

## Current Research

# Feeding Infants and Toddlers Study: Do Vitamin and Mineral Supplements Contribute to Nutrient Adequacy or Excess among US Infants and Toddlers?

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*Editor's note: The Appendix that accompanies this article is available online at [www.adajournal.org](http://www.adajournal.org).*

### ABSTRACT

**Objective** To report the prevalence of dietary supplement use in a random sample of US infants 4 to 24 months of age, and to compare demographic characteristics, usual nutrient intakes, and food patterns of supplement users and nonusers.

**Design** Data from 24-hour recalls collected for the 2002 Feeding Infants and Toddlers Study were analyzed. Recalls included nutrient contributions from dietary supplements as well as all foods and beverages. We estimated usual energy and nutrient intakes of supplement users and nonusers, as well as the prevalence of nutrient adequacy and excess in the two groups. We also compared demographic characteristics and food patterns of supplement users and nonusers and, for supplement users, estimated the proportion of total intake provided by foods and the proportion provided by supplements.

**Subjects** A national random sample of 3,022 infants and toddlers age 4 to 24 months, including 430 vitamin and/or mineral supplement users and 2,592 nonusers.

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**Statistical analysis** We compared means, percentile distributions, and proportions by age and supplement subgroup, and applied the Dietary Reference Intakes to assess usual nutrient intakes. We conducted regression analysis to determine which population characteristics predict the use of dietary supplements in this population.

**Results** Overall, 8% of infants age 4 to 5 months received some type of dietary supplement. The prevalence of supplement use increased with age, to 19% among infants 6 to 11 months and 31% among toddlers 12 to 24 months. The vast majority of supplement users (97%) received only one type of supplement, most commonly a multivitamin and/or mineral supplement. Vitamin/mineral supplement use among infants and toddlers was associated with being a first-born child and being reported by the primary caretaker as being a picky eater. Characteristics that were independent predictors of supplement use were living in the Northeast, being male, and living in a household with fewer children. We found no significant differences between supplement users and nonusers in mean daily intakes of nutrients or nutrient density from foods alone, and few differences in food consumption. Overall, the prevalence of inadequate intakes was low (<1% to 2%). However, 65% of supplement nonusers and 9% of supplement users had vitamin E intakes less than the Estimated Average Requirement. Excessive intakes (ie, intakes above the Tolerable Upper Intake Level) were noted for both supplement users and nonusers for vitamin A (97% and 15% of toddlers) and zinc (60% and 59% of older infants and 68% and 38% of toddlers) as well as for folate among supplement users (18% of toddlers).

**Conclusions** Generally, healthy infants and toddlers can achieve recommended levels of intake from food alone. Dietetics professionals should encourage caregivers to use foods rather than supplements as the primary source of nutrients in children's diets. Vitamin and mineral supplements can help infants and toddlers with special nutrient needs or marginal intakes achieve adequate intakes, but care must be taken to ensure that supplements do not lead to excessive intakes. This is especially important for nutrients that are widely used as food fortificants, including vitamin A, zinc, and folate.

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| Nutrient  | Target group   | Recommendation   |
|-----------|--|--|
| Vitamin D | Breastfed infants and nonbreastfed infants             | 200 IU vitamin D as a supplement, beginning within the first 2 months after birth if not consuming at least 500 mL per day of vitamin D-fortified milk or formula.   |
|           | Toddlers   | 200 IU vitamin D as a supplement unless consuming at least 500 mL per day of vitamin D-fortified milk, getting regular sunlight exposure, or taking a daily multivitamin containing at least 200 IU of vitamin D.  |
| Iron      | Breastfed infants 6 to 12 months                       | Iron from complementary foods at 6 months of age; 1 mg/kg/d elemental iron if unable to ingest adequate amount of iron from complementary foods.   |
|           | Nonbreastfed infants under 12 months                   | Ingest iron-fortified formula (10-12 mg/L) until weaning at 12 months of age.  |
|           | Breastfed preterm or low-birth-weight infant           | Oral iron supplement drops at 2 mg/kg/d starting at 1 month until 12 months of age.  |
|           | Formula-fed preterm infant<br>Toddlers 12 to 24 months | May benefit from an additional iron supplement (drops) of 1 mg/kg/d. Limit milk intake to 24 fl oz/d to avoid displacement of more iron-rich foods. Consider daily iron supplement for high-risk children, especially those without meat-based source of iron in their diet. |
| Fluoride  | Infants 6 months to children up to 3 years             | Supplement with 0.25 mg/d in areas with <0.3 ppm fluoride concentration in community drinking supplies.  |

**Figure 1.** American Academy of Pediatrics recommendations on vitamin and mineral supplements for infants and toddlers. Source: American Academy of Pediatrics. *Pediatric Nutrition Handbook*. 5th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2004:71, 307-308, 793. IU=international units. ppm=parts per million.

The dietary supplement industry is large and diverse, including vitamin and mineral supplements, herbs and botanicals, sport and weight-loss supplements, and meal replacements. Globally, dietary supplements generated about \$60 billion in sales in 2003; more than 40% of this total was attributable to vitamin and mineral supplements (1). The industry has expanded rapidly since the early 1990s and continues to grow. In the United States alone, sales of vitamin and mineral supplements increased 9% between 2002 and 2003, from \$7.7 billion to \$8.4 billion (1).

While nutrition and health professionals recommend wise food choices as the optimal foundation for a nutritionally adequate diet, it is recognized that consumption of fortified foods and/or vitamin/mineral supplements may be desirable for certain groups of individuals (2-4). For example, the Dietary Reference Intakes (DRIs) include recommendations for use of fortified foods or supplements for specific population groups that have very high nutrient needs or compromised absorption (2). The American Academy of Pediatrics recommends oral supplementation with vitamin D, iron, and fluoride for exclusively breastfed infants and, under certain conditions, for specific older infants and toddlers (4) (see Figure 1). On the other hand, excessive intakes of single nutrients may cause toxicities, nutrient imbalances, or other adverse reactions (2).

A review of data from the National Health and Nutrition Examination Survey (NHANES) by Briefel and Johnson documented an increase in supplement use between 1971 to 1974 and 1999 to 2000 among adults age 20 and older (5). In contrast, reported rates of supplement use among preschool children decreased during the same period (5,6). Among 1- to 2-year-olds, for example, supplement use decreased by 24 percentage points, from 55% to 31%. Fewer data are available for infants because of

variations in the age groups covered in the various NHANES cycles; however, the available data suggest that supplement use among infants has also decreased over time (5,6). Several factors may have contributed to the decrease in supplement use among infants and toddlers, including changes in clinical practice guidelines, improved scientific information on the dietary needs of infants and children, and parents' dietary and health attitudes and practices (2,4,7,8).

We know very little about how the use of supplements affects nutrient intakes of infants and toddlers. National surveys such as NHANES and the Continuing Survey of Food Intakes by Individuals (CSFII) have not estimated total nutrient intakes incorporating contributions from both foods and supplements. Questions about supplement use in NHANES III (1988-1994) and NHANES 1999-2002 make estimates of total nutrient intake possible. However, because collection of data on supplement use did not occur in coordination with 24-hour dietary recalls, it is not possible to estimate nutrient intakes in a manner that is consistent with the most recent recommendations (6,9-11).

To our knowledge, there are only two published articles that compare nutrient intakes by infants and toddlers who use and do not use supplements. One article, which is considerably dated, reported on infants and toddlers who were included in a supplement intervention rather than in a free-living population (12). The sample was small (n=90) and was limited to low-income toddlers in Denver, CO. The other, more recent, article reported data from the Iowa Fluoride Study, which included a longitudinal sample of 400 infants from birth through age 24 months (13). The sample was not randomly selected, was limited to one geographic area, was mainly white, and had relatively high levels of income and education (6,13). Findings from both of these studies have limited gener-

alizability to the general population of US infants and toddlers. Moreover, nutrient intake estimates from both studies need to be interpreted with caution because they were not generated using the estimation methods recommended by the Institute of Medicine (IOM) (14).

This article presents findings from a comprehensive analysis of supplement use in a national random sample of 3,022 US infants and toddlers ages 4 to 24 months. We describe patterns of supplement use, characteristics of supplement users and nonusers, and independent predictors of supplement use. We also compare usual nutrient intakes of supplement users and nonusers using IOM-recommended methods. Finally, we describe the relative contributions of food and supplements to total daily intakes and assess differences in the food consumption patterns of supplement users and nonusers.

## **METHODS**

### **Sample Design and Subjects**

The 2002 Feeding Infants and Toddlers Study (FITS) was sponsored by Gerber Products Company (Parsippany, NJ) to update our knowledge about the food and nutrient intakes of infants and toddlers in the United States (15,16). FITS included a stratified random sample of infants between 4 and 24 months of age. The sample was drawn from the New Parent Database (Experian's New Parents Database, February to May 2002, Experian, Lincoln, NE), a commercial database that was judged to provide the most coverage of infants and toddlers (16). Infants and toddlers were sampled in six age groups: 4-6 months, 7-8 months, 9-11 months, 12-14 months, 15-18 months, and 19-24 months. Infants 4-6 and 9-11 months of age were oversampled because these two age groups typically experience significant transitions in infant feeding patterns and practices (from liquid diets to the addition of complementary foods, and from complementary foods to the addition of table foods, respectively).

There was some undercoverage of minorities in the sample frame. We corrected for coverage bias in the post-stratification stage. Sample weights were developed to adjust for oversampling, nonresponse, and undercoverage of some subgroups of children not included in the sample frame. A detailed overview of the FITS study design and characteristics of the full FITS sample are available elsewhere (15,16).

### **Data Collection Methods**

FITS data were collected by Mathematica Policy Research, Inc (Princeton, NJ). All data collection instruments and procedures were reviewed and approved by Mathematica Policy Research's institutional review board compliance officer and quality assurance system. Parents or primary caregivers of sampled infants and toddlers completed a household survey to collect information about sociodemographic characteristics. They also completed a single 24-hour dietary recall for the sampled infant or toddler. For statistical purposes, a random subsample of 703 respondents was selected to complete a second 24-hour dietary recall, 3 to 10 days after the first recall and on a different day of the week. All recalls were completed between March and July 2002. Trained inter-

viewers conducted the 24-hour recalls over the telephone using the Nutrition Data System for Research (NDS-R, version 4.03, 2001, University of Minnesota Nutrition Coordinating Center, Minneapolis).

An information packet was mailed to respondents 7 to 10 days before the interview. The packet included a detailed 2-dimensional booklet for use in reporting portion sizes. The booklet was designed specifically for FITS and was pilot-tested with mothers of infants and toddlers (16).

The 24-hour recall protocol included collection of data on use of dietary supplements. After interviewers had collected information about all foods and beverages consumed, they asked caregivers whether the child had taken any supplements ("Did \_\_\_ take any vitamin, mineral, or other dietary or herbal supplement yesterday?"). Respondents were asked to consider both prescribed and over-the-counter supplements. If supplements had been consumed, interviewers encouraged respondents to get the bottle and use the label to provide information about type and dosage of each supplement used.

Interviewers entered information using Nutrition Data System for Research prompts. Supplement information could be recorded by brand name or as a generic type of supplement selected from a menu list. Respondents reported the form and amount of the supplement taken as servings, tablets, fluid ounces, milligrams, milliliters, teaspoons, bottles, drops, and doses expressed as a percentage of the Recommended Dietary Intake or Daily Value (eg, "each 100%=5,000 IU" for vitamin A supplements) or amounts of units (eg, in micrograms, milligrams, international units, or retinol equivalents for vitamin A). Supplements not included in the Nutrition Data System for Research database at the time of the interview were recorded with as much detail as possible so that they could be resolved and coded by experienced research nutritionists at a later time. We classified supplements in a similar manner to the scheme used in NHANES 1999-2000 (17). Additional details about collection, processing, and quality control of 24-hour recall data are available elsewhere (15,16).

## **ANALYSIS METHODS**

### **Defining Supplement Users and Nonusers**

The majority of supplements reported were vitamin and mineral supplements. For this reason, analyses that compare supplement users and nonusers focus on vitamin/mineral supplements. In analyses that compare nutrient intakes from foods, food consumption patterns, and personal, maternal, and demographic characteristics of supplement users and nonusers, supplement users are defined as those for whom a vitamin/mineral supplement was reported in the single 24-hour recall collected for all sample members. Analyses that focus on usual nutrient intakes incorporate data from the second 24-hour recall (see subsequent section on Assessing Usual Nutrient Intakes). In these analyses, supplement users are defined as those for whom a vitamin/mineral supplement was reported in either the first or second 24-hour recall. All analyses of nutrient and food intakes were completed for two age groups: infants aged 6-11 months and toddlers aged 12-24 months. We were unable to separately ana-

lyze data for infants aged 4-5 months because of a small sample of supplement users (n=24).

### Estimating the Prevalence of Supplement Use

Estimating the prevalence of supplement use poses methodological challenges because supplement use can vary from day to day for each individual, and estimates based on dietary recall data reflect use only on the recall day or days (6,9,10,18). In FITS, there are two possible ways to estimate the prevalence of supplement use: (a) using data from the single 24-hour recall collected for all sample members, or (b) using an “adjusted” estimate that incorporates data from the second 24-hour recall completed for a random subsample of sample members. The first option is the most straightforward and is consistent with the definition of supplement users and nonusers in analyses that compare population characteristics, nutrients from food and supplements, and food consumption patterns, as well as the analysis that examines predictors of supplement use. However, prevalence estimates based on a single 24-hour recall underestimate usual supplement use because they do not include supplement users who irregularly take supplements and did not take a supplement on the day of the recall.

The second option—estimating an adjusted prevalence of supplement use based on the second 24-hour recall—allows us to include those who irregularly take supplements. The adjusted prevalence estimates provide a more reliable estimate of the actual prevalence of supplement use and are more consistent with the approach used to estimate usual nutrient intakes. We estimated the prevalence of supplement use using both approaches.

### Assessing Usual Nutrient Intakes

We used methods recommended by the IOM to estimate usual energy and nutrient intakes of infants 6 to 11 months and toddlers 12 to 24 months and to compare usual intakes to appropriate DRIs (14). The approach uses the second 24-hour recall that was collected for a subsample of the population to estimate and adjust for day-to-day variability in intake, thereby yielding a more reliable estimate of usual intake distributions. We used the personal computer version of the Software of Intake Distribution Estimation (PC-SIDE, version 1.02, 2001, Iowa State University, Ames) to estimate the mean and percentiles of usual intake distributions as well as proportions above or below defined cutoff values.

Estimated intakes include contributions from all reported foods and beverages as well as from supplements and breast milk. For infants who were exclusively breastfed we assumed intakes of 780 mL per day and 600 mL per day for infants younger than 7 months and infants 7 months and older, respectively. For infants who were receiving both breast milk and formula, the volume of formula was subtracted from these totals to estimate the amount of breast milk consumed. The method used to impute breast milk intake among infants was based on assumptions used in establishing calcium DRIs (19) and has been used by other researchers (20). For toddlers, we used methods developed by Dewey and imputed the amount of breast milk consumed based on the total number of minutes that the child breastfed (21).

Nutrients included in the analysis were vitamins A, C, D, E, and B-12, folate, calcium, iron, phosphorus, potassium, sodium, zinc, and fiber. For nutrients with an Estimated Average Requirement (EAR), a Recommended Dietary Allowance (RDA), and a symmetrical requirement distribution, we used the IOM-recommended EAR cutpoint method to estimate the proportion of the population with usual intakes less than the EAR (14). This is an estimate of the proportion of the population with inadequate intakes.

In cases in which nutrient requirements are expressed in terms of an Adequate Intake (AI) rather than an EAR, we compared means of the usual nutrient intake distribution to the AI. The AI is a level of intake that is expected to meet the requirements of nearly all healthy individuals in a given population group. As such, the AI cannot be used to determine the proportion of the population with inadequate intakes (14). However, populations with mean usual intakes at or more than the AI can be assumed to have nutritionally adequate diets (14). For infants, nutrient requirements are expressed as AIs for all nutrients examined except iron and zinc. For these two nutrients, RDAs and EARs have been established for infants 7 to 11 months.

For nutrients with established Tolerable Upper Intake Levels (ULs), we estimated the proportion of the population with usual intakes that exceeded the UL. ULs are the highest level of usual intake that is likely to pose no risks of adverse health effects; individuals with usual intakes that exceed the UL are at risk for adverse effects. For infants, ULs have been established only for iron and zinc intakes of infants 7 to 11 months of age.

Energy intakes were assessed in relation to estimated energy requirements that take into consideration children's ages, weights, and physical activity levels (22).

Folate and vitamins A and E were estimated in units consistent with the DRIs. The version of the Nutrition Data System for Research used in the analysis included dietary folate equivalents. Vitamin A in retinol activity equivalents (RAEs) was estimated from Nutrition Data System for Research values for retinol and carotenoids using the following formula (23):

$$\text{RAE} = \mu\text{g retinol} + \frac{1}{2}(\mu\text{g beta carotene equivalents} \div 6)$$

In addition, estimates of usual intakes of preformed vitamin A,  $\alpha$  tocopherol from fortified foods and supplements, and synthetic folate were generated to permit appropriate comparison to defined ULs. The UL for vitamin A is based on preformed vitamin A (retinol), the UL for vitamin E applies to any form of  $\alpha$  tocopherol found in fortified foods and/or supplements, and the UL for folate applies to synthetic forms of the vitamin found in fortified foods and supplements.

### Nutrients from Food and Supplements and Food Consumption Patterns

To compare the amount of nutrients provided in foods consumed by supplement users and nonusers, we used the single 24-hour recall completed for the full sample and calculated mean daily intakes of vitamins and minerals from foods alone. For supplement users, we also

calculated mean daily intakes from supplements alone. We also estimated the percentage of supplement users and nonusers who consumed 30 different food groups on the day of the recall (see Appendix, available online at [www.adajournal.org](http://www.adajournal.org)). The food group classification system used in FITS is described elsewhere (24).

### Statistical Analyses

SAS version 8.2 (2001, SAS Institute, Inc, Cary, NC) was used to create data files, classify types of supplements, and define supplement users and nonusers. All statistical procedures were completed using SUDAAN, version 9.0 (2004, Research Triangle Institute, Research Triangle Park, NC), incorporating appropriate sample weights and design effects. We used *t* tests to assess the statistical significance of differences in characteristics of supplement users and nonusers, as well as differences in usual nutrient intakes, mean daily intakes from food, and the proportion of the population consuming specific food groups. We followed accepted reporting guidelines for nutrition data with respect to the reliability of point estimates (25).

The data presented in the tables meet minimum sample size requirements ( $n > 25$ ). We flagged estimates with a † if the coefficient of variation (calculated as standard error ÷ mean) is 30% or more. These estimates may be unreliable due to a high variability. This is most problematic in cases in which the proportion of a group with a particular characteristic or food consumption level is very low (<10%) and there is high variability within the group. In these cases, the estimate is based on an adequate sample size but should be interpreted with caution due to a high coefficient of variation.

We used logistic regression to identify independent predictors of vitamin/mineral supplement use. Use of a supplement (based on the single 24-hour recall) was the dependent variable, and the independent variables included maternal characteristics (mother's age, marital status, education, work status, race/ethnicity), household characteristics (income, region, urbanicity, number of children younger than 18 years), and child characteristics (sex; birth weight; age; whether the child was enrolled in the Special Supplemental Nutrition Program for Women, Infants, and Children; and whether the child was first-born, was enrolled in day care, had a reported allergy, had a long-term medical problem, or was a picky eater). The picky eater variable reflects primary caregiver's perceptions about the child's eating habits. Caregivers were asked whether they considered the child to be a very picky eater, a somewhat picky eater, or not a picky eater. Interviewers did not define the term *picky eater*. Children whose caregivers described them as either very picky or somewhat picky were considered picky eaters for purposes of this analysis.

High school education/some college and non-Hispanic white race/ethnicity were used as the reference groups for mother's education and child's race/ethnicity. Annual household income of less than \$15,000, Northeast region, and suburban location were used as the reference groups for each of these respective household characteristics. For most independent variables, data were missing for fewer than 5% of the observations. For mother's age, income, and whether the child was a picky eater, rates of missing

data were higher (17%, 15%, and 6%, respectively). (Mother's age was generally missing when the respondent was not the mother.) For all of these variables, we imputed the sample mean from nonmissing values. We also included a dummy variable that indicated that income data were missing. Independent variables were considered to be significant predictors of supplement use if the *P* value was <.05. Odds ratios and their 95% confidence intervals were calculated.

## RESULTS

### Prevalence of Supplement Use and Types of Supplements Used

Table 1 presents 1-day and adjusted prevalence estimates of supplement use by age group and for the entire sample. Based on a single 24-hour recall, we estimated an overall prevalence of supplement use of 19%. Data for the random subsample with two 24-hour recalls demonstrated that prevalence estimates based on a single day underestimate actual supplement use. In this random subsample, 8% used a dietary supplement on both days and 6% used a supplement on one of the recall days but not the other (data not shown). The adjusted prevalence estimate of 25% overall provides a more reliable estimate of actual supplement use in this population. Use of supplements increased with age. The adjusted prevalence of supplement use was 8% among infants 4 to 5 months, 19% among infants 6 to 11 months, and 31% among toddlers 12 to 24 months. (In the text that follows, all prevalence estimates are adjusted estimates.)

The vast majority of supplement users (97%) received only one type of supplement (23.9% out of 24.7% or 97% of the 4- to 24-month-old supplement users; see Table 1). Moreover, most supplement users (91%) received vitamin and mineral supplements. About 10% of supplement users received other types of dietary supplements. These were almost all electrolyte beverages, which are most often consumed for digestive illness. There was a single case of a fiber supplement (Citrucel, GlaxoSmithKline, Pittsburgh, PA) and a single case of an antacid tablet (Tums, GlaxoSmithKline). There were no cases of herbal supplements. The most common type of vitamin/mineral supplement was a combination multivitamin and mineral product, most often including vitamins A, C, B-6, B-12, D, and E; thiamin; riboflavin; niacin; iron; and fluoride. Single vitamin preparations were rare.

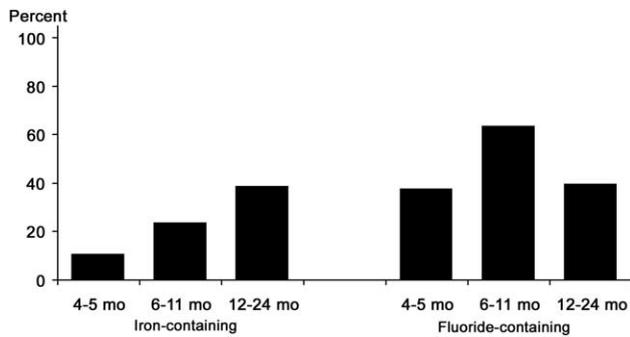
Among vitamin/mineral supplement users, there was variation across age groups in the proportion who received supplements that provided iron and fluoride (Figure 2). The percentage of users who received supplements that provided iron\* increased with age, from 11% among infants 4 to 5 months to 24% among infants 6 to 11 months to 35% among toddlers 12 to 24 months. The proportion of supplement users who received supplements containing fluoride ranged from approximately 40% among infants 4 to 5 months and toddlers 12 to 24 months to 64% among infants 6 to 11 months. The adjusted prevalence of supplement use

\*Supplements categorized as iron-containing included iron in the name or met at least 50% of the RDA for iron per recommended dosage.

**Table 1.** Prevalence of dietary supplement use among US infants and toddlers aged 4 to 24 months<sup>a</sup>

|                                       | Age (Months)         |                  |                                      |                      |       |                                      |                      |       |                                      |                             |       |                                      |
|---------------------------------------|----------------------|------------------|--------------------------------------|----------------------|-------|--------------------------------------|----------------------|-------|--------------------------------------|-----------------------------|-------|--------------------------------------|
|                                       | 4-5 (n=624)          |                  |                                      | 6-11 (n=1,395)       |       |                                      | 12-24 (n=1,003)      |       |                                      | Total 4-24 Months (n=3,022) |       |                                      |
|                                       | 1-day prevalence (%) | ±SE <sup>b</sup> | Adjusted prevalence <sup>c</sup> (%) | 1-day prevalence (%) | ±SE   | Adjusted prevalence <sup>c</sup> (%) | 1-day prevalence (%) | ±SE   | Adjusted prevalence <sup>c</sup> (%) | 1-day prevalence (%)        | ±SE   | Adjusted prevalence <sup>c</sup> (%) |
| Any dietary supplement <sup>d</sup>   | 4.9                  | ±0.90            | 8.1                                  | 14.5                 | ±1.10 | 18.9                                 | 25.0                 | ±1.60 | 31.1                                 | 19.4                        | ±1.00 | 24.7                                 |
| 1 type                                | 4.9                  | ±0.90            | 8.1                                  | 13.5                 | ±1.00 | 18.4                                 | 23.7                 | ±1.60 | 30.0                                 | 18.4                        | ±1.00 | 23.9                                 |
| 2 or more types                       | 0.0                  | ±0.00            | 0.0                                  | 0.9†                 | ±0.40 | 1.6                                  | 1.3†                 | ±0.40 | 1.5                                  | 1.0                         | ±0.20 | 1.4                                  |
| Vitamin/mineral supplement            | 3.7                  | ±0.80            | 5.8                                  | 13.4                 | ±1.10 | 16.0                                 | 23.7                 | ±1.60 | 29.5                                 | 18.2                        | ±1.00 | 22.6                                 |
| 1 type                                | 3.7                  | ±0.80            | 5.8                                  | 12.8                 | ±1.00 | 15.4                                 | 22.6                 | ±1.60 | 28.8                                 | 17.4                        | ±1.00 | 22.0                                 |
| 2 or more types                       | 0.0                  | ±0.00            | 0.0                                  | 0.6†                 | ±0.30 | 0.6                                  | 1.1†                 | ±0.40 | 1.1                                  | 0.8                         | ±0.20 | 0.8                                  |
| Single vitamin                        | 0.1†                 | ±0.10            | 0.1                                  | 0.2†                 | ±0.20 | 0.2                                  | 0.1†                 | ±0.10 | 0.1                                  | 0.1†                        | ±0.10 | 0.1                                  |
| Single mineral                        | 0.5†                 | ±0.30            | 0.5                                  | 3.4                  | ±0.60 | 4.5                                  | 3.3                  | ±0.60 | 6.9                                  | 3.0                         | ±0.40 | 5.4                                  |
| Multivitamin                          | 1.8†                 | ±0.60            | 3.2                                  | 3.3                  | ±0.60 | 4.4                                  | 6.7                  | ±0.90 | 9.1                                  | 5.1                         | ±0.60 | 7.0                                  |
| Multimineral                          | 0.0                  | ±0.00            | 0.0                                  | 0.0                  | ±0.00 | 0.0                                  | 0.1†                 | ±0.10 | 0.1                                  | 0.0                         | ±0.00 | 0.0                                  |
| Combination                           | 1.2†                 | ±0.50            | 2.0                                  | 7.0                  | ±0.80 | 9.2                                  | 14.4                 | ±1.40 | 15.9                                 | 10.6                        | ±0.80 | 12.2                                 |
| Other type of supplement <sup>d</sup> | 1.3†                 | ±0.40            | 2.4                                  | 1.4                  | ±0.40 | 3.9                                  | 1.4                  | ±0.40 | 2.1                                  | 1.4                         | ±0.30 | 2.6                                  |

<sup>a</sup>Data from the 2002 Feeding Infants and Toddlers Study.  
<sup>b</sup>SE=standard error.  
<sup>c</sup>Adjusted prevalence is based on two 24-hour dietary recalls.  
<sup>d</sup>Includes electrolyte beverages, fiber supplements, and antacids.  
†Indicates a coefficient of variation of 30% or higher; point estimate may be unreliable.



**Figure 2.** Use of iron-containing or fluoride-containing supplements among vitamin/mineral supplement users. n=430 users; adjusted based on two 24-hour dietary recalls. Data from the 2002 Feeding Infants and Toddlers Study.

was comparable for breastfeeding and nonbreastfeeding infants and toddlers (19% vs 15%) (data not shown).

### Characteristics of Vitamin/Mineral Supplement Users

Table 2 shows results of bivariate analyses that compared personal, maternal, and household characteristics of supplement users and nonusers. Of all the characteristics examined, only two proved to be significantly different for supplement users and nonusers: being first-born and being reported by the primary caretaker as being a very picky or sometimes picky eater. The proportion of supplement users who were first born was significantly higher than the proportion of nonusers (64% vs 55%;  $P<.01$ ). Likewise, the proportion of supplement users who were characterized as being picky eaters was significantly higher than the proportion of nonusers (45% vs 35%;  $P<.05$ ).

### Predictors of Vitamin/Mineral Supplement Use

Results of the multivariate regression (Table 3) identified three characteristics that were independent predictors of supplement use. These include region, sex, and household composition. Infants and toddlers who lived in the South, Midwest, or West were less likely than infants who lived in the Northeast to use supplements, and girls were less likely than boys to use supplements. The likelihood of supplement use also decreased as the number of children in the household increased. For each additional child younger than 18, the likelihood of supplement use decreased by 24% ( $1.00-0.76=0.24$ , or 24%).

### Usual Nutrient Intakes of Vitamin/Mineral Supplement Users and Nonusers

Mean usual energy intakes of supplement users and nonusers were not significantly different. Among infants 6 to 11 months, mean usual energy intake ( $\pm$ standard error of the mean) was  $922\pm 13.3$  kcal ( $3,859\pm 55.7$  kJ)<sup>†</sup> for users compared with  $876\pm 6.0$  kcal ( $3,667\pm 25.1$  kJ) for nonusers (data not shown). Among toddlers, mean usual energy

<sup>†</sup>To convert kilocalories (kcal) to kilojoules (kJ), multiply kcal $\times 4.186$ .

**Table 2.** Selected characteristics of vitamin/mineral supplement users and nonusers: Infants and toddlers aged 4 to 24 months<sup>a</sup>

| Characteristics of infant or toddler           | Supplement users <sup>b</sup> (n=430) |                 | Supplement nonusers (n=2,592) |     |
|--|---------------------------------------|-----------------|-------------------------------|-----|
|  | %                                     | SE <sup>c</sup> | %                             | SE  |
| First-born                                     | 64**                                  | 2.8             | 55                            | 1.3 |
| Age <sup>d</sup> (mo)                          |                                       |                 |                               |     |
| 4-5  | 2                                     | 0.6             | 14                            | 0.6 |
| 6-11   | 22                                    | 2.0             | 32                            | 1.0 |
| 12-24  | 75                                    | 2.1             | 54                            | 1.2 |
| Receiving WIC <sup>e</sup>                     | 22                                    | 2.5             | 26                            | 1.2 |
| Ever breastfed                                 | 81                                    | 2.5             | 75                            | 1.2 |
| Currently breastfeeding                        | 12                                    | 1.6             | 15                            | 0.8 |
| Hispanic                                       | 13                                    | 2.2             | 13                            | 0.9 |
| Reported to be a "picky eater" <sup>f</sup>    | 45*                                   | 3.1             | 35                            | 1.3 |
| <b>Maternal characteristics</b>                |                                       |                 |                               |     |
| Mean age (y)                                   | 30                                    | 0.5             | 30                            | 0.2 |
| 11th grade education or less                   | 4                                     | 1.2             | 7                             | 0.7 |
| Completed college                              | 41                                    | 3.0             | 39                            | 1.3 |
| <b>Household characteristics</b>               |                                       |                 |                               |     |
| Mean annual household income <sup>g</sup> (\$) | 55,425                                | 1,796           | 53,940                        | 767 |
| $\leq 130\%$ poverty level <sup>gh</sup>       | 9                                     | 1.8             | 11                            | 0.9 |
| $\leq 185\%$ poverty level <sup>gh</sup>       | 23                                    | 2.8             | 24                            | 1.3 |

<sup>a</sup>Data from the 2002 Infants and Toddlers Feeding Study.  
<sup>b</sup>Defined as taking vitamin/mineral supplement(s) on the single 24-hour recall.  
<sup>c</sup>SE=standard error.  
<sup>d</sup>Distribution for age of supplement users does not sum to 100% because of rounding.  
<sup>e</sup>WIC=Special Supplemental Nutrition Program for Women, Infants, and Children.  
<sup>f</sup>Reported by the primary caretaker to be a "very picky" or "somewhat picky" eater.  
<sup>g</sup>Excludes those with missing income levels.  
<sup>h</sup>Poverty status is calculated using the annual household income and family size in comparison to federal poverty thresholds for 2002. In 2002, the poverty threshold for a family of four was \$18,392.  
\*Significantly different from nonusers,  $P<.05$  level.  
\*\*Significantly different from nonusers,  $P<.01$  level.

intake was  $1,284\pm 22.5$  kcal ( $5,375\pm 94.2$  kJ) for users and  $1,237\pm 10.3$  kcal ( $5,178\pm 43.1$  kJ) for nonusers (data not shown). Mean usual energy intakes of infants and toddlers in both supplement groups exceeded the mean estimated energy requirement.

Tables 4 through 6 summarize data about the usual nutrient intakes of supplement users and nonusers. Table 4 presents data for infants 6 to 11 months. Data for toddlers 12 to 24 months are presented in Tables 5 (supplement users) and 6 (nonusers). In each table, the leftmost panel shows the relevant DRIs for each nutrient examined. Among infants 6 to 11 months, supplement users had significantly higher mean usual intakes of all vitamins examined as well as higher mean usual intakes of iron and potassium. For all of these nutrients, however, mean usual intakes of both users and nonusers exceeded the AIs, indicating that both groups of infants had adequate intakes. Supplement users also had a significantly higher mean usual intake of fiber. An AI for fiber has not

**Table 3.** Predictors of vitamin/mineral supplement use among infants and toddlers aged 4 to 24 months<sup>a</sup>

| Variable  | Odds ratio | P value | 95% Confidence interval |
|---|------------|---------|-------------------------|
| Intercept   | 0.183      | .061    | 0.031-1.078             |
| <b>Characteristics of infant or toddler</b>                     |            |         |                         |
| Race/ethnicity (omitted category=non-Hispanic, white)           |            |         |                         |
| Hispanic  | 0.921      | .709    | 0.596-1.422             |
| Black   | 0.899      | .719    | 0.504-1.604             |
| Female sex  | 0.708*     | .014    | 0.537-0.933             |
| Receiving WIC <sup>b</sup>                                      | 0.988      | .956    | 0.643-1.517             |
| First-born  | 1.019      | .930    | 0.674-1.539             |
| In day care   | 0.725      | .055    | 0.522-1.007             |
| Birth weight (kg)   | 0.915      | .507    | 0.704-1.190             |
| Has an allergy  | 0.975      | .936    | 0.520-1.825             |
| Has a long-term medical problem                                 | 1.495      | .315    | 0.682-3.278             |
| “Sometimes” or “very picky” eater                               | 1.260      | .128    | 0.936-1.696             |
| Missing “picky eater” variable                                  | 0.780      | .501    | 0.378-1.609             |
| Age (mo)  | 1.102      | .000    | 1.077-1.128             |
| <b>Maternal characteristics</b>                                 |            |         |                         |
| Age   | 1.015      | .298    | 0.987-1.045             |
| Married   | 0.684      | .094    | 0.438-1.067             |
| Education (omitted category=high school education/some college) |            |         |                         |
| 11th grade education or less                                    | 0.542      | .087    | 0.269-1.093             |
| Completed college   | 0.919      | .592    | 0.675-1.251             |
| Currently working   | 0.940      | .714    | 0.676-1.307             |
| <b>Household characteristics</b>                                |            |         |                         |
| Annual household income (\$) (omitted category =<15,000)        |            |         |                         |
| 15,000-34,999   | 2.015      | .210    | 0.674-6.028             |
| 35,000-74,999   | 1.759      | .314    | 0.585-5.287             |
| ≥\$75,000   | 1.827      | .301    | 0.583-5.729             |
| Missing income variable   | 1.819      | .293    | 0.597-5.541             |
| Region (omitted category=Northeast)                             |            |         |                         |
| Midwest   | 0.315*     | .000    | 0.213-0.466             |
| South   | 0.294*     | .000    | 0.201-0.429             |
| West  | 0.580*     | .006    | 0.392-0.857             |
| Urbanicity (omitted category=suburban)                          |            |         |                         |
| Urban   | 0.853      | .342    | 0.615-1.184             |
| Rural   | 1.135      | .550    | 0.749-1.722             |
| No. children in household <18 y                                 | 0.761*     | .008    | 0.622-0.931             |

<sup>a</sup>Data from the 2002 Feeding Infants and Toddlers Study, n=3,022.

<sup>b</sup>WIC=Special Supplemental Nutrition Program for Women, Infants, and Children.

\*P<.05.

been established for this age group. Among infants 6 to 11 months, a small proportion of both supplement users and nonusers had inadequate intakes (ie, intakes less than the EAR) for iron (3% vs 8%) and zinc (3% vs 5%) (data not shown). In addition, the prevalence of excessive zinc intakes in this age group (ie, the proportion with usual intakes above the UL) was similar among supplement users than nonusers (60% vs 59%) (data not shown).

A similar pattern of differences in mean usual intakes was observed among toddlers. In this age group, however, there were no significant differences in intakes of potassium or fiber, but supplement users had a significantly higher intake of zinc. For the most part, the prevalence of inadequate intakes was very low (<1%-2%) for both users

and nonusers. Vitamin E was an exception. Almost two thirds (65%) of supplement nonusers had inadequate vitamin E intakes, compared with 9% of users. The prevalence of excessive intakes was higher among supplement users than nonusers for vitamin A (97% vs 15%), folate (18% vs <1%), and zinc (68% vs 38%). Substantial proportions of both users and nonusers had excessive sodium intakes (60% and 57%, respectively).

#### Contributions of Foods and Vitamin/Mineral Supplements to Total Daily Intakes

Table 7 shows mean daily intakes from foods (based on the single 24-hour recall) for supplement users and non-

**Table 4.** Usual intake of selected micronutrients among supplement users and nonusers: Infants aged 6 to 11 months<sup>a</sup>

| Nutrient                          | AI <sup>b</sup> | Supplement User (n=187) |       |        |                         |       |       | Supplement Nonuser (n=1,208) |      |        |                       |       |       |
|-----------------------------------|-----------------|-------------------------|-------|--------|-------------------------|-------|-------|------------------------------|------|--------|-----------------------|-------|-------|
|                                   |                 | 10th                    | 25th  | Median | Mean±SEM <sup>c</sup>   | 75th  | 90th  | 10th                         | 25th | Median | Mean±SEM              | 75th  | 90th  |
| <b>Vitamins</b>                   |                 |                         |       |        |                         |       |       |                              |      |        |                       |       |       |
| Vitamin A (μg, RAE <sup>d</sup> ) | 500             | 748                     | 891   | 1,053  | 1,083**±21.4            | 1,239 | 1,451 | 503                          | 582  | 686    | 707±5.6               | 820   | 971   |
| Vitamin C (mg/d)                  | 50              | 97                      | 111   | 128    | 129**±1.9               | 146   | 163   | 59                           | 74   | 93     | 98±0.99               | 116   | 142   |
| Vitamin D (μg/d)                  | 5               | 7.1                     | 10.2  | 13.4   | 13.4 <sup>e</sup> ±0.35 | 16.5  | 19.2  | ND <sup>f</sup>              | ND   | ND     | 6.7 <sup>a</sup> ±0.2 | ND    | ND    |
| Vitamin E (mg/d)                  | 5               | 8.3                     | 9.6   | 11.8   | 14.2**±0.64             | 15.8  | 21.9  | 6.4                          | 7.6  | 9.2    | 9.6±0.08              | 11.2  | 13.4  |
| Folate (μg/d)                     | 80              | 104                     | 134   | 179    | 276**±30.7              | 265   | 464   | 95                           | 132  | 172    | 183±2.3               | 217   | 279   |
| Vitamin B-12 (μg/d)               | 0.5             | 0.9                     | 1.4   | 2.4    | 2.6**±0.13              | 3.4   | 4.6   | 0.7                          | 1.2  | 1.6    | 1.7±0.02              | 2.1   | 2.8   |
| <b>Minerals</b>                   |                 |                         |       |        |                         |       |       |                              |      |        |                       |       |       |
| Calcium (mg/d)                    | 270             | 408                     | 487   | 593    | 618±13.4                | 721   | 859   | 384                          | 474  | 591    | 620±6.1               | 730   | 887   |
| Iron (mg/d)                       | 11              | 9.6                     | 12.9  | 17.2   | 17.9**±0.50             | 22.1  | 27.0  | 7.7                          | 11.1 | 14.7   | 15.4±0.19             | 19.1  | 23.7  |
| Phosphorus (mg/d)                 | 275             | 320                     | 394   | 491    | 519±13.2                | 611   | 749   | 285                          | 373  | 473    | 505±5.9               | 601   | 757   |
| Potassium (mg/d)                  | 700             | 913                     | 1,057 | 1,245  | 1,283*±23.2             | 1,467 | 1,703 | 775                          | 946  | 1,159  | 1,215±11.4            | 1,417 | 1,717 |
| Sodium (mg/d)                     | 370             | 186                     | 257   | 401    | 543±33.8                | 661   | 1,054 | 178                          | 237  | 357    | 484±11.1              | 588   | 952   |
| Zinc (mg/d)                       | 3               | 3.3                     | 4.2   | 5.4    | 5.8±0.19                | 6.7   | 8.5   | 3.0                          | 4.2  | 5.4    | 5.5±0.06              | 6.6   | 8.0   |
| Fiber (g/d)                       | NA <sup>g</sup> | 3.1                     | 4.2   | 5.8    | 6.3*±0.22               | 7.7   | 10    | 2.5                          | 3.8  | 5.4    | 5.7±0.08              | 7.3   | 9.2   |

<sup>a</sup>Data from the 2002 Feeding Infants and Toddlers Study.  
<sup>b</sup>AI=Adequate Intake.  
<sup>c</sup>SEM=standard error of the mean.  
<sup>d</sup>RAE=retinol activity equivalents.  
<sup>e</sup>A standard error of the mean could not be calculated due to skewness. We applied the observed SEM of the day 1 mean intake to compare the means.  
<sup>f</sup>ND=not determined due to skewness of the data.  
<sup>g</sup>NA=not applicable.  
\*Significantly greater than supplement nonusers, *P*<.05.  
\*\*Significantly greater than supplement nonusers, *P*<.01.

users (estimates of nutrients from foods includes beverages). For supplement users, mean daily intakes from supplements only are also shown. There were no significant differences between supplement users and nonusers in mean nutrient intakes from foods. In addition, we found no significant differences between users and nonusers in mean nutrient density (nutrients per 1,000 kcal) (data not shown).

Among supplement users 6 to 11 months of age, supplements contributed, on average, approximately 50% of their total daily intake of vitamin D, 18% of vitamin E, 28% of vitamin A, 21% of vitamin C, and 10% of iron (data not shown). Among toddlers, supplements contributed a mean of 54% of their total daily intake of vitamin D, 45% of vitamin E, 42% of vitamin A, 34% of vitamin C, 22% of folate, and 21% of iron (Figure 3). Supplements contributed less than 10% of daily intakes of zinc (8%) and calcium (2%).

#### Food Consumption Patterns of Vitamin/Mineral Supplement Users and Nonusers

Overall, there were few significant differences in foods consumed by supplement users and nonusers (based on the single 24-hour recall). Among infants 6 to 11 months, supplement users were more likely than nonusers to have consumed rice or pasta (18% vs 11%), meat or other protein sources (72% vs 62%), and any type of sweet, dessert, or sweetened beverage (56% vs 47%) (Appendix). Among toddlers, supplement users were less likely than nonusers to have consumed formula (4% vs 9%), baby

food fruit (3% vs 7%), and carbonated sodas (4% vs 11%) and more likely than nonusers to have consumed fresh fruit (62% vs 52%) and nonmeat protein sources (cheese, eggs, peanut butter, dried beans and peas) (73% vs 64%).

#### DISCUSSION

This article makes an important contribution to our knowledge about the use of supplements among infants and toddlers and about the effects supplements have on usual nutrient intakes. Our analysis showed that use of dietary supplements is relatively uncommon among young infants (8% among 4- and 5-month-olds), but increases as children age (31% among 12- to 24-month-olds). This is consistent with data from NHANES III and data from the Iowa Fluoride Study (13,26). We also found that most infants and toddlers receive only one type of supplement, that vitamin/mineral combinations are the most common type of supplement, and that most supplement users receive supplements on a regular basis. These findings are also consistent with data from NHANES III and data from the Iowa Fluoride Study (13,26).

In comparing characteristics of supplement users and nonusers, we found that supplement use was more common among children who were first born and children who were considered to be "picky eaters." Comparable results have been reported by Yu and colleagues (27) (first born) and Birch and Lee (picky eaters) (28). Logistic regression results showed that being male, living in the Northeast, and living in a household with fewer children are independent predictors of supplement use. A greater

**Table 5.** Usual intake of selected micronutrients among supplement users: Toddlers aged 12 to 24 months<sup>a</sup>

| Nutrient                          | Dietary Reference Intakes |                  |                 |                    | Usual Intake Percentiles (n=239) |       |        |                       |       |       | Inadequate/<br>Excessive Usual<br>Intake<br>(n=239) |      |
|-----------------------------------|---------------------------|------------------|-----------------|--------------------|----------------------------------|-------|--------|-----------------------|-------|-------|---|------|
|                                   | EAR <sup>b</sup>          | RDA <sup>c</sup> | AI <sup>d</sup> | UL <sup>e</sup>    | 10th                             | 25th  | Median | Mean±SEM <sup>f</sup> | 75th  | 90th  | %<EAR   | %>UL |
| <b>Vitamins</b>                   |                           |                  |                 |                    |                                  |       |        |                       |       |       |   |      |
| Vitamin A (μg, RAE <sup>g</sup> ) | 210                       | 300              |                 | 600 <sup>h</sup>   | 755                              | 878   | 1,025  | 1,052**±16.8          | 1,192 | 1,377 | <1  | 97   |
| Vitamin C (mg/d)                  | 13                        | 15               |                 | 400                | 59                               | 81    | 11     | 125**±4.3             | 151   | 204   | <1  | <1   |
| Vitamin D (μg/d)                  |                           |                  | 5               | 50                 | 10.7                             | 12.9  | 15.1   | 14.8**±0.20           | 17.0  | 18.4  | NA <sup>i</sup>                                     | 0    |
| Vitamin E (mg/d)                  | 5                         | 6                |                 | 200 <sup>j,k</sup> | 5.2                              | 6.8   | 8.5    | 9.7**±0.29            | 11.9  | 16.2  | 9   | 0    |
| Folate (μg/d)                     | 120                       | 150              |                 | 300 <sup>k</sup>   | 188                              | 255   | 365    | 443**±16.3            | 580   | 959   | 2   | 18   |
| Vitamin B-12 (μg/d)               | 0.7                       | 0.9              |                 | ND <sup>l</sup>    | 3.1                              | 4.0   | 5.1    | 5.2**±0.11            | 6.3   | 7.5   | <1  | NA   |
| <b>Minerals</b>                   |                           |                  |                 |                    |                                  |       |        |                       |       |       |   |      |
| Calcium (mg/d)                    |                           |                  | 500             | 2,500              | 597                              | 748   | 934    | 955±18.8              | 1,139 | 1,340 | NA  | <1   |
| Iron (mg/d)                       | 3.0                       | 7.0              |                 | 40                 | 6.4                              | 8.6   | 11.8   | 12.7**±0.35           | 16.0  | 20.3  | <1  | <1   |
| Phosphorus (mg/d)                 | 380                       | 460              |                 | 3,000              | 722                              | 842   | 988    | 1,002±14.6            | 1,146 | 1,300 | <1  | 0    |
| Potassium (mg/d)                  |                           |                  | 3,000           | ND                 | 1,427                            | 1,676 | 1,990  | 2,035±32.6            | 2,344 | 2,700 | NA  | NA   |
| Sodium (mg/d)                     |                           |                  | 1,000           | 1,500              | 1,111                            | 1,335 | 1,620  | 1,682±32.1            | 1,959 | 2,327 | NA  | 60   |
| Zinc (mg/d)                       | 2.5                       | 3.0              |                 | 7                  | 5.8                              | 6.6   | 7.8    | 8.1**±0.13            | 9.2   | 10.8  | <1  | 68   |
| Fiber (g/d)                       |                           |                  | 17 <sup>m</sup> | ND                 | 4.9                              | 6.2   | 7.9    | 8.4±0.21              | 10    | 12.6  | NA  | NA   |

<sup>a</sup>Data from the 2002 Feeding Infants and Toddlers Study (FITS).<sup>b</sup>EAR=Estimated Average Requirement.<sup>c</sup>RDA=Recommended Dietary Allowance.<sup>d</sup>AI=Adequate Intake.<sup>e</sup>UL=Tolerable Upper Intake Level.<sup>f</sup>SEM=standard error of the mean.<sup>g</sup>RAE=retinol activity equivalent.<sup>h</sup>The UL for vitamin A is based on preformed vitamin A (retinol). Assessment of the proportion of the population with intakes above the UL is based on intakes of preformed vitamin A rather than total RAEs.<sup>i</sup>NA=not applicable.<sup>j</sup>As α-tocopherol; applies to any form of supplemental α-tocopherol.<sup>k</sup>The ULs for vitamin E and folate apply to synthetic forms obtained from supplements, fortified foods, or a combination of the two. Assessment of the proportion of the population with intakes about the ULs is based on synthetic sources rather than total intake.<sup>l</sup>ND=not determined.<sup>m</sup>The AI for children aged 1 to 3 y is 19 g/d, based on a recommendation of 14 g fiber/1,000 kcal and a median intake of 1,372 kcal/d for 1- to 3-year-olds in the Continuing Survey of Food Intakes by Individuals. Adjusting for the lower median energy intake of the 12- to 24-month-old FITS toddlers leads to an adjusted AI of 17 g/d.\*\*Significantly greater than supplement nonusers, *P*<.01.

prevalence of supplement use among male infants and toddlers was also observed in NHANES III (26). Yu and her colleagues found that, among 3-year-olds, supplement use was also predicted by maternal education, race (prevalence greater among whites than blacks and Hispanics), having a chronic condition, and having food allergies. Only the first two of these characteristics was assessed in our analysis and neither turned out to be significant. Eichenberger Gilmore and her colleagues reported a substantially greater prevalence of supplement use among breastfed infants than nonbreastfed infants (13). In our analysis, breastfeeding status was not associated with supplement use. This may be partly due to the fact that the FITS sample included older infants (4 to 11 months vs 0 to 11 months).

Our analysis of usual nutrient intakes of supplement users and nonusers is the first to use IOM-recommended approaches to assessing nutrient intakes and applying DRI reference standards. Among infants aged 6 to 11 months, mean usual intakes of vitamins A, B-12, C, D, and E, as well as intakes of folate, iron, and potassium

were significantly greater for vitamin/mineral supplement users than nonusers. Because most nutrient requirements for this age group have been defined in terms of AIs, we cannot say with certainty whether these differences have any impact on the proportion of infants who have adequate nutrient intakes. However, the fact that both users and nonusers had mean usual intakes that were well in excess of the AIs, suggests that such differences are likely to be small. We can say more about iron and zinc intakes because EARs for these two nutrients have been defined for infants 7 to 11 months. In both cases, the proportion of the population with intakes less than the EAR was greater for supplement nonusers than users (8% vs 3% for iron and 5% vs 3% for zinc). This suggests that supplement use may be important in ensuring adequate intakes among infants with marginal intakes of iron and zinc.

Among toddlers, mean usual intakes of vitamins A, B-12, C, D, and E, as well as for folate, iron, and zinc were significantly greater among supplement users than supplement nonusers. For vitamin D and calcium, nutrient

**Table 6.** Usual intake of selected micronutrients among supplement nonusers: Toddlers aged 12 to 24 months<sup>a</sup>

| Nutrient                          | Dietary Reference Intakes |                  |                    |                    | Usual Intake Percentiles (n=764) |       |        |                       |       |       | Inadequate/<br>Excessive Usual<br>Intake<br>(n=764) |      |
|-----------------------------------|---------------------------|------------------|--------------------|--------------------|----------------------------------|-------|--------|-----------------------|-------|-------|---|------|
|                                   | EAR <sup>b</sup>          | RDA <sup>c</sup> | AI <sup>d</sup>    | UL <sup>e</sup>    | 10th                             | 25th  | Median | Mean±SEM <sup>f</sup> | 75th  | 90th  | %<EAR   | %>UL |
| <b>Vitamins</b>                   |                           |                  |                    |                    |                                  |       |        |                       |       |       |   |      |
| Vitamin A (μg, RAE <sup>g</sup> ) | 210                       | 300              |                    | 600 <sup>h</sup>   | 334                              | 426   | 545    | 576**±8.0             | 688   | 848   | 1   | 15   |
| Vitamin C (mg/d)                  | 13                        | 15               |                    | 400                | 32                               | 48    | 73     | 80**±1.6              | 104   | 137   | <1  | <1   |
| Vitamin D (μg/d)                  |                           |                  | 5                  | 50                 | 3.3                              | 4.8   | 6.5    | 6.7**±0.10            | 8.3   | 10.2  | NA <sup>i</sup>                                     | 0    |
| Vitamin E (mg/d)                  | 5                         | 6                |                    | 200 <sup>j,k</sup> | 2.6                              | 3.3   | 4.3    | 4.6**±0.06            | 5.6   | 7.0   | 65  | 0    |
| Folate (μg/d)                     | 120                       | 150              |                    | 300 <sup>k</sup>   | 166                              | 207   | 263    | 276**±3.5             | 331   | 403   | 2   | <1   |
| Vitamin B-12 (μg/d)               | 0.7                       | 0.9              |                    | ND <sup>l</sup>    | 1.8                              | 2.4   | 3.1    | 3.2**±0.04            | 3.9   | 4.7   | <1  | NA   |
| <b>Minerals</b>                   |                           |                  |                    |                    |                                  |       |        |                       |       |       |   |      |
| Calcium (mg/d)                    |                           |                  | 500                | 2,500              | 521                              | 695   | 910    | 932±12                | 1,145 | 1,372 | NA  | <1   |
| Iron (mg/d)                       | 3.0                       | 7.0              |                    | 40                 | 5.0                              | 6.3   | 8.2    | 8.8**±0.13            | 10.7  | 13.4  | <1  | 0    |
| Phosphorus (mg/d)                 | 380                       | 460              |                    | 3,000              | 593                              | 750   | 939    | 956±10.6              | 1,143 | 1,342 | 2   | 0    |
| Potassium (mg/d)                  |                           |                  | 3,000              | >ND                | 1,315                            | 1,583 | 1,913  | 1,951±18.8            | 2,277 | 2,636 | NA  | NA   |
| Sodium (mg/d)                     |                           |                  | 1,000              | 1,500              | 1,031                            | 1,274 | 1,581  | 1,625±17.8            | 1,929 | 2,277 | NA  | 57   |
| Zinc (mg/d)                       | 2.5                       | 3.0              |                    | 7                  | 4.1                              | 5.1   | 6.3    | 6.5**±0.07            | 7.7   | 9.2   | <1  | 38   |
| Fiber (g/d)                       |                           |                  | 19/17 <sup>m</sup> | ND                 | 4.7                              | 5.9   | 7.5    | 7.9±0.10              | 9.4   | 11.5  | NA  | NA   |

<sup>a</sup>Data from the 2002 Feeding Infants and Toddlers Study (FITS).<sup>b</sup>EAR=Estimated Average Requirement.<sup>c</sup>RDA=Recommended Dietary Allowance.<sup>d</sup>AI=Adequate Intake.<sup>e</sup>UL=Tolerable Upper Intake Level.<sup>f</sup>SEM=standard error of the mean.<sup>g</sup>RAE=retinol activity equivalent.<sup>h</sup>The UL for vitamin A is based on preformed vitamin A (retinol). Assessment of the proportion of the population with intakes above the UL are based on intakes of preformed vitamin A, not total RAEs.<sup>i</sup>NA=not applicable.<sup>j</sup>As α-tocopherol; applies to any form of supplemental α-tocopherol.<sup>k</sup>The ULs for vitamin E and folate apply to synthetic forms obtained from supplements, fortified foods, or a combination of the two. Assessment of the proportion of the population with intakes about the ULs for these nutrients are based on synthetic sources rather than total intake.<sup>l</sup>ND=not determined.<sup>m</sup>The AI for children aged 1 to 3 years is 19 g/d, based on a recommendation of 14 g fiber/1,000 kcal and a median intake of 1,372 kcal/d for 1- to 3-year-olds in the Continuing Survey of Food Intakes by Individuals. Adjusting for the lower median energy intake of the 12- to 24-month-old FITS toddlers leads to an adjusted AI of 17 g/d.\*\*Significantly lower than supplement users, *P*<.01.

requirements are expressed as AIs. Mean intakes exceeded the AIs among both supplement users and nonusers, suggesting that both groups had adequate intakes. For most of the nutrients with defined EARs (vitamins A, B-12, and C, folate, iron, phosphorus, and zinc), the prevalence of inadequate intakes was low for both supplement users and nonusers, indicating that the nutrients provided by supplements did not make a critical contribution to ensuring adequate intakes.

Vitamin E was an exception. Approximately two thirds of nonusers (65%) and one tenth of users (9%) had usual intakes of vitamin E that were less than the EAR. Vitamin/mineral supplements clearly make a difference in the proportion of toddlers who have usual intakes that are consistent with the EAR. However, the true significance of this effect is uncertain. A previous analysis of FITS data reported this finding for the full sample (29), and other researchers have reported similar findings for infants, toddlers, school-age children, adolescents, and adults (30). Yet, clinical evidence of vitamin E deficiency is rare (31). There is some concern that the EAR for

vitamin E may be too high (30). In addition, there may be problems with assessment of vitamin E intakes because of imprecise collection of information about fats and oils and/or problems with nutrient database values (29).

Data on the prevalence of excessive intakes raise more concerns. Nearly all toddlers who used supplements had intakes above the UL for vitamin A, as did 15% of supplement nonusers. In addition, substantial proportions of supplement users and nonusers had usual intakes of zinc that exceeded the UL. This was true for both infants and toddlers. Finally, almost one in five toddlers who used supplements had folate intakes that exceeded the UL. Comparable patterns were noted in CSFII 1994-1996, 1998 data for usual intakes of vitamin A and zinc from food alone (folate was not included in the analysis) (30).

The apparently excessive intakes of vitamin A and zinc may be an artifact of the method used to set the ULs. For both nutrients, there is a relatively narrow margin between the UL and the RDA (30). It is important to note, however, that preformed vitamin A and zinc are widely used as fortificants in foods that are commonly consumed

**Table 7.** Mean daily intakes of vitamin/mineral supplement nonusers and users by source: Infants aged 6 to 11 months and toddlers aged 12 to 24 months<sup>ab</sup>

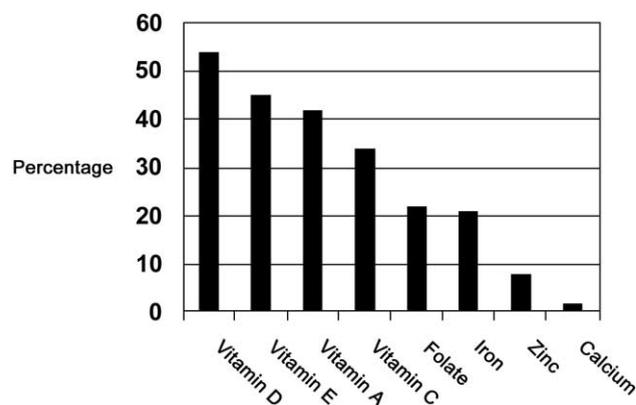
|                                   | Infants 6-11 Months                   |                                       |                               | Toddlers 12-24 Months                 |                                       |                            |
|-----------------------------------|---------------------------------------|---------------------------------------|-------------------------------|---------------------------------------|---------------------------------------|----------------------------|
|                                   | Nonuser<br>(n=1,218)                  | User (n=177)                          |                               | Nonuser<br>(n=774)                    | User (n=229)                          |                            |
|                                   | Intake from<br>foods and<br>beverages | Intake from<br>foods and<br>beverages | Intake<br>from<br>supplements | Intake from<br>foods and<br>beverages | Intake from<br>foods and<br>beverages | Intake from<br>supplements |
|                                   | ← mean ± SEM <sup>c</sup> →           |                                       |                               |                                       |                                       |                            |
| <b>Vitamins</b>                   |                                       |                                       |                               |                                       |                                       |                            |
| Vitamin A (μg, RAE <sup>d</sup> ) | 718 ± 10                              | 719 ± 24.9                            | 380 ± 36.2                    | 571 ± 13.6                            | 622 ± 37.1                            | 442 ± 16.5                 |
| Vitamin C (mg/d)                  | 97 ± 1.6                              | 103 ± 3.8                             | 28 ± 1.7                      | 80 ± 2.8                              | 88 ± 6.1                              | 38 ± 2.1                   |
| Vitamin D (μg/d)                  | 7 ± 0.1                               | 6 ± 0.3                               | 8 ± 0.4                       | 7 ± 0.2                               | 7 ± 0.2                               | 8 ± 0.3                    |
| Vitamin E (mg/d)                  | 9 ± 0.1                               | 9 ± 0.3                               | 4 ± 1.2                       | 4 ± 0.1                               | 4 ± 0.2                               | 6 ± 0.5                    |
| Folate (μg/d)                     | 134 ± 2.2                             | 136 ± 6.3                             | 36 ± 2.5                      | 208 ± 4.6                             | 204 ± 6.2                             | 94 ± 1.2                   |
| Vitamin B-12 (μg/d)               | 2 ± 0.03                              | 2 ± 0.1                               | 1 ± 0.2                       | 3 ± 0.1                               | 3 ± 0.1                               | 2 ± 0.2                    |
| <b>Minerals</b>                   |                                       |                                       |                               |                                       |                                       |                            |
| Calcium (mg/d)                    | 618 ± 9.2                             | 617 ± 21.8                            | 2 ± 1.3                       | 929 ± 18.8                            | 952 ± 30.9                            | 16 ± 3.6                   |
| Iron (mg/d)                       | 15 ± 0.3                              | 16 ± 0.8                              | 2 ± 0.4                       | 9 ± 0.2                               | 9 ± 0.3                               | 4 ± 0.5                    |
| Phosphorus (mg/d)                 | 502 ± 8.3                             | 520 ± 19.4                            | 2 ± 1.3                       | 959 ± 16.5                            | 988 ± 26.2                            | 10 ± 2.4                   |
| Potassium (mg/d)                  | 1,214 ± 16.5                          | 1,289 ± 39.6                          | 0.14 ± 0.14                   | 1,952 ± 30.9                          | 2,032 ± 48.1                          | 0.2 ± 0.2                  |
| Sodium (mg/d)                     | 484 ± 16.8                            | 555 ± 67.8                            | 0                             | 1,630 ± 33.5                          | 1,665 ± 59.9                          | 0                          |
| Zinc (mg/d)                       | 6 ± 0.1                               | 6 ± 0.2                               | 0.4 ± 0.22                    | 7 ± 0.1                               | 7 ± 0.2                               | 1 ± 0.4                    |
| Fiber (g/d)                       | 5.7 ± 0.1                             | 6.3 ± 0.4                             | 0                             | 7.9 ± 0.2                             | 8.4 ± 0.3                             | 0                          |

<sup>a</sup>Data from the 2002 Feeding Infants and Toddler Study, means based on Day 1 dietary intake data.

<sup>b</sup>None of the differences between supplement nonusers and users in mean daily intakes from food and beverages were statistically significant.

<sup>c</sup>SEM=standard error of the mean.

<sup>d</sup>RAE=retinol activity equivalent.



**Figure 3.** Proportion of daily nutrient intake from supplements among users, toddlers age 12 to 24 months. n=229 users; based on 1-day 24-hour dietary intake. Data from the 2002 Feeding Infants and Toddlers Study.

by infants and toddlers. Another article in this *Journal of the American Dietetic Association* supplement found that the leading sources of vitamin A in the diets of toddlers were milk (30% of all vitamin A), supplements (15%), and fortified noninfant cereals (8%) (32). The leading sources of zinc in toddlers' diets were milk (28%), fortified noninfant cereals (12%), beef (7%), and cheese (6%) (32). In recent years, fortification with folate has also become widespread. In FITS, the major sources of folate in the

diets of older infants were infant formula (45%), fortified ready-to-eat cereals (11%), and supplements (5%); in the diets of toddlers, the major sources were fortified ready-to-eat cereals (20%), supplements (14%), milk (8%), pasta (8%), and breads/rolls/biscuits/bagels/tortillas (7%) (32). Although toxicities are rare, the potential for excessive intakes from fortified foods and supplements should not be overlooked.

#### LIMITATIONS

This study has some limitations that should be acknowledged. All of our data were self-reported, and caregivers may have overreported or underreported intakes. There is reason to believe that overreporting was more common than underreporting (29). However, mean energy intakes of FITS toddlers are consistent with mean energy intakes reported for 1-year-olds in CSFII 1994-1996, 1998 (33) and NHANES III (34), and another article in this supplement shows that portion sizes reported for toddlers in FITS are consistent with those reported for toddlers in CSFII 1994-1996, 1998 (35). Thus, if overreporting is present, it seems to be comparable to that observed in national nutrition monitoring surveys. Sample sizes did not allow for more detailed comparisons of subgroups defined by race/ethnicity or socioeconomic status. In addition, because of constraints related to respondent burden, we were unable to collect information on other factors that may influence supplement use, such as caregivers' own use of supplements and their beliefs and attitudes about supplements. We were unable to assess

fluoride intakes because the NDS-R does not include values for fluoride. Finally, the small sample of supplement users younger than 6 months of age made it impossible for us to assess nutrient intakes of supplement users in this age group.

## CONCLUSIONS

In the absence of evidence-based standards for the use of supplements in infants and children, dietetics professionals and other health practitioners should continue to emphasize foods rather than supplements as the optimal source of nutrients for healthy children (36). The FITS data demonstrate that healthy infants and toddlers can readily obtain required levels of nutrients without using supplements. At the same time, nutrition practitioners should be fully cognizant of the special circumstances that might warrant vitamin/mineral supplementation. This includes the American Academy of Pediatrics recommendations regarding vitamin D, iron, and fluoride in infants up to 12 months (4), as well as Centers for Disease Control and Prevention recommendations for preventing iron-deficiency anemia (7).

With regard to iron, nutrition practitioners need to be aware of factors that may enhance or inhibit iron absorption. Foods that are meat products or rich in vitamin C, vitamin A, and/or ethylenediaminetetraacetic acid may enhance the bioavailability of iron. Polyphenols (in certain vegetables), tannins (in tea), phytates (in bran), and calcium (in dairy products) may inhibit the absorption of iron (37,38).

In assessing diets of infants and toddlers, care should be taken to collect detailed information about both food and supplement intakes. This is especially important for nutrients commonly used in fortified foods, such as vitamin A, zinc, and folate. Information about intake and sources of water should also be collected to ensure accurate assessment of fluoride intake.

Dietetics professionals need to caution parents about the potential for excessive intakes from reliance on fortified foods and unwarranted supplementation.

Future research should assess the appropriateness of DRIs for vitamin E, vitamin A, and zinc. Finally, future research should assess total nutrient intakes of supplement users and nonusers younger than 6 months of age.

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**Appendix.** Percentage of older infant and toddler vitamin/mineral supplement users and nonusers consuming different types of foods, food groups, and beverages<sup>a</sup>

|  | Infants 6-11 Months |                    | Toddlers 12-24 Months |                  |
|--|---------------------|--------------------|-----------------------|------------------|
|  | Users (n=177)       | Nonusers (n=1,218) | Users (n=229)         | Nonusers (n=774) |
|  | ← % →               |                    |                       |                  |
| <b>Food group: Milk</b>  |                     |                    |                       |                  |
| Breast milk  | 29.3                | 23.6               | 6.1                   | 6.7              |
| Formula  | 74.8                | 79.3               | 4.1**                 | 8.6              |
| Whole cow's milk, unflavored   | 5.8                 | 7.9                | 68.1                  | 63.3             |
| Yogurt   | 13.3                | 8.9                | 20.7                  | 15.7             |
| <b>Food group: Grain products</b>                                    |                     |                    |                       |                  |
| Any grain or grain product   | 96.0                | 93.2               | 99.2                  | 98.5             |
| Infant cereal  | 71.8                | 73.9               | 11.0                  | 10.0             |
| Noninfant cereal   | 33.8                | 26.8               | 54.5                  | 57.1             |
| Not presweetened cereal  | 29.0                | 22.9               | 36.9                  | 38.3             |
| Crackers, pretzels, rice cakes                                       | 27.7                | 22.5               | 50.7                  | 43.6             |
| Rice and pasta <sup>b</sup>  | 18.3*               | 10.5               | 38.8                  | 33.2             |
| <b>Food group: Fruits</b>  |                     |                    |                       |                  |
| Any fruit and 100% fruit juice                                       | 89.2                | 86.2               | 90.0                  | 85.8             |
| Any fruit <sup>c</sup>   | 71.5                | 75.3               | 72.1                  | 70.8             |
| 100% Fruit juice   | 56.4                | 47.9               | 65.1                  | 57.5             |
| Fruit preparation  |                     |                    |                       |                  |
| Baby food fruit  | 50.0                | 56.9               | 3.3**                 | 7.0              |
| Non-baby food fruit  | 32.5                | 27.8               | 71.2                  | 66.6             |
| Fresh fruit  | 23.8                | 18.5               | 61.8**                | 51.7             |
| <b>Food group: Vegetables</b>  |                     |                    |                       |                  |
| Any vegetable <sup>d</sup>   | 74.1                | 69.0               | 82.9                  | 78.7             |
| Type of preparation  |                     |                    |                       |                  |
| Baby food vegetables   | 40.8                | 46.7               | 4.7                   | 4.7              |
| Cooked vegetables  | 37.2                | 28.7               | 73.3                  | 72.3             |
| Raw vegetables   | 6.1                 | 2.9                | 17.3                  | 13.7             |
| Types of vegetables <sup>d</sup>                                     |                     |                    |                       |                  |
| Deep yellow vegetables <sup>e</sup>                                  | 41.3                | 34.6               | 14.7                  | 16.4             |
| Other nonstarchy vegetables <sup>f</sup>                             | 29.6                | 28.8               | 47.2                  | 41.9             |
| Starchy vegetables: potato   | 20.1                | 16.0               | 37.6                  | 39.9             |
| <b>Food group: Meat or other protein sources</b>                     |                     |                    |                       |                  |
| Any meat or protein source <sup>g</sup>                              | 72.0*               | 61.8               | 96.9                  | 93.4             |
| Baby food meat   | 6.8                 | 3.2                | 0.5                   | 0.2              |
| Other protein sources <sup>h</sup>                                   | 28.0                | 20.9               | 73.1*                 | 63.7             |
| Protein sources in mixed dishes                                      | 47.2                | 41.1               | 21.0                  | 25.5             |
| <b>Food group: Any type of dessert, sweet, or sweetened beverage</b> |                     |                    |                       |                  |
| Any type of dessert, sweet, or sweetened beverage                    | 56.4*               | 47.1               | 90.1                  | 86.2             |
| Desserts and candy   | 48.4                | 41.0               | 70.9                  | 67.5             |
| Other sweets   | 9.5                 | 6.9                | 32.4                  | 32.2             |
| Sweetened beverages <sup>i</sup>                                     | 9.8                 | 7.3                | 33.2                  | 39.6             |
| Carbonated sodas   | 1.2                 | 1.0                | 4.4**                 | 10.7             |
| Fruit-flavored drinks  | 8.2                 | 6.1                | 31.3                  | 31.6             |
| <b>Food group: Other</b>   |                     |                    |                       |                  |
| Any type of salty snack <sup>j</sup>                                 | 6.1                 | 3.0                | 20.1                  | 22.8             |

<sup>a</sup>Data from the 2002 Feeding Infants and Toddlers Study, users and nonusers subgroups; 24-hour dietary recall data, day 1 intake.

<sup>b</sup>Does not include rice or pasta in mixed dishes. Includes rice (eg, white, brown, wild, and Spanish rice without meat) and pasta (eg, spaghetti, macaroni, and egg noodles).

<sup>c</sup>Total includes all baby food and non-baby food fruits and excludes 100% fruit juices and juice drinks.

<sup>d</sup>Total includes commercial baby food, cooked vegetables, raw vegetables, and 100% vegetable juices.

<sup>e</sup>Reported deep-yellow vegetables include carrots, pumpkin, sweet potatoes, and winter squash.

<sup>f</sup>Reported nonstarchy vegetables include asparagus, cauliflower, cabbage, onions, green beans, mixed vegetables, peppers, and tomatoes.

<sup>g</sup>Includes baby food and non-baby food sources.

<sup>h</sup>Includes cheese, eggs, peanut butter, and dried peas and beans.

<sup>i</sup>Includes soda, ades, fruit-flavored drinks, and other sweetened beverages.

<sup>j</sup>Includes potato chips, popcorn, cheese curls or puffs, tortilla chips, corn chips, and other types of chips and salty snacks.

\*Significantly different from nonusers at the  $P < .05$  level of significance.

\*\*Significantly different from nonusers at the  $P < .01$  level of significance.