

# Longitudinal and Secular Trends in Dietary Supplement Use: Nurses' Health Study and Health Professionals Follow-Up Study, 1986-2006

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## ARTICLE INFORMATION

### Article history:

Accepted 18 July 2013

Available online 9 October 2013

### Keywords:

Dietary supplement

Longitudinal trend

Secular trend

Nurses' Health Study

Health Professionals Follow-Up Study

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2212-2672/\$36.00

<http://dx.doi.org/10.1016/j.jand.2013.07.039>

## ABSTRACT

Most studies on the prevalence of supplement use in the United States were cross-sectional or evaluated trends in limited variety of supplements. The objective of this study was to describe the longitudinal and secular trend of dietary supplement use over the past 20 years in health professionals using data from two large prospective cohorts. We analyzed cohort data from 1986 to 2006 in the Nurses' Health Study (NHS) and the Health Professionals Follow-Up Study (HPFS). In 1986, 74,194 women aged 40 to 65 years in the NHS and 50,497 men aged 40 to 75 years in the HPFS were included. Use of dietary supplements including multivitamins, vitamins, and minerals was repeatedly asked every 4 years. Generalized estimating equation models were used for repeated analysis. Prevalence of use of any supplement increased among both women (71.3% to 88.3%) and men (56.4% to 80.7%) from 1986 to 2006. Notably, longitudinal increases in the prevalence of use of vitamin D (2.2% to 32.2% for women and 1.1% to 6.7% for men), folic acid (0.8% to 10.7% for women and 1.1% to 13.8% for men), and fish oil (1.6% to 18.1% for women and 3.3% to 22.2% for men) supplements were observed from 1990 to 2006. However, the use of vitamin A, beta carotene, vitamin C, and vitamin E supplements peaked in 1994 or 1998, then declined steadily. A secular increase in use of multivitamins, vitamin D, folic acid, and fish oil across same age group was noted. In conclusion, the use of many types of dietary supplements has increased over time, but the use of antioxidant supplements has declined. The secular increase in the prevalence of use of supplements across the same age group suggests that aging of the population is not the primary reason for the increase. These findings in health professionals need to be replicated in the general populations.

*J Acad Nutr Diet.* 2014;114:436-443.

**T**HE PREVALENCE OF DIETARY SUPPLEMENT USE HAS increased over time in the United States.<sup>1-3</sup> In addition, dietary supplements have diversified to include herbals, botanicals, amino acids, and enzymes, in addition to vitamin and mineral supplements.<sup>3,4</sup> The increase in the prevalence and variety of dietary supplement use has continued with exponential growth of the supplement industry<sup>5</sup> and convenient purchase through supermarkets and the Internet. However, unexpected negative effects of supplements of vitamin A, beta carotene, vitamin C, and alpha tocopherol on lung cancer and cardiovascular disease have been reported in recent decades.<sup>6-8</sup> Therefore, longitudinal trends in the use of various supplements need to be characterized among US adults. Most previous studies on the prevalence of supplement use in the US population were cross-sectional and based on national surveys, including the National Health and Nutrition Examination Survey (NHANES) and Continuing Survey of Food Intakes by Individuals.<sup>9-16</sup> Evaluations of trends in supplement use using data from these national surveys are limited by inconsistencies in

definitions of dietary supplements, survey questions, reference periods, and methodologies over time.<sup>17</sup> The few studies evaluating trends in supplement use have been subject to limitations such as limited variety of supplements,<sup>2</sup> cross-sectional comparison,<sup>1-3</sup> or exclusive focus on elderly women.<sup>18</sup> In addition, some studies reported trends only until the year 2000<sup>1-3</sup> or compared only two cycles.<sup>18</sup> Therefore, trends after 2000 and fluctuations in supplement use after major publications on supplements need to be examined using repeated data from cohort studies.

The surveys on supplement use in the Nurses' Health Study (NHS) and Health Professionals Follow-up Study (HPFS) were launched in 1980 and 1986, respectively, and have been repeated every 2 years. Because these cohort participants are health-care workers, trends in their supplement use may well reflect consumer response to the results of scientific research. Because longitudinal changes in supplement use may be partly attributed to the aging of cohort participants, examining secular trends in supplement use among participants of the same age group at different times can provide insights

into the potential effect of factors other than age on supplement use.

The aim of this study was to explore the secular and longitudinal trends of dietary supplement use among US health professionals using repeated measurements of supplement use over 20 years.

## METHODS

### Study Population

The NHS is a prospective cohort study of 121,700 female registered nurses, age 30 to 55 years in 1976. The HPFS included 51,529 male health professionals (dentists, veterinarians, pharmacists, optometrists, osteopathic physicians, and podiatrists), age 40 to 75 years in 1986. The follow-up rates of the participants in these cohorts have exceeded 90%.<sup>19</sup>

The questions about supplement use were first asked in 1980 for the NHS and 1986 for the HPFS, and were repeated every 2 years thereafter. The assessment methods on supplement use, including daily dose, were consistent across the studies and time periods of every 4 years since 1986. Thus, to maintain consistency across the cohorts, we analyzed data on supplement use every 4 years between 1986 and 2006. We censored those who did not respond to a questionnaire on supplement use for that questionnaire cycle. We did not exclude the participants based on any particular health conditions. The procedures and protocols of the study were approved by the Institutional Review Boards of Brigham and Women's Hospital and the Harvard School of Public Health. The reply to the self-administered questionnaire was considered to imply informed consent.

### Assessment of Supplement Use

Participants were asked whether they currently took any supplements, such as multivitamins, vitamin A, beta carotene, vitamin C, vitamin D, vitamin E, vitamin B-6, folic acid, vitamin B-complex, calcium, iron, selenium, zinc, and magnesium. In addition, for multivitamins they were asked to report the number of pills per week (four choices:  $\leq 2$ , 3-5, 6-9, or  $\geq 10$ /week) and brand name of multivitamins. For some individual vitamin (vitamin A, vitamin C, vitamin E, and vitamin B-6) and mineral supplements (selenium, calcium, and zinc), questions asked for information on daily dose (five choices: eg, vitamin C  $< 400$  mg, 400-700 mg, 750-1,250 mg,  $\geq 1,300$  mg, or don't know). For vitamin A and vitamin C, participants were asked if they took it seasonally or during most months. Frequency of use of these supplements was not queried. We defined all respondents who reported taking supplements (including seasonal use) as supplement-users. For beta carotene, B-complex, vitamin D, folic acid, iron, magnesium, and fish oil, dosage information was not asked. Fish oil was included since 1988. In the two cohort studies, the reproducibility and validity of the questionnaire for total vitamin and mineral intake, which included intake from food and supplements, were previously documented.<sup>20,21</sup> Intra-class correlation coefficients for total vitamin and mineral intakes assessed by two food frequency questionnaires (FFQs) 1 year apart ranged from 0.58 to 0.60 in the NHS and from 0.57 to 0.80 in the HPFS, supporting reproducibility of the intake measure. The correlation coefficients between the energy-adjusted vitamin intakes measured by diet records and the FFQ ranged from 0.49 to 0.75 in the NHS and from

0.41 to 0.87 in the HPFS, supporting validity of the intake measure.

### Statistical Analysis

We calculated the prevalence of use of each supplement in each follow-up cycle. To observe the secular trend of the prevalence of supplement use, we grouped the participants based on age in 1986 ( $< 50$ , 50-59, and  $\geq 60$  years) and then shifted the line of each age group to the same median age over time. Generalized estimating equation models for repeated analysis were fitted by the GENMOD procedure and adjusted for age in 1986 and current smoking status in each year. We conducted separate analyses for each cohort. As the NHS was launched in 1976, the participants who did not fill in questionnaires in 1986 could be included in later years. Therefore, we did a sensitivity analysis just by keeping the participants who filled in questionnaires in 1986. *P* values less than 0.05 were considered statistically significant. All analyses were done using the SAS statistical package (version 9.2, 2009, SAS Institute, Inc).

## RESULTS AND DISCUSSION

The number of participants included in this analysis in 1986 was 74,194 for the NHS and 50,497 for the HPFS. The mean age of participants in 1986 was  $53.0 \pm 7.2$  years for the NHS and  $54.8 \pm 9.9$  years for the HPFS.

### Prevalence of Any Supplement Use

In 1986, the percentage of participants who used at least one supplement including multivitamins was 71.3% among women and 56.4% among men. This increased to 88.3% among women and 80.7% among men in 2006 (Table 1). The prevalence of use of at least one supplement was higher in our populations than in recent national surveys (65.0% in the NHANES in 2003-2006<sup>16</sup>; 73.0% in the Health and Diet Survey in 2002<sup>15</sup>; 50.4% in the National Health Interview Survey in 2000<sup>3</sup>) or a cohort study among postmenopausal women (85.4% in the Iowa Women's Health Study [IWHS] in 2004<sup>18</sup>). Because our participants were health-care professionals, they might be more knowledgeable about dietary supplements and use them more often than the general population. However, the prevalence of use of vitamin C supplements in the NHS (28.3%) was similar to that of the IWHS (28.9%).<sup>18</sup> Studies using the national surveys did not provide any data on trends of supplement use over time.

### Longitudinal Trends of Supplement Use

As shown in Table 2, the use of multivitamins, vitamin D, folic acid, calcium, magnesium, and fish oil supplements has continued to increase since 1990. Notably, the proportions of participants who took vitamin D (2.2% to 32.2% for women and 1.1% to 6.7% for men), folic acid (0.8% to 10.7% for women and 1.1% to 13.8% for men), and fish oil (1.6% to 18.1% for women and 3.3% to 22.2% for men) supplements increased substantially from 1990 to 2006.

The use of vitamin D supplements increased primarily in the 2000s. It is widely recognized that vitamin D plays an important role in calcium absorption for bone health, especially in postmenopausal women.<sup>22</sup> Despite fortification of milk with vitamin D, one third of the US population had vitamin D inadequacy or deficiency in 2001 to 2006.<sup>23</sup>

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