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Original Contribution

Trends in Dietary Supplement Use in a Cohort of Postmenopausal Women From Iowa

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Although it is widely known that use of dietary supplements is common in the United States, little is known about use patterns among older Americans. The authors examined trends in dietary supplement use and its contribution to total nutrient intake in the Iowa Women's Health Study cohort in 1986 (baseline) and 2004 (follow-up). The proportion of women who reported using dietary supplements increased substantially between baseline (66%) and follow-up (85%). Moreover, a substantial proportion of women reported using multiple dietary supplements, with 27% using 4 or more products in 2004. Dietary supplements contributed substantially to total intake of many nutrients at baseline, and their contribution became relatively greater at follow-up for most nutrients examined. For most nutrients, no decline in intake was observed, as might have been expected in an aging cohort. Rather, intake of many nutrients increased, primarily because of the rising use of dietary supplements. Use of dietary supplements by older individuals is of particular importance because of the potential benefits of maintaining nutrient intake levels despite potentially declining food intake. However, possible risks from obtaining a large proportion of purified nutrients from dietary supplements rather than deriving them from foods should be studied.

aged; dietary supplements; women

The prevalence of dietary supplement use has been increasing over the past several decades (1–3), with recent national survey data indicating that approximately one-half of US adults take one or more dietary supplements (3). Interestingly, the use of dietary supplements is higher among older compared with younger Americans (3, 4). For example, in 1999–2000, 63.3% of US adults 60 years of age or older reported using a dietary supplement compared with 43.3% of those 20–39 years of age (3).

The use of dietary supplements by older individuals is of interest because of the potential benefits as well as risks associated with these products among this population subgroup. On the benefits side, vitamin- and mineral-containing dietary supplements may be useful in countering age-related declines in food and nutrient intake that have historically been of concern because of decreased appetite, chronic illness, and poor quality of living conditions (e.g., low income, mobility problems) (5, 6). Also, dietary supplements may be useful in maintaining adequate nutriture regarding nutrients for which decreased absorption is associated with age (3, 7). For example, because 5%–20% of older people are unable to absorb naturally occurring vitamin B_{12}, use of a vitamin B_{12} supplement or intake of vitamin B_{12}-fortified foods is recommended for those older than 50 years of age (8). However, there are potential concerns with use of dietary supplements, including toxicity by overdosage, drug interactions, bioavailability/bioequivalence, adverse effects (e.g., gastrointestinal problems, nausea, and vomiting) (9–11), and chronic disease risk in subgroups of the population (12–14). For example, in the Alpha Tocopherol, Beta-Carotene Cancer Prevention trial, male smokers who took a beta-carotene supplement alone or in combination with vitamin E or vitamin A had higher incidence rates of lung cancers and overall mortality in comparison to men in the control arm of the trial (15).

At this time, the contribution of dietary supplements to nutritional adequacy among older adults is unclear. Likewise, the extent to which dietary supplements may be contributing to overconsumption of nutrients is not well understood. Although a number of studies have reported the prevalence of use of dietary supplements among older Americans (3, 16), only one study has been known to

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quantify the contribution of dietary supplements to total nutrient intake (16). This study utilized survey data collected more than a decade ago (1994–1996) and did not gather brand name and formulation information for supplements reported by participants. Consequently, composition information had to be imputed by the investigators.

To provide current data, we analyzed information on food intake and dietary supplement use collected from a cohort of women who were 55–69 years of age in 1986 (baseline measure) and 73–87 years of age in 2004 (follow-up measure). Using these data, we examined the contribution of supplement use to total nutrient intake and trends in nutrient intake over a nutritionally vulnerable life-stage period.

MATERIALS AND METHODS

Subjects

The Iowa Women's Health Study is a prospective cohort study of cancer incidence in a sample of Iowa women. The study has been described in detail elsewhere (17). Briefly, it started in January 1986 with a sample of 99,826 free-living women aged 55–69 years residing in Iowa. Study subjects were randomly selected from among those who had a valid Iowa driver's license and were mailed a questionnaire, which included questions about sociodemographics, body measurements, physical activity level, smoking and alcohol consumption, gynecologic history, and dietary intake and supplement use. Approximately 42% ($n = 41{,}836$) of women completed the baseline questionnaire. A comparison of baseline respondents with nonrespondents showed that respondents were slightly younger and were more likely to live in rural areas (17). Respondents were predominately white (99%), with most having completed high school or a greater level of education (87%). The average age of participants at baseline was 62 years.

In 2004, dietary intake and supplement use were reassessed by using a food frequency questionnaire nearly identical to the instrument used at baseline. Of the 41,836 participants who completed the baseline survey, 30,232 were believed to be alive in 2004 and were mailed a follow-up questionnaire. Of those mailed a follow-up questionnaire, 20,844 (68.9%) returned a completed follow-up survey. Those who returned a completed survey were slightly younger and had more education, but there were no differences in dietary supplement intake patterns between follow-up responders and nonresponders (data not shown).

Dietary information

At baseline, a 127-food-item Harvard food frequency questionnaire was used to assess women's usual food and nutrient intake (18). The food frequency questionnaire included a series of questions to assess use of dietary supplements. It asked participants to report whether they used a multivitamin; if they responded affirmatively, they were asked to record the product name and brand. This information was used to calculate nutrient intake estimates based on product-specific formulations. In addition, participants were asked whether they used any of the following individual vitamin and mineral supplements: vitamin A, vitamin C, vitamin D, vitamin E, selenium, iron, zinc, and calcium. For each of these vitamins and minerals, participants were asked to report the dose by checking one of 5 response options. For example, the response options provided for zinc were less than 25 mg, 25–74 mg, 75–100 mg, 101 mg or more, and don't know (a default dose was assigned). Participants were also asked whether they took other supplements on a regular basis, with the following response options provided: folic acid, vitamin B_6, B-complex vitamins, chromium, copper, magnesium, iodine, lecithin, rutin, and beta-carotene. Dose was not queried for these products, with a default dose assigned for each. Herbal product use was not assessed.

The 2004 follow-up survey included a food frequency questionnaire nearly identical to that used at baseline. Regarding the food items on the questionnaire, the follow-up food frequency questionnaire differed from the baseline questionnaire in the following ways: 1) mushrooms and green or chili peppers were included in the baseline questionnaire but not the follow-up questionnaire; and 2) carrots were included as a single item—carrots (1 whole or ½ cup cooked (1 cup = 240 g))—on the baseline questionnaire but as 2 separate items—carrots, raw (½ carrot or 2–4 sticks); carrots, cooked (½ cup)—on the follow-up questionnaire. With regard to the supplement-use portion of the questionnaire, the follow-up food frequency questionnaire differed from the baseline questionnaire in the following ways: 1) vitamin D use was queried as part of the "other supplement" question, so dose information was not queried in the follow-up questionnaire; 2) dose information was collected for vitamin B_6 on the follow-up but not the baseline food frequency questionnaire, where it was assessed with the "other supplement" question; 3) use of cod liver oil, omega-3 fatty acids, brewer's yeast, and "other" supplements was queried in the follow-up but not the baseline survey; and 4) lecithin and rutin use were queried in the baseline but not the follow-up questionnaire. The nutrient composition information used for foods and supplements in the follow-up questionnaire was updated to reflect marketplace changes and updated nutrition composition information available from the US Department of Agriculture Nutrient Data Laboratory.

In a validation study with 194 female nurses, the food frequency questionnaire used in the present study was found to account for 93% of total energy intake (19). In a validation study in the Iowa population, the energy-adjusted correlations between total fat, saturated fat, and carbohydrate intake estimates derived from the food frequency questionnaire compared with the average of five 24-hour dietary recalls were 0.62, 0.59, and 0.45, respectively (18).

Although the dietary supplement component of the food frequency questionnaire used in the study has not been validated, evaluations have been conducted with similar instruments (20–22). Results from these validation studies indicate that nutrient estimates derived from this type of questionnaire are highly correlated with supplement use based on an inventory approach, where detailed information is collected about the products used and amounts taken

(20, 21), especially for frequently consumed products (such as multivitamins) (22). For example, in a validation study with 104 adult vitamin supplement users, the correlations between vitamin C, vitamin E, and calcium intake estimates derived from a supplement-use questionnaire such as ours and a detailed supplement inventory were 0.89, 0.84, and 0.76, respectively (20).

Inclusion and exclusion criteria

For the results reported herein, all analyses were restricted to those women who completed a food frequency questionnaire at both baseline and follow-up and met the following inclusion criteria: 1) left no more than 30 items blank on the food frequency questionnaire at baseline and follow-up; and 2) had plausible energy intake estimates at both baseline and follow-up (600–5,000 kcal/day). After these inclusion criteria were applied, data for 18,346 women were available for analyses.

Statistical analyses

T tests and McNemar's tests were used to test the null hypothesis of no difference in the levels of nutrient intake and in the prevalence of use of dietary supplements between baseline and follow-up. The demographic and health-related characteristics of supplement users and nonusers were compared by using the chi-square test. All analyses were conducted with SAS version 9.1 software (SAS Institute, Inc., Cary, North Carolina).

RESULTS

The average age of participants at baseline was 60.6 years (78.6 years at follow-up). At baseline (1986), 65.5% of the women reported using one or more dietary supplements. This proportion was greater at follow-up, with 85.4% reporting use of one or more dietary supplements in 2004. A substantial proportion of women in the cohort reported using multiple dietary supplements (Table 1). For example, at follow-up, 38.2% of the women reported using 2 or 3 dietary supplements and 26.9% reported using 4 or more supplements.

The types of dietary supplements reported to have been taken at baseline and follow-up are displayed in Table 2. To summarize, at both baseline and follow-up, the most commonly used products were multivitamins, calcium, and vitamin C.

To examine the contribution of dietary supplement use to nutrient intake, mean nutrient intake estimates from foods only, supplements only, and foods and supplements combined (total) were calculated for selected nutrients (Table 3). Results from these analyses indicate that dietary supplements contributed substantially to total intake of many nutrients at both baseline and follow-up. For example, mean vitamin C intake from foods only at baseline was 155 mg/day compared with 297 mg/day from foods and supplements combined.

In general, nutrient intake estimates from foods only were similar or changed only slightly between baseline and follow-up. In contrast, mean intake from supplements increased significantly between baseline and follow-up for most nutrients examined, resulting in a substantial increase in total intake estimates for many nutrients. For example, mean vitamin D intake from food decreased somewhat from

Table 1. Proportion of Women at Baseline (1986) and Follow-up (2004) Reporting Use of One or More Dietary Supplements, Iowa Women's Health Study ($n = 18,346$)

No. of Supplements Reported	Baseline (1986)		Follow-up (2004)	
	%	No.	%	No.
0	35.5	6,512	14.6	2,677
1	22.6	4,146	20.0	3,670
2–3	26.2	4,798	38.2	7,006
4–5	8.1	1,493	16.9	3,105
6–7	3.8	702	5.7	1,039
8–9	2.1	378	2.5	458
≥10	1.7	317	2.1	391

Table 2. Prevalence of Use of Multivitamin and Other Types of Dietary Supplements at Baseline (1986) and Follow-up (2004), Iowa Women's Health Study ($n = 18,346$)

	Baseline (1984)		Follow-up (2004)	
	%	No.	%	No.
Multivitamin/mineral	31.7	5,821	62.5	11,462
Vitamin A	6.6	1,211	5.5	1,006
Beta-carotene	0.9	173	2.5	452
Vitamin B_6[a]	2.9	538	7.7	1,413
B-complex vitamin	8.3	1,513	7.4	1,361
Vitamin C	27.4	5,032	28.9	5,305
Vitamin D[a]	10.9	1,995	11.9	2,185
Vitamin E	13.5	2,473	31.9	5,856
Folic acid	1.2	227	6.9	1,268
Calcium	46.2	8,474	60.4	11,078
Copper	0.5	96	1.3	240
Iodine	1.1	203	0.9	157
Iron	6.2	1,136	8.1	1,487
Magnesium	3.6	651	6.7	1,224
Selenium	3.0	547	4.7	853
Zinc	6.3	1,147	7.9	1,451
Brewer's yeast	NA	NA	0.6	100
Chromium	0.5	90	NA	NA
Cod liver oil	NA	NA	2.8	519
Lecithin	5.6	1,028	NA	NA
Omega-3	NA	NA	5.2	962
Rutin	0.6	110	NA	NA
Other supplements	NA	NA	14.5	2,655

Abbreviation: NA, not applicable because the supplement was not listed on the questionnaire.

[a] Asked about in a different way at baseline and follow-up.

Table 3. Comparison of Mean Nutrient Intake From Foods Only, Supplements Only, and Foods and Supplements Combined (Total) at Baseline (1986) and Follow-up (2004), Iowa Women's Health Study (n = 18,346)

Nutrient	Baseline (1986)			Follow-up (2004)			% Change Baseline to Follow-up		
	Foods Only	Supplements Only	Total	Foods Only	Supplements Only	Total	Foods Only[a]	Supplements Only[a]	Total[a]
Vitamin A, IU	12,310.3	2,269.3	14,579.6	10,787.1	3,548.7	14,335.9	−12.4	56.4	−1.7
Vitamin B_1, mg/day	1.4	2.1	3.5	1.5	5.5	7.0	7.1	161.9	100.0
Vitamin B_2, mg/day	2.0	2.1	4.1	2.0	5.7	7.7	0.0	171.4	87.8
Vitamin B_6, mg/day[b]	2.0	3.2	5.2	2.3	9.9	12.2	15.0	209.4	134.6
Vitamin B_{12}, mcg/day	10.3	3.2	13.5	7.7	11.9	19.6	−25.2	271.9	45.2
Vitamin C, mg/day	154.9	142.2	297.1	161.2	168.7	329.9	4.1	18.6	11.0
Vitamin D, IU/day[b]	250.2	160.9	411.1	239.5	289.1	528.6	−4.3	79.7	28.6
Niacin, mg/day	21.1	12.6	33.7	22.6	17.5	40.1	7.1	38.9	19.0
Calcium, mg/day	811.7	309.5	1,121.2	855.0	474.0	1,329.0	5.3	53.2	18.5
Copper, mg/day	1.4	0.2	1.6	1.4	0.7	2.1	0.0	250.0	31.3
Iron, mg/day	14.3	4.9	19.2	15.3	8.0	23.3	7.0	63.3	21.4
Magnesium, mg/day	291.4	13.2	304.6	336.6	37.2	373.8	15.5	181.8	22.7
Manganese, mg/day	2.8	0.3	3.1	3.7	1.3	5.0	32.1	333.3	61.3
Phosphorous, mg/day	1,278.1	16.0	1,294.1	1,377.5	23.7	1,401.2	7.8	48.1	8.3
Zinc, mg/day	12.5	4.0	16.5	13.4	9.4	22.8	7.2	135.0	38.2

[a] $P < 0.0001$ for all t-test comparisons between baseline and follow-up.
[b] Asked about in a different way at baseline and follow-up.

250 IU/day at baseline to 240 IU/day at follow-up. In contrast, mean vitamin D intake from supplements increased from 161 IU/day at baseline to 289 IU/day at follow-up. Consequently, total vitamin D intake increased from a mean of 411 IU/day at baseline to 529 IU/day at follow-up.

Women who reported not taking any types of dietary supplements at follow-up were more likely to be older, less well educated, and heavier. In addition, they were more likely to smoke and to engage in a low level of physical activity. Interestingly, those who did not take a dietary supplement were less likely to drink alcohol compared with those who reported using one or more dietary supplements (Table 4).

DISCUSSION

In this study of postmenopausal women, we found that a substantial proportion reported using dietary supplements, with the prevalence of use dramatically increasing during the 18-year follow-up period. The use of multiple supplements was also found to be widespread. As a result of these use patterns, dietary supplements accounted for a large proportion of total intake of many nutrients in this older population.

The high prevalence of use of dietary supplements in our study is consistent with a previous cross-sectional study in which 84% of the women aged 65–84 years in a northern California health plan surveyed in 1998 reported using at least one dietary supplement (23). Somewhat lower prevalence rates have been found in national surveys. The prevalence of use of dietary supplements was 47% among women aged 51 years or older in the US Department of Agriculture's Continuing Survey of Food Intakes by Individuals (1994–1996) (16), 66% among women aged 60–74 years in the 1999–2000 National Health and Nutrition Examination Survey (2), and 73% among women aged 65 years or older in the 2001 Behavioral Risk Factor Surveillance System (24). The different prevalence rates found across studies may be due to differences in the way supplement use was assessed in each, demographic differences between study populations, and differing survey time periods.

Our findings suggest that the use of dietary supplements by older individuals could be beneficial in countering age-related declines in food and nutrient intakes and in maintaining adequate nutriture for nutrients for which absorption declines with age. Total nutrient intake increased between the baseline and follow-up surveys for all nutrients examined. For most nutrients, these increases appeared to be attributable to changes in dietary supplement use.

However, some concerns related to use of dietary supplements by older women must be considered. First, drug-supplement interactions may be an issue. The Slone Survey, a population-based survey investigating dietary supplement and medication use in ambulatory adult US residents, showed that 80% of women aged 65 years or older reported taking at least one prescription drug, and 28% took 5 or more during the preceding week in 2006 (25). Thus, it is likely that concomitant use of prescription drugs and dietary supplements is high among older women. When some drugs are used in combination with certain dietary supplements, the effectiveness of these drugs can potentially be reduced or increased, or unexpected side effects may result (9, 25). For example, it was reported that the beneficial response of high density lipoprotein to simvastatin-niacin therapy in

Table 4. Comparison of Demographic and Health-related Characteristics of Dietary Supplement Users and Nonusers at Follow-up (2004), Iowa Women's Health Study ($n = 18{,}346$)[a]

Characteristic in 2004[a]	Dietary Supplement Users		Dietary Supplement Nonusers	
	%	No.	%	No.
Age, years				
70–79.99	62.1	9,736	58.2	1,558
80–89.99	37.9	5,933	41.8	1,119
Education[b]				
1–8 years	5.6	877	8.6	231
9–12 years	7.3	1,138	9.6	256
High school graduate	41.3	6,477	43.9	1,175
Beyond high school	45.7	7,160	37.8	1,012
Self-rated health[b]				
Excellent/very good	35.2	5,519	32.4	868
Good	46.3	7,257	43.6	1,166
Fair	16.3	2,560	20.6	551
Poor	2.1	324	3.2	87
Body mass index, kg/m^2				
<22	23.3	3,575	19.1	497
22–24.99	26.8	4,115	21.5	560
25–29.99	33.6	5,150	37.7	957
≥30	16.3	2,500	22.7	592
Physical activity level[c]				
1	44.2	6,810	58.6	1,547
2	29.1	4,484	24.5	646
3	26.7	4,124	16.9	447
Current smoker	3.4	522	5.0	132
Alcohol intake, mL/day				
0	66.8	1,0460	74.6	1,998
0.01–10	24.7	3,876	19.4	519
≥10.01	8.5	1,333	6.0	160

[a] $P < 0.001$ for results of chi-square tests comparing supplement users vs. nonusers.

[b] Data were missing for some variables, so total numbers are not identical.

[c] Physical activity level: 3) more than 4 times/week for moderate physical activities (e.g., bowling, golf, light sports or physical exercise, gardening, taking long walks) or more than 2 times/week for vigorous physical activities (e.g., jogging, racquet sports, swimming, aerobics, strenuous sports); 2) more than 2 times/week for moderate physical activities or a few times a month for both moderate and vigorous physical activities; 1) those not belonging to activity level 2 or 3.

patients with coronary artery disease was substantially attenuated when antioxidant supplements were taken simultaneously (26). This information may have important clinical implications for lipid therapy since antioxidant supplements have been widely used in the United States.

Unfortunately, we could not examine the extent to which potentially unsafe combinations of drugs and supplements were used because medication use was not assessed in our surveys. Research is warranted to examine this issue among older adults. Health care providers should also consider their patients' dietary supplement use habits when prescribing medications that may interact with a dietary supplement.

Another major concern related to dietary supplement use by older adults is the potential for supplements to contribute to excessive intake of nutrients for which harmful effects have been found at high doses. This concern could be serious given our finding that many of those using supplements were taking individual vitamins and minerals in addition to a multivitamin. We did not examine the extent to which supplements may be leading to excessive intake among study participants because of concerns that assessment of dose on the study questionnaire was not precise enough for this purpose. Additional research is warranted to examine the extent to which supplements may be leading to excessive intake of nutrients that can be harmful in high doses.

Another issue is that nutrients obtained in purified form may not have the same biologic effect as nutrients obtained from foods (27), perhaps in part because nutrients and food components found in foods act synergistically. Some studies have found consumption of isolated nutrients to be associated with increased risk of chronic disease (27). For example, in the Iowa Women's Health Study, vitamin C from supplemental sources was found to be associated with increased risk of death from cardiovascular disease among women with diabetes (12). Other issues to consider include the expense of dietary supplements and concern that supplements may compromise total diet quality. Indeed, it is possible that dietary supplements may be taken in lieu of making dietary changes that would be beneficial with respect to intake of fat, added sugars, and other nonvitamin, nonmineral food components.

Our study has a number of limitations that are important to note. First, the low response rates to the baseline and follow-up surveys (42% of randomly selected women, 69% of living study participants, respectively) may affect the representativeness of the study sample. However, previous characterizations of baseline nonrespondents (17) and present study results suggest little response-related bias. A second issue is that the study population consisted predominately of Caucasian women from Iowa. Thus, strictly interpreted, our study results should be generalized to similar population groups only. In particular, results should not be generalized to men since women tend to be greater consumers of dietary supplements (28, 29). A third limitation is that we could not examine the extent to which supplements may be leading to excessive intake because of concerns that assessment of dose on the study questionnaire was not precise enough for this purpose. A final issue is that, for some nutrients (e.g., vitamin E), the unit of measure changed between baseline and follow-up. As a result, it was not possible to examine trends in intake for these nutrients. Finally, this study could not separate trends due to aging of this population from cohort effects.

In conclusion, the use of dietary supplements appears to be highly prevalent among older women in the United States. While full interpretation of this finding requires follow-up for clinical events, we note that there could be both benefits and risks to use of dietary supplements. Most notably, they may be useful in maintaining vitamin and mineral intake levels despite potentially declining food intake. However, the possibility that there are risks from obtaining a large proportion of purified nutrients from dietary supplements rather than deriving them from foods should be studied, especially in the elderly.

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