall day was designed to be immediately after the weekend or a day off to assess any possible variation in diet during days off. All recalls were collected in a standardized way by centrally trained and certified local interviewers, supervised by centrally trained and certified site nutritionists, the country nutritionist, and the international nutrition coordinator. Details on quality control of dietary data collection are published elsewhere (22). Briefly, at each visit the interviewer asked the participant if he/she had taken any vitamins, minerals, tonics, or supplements. Supplements encompassed vitamin/mineral and other products purchased over the counter. If the reply was affirmative, a dietary supplement form was completed. The participant was also asked to bring to the next clinic visit all vitamin, mineral, and other supplements he/she was currently taking. For each dietary supplement, name, description, amount, and frequency of use were recorded for that day. After collecting the information, the interviewer reviewed with the participant each supplement reported, confirming name, unit, and dosage. In the United States, the interviewer then checked to see if the supplement was listed in NDS. If it was, this was noted on the form and the information was entered in the computer. If there was a supplement not in NDS, this was detailed on the form. A separate supplement ingredient form was completed for each supplement not in NDS, documenting its ingredients and dosage from the product label.

In NDS version 29 there were 60 nutrient codes for supplements encompassing specified quantities of mostly vitamins and minerals generally recognized as important nutritionally and meriting ingestion as supplements. For non-NDS dietary supplements, a separate computerized database was developed with all information from product labels entered on the supplement ingredient form. Non-NDS-listed supplements were often made up of materials of uncertain merit (herbals/botanicals, animal products, phospholipids, enzymes, as well as minerals and vitamins) were detailed in computer entries. Often for these supplements, no information was obtainable on ingredients and/or their amounts; this fact was also entered into the computer. Thus, comprehensive collection and computerization of both NDS and non-NDS supplements yielded detailed information on all supplements reported by participants during all four dietary recalls. For purposes of quality control, all data (100%) from supplement ingredient forms were reentered and checked. All revisions were documented. An additional, randomly selected 20% were reentered for a second time as a double check.

For analyses, participants were first dichotomized by use or nonuse of any supplement. Users were divided into users of NDS-listed supplements only and users of non-NDS-listed supplements (without or with concomitant use of NDS-listed supplements). NDS-listed supplements were composed almost exclusively of vitamins and minerals of known amounts.

χ^2 analyses were performed to assess differences in supplement use by sex, age, education, ethnicity, and sample. Logistic regression was also done adjusted for

Table 1. Demographic characteristics and supplement use by International Population Study on Macronutrients and Blood Pressure US participants (N=2,195)

Characteristic	No supplement	Any dietary supplement	NDS ^a -listed supplement only	Non-NDS-listed supplement	P value ^b
	←————— % —————→				
Sex					
Male	53	46	23	23	<.001
Female	43	56	34	22	
Age (y)					
40-49	52	48	24	23	<.001
50-59	44	56	34	22	
Education (y)					
<12	69	31	21	10	<.001
12	54	46	28	19	
13-15	47	53	31	22	
16	47	53	28	24	
>16	42	58	30	28	
Ethnicity					
African American	59	41	27	14	<.001
Asian American	37	63	31	32	
All Hispanic American	57	43	22	21	
Hispanic white American	52	48	25	23	
Hispanic African American	61	39	19	20	
Non-Hispanic white American	46	54	31	23	
Other American	55	45	23	22	
Sample					
Baltimore, MD	56	44	31	13	<.001
Chicago, IL	43	57	30	27	
Corpus Christi, TX (Hispanic American)	58	42	22	20	
Corpus Christi, TX (Non-Hispanic American)	44	56	21	35	
Honolulu, HI	33	67	31	36	
Jackson, MS	55	45	26	19	
Minneapolis, MN	47	53	39	14	
Pittsburgh, PA	51	49	34	15	

^aNDS=Nutrition Data System.

^bNo supplement use vs only supplement use.

age, sex, education, and sample to assess lifestyle and biomedical factors related to any, NDS-only, and non-NDS supplement use. To assess dietary adequacy, mean daily intakes from foods, supplements, and foods plus supplements for multiple nutrients were calculated for users and nonusers of supplements and compared with DRIs. Of the new DRI categories, EARs were used here for all micronutrients except calcium, for which only AIs are available (17,18).

The number of supplement users who reached ULs for selected micronutrients was also calculated using SAS version 8.0 (1999, SAS Institute, Inc, Cary, NC) for all analyses.

RESULTS

Of all 2,195 US INTERMAP participants, 1,136 (52%) reported use of dietary supplements; 640 (29%) used NDS-listed supplements only, 496 (23%) non-NDS-listed supplements. The latter encompassed 920 products with 1,009 specified ingredients; among these there were 294 brand-name products with unknown ingredients or

amounts. Some of these products were proprietary formulas with listed ingredients but no amounts; proprietary blends stating only "proprietary protein blend" or "proprietary blend," without ingredients; supplements with no amounts for some ingredients; supplements with ingredients but no specific amounts per serving size; supplements with unit amounts that were uninterpretable (eg, 6×8%); and supplements that just stated serving size as "one dose" without amounts. Some of the most frequently ingested herbal/botanical/other supplements included ginkgo biloba, ginseng, bioflavonoids, and phospholipids.

Relation of Demographic Characteristics to Supplement Use

There were significant differences in supplement use by sex, age, education, ethnicity, and sample ($P<.001$) for any dietary supplement use, NDS-listed dietary supplements only, and non-NDS-listed supplements (Table 1). More women than men used supplements (56% vs 46%). In the 50- to 59-year age group, 56% used supplements; 48% in the 40- to 49-year age group used supplements. Of

Table 2. Factors related to supplement use: Comparison of no supplement use with any supplement use with Nutrition Data System (NDS)-only supplement use and non-NDS supplement use among participants in the International Population Study on Macronutrients and Blood Pressure^a

Variable	Factors Related to any Supplement Use			Factors Related to NDS-only Supplement Use			Factors Related to non-NDS Supplement Use		
	OR ^b	95% CI ^c	P value	OR	95% CI	P value	OR	95% CI	P value
Body mass index ^d	0.87	(0.80-0.95)	.0027	1.06	(0.96-1.17)	.2670	1.14	(1.02-1.28)	.0183
Special diet (yes/no)	1.32	(1.05-1.66)	.0163	0.96	(0.75-1.23)	.7493	0.72	(0.55-0.93)	.0133
Current smoker (yes/no)	0.63	(0.49-0.80)	.0001	1.27	(0.96-1.67)	.0922	1.58	(1.15-2.16)	.0045
Exsmoker (yes/no)	1.47	(1.21-1.78)	<.0001	0.78	(0.63-0.95)	.1510	0.79	(0.63-0.98)	.0347
Current drinker (yes/no)	1.16	(0.96-1.41)	.1286	0.81	(0.66-1.01)	.0588	1.03	(0.82-1.30)	.8057
Exdrinker (yes/no)	1.02	(0.82-1.27)	.8763	1.19	(0.93-1.53)	.1611	0.79	(0.61-1.03)	.0774
Disease diagnosis (yes/no)	1.11	(0.93-1.33)	.2553	0.77	(0.63-0.93)	.0079	1.19	(0.96-1.48)	.1087
High blood pressure/CVD ^e treatment (yes/no)	1.25	(1.01-1.54)	.0378	0.64	(0.15-0.80)	.0001	1.30	(1.00-1.68)	.0472
Diabetes (yes/no)	1.32	(0.96-1.82)	.0915	1.01	(0.71-1.43)	.9724	0.61	(0.39-0.96)	.0305
High blood pressure (yes/no)	0.89	(0.73-1.07)	.2028	1.38	(1.12-1.69)	.0021	0.81	(0.64-1.01)	.0629
Heart disease (yes/no)	0.81	(0.56-1.16)	.2532	1.52	(1.04-2.20)	.0294	0.79	(0.50-1.24)	.3038
Stroke (yes/no)	1.12	(0.56-2.25)	.7568	1.12	(0.53-2.36)	.7756	0.72	(0.29-1.79)	.4740

^aAll models were adjusted for age, sex, education, and sample.

^bOR=odds ratio.

^cCI=confidence interval.

^dCalculated as kg/m².

^eCVD=cardiovascular disease.

men, 23% reported consuming NDS-listed supplements only, 23% reported use of non-NDS-listed supplements; of women, 34% reported using NDS-listed supplements only, 22% reported use of non-NDS supplements. Similar patterns of NDS only and non-NDS-supplement use were observed by age.

Asian Americans, primarily East Asians (282 of 318, mainly from the Japanese-American sample in Honolulu, HI) were the most frequent users of supplements (63%); Hispanic African Americans were the least frequent (39%) (Table 1). Use of NDS-listed supplements only ranged from 31% (Asian Americans and non-Hispanic white Americans) to 19% (Hispanic African Americans); use of non-NDS-listed supplements, from 32% (Asian Americans) to 14% (African Americans).

Use of supplements varied considerably across the eight samples (Table 1). The Honolulu, HI, sample of Japanese Americans reported the highest supplement use (67%); the Corpus Christi Hispanic-American sample reported the lowest (42%). Minneapolis, MN, participants were the highest users of NDS-listed supplements only (39%); Corpus-Christi non-Hispanic Americans were the lowest (21%). Honolulu, HI, participants were the highest users of non-NDS-listed supplements (36%); Baltimore, MD, the lowest (13%).

Relation of Lifestyle and Biomedical Traits, Disease Diagnoses, and Treatment Status to Supplement Use

In multiple logistic analyses controlled for age, sex, education, and sample, former smoking (compared to never smoking) was associated positively and significantly with any, NDS-only, and non-NDS supplement use, whereas the relationship of current smoking (vs nonsmoking) status was significantly inverse (Table 2).

Overweight/obesity was associated with less frequent supplement use (Table 2). BMI was also inversely related to NDS-only and non-NDS supplement use (Table 2). Persons reporting consumption of a special diet were more likely to use supplements than others. Current drinkers (vs nondrinkers) tended to be more frequent supplement users, especially of NDS-listed supplements.

Persons with diagnosed diabetes or receiving antihypertensive drug treatment were more frequent consumers of supplements (Table 2). In contrast, among those with diagnosed heart disease or high blood pressure, there was an inverse association with NDS-only supplement use.

Vitamin Intakes from Foods, Supplements, and Foods Plus Supplements

The most commonly consumed vitamins from supplements were vitamins C, E, B-6, and B-12. For vitamins A and C, and niacin, average intakes from foods only exceeded EARs, but not for vitamin E and folate (Table 3). Dietary intakes of vitamins from foods were on average higher among supplement users than nonusers for vitamin C and folate. Vitamins A, C, and E; niacin; and folate intakes were substantially higher from foods plus supplements than from foods alone (eg, total folate intake for female supplement users was 591 µg/day, whereas from foods alone it was 269 µg/day). Total intakes of vitamins among supplement users on average were considerably above 100% of EARs, whereas for nonusers they were below the EARs for vitamin E and folate. For supplement users of vitamins A, C, and E and niacin, total intakes were several-fold greater than the EARs.

Table 3. Vitamin and mineral intake per day of selected nutrients from foods, supplements, and foods plus supplements among users and nonusers of supplements among US participants in the International Population Study on Macronutrients and Blood Pressure

			Foods Only		Supplements Only		Foods+Supplements		% EAR ^a and AI ^b (Foods+Supplements)	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
<i>mean ± standard deviation</i>										
Vitamin A ($\mu\text{g/d}$)^c										
Users	350	409	1,309±845	1,182±831	1,570±1,366	1,374±1,286	2,879±1,670	2,556±1,524	461±267	511±305
Nonusers	753	683	1,121±879	1,000±791	0	0	1,121±879	1,000±791	179±141	200±158
Vitamin C (mg/d)^d										
Users	430	484	134±84	108±65	489±853	412±589	623±866	520±596	831±1,154	867±993
Nonusers	673	608	113±85	93±65	0	0	113±85	93±65	151±113	155±108
Vitamin E (mg/d)^e										
Users	416	481	11±5	9±4	148±190	150±196	159±189	158±196	1,325±1,575	1,317±1,633
Nonusers	687	611	11±5	9±5	0	0	11±5	9±5	92±42	75±42
Niacin (mg/d)^f										
Users	365	422	30±9	21±6	41±83	37±86	71±83	59±86	592±692	536±782
Nonusers	738	670	29±9	21±6	0	0	29±9	21±6	242±75	191±55
Folacin ($\mu\text{g/d}$)^g										
Users	372	416	339±129	269±106	342±313	322±203	681±334	591±240	213±104	185±75
Nonusers	731	676	318±140	247±109	0	0	318±140	247±109	99±44	77±34
Phosphorous (mg/d)^h										
Users	277	293	1,537±479	1,130±317	98±149	82±94	1,634±503	1,212±332	282±87	209±57
Nonusers	826	799	1,472±444	1,090±332	0	0	1,472±444	1,090±332	254±77	188±57
Zinc (mg/d)ⁱ										
Users	349	390	14±6	10±3	16±16	14±12	30±17	24±13	319±181	353±191
Nonusers	754	702	14±6	10±4	0	0	14±6	10±4	149±64	147±59
Selenium ($\mu\text{g/d}$)^j										
Users	306	324	165±128	110±33	39±62	33±46	203±141	143±57	451±313	318±127
Nonusers	797	768	149±47	109±38	0	0	149±47	109±38	331±104	242±84
Magnesium (mg/d)^k										
Users	322	367	389±116	288±84	126±164	131±153	515±213	419±182	147±61	158±69
Nonusers	781	725	353±114	265±87	0	0	353±114	265±87	101±33	100±33
Calcium (mg/d)^l (age ≤50)										
Users	192	245	972±473	749±320	268±362	414±459	1,240±572	1,163±609	124±57	116±61
Nonusers	445	380	860±377	670±308	0	0	860±377	670±308	86±38	67±31
Calcium (mg/d)^l (age >50)										
Users	160	231	849±369	740±324	285±293	532±500	1,134±453	1,272±588	95±38	106±49
Nonusers	306	236	876±399	655±289	0	0	876±399	655±289	73±33	55±24
Iron (mg/d)^m (age ≤50)										
Users	172	200	21±9	15±6	16±40	29±87	37±42	44±87	617±700	543±1,074
Nonusers	465	425	19±8	14±5	0	0	19±8	14±5	317±133	173±62

(continued)

	Foods Only		Supplements Only		Foods+Supplements		% EAR^a and AI^b (Foods+Supplements)	
	Men	Women	Men	Women	Men	Women	Men	Women
Iron (mg/d)^m (age >50)					← mean± standard deviation →			
Users	136	181	19±7	15±5	15±20	19±32	34±21	567±350
Nonusers	330	286	19±8	14±5	0	0	19±8	317±133
								680±640 280±100

EAR/AI (Ages 31-50 and 51-70);
^aEAR=Estimated Average Requirement. EAR values used for all nutrients except calcium.
^bAI=Adequate Intake. AI values used for calcium.
^cEAR for men=625 µg/d, for women=500 µg/d.
^dEAR for men=75 mg/d, for women=60 mg/d.
^eEAR for men and women=12 mg/d, total α-tocopherol equivalents.
^fEAR for men=12 mg/d, for women=11 mg/d.
^gEAR for men and women=320 µg/d.
^hEAR for men and women=580 mg/d.
ⁱEAR for men=9.4 mg/d, for women=6.8 mg/d.
^jEAR for men and women=45 µg/d.
^kEAR for men=350 mg/d, for women=265 mg/d.
^lAI for men and women aged 31-50 y=1,000 mg/d, and for men and women aged 51-70 y=1,200 mg/d.
^mEAR for men aged 31-70 y=6.0 mg/d, and for women aged 31-50 y=8.1 mg/d and aged 51-70 y=5.0 mg/d.

Nutrients and level exceeding UL	Men (n)	Women (n)	Total (n)
Folacin ($\geq 1,000 \mu\text{g/d}$)	8	6	14
Vitamin E ($\geq 1,000 \text{ mg/d}$)	3	3	6
Magnesium ($\geq 350 \text{ mg/d}$)	21	32	53
Zinc ($\geq 40 \text{ mg/d}$)	24	10	34
Selenium ($\geq 400 \mu\text{g/d}$)	3	0	3
Calcium ($\geq 2,500 \text{ mg/d}$)	1	3	4
Niacin ($\geq 35 \text{ mg/d}$)	105	97	202
Vitamin C ($\geq 2,000 \text{ mg/d}$)	14	15	29

The most commonly consumed mineral from supplements was calcium (Table 3). For five (of the six) minerals (ie, phosphorus, iron, magnesium, selenium, and zinc) studied, average intake from food alone was as high or higher than the EARs, but average intake of calcium was less than the AI. Mean phosphorus and magnesium intakes from food were higher among users than nonusers of supplements. Among dietary supplement users, intakes of phosphorus, iron, magnesium, selenium, and zinc from foods plus supplements exceeded 100% of the EARs, but for calcium for older supplement users total intake was below AI.

A total of 202 participants had intakes of niacin from supplements that exceeded the UL (Table 4). Niacin was the nutrient with the largest number of participants who consumed amounts greater than or equal to the UL. For 53, 34, and 29 participants, magnesium, zinc, and vitamin C ULs, respectively, were also reached or exceeded.

In the US INTERMAP study of middle-aged men and women, approximately half of US participants used supplements, of whom approximately half used non-NDS-listed supplements. Percentage of users varied by sex, age, ethnicity, years of education, geographic location, lifestyle characteristics, and health status. Women, older adults, Asian Americans, those with higher education, and former cigarette smokers were more likely to use supplements. There was a wide range in percentage users by ethnicity, and by population sample. Substantiating reports on increasing use of botanicals and other alternative supplements in the United States, sizeable proportions of INTERMAP participants used non-NDS supplements, 23% overall. Supplement users had mean total intakes—from foods plus supplements—of selenium, zinc, phosphorus, magnesium, vitamins C and E, niacin, and folate >100% of the EARs. For supplements such as vitamins E and C, supplement users had intakes from foods plus supplements that were >700% of the EARs.

Some participants had intakes of nutrients from supplements alone that exceeded the ULs of safe intake.

Some demographic patterns of supplement use observed in INTERMAP were similar to those of other studies; notably, by sex, age, and education (11,23-26). Unlike other studies, we found that Asian Americans (mostly Japanese migrants to Hawaii) were the ethnic group with the greatest percentage of supplement use. In the third National Health and Nutrition Examination Survey, this proportion was highest for non-Hispanic white Americans compared with minority groups; Asian Americans were not identified as a separate ethnic group (1). In the Vitamins and Lifestyle Study (23) investigation of vitamin and mineral use, white people were the highest percent users among adults aged 50 to 75 years in western Washington, Asians the lowest. In apparent contrast to our finding. In the Vitamins and Lifestyle Study, Asian participants were from western Washington State; in our study, Asian participants were predominantly Japanese-Americans from Hawaii. Like INTERMAP, the Multiethnic Cohort Study reported that Asian Americans mainly of Japanese ancestry were the highest proportion of supplement users compared to African Americans, native Hawaiians, and Latinos (26).

Findings for some of the lifestyle factors, like smoking, were consistent with those of other studies. Current cigarette smokers reported less supplement use, reflecting commonality of their poorer health behaviors (5,26).

Although supplement use can enhance micronutrient intake, some participants were consuming amounts that were excessive when compared with dietary requirements.

Some studies report that supplement use is more common among those who classify themselves as being "healthy" than "not healthy" (8,27). We found a positive, nonsignificant association between any supplement use and presence of diabetes or stroke. The Beaver Dam Study (5) reported that middle-aged men with a history of heart disease were more likely to use a supplement than those without this history. The Vitamins and Lifestyle Study also found a higher proportion of respondents with medical conditions to be users of dietary supplements. In a review on use of dietary supplements, Halsted (28) comments that those with intractable chronic and fatal diseases tend to turn to herbal supplements more often than other patient groups. In the INTERMAP study, we did not collect information on factors motivating supplement use. The Vitamins and Lifestyle Study results reported that supplement consumers may be motivated to self-treatment (23).

More people diagnosed with a disease or using prescription medication for hypertension/cardiovascular disease used NDS-listed supplements only than non-NDS-listed supplements. There are reports from several studies assessing intakes of specific supplements in relation to disease diagnosis (eg, antioxidants, folate, calcium, or vita-

min D) (26,29,30). People with a disease condition may be more likely to take a supplement with a research record than a herbal/botanical/nontraditional supplement with an uncertain or unknown influence on health (31).

It has been stated that supplementation with a formulation that is close to 100% Daily Value can reduce prevalence of suboptimal micronutrient status, particularly among older adults (31). However, if nutrient intake is already adequate, then it is questionable whether supplement use improves micronutrient profile (32). The contribution of foods to micronutrient adequacy varies from one nutrient to another. In INTERMAP, we observed that intakes from foods only for some nutrients, especially among women, did not meet 100% of the EAR (eg, folate and vitamin E). Supplement use substantially increased amounts of these nutrients. For vitamin E, supplement use increased intake greatly (eg, intake from food alone among supplement users was 75% to 100% of the EARs and from supplements alone was >1,000% of the EAR).

Many participants in our study met 100% of the DRIs for some nutrients from food consumption alone. For phosphorus, niacin, and vitamin C, food alone provided an adequate intake meeting the EAR. Among such participants, benefit of supplement intake is undetermined. These data also confirm that meeting the DRIs by diet alone is possible.

Although supplement use can enhance micronutrient intake, some participants were consuming amounts that were excessive when compared with dietary requirements. Similar to results reported by Troppmann and colleagues (15) and Dwyer and colleagues (13), we identified almost 202 participants with niacin intakes ≥ 35 mg/day. The consistent reports of high niacin intake from supplements may reflect prescription of large doses of this supplement for lipid lowering (33). There were a few other participants with intakes of other supplements that were greater than or equal to ULs, indicating possible adverse effects on health, including intakes of vitamin E $\geq 1,000$ mg/day, calcium $\geq 2,500$ mg/day, and magnesium ≥ 350 mg/day. ULs are set to relate to total intake from food and supplements. Megadosing of certain micronutrients from supplements alone is apparently occurring and merits attention.

One of the strengths of our study is the extensive data on non-NDS supplement use (ie, intake of supplements of questionable or unknown values). The INTERMAP level of non-NDS supplement use was higher than that reported by the Slone Survey of Americans, where 14% of the population took a herbal supplement in the preceding week (25). There are few reports about intakes of herbal/botanical supplements and health conditions (25,34).

One of the criticisms of dietary supplement data based on a single 24-hour recall is that micronutrient intake may be underestimated due to variations in supplement intake and due to recall errors. In INTERMAP we used four 24-hour recalls, thereby reducing this error.

Results from the INTERMAP study show that high proportions of middle-aged Americans from population samples across the country used dietary supplements in the late 1990s. These proportions varied by age, sex, ethnicity, education, geographic region, BMI, smoking habits, and medical status, as did types and amounts of supplements used. Supplement use sizably increased di-

etary intakes of some micronutrients (eg, vitamins C and E), where amounts from supplements were several-fold greater than from foods. Sizeable proportions of these Americans—almost one quarter overall—reported use of supplements containing nonvitamin and nonmineral materials, sometimes not identifiable or quantifiable (ie, supplements of questionable value). Health care providers need to discuss dietary supplement use with patients, and vice versa. Our data underscore the importance of assessing dietary supplement use in diet-related research. These data also underscore the importance of increased attention by medical care and public health to amounts, types, and merits/problems of supplement use by the US population.

CONCLUSIONS

Dietetics and other health care professionals, including nutrition researchers, need to assess intakes of supplements, and use the findings in their work for public policy enhancement. Also, because use of dietary supplements can change nutrient intake dramatically, it is important that dietetics professionals assess dietary supplement intake.

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