National Report on Biochemical Indicators of Diet and Nutrition in the U.S. Population

1999–2002

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

National Report on Biochemical Indicators of Diet and Nutrition in the U.S. Population 1999–2002

July 2008

Department of Health and Human Services
Centers for Disease Control and Prevention

Centers for Disease Control and Prevention
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Atlanta, Georgia 30341-3724

NCEH Pub. No. 08-2982c

The Centers for Disease Control and Prevention (CDC) protects people's health and safety by preventing and controlling diseases and injuries; enhances health decisions by providing credible information on critical health issues; and promotes healthy living through strong partnerships with local, national, and international organizations.

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Introduction

Background

This report provides reference information for blood or urine concentrations of 27 biochemical indicators of diet and nutrition measured by the Centers for Disease Control and Prevention (CDC), Division of Laboratory Sciences at the National Center for Environmental Health (NCEH/DLS). The indicators were measured in specimens from a representative sample of the noninstitutionalized civilian U.S. population during all or part of the four-year period from 1999 through 2002. These specimens were collected by CDC's National Health and Nutrition Examination Survey (NHANES), which is conducted by CDC's National Center for Health Statistics (NCHS). NHANES is a series of surveys designed to collect data on the health and nutritional status of the U.S. population. This report covers one important facet in the assessment of nutritional status of the U.S. population: biochemical measurements. Other aspects, such as anthropometric body measurements, hematologic measurements, clinical signs of nutritional deficiency or excess, and dietary intake, are not covered.

For this report, a biochemical indicator means a vitamin, iron-status indicator, trace element, or other dietary indicator with potential health relevance. Although most biochemical indicators presented in this report enter the human body from foods or supplements, the body itself produces some indicators in response to dietary intake. Blood and urine concentrations reflect the amount of nutrients and dietary compounds actually in the body from all of these sources.

The biochemical indicators covered in this report are:

- Water-soluble vitamins and related biochemical compounds.
- Fat-soluble vitamins and micronutrients.
- Iron-status indicators.
- Trace elements.
- Isoflavones and lignans (so-called phytoestrogens).

Some indicators covered in this report have no nutritional value (e.g., homocysteine, methylmalonic acid, iron-status indicators, phytoestrogens). Yet, they are important because 1) they reflect micronutrient or metabolic status or 2) because they are a naturally occurring ingredient in the human diet (i.e., they are consumed as food or as dietary supplements) and have been associated with potential positive or negative health outcomes.

On the other hand, some important micronutrients, such as vitamin C, vitamin B6, or certain minerals (e.g., sodium, potassium, calcium, phosphorus, chloride, magnesium) are omitted from this report. Data were either unavailable for the report years covered or were not representative of micronutrient status. Future reports may, however, include other biochemical indicators of diet and nutrition.

Addressing Data Needs

This report is CDC's first product that presents data—in a single source—concerning NCEH/DLS measurements of a wide range of biochemical indicators of diet and nutrition from the most recent continuous NHANES survey, starting in 1999.

NCHS has historically released or commissioned a variety of products presenting NHANES results. Among these are Data Briefs, Data Tables, Advance Data, Series Reports, and Reports through the Life Sciences Research Office (LSRO). See the following for further information: http://www.cdc.gov/nchs/about/major/nhanes/survey_results_and_products.htm.

NHANES Series Reports (mainly Series 11) and LSRO Reports have always been of particular value to the nutrition community (see Appendix A). The two latest reports on nutritional biochemistry reference data were prepared for NHANES III (1988–1994). One covered hematologic and iron-related analytes, and the other covered blood folate and vitamin B12.

Public Health Uses

The primary purpose of this report is to improve our understanding of the concentrations of biochemical indicators of diet and nutrition in the general U.S. population and in selected subpopulations. These data will help assess inadequate or excess intake and will inform analyses on the relation between biochemical indicators and health outcomes. Other potential public health uses of the information include the following:

- Establishing and improving upon existing population reference levels that physicians, clinicians, scientists, and public health officials can use to determine whether a person or a group of people has an unusually high or low level of a biochemical indicator of diet and nutrition.
- Determining whether the nutritional status of special population groups, such as minorities, children, women of childbearing age, or the elderly is different from that of other groups, or whether it needs improvement.
- Tracking, over time, trends in biochemical indicator levels in the population.
- Assessing the effectiveness of public health efforts to improve the diet and nutritional status of U.S. residents.
- Stimulating research to perform more in-depth analyses of the NHANES data and to generate hypotheses for future nutrition and human health studies.

Data Presented for Each Biochemical Indicator

This publication contains tables of descriptive statistics on the distribution of blood and urine concentrations for each biochemical indicator of diet and nutrition. Statistics include unadjusted geometric means and selected percentiles with confidence intervals.

The data are grouped by age, sex, and race/ethnicity. A geometric mean provides a better estimate of central tendency for data distributions with a long tail at the upper end of the distribution. When measuring biochemical indicators, this type of distribution is common. The geometric mean is influenced less by high values than is the arithmetic mean. Scientists can use the presented percentile levels (5th or 10th, 50th, and 90th or 95th) to determine which serum, blood, or urine concentrations of indicators are common to people in the U.S. population and which concentrations are unusual. We used the unweighted sample size as a criterion for indicating reliable results (U.S. Centers for Disease for Control and Prevention 1996, Appendix B, Table 1). We assumed an average design effect of 1.4 and used a sample size of at least 112 persons to define estimates for the 10th and 90th percentiles as reliable and a sample size of at least 224 persons to define estimates for the 5th and 95th percentiles as reliable. We present 10th and 90th percentile levels for a biochemical indicator when the sample size was too small for 5th and 95th percentile levels in several subgroups. This is the case after stratifying by age, sex, and race/ethnicity with data from only two years (carotenoids, 25-hydroxyvitamin D, some iron-status indicators) or with data from only a subset of the population (iodine, selenium, phytoestrogens). For urine measurements, data are shown for both the concentration and for the concentration corrected for the urinary creatinine level.

General information is provided for each indicator that also aids in interpreting levels.

To address sources of these nutrients, biochemical pathways in the body, and known health effects, the text contains a brief overview about each indicator.

Selected observations and highlights—mainly derived from the data tables provided in this publication—are presented in each chapter.

The observations describe categorical differences between demographic subgroups, whereas the highlights summarize the observations in a public health context.

Interpreting the Data

Adequate serum or blood concentrations of biochemical indicators do not necessarily indicate that NHANES participants consume healthful and balanced diets. Some foods are fortified with micronutrients (e.g., iron, thiamin, riboflavin, niacin, folate, vitamin A, vitamin D), and some people take dietary supplements that contain vitamins, minerals, or both.

Although certain dietary deficiencies are well documented and have characteristic signs and symptoms, suboptimal concentrations have been associated with the risk for adverse health effects such as cardiovascular disease, stroke, impaired cognitive function, cancer, eye diseases, poor bone health, and other conditions. Adverse health effects, including toxicity, are also possible from consuming excess amounts of certain nutrients. Research studies, separate from this report, are required to determine those concentrations of a biochemical indicator that may indicate risk for disease and those concentrations that are of negligible health concern. In collaboration with other agencies and institutions, CDC encourages, and itself conducts, measurements for this type of research.

This report contains unadjusted geometric means and selected percentiles of biochemical indicators of diet and nutrition for the civilian, noninstitutionalized U.S. population. A limited interpretation of relative differences between population groups is possible by identifying groups with non-overlapping confidence intervals. These observed differences, however, should not be interpreted as causal. The intent is to describe the characteristics of the population and of selected subgroups, and not to explain why the groups look the way they do or why they differ from each other. For example, for biochemical indicators correlated with age, age may account for some of the effects. Furthermore, differences in biochemical indicator concentrations of selected subgroups do not necessarily imply health problems. More in-depth statistical analyses, such as adjusting for demographic variables or covariates, and taking interactions or predictive variables into consideration, are beyond the scope of this publication. We hope nonetheless that scientists will be stimulated to examine the data further by analyzing the raw data available at this Web site: http://www.cdc.gov/nchs/nhanes.htm.

Chemists prepare serum material for quality assurance.

Laboratories may use different methods for measuring the indicators reported here. Different methods may result in different method-specific reference ranges. Consequently, to apply these results, health science professionals should check with their particular laboratory to be sure their methods compare closely with those used in this report (see Appendix B).

Useful Sources of Information about Using Nutrition Monitoring to Interpret Data

Information about dietary intake is critical to research examining the reasons for nutritional inadequacies and for programs to improve diet and nutritional status. Selected NCHS Advance Data Reports provide useful overviews (see Appendix A). Also of value are the U.S. Department of Agriculture's (USDA) databases on food surveys and food composition:

What We Eat in America (WWEIA) is the dietary intake interview section of NHANES (http://www.ars.usda.gov/foodsurvey).

The Food and Nutrient Database for Dietary Studies (FNDDS) (http://www.ars.usda.gov/Services/docs.htm?docid=12089) is a database of foods, their nutrient values, and weights for typical food portions. This database helps to analyze data from the WWEIA survey by using the nutrient values from the National Nutrient Database for Standard Reference (http://www.ars.usda.gov/Services/docs.htm?docid=8964).

The Directory of Federal and State Nutrition Monitoring and Related Research Activities (Interagency Board for Nutrition Monitoring and Related Research 2000) is the fourth update in a series that provides information on the complex system of nutrition monitoring in the United States. It is a guide to those federal and state survey, surveillance, and research activities that are part of the National Nutrition Monitoring and Related Research Program (http://www.cdc.gov/nchs/about/otheract/nutrishn/nutrishn.htm).

The Third Report on Nutrition Monitoring in the United States (Interagency Board for Nutrition Monitoring and Related Research 1995) provides the latest update on the dietary, nutritional, and nutrition-related health status of United States residents, the relation between diet and health, and the factors that influence dietary and nutritional status.

The National Health and Nutrition Examination Survey (NHANES)

CDC laboratory scientists used biological specimens obtained from participants in NHANES to measure biochemical indicators of diet and nutrition for this publication. NHANES is a series of NCHS-conducted surveys designed to collect data on the health and nutritional status of the U.S. population. This is the only national survey that collects biological samples. The NHANES surveys began in 1960 with the fielding of the first Health Examination Survey (HES 1). The nutritional component was added in the early 1970s in NHANES I. In 1999 NHANES became a continuous survey, sampling the U.S. population annually and releasing the data in two-year cycles.

NHANES collects information on a wide range of health-related behaviors, conducts physical examinations, and collects samples for laboratory tests. Because of physical examination and biological measures, NHANES is unique in its ability to examine public health issues, such as risk factors for cardiovascular disease, in the U.S. population. To select a representative sample of the civilian, noninstitutionalized population in the United States, the survey sampling plan follows a complex, stratified, multistage, probability-cluster design. The civilian, noninstitutionalized population consists of persons who are neither in the military nor institutionalized (e.g., residents of nursing homes, college dormitories, or prisons).

The NHANES protocol includes a home interview followed by a standardized physical examination at a mobile examination center. As part of the examination, for participants aged 1 year and older, blood is obtained by venipuncture. Urine specimens are collected from participants aged 6 years and older. By design, approximately half of the participants are evaluated after an overnight fast. Furthermore, close to 90 percent of all participants have fasted for more than 3 hours before providing a biological sample. Because the mobile examination centers can be adversely affected by weather, data are collected in northern latitudes in summer and in southern latitudes in winter. This seasonal-latitude structure might indirectly affect biochemical indicators.

Additional detailed information about the design and conduct of the NHANES survey is available at: http://www.cdc.gov/nchs/nhanes.htm. Information about how biological specimens are collected is available at the following Web site: http://www.cdc.gov/nchs/data/nhanes/blood.pdf and in the Laboratory Procedures Manual, which can be found at: http://www.cdc.gov/nchs/data/nhanes/lab1-6.pdf or at http://www.cdc.gov/nchs/data/nhanes/lab7-11.pdf.

Data Analysis

NCHS has developed a comprehensive Web-based tutorial (http://www.cdc.gov/nchs/tutorials/Nhanes/index.htm) to help users better understand the complex survey design and to help them analyze continuous NHANES data.

Because the NHANES sample design is complex, sample weights adjust for the unequal probability of selection into the survey. Sample weights also adjust for possible bias resulting from nonresponse and are post-stratified to U.S. Census Bureau estimates of the U.S. population. Data were analyzed using the statistical software package Statistical Analysis System (SAS) (SAS Institute Inc., 2002) and the statistical software package SUDAAN (SUDAAN Release 8.0, 2001). SUDAAN uses sample weights and calculates variance estimates that account for the complex survey design. Guidelines for the analysis of NHANES data are provided by NCHS at: http://www.cdc.gov/nchs/about/major/nhanes/nhanes2003-2004/analytical_guidelines.htm. Variance estimates were calculated using the Taylor series (linearization) method within SUDAAN. The Korn and Graubard method was used to compute Clopper-Pearson 95 percent confidence intervals (see Appendix C).

The tables show selected percentiles and unadjusted geometric means of analyte concentrations. Geometric means were calculated by taking the log of each concentration, calculating the mean of those log values, then taking the antilog of that mean (the calculation can be done using any log base, such as 10 or e). Percentile estimates were calculated using SAS Proc Univariate with weighted data. Results are shown for the total population and also by age group, sex, and race/ethnicity as defined in NHANES. For these analyses, sex is coded as male or female, and race/ethnicity is categorized as Mexican American, non-Hispanic black, and non-Hispanic white. Other racial or ethnic groups are sampled, but the proportion of the total population represented by these other groups is not large enough to produce valid estimates. Other racial/ethnic groups are included in estimates based on the entire population sample. Data for each racial/ethnic group are presented in three separate tables.

For calculation of geometric means, concentrations less than the limit of detection (LOD) were assigned a value equal to the LOD divided by the square root of 2. The LOD is the level at which the measurement has a 95 percent probability of being greater than zero (Taylor 1987). By comparison, assigning a value of the LOD divided by 2 made little difference in geometric mean estimates. Percentile estimates less than the LOD for the nutritional indicators are reported as "< LOD." If the proportion of results below the LOD was greater than 40 percent, geometric means were not calculated. Appendix D contains a table of LOD values for each biochemical indicator. As a result of changes to analytical methods, even for the same indicator, LOD values may change over the time period of the report. This was the case only for urinary phytoestrogens. We used the higher of the two LOD values for the analysis of the combined four-year data.

For biochemical indicators measured in urine, we present separate tables for the concentration of the indicator expressed as "per volume of urine" (uncorrected table) and the concentration of the indicator expressed as "per gram of creatinine" (creatinine-corrected table). Comparison of an individual participant's result to population data in the tables requires correction for urinary dilution: thus, an individual creatinine-corrected result is best compared to the creatinine-corrected data tables. Study populations of sufficient size can be compared to the tables having either of the corresponding units. We used the uncorrected tables to compare urine concentrations across groups. Because instrument responses are measured in units of weight per volume, LOD calculations were performed using the concentration of the indicator expressed as per volume of urine. For this reason, LOD results for urine measurements in Appendix D are in weight per volume of urine. In the creatinine-corrected tables, a result for a geometric mean or percentile was reported as less than the LOD (< LOD) if the corresponding geometric mean or percentile was < LOD in the uncorrected table. Thus, for example, if the 5th percentile for males was < LOD in the uncorrected table, it would also be < LOD in the creatinine-corrected table.

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1

Water-Soluble Vitamins & Related Biochemical Compounds

- Folate (serum and red blood cell)
- Vitamin B12
- Homocysteine
- Methylmalonic acid

Water-Soluble Vitamins & Related Biochemical Compounds

Folate and vitamin B12 belong to the group of water-soluble B vitamins that occur naturally in food. Leafy green vegetables (such as spinach and turnip greens), fruits (such as citrus fruits and juices), and dried beans and peas are all natural sources of folate. Folic acid is the synthetic form of folate found in supplements and added to fortified foods. Because of wide consumption of fortified foods in the United States, these products have become an important contributor of folic acid to the U.S. diet. Folate functions as a coenzyme in single-carbon transfers in the metabolism of nucleic and amino acids and is therefore especially important during periods of rapid cell division and growth, such as occurs during infancy and pregnancy.

Vitamin B12 (cobalamin) is found naturally in animal foods including fish, meat, poultry, eggs, milk, and milk products. For vegetarians, fortified breakfast cereals are a particularly valuable source of vitamin B12. Vitamin B12 functions as a coenzyme for a critical methyl transfer reaction that converts homocysteine to methionine and for a separate reaction that converts L-methylmalonyl-coenzyme A to succinyl-coenzyme A.

Homocysteine (Hcy) is an amino acid naturally found in the blood. Plasma Hcy concentrations are strongly influenced by diet as well as by genetic factors. Elevated concentrations are found in people whose folate, vitamin B12, or vitamin B6 status is suboptimal (Selhub 1993), and in people with impaired renal function (Wollensen 1999).

Methylmalonic acid (MMA) is a dicarboxylic acid naturally found in the blood. Plasma MMA concentrations are elevated when serum vitamin B12 concentrations are low or intermediate and are therefore a useful diagnostic test for confirming vitamin B12 deficiency (Baik 1999).

A chronic dietary deficiency of either folate or vitamin B12 causes macrocytic anemia, although strict dietary deficiencies are rare. Certain drugs (e.g., alcohol, methotrexate, anticonvulsants, sulfa drugs) may interfere with the absorption or utilization of folate, and disorders of the small bowel that limit absorption (e.g., Crohn's disease, jejunal bypass

surgery) can cause folate deficiency (Halsted 1990). Most people who develop a vitamin B12 deficiency have an underlying stomach or intestinal disorder that limits the absorption of vitamin B12. Subtly reduced cognitive function resulting from early vitamin B12 deficiency is sometimes the only symptom of these intestinal disorders. Severe vitamin B12 deficiency can cause permanent nerve damage and dementia. Hematologic signs, however, are not always present in vitamin B12 deficiency and hematologic signs and neurologic abnormalities can be inversely correlated (Baik 1999).

Clinical trials have shown that folic acid supplementation effectively reduces the number of neural tube birth defects (NTDs) (Czeizel 1992; MRC Vitamin Study Research Group 1991). Thus, CDC and the U.S. Public Health Service have recommended that every woman who could become pregnant consume at least 400 micrograms (µg) of folic acid each day (U.S. Centers for Disease Control and Prevention 1992). Since 1998, the U.S. Food and Drug Administration (FDA) has required the addition of folic acid to enriched breads, cereals, flours, corn meals, pastas, rice, and other grain products (U.S. Food and Drug Administration 1996a). Recent observational studies have suggested potential benefits of the U.S. folic acid fortification, such as reduced NTD rates (Williams 2005), decreased prevalence of inadequate serum and RBC folate concentrations (Pfeiffer 2005), and declines in the incidence of stroke (Yang 2006) and neuroblastoma (French 2003). Potential roles are currently being studied for 1) folate in altering the risks for heart disease and cancer, 2) vitamin B12 in modulating the risks for cognitive impairment, and 3) Hcy as a risk factor for or a marker of cardiovascular disease.

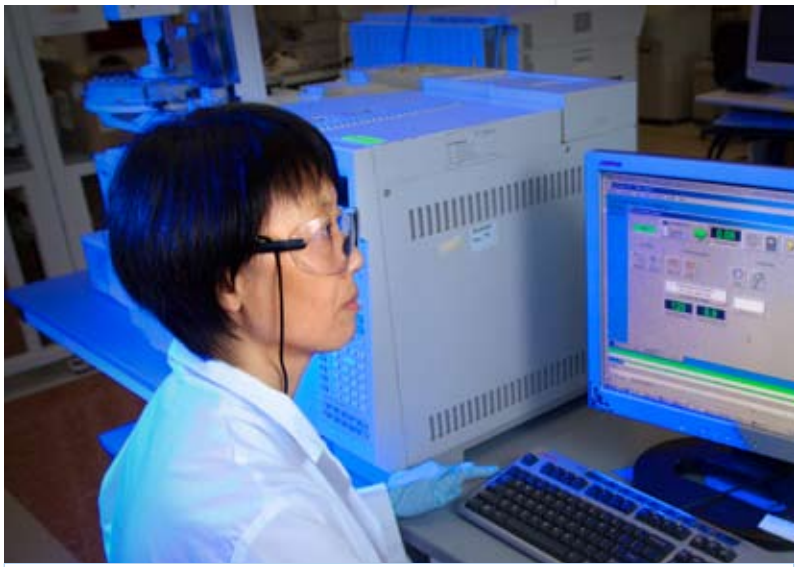
The recommended dietary allowance (RDA) for both men and women is 400 µg per day of dietary folate equivalents (DFEs). DFEs adjust for the nearly 50 percent lower bioavailability of dietary folate compared with the bioavailability of folic acid: 1 µg of dietary folate equivalent equals 0.6 µg of folic acid from fortified food or from a supplement taken on an empty stomach (Institute of Medicine 1998). The RDA for vitamin B12 for adults is 2.4 µg per day. Because as many as 10 to 30 percent of older people may be unable to absorb naturally occurring vitamin B12, it is advisable for people older than 50 years to meet their RDA mainly by consuming foods fortified with vitamin B12 or by taking a supplement containing vitamin B12. People with vitamin B12 deficiency caused by a lack of intrinsic factor or intestinal malabsorption require parenteral B12 treatment (Institute of Medicine 1998).

Excess folic acid may mask and potentially delay diagnosis of anemia among people with vitamin B12 deficiency resulting in increased risk for neurological damage. Consequently, the Institute of Medicine (1998) recommends that folic acid intake for adults (aged 19 years and older) not exceed 1000 µg per day. Because no data were available for children, the Institute of Medicine used the level for adults adjusted by weight: 300–800 µg per day, depending on the age group. Folate intake from food is not associated with any health risk.

Clinical laboratories typically use conventional units for measuring concentrations of folate (nanograms per milliliter [ng/mL]) and vitamin B12 (picograms [pg]/mL) but use international system (SI) units for Hcy and MMA (micromole per liter [µmol/L]).

Conversion factors to SI units are as follows: 1 ng/mL = 2.266 nanomol (nmol)/L for folate and 1 pg/mL = 0.738 picomol (pmol)/L for vitamin B12.

Several methods measure concentrations in blood of these B vitamins and related biochemical compounds. Because of significant differences in measuring folate concentrations, caution should be used when comparing other data sets with the tables in this report. Method-specific cut-off values and reference ranges should be used in medical diagnostics (Life Sciences Research Office 1994). Folate data presented in this report were generated using the BioRad Quantaphase II radioassay. This assay measures approximately 35 percent lower than the microbiologic gold-standard assay (Life Sciences Research Office 1994). As a result, for this report, the conventional cut-off values of less than 3 ng/mL for low serum folate concentrations and less than 140 ng/mL for low red blood cell (RBC) folate concentrations (Life Sciences Research Office 1984) should be adjusted to less than 2 ng/mL and less than 95 ng/mL, respectively. Common methods for measuring serum vitamin B12, plasma Hcy, and MMA generally produce comparable results. A widely used cut-off value for low serum vitamin B12 concentrations is 200 pg/mL (Gibson 1990). Generally used cut-off values for elevated concentrations of plasma Hcy and MMA are 13 µmol/L (Jacques 1999) and 0.37 µmol/L (Hølleland 1999), respectively.



Chemist reviews data for methylmalonic acid.

For more information on B vitamins and related biochemical indicators, see the Institute of Medicine's Dietary Reference Intake reports (Institute of Medicine 1998), fact sheets from the National Institutes of Health (NIH), Office of Dietary Supplements (http://ods.od.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx), as well as information from the American Society for Nutrition (http://jn.nutrition.org/nutinfo/).

One national health objective for Healthy People 2010 is to increase the proportion of pregnancies for which RBC folate concentration is optimum by increasing the median RBC folate concentration to 220 ng/mL among women aged 15–44 years (objective 16.16b; U.S. Department of Health and Human Services 2000).

Monitoring the folate status of the U.S. population over time has been a priority since serum and RBC folate results from NHANES II (1976–1980) (Senti 1985) and NHANES III (1988–1994) (Wright 1998) suggested that the folate status of some population groups might be of public health concern. Vitamin B12 status of the U.S. population has been monitored since the second phase of NHANES III (1991–1994) (Wright 1998). In

a recent (2007) study, Pfeiffer et al. showed that, in women of childbearing age, the introduction of folic acid fortification has dramatically lowered the prevalence of low serum (< 3 ng/mL) and RBC folate concentrations (< 140 ng/mL) from 21 percent and 38 percent, respectively, to less than 1 percent and 5 percent, respectively. Serum vitamin B12 concentrations, however, did not change appreciably. Circulating Hcy concentrations from prefortification to postfortification decreased by approximately 10 percent in a national sample of the U.S. population (Pfeiffer 2008).

Selected Observations and Highlights

The following representative observations are taken from the tables of 1999–2002 data contained in this report. Statements about categorical differences between demographic groups noted below are based on non-overlapping confidence limits from univariate analysis without adjusting for demographic variables (e.g., age, sex, race/ethnicity) or other blood concentration determinants (e.g., dietary intake, supplement usage, smoking, BMI). A multivariate analysis may alter the size and statistical significance of these categorical differences. Furthermore, additional significant differences of smaller magnitude may be present despite their lack of mention here (e.g., if confidence limits slightly overlap or if differences are not statistically significant before covariate adjustment has occurred). For a selection of citations of descriptive NHANES papers related to these biochemical indicators of diet and nutrition, see Appendix E.

General Observations

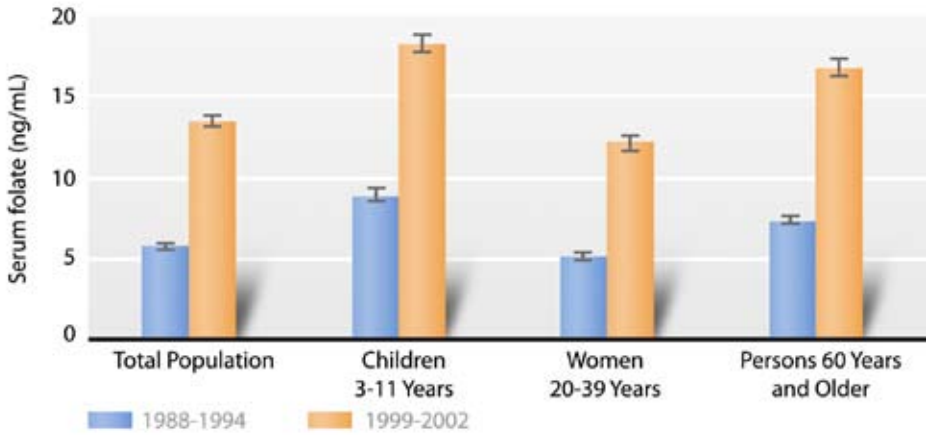
- Serum and RBC folate concentrations show a U-shaped age pattern with higher concentrations in children and older people (≥ 60 years) than in young or middle-aged adults.
- Serum vitamin B12 concentrations first decline from childhood to middle-age, then stabilize. Plasma MMA concentrations are similar across all age groups, except that older people have higher concentrations.
- Plasma Hcy concentrations increase with age.
- Women have higher serum and RBC folate concentrations than do men, and men have higher plasma Hcy and MMA concentrations.
- For serum and RBC folate, non-Hispanic whites have higher concentrations than do Mexican Americans, who themselves have higher concentrations than do non-Hispanic blacks.
- Serum vitamin B12 concentrations are higher in non-Hispanic blacks than in the other two racial/ethnic groups, and plasma MMA concentrations are higher in non-Hispanic whites than in either Mexican Americans or in non-Hispanic blacks.
- Plasma Hcy concentrations are higher in non-Hispanic whites than in the other two racial/ethnic groups.

- Less than 5 percent of adolescent and adult women have low serum (< 2 ng/mL) and RBC folate concentrations (< 95 ng/mL)–cut-off values indicative of inadequate folate status (based on 5th percentile).
- Approximately 5 percent of older people have moderately low concentrations of serum vitamin B12 (< 200 pg/mL) (based on 5th percentile), and over 5 percent of older people have elevated concentrations of plasma Hcy (> 13 µmol/L) and of MMA (> 0.37 µmol/L) (based on 95th percentile).

Highlights

Since 1998, when fortification of enriched grains and cereal products with folic acid became mandatory, serum folate concentrations have more than doubled, and RBC folate concentrations have increased by about 50 percent in all population subgroups (Fig. 1.a). This greater than expected increase in blood concentrations was shown previously (Pfeiffer 2007). Underreporting of foods consumed, increased consumer selection of folate-rich foods as a result of health claims, and increasing availability of the number and types of nonstandardized folate-fortified foods (e.g., breakfast cereals) could be some of the reasons for the greater than expected increase in blood concentrations (U.S. Food and Drug Administration 1996b).

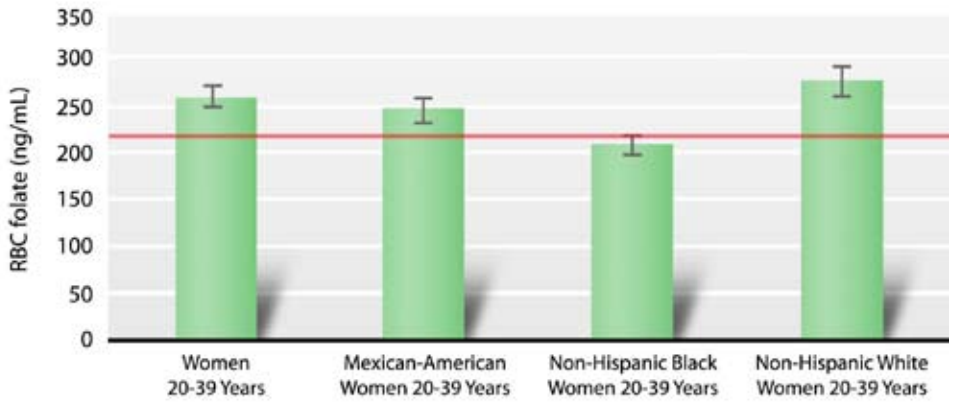
Figure 1.a



Geometric mean concentrations (95 percent confidence intervals) of serum folate in the U.S. population, aged 3 years and older, and in population subgroups, National Health and Nutrition Examination Survey, 1988–2002. Data shown for NHANES 1988–1994 are not part of the tables displayed in this report but were analyzed separately to generate this figure.

The Healthy People 2010 objective to increase the median RBC folate concentration in women to 220 ng/mL was achieved for Mexican-American and non-Hispanic white women aged 20–39 years: their median RBC folate concentrations were 250 ng/mL and 278 ng/mL, respectively (Fig. 1.b). This objective was, however, not achieved for non-Hispanic black women (210 ng/mL) (Fig. 1.b). Interestingly, offspring of non-Hispanic black women have the lowest incidence of NTDs, whereas offspring of Mexican-American women have the highest NTD incidence (Williams 2005). These findings show that RBC folate concentrations alone do not account for differences in NTD rates among race/ethnic groups in the U.S. population.

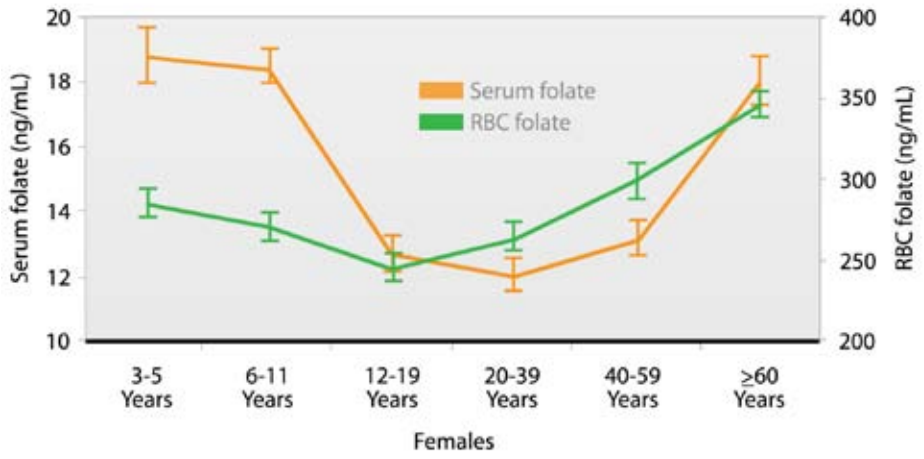
Figure 1.b



Median concentrations (95 percent confidence intervals) of red blood cell (RBC) folate among 20–39 year-old women by race/ethnicity, National Health and Nutrition Examination Survey, 1999–2002.

Although the majority (> 95 percent) of females have an adequate folate status, it is interesting to note that adolescents (aged 12–19 years) and adult women (aged 20–59 years), age groups for which good folate status is most critical, have lower serum folate concentrations than do females in other age groups (Fig. 1.c). Adolescent females aged 12–19 years also have lower RBC folate concentrations than do females in other age groups (Fig. 1.c).

Figure 1.c



Cross-sectional age pattern showing geometric mean concentrations (95 percent confidence intervals) of serum and red blood cell (RBC) folate in females, National Health and Nutrition Examination Survey, 1999–2002.

Table 1.1.a. Serum folate: Total population

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	13.5 (13.1-13.8)	5.70 (5.50-6.00)	13.6 (13.2-13.9)	30.8 (29.9-32.0)	15912
3–5 years	18.5 (17.7-19.3)	9.90 (8.80-10.8)	18.3 (17.7-18.8)	34.8 (32.0-41.0)	799
6–11 years	18.1 (17.6-18.7)	9.90 (9.40-10.6)	18.0 (17.6-18.5)	33.2 (31.6-35.0)	1908
12–19 years	12.6 (12.2-13.1)	6.00 (5.60-6.30)	12.8 (12.4-13.4)	24.7 (23.0-26.6)	4332
20–39 years	11.4 (11.0-11.9)	5.10 (4.80-5.40)	11.2 (10.8-11.8)	25.1 (23.4-26.9)	3184
40–59 years	12.8 (12.3-13.2)	5.50 (5.20-5.90)	12.9 (12.4-13.3)	28.7 (27.1-30.1)	2674
60 years and older	16.8 (16.3-17.3)	6.80 (6.40-7.20)	17.0 (16.4-17.6)	40.3 (37.4-43.0)	3015
Males					
Total, 3 years and older	12.8 (12.4-13.2)	5.50 (5.20-5.90)	13.0 (12.5-13.4)	28.3 (27.4-29.4)	7747
3–5 years	18.2 (17.1-19.4)	9.40 (8.60-10.7)	17.7 (16.4-18.6)	41.0 (31.2-44.8)	417
6–11 years	17.8 (17.0-18.6)	9.70 (8.90-10.7)	17.7 (16.8-18.4)	32.3 (29.6-35.9)	973
12–19 years	12.5 (12.0-13.0)	6.00 (5.50-6.30)	12.9 (12.3-13.3)	24.6 (22.8-26.6)	2169
20–39 years	10.7 (10.3-11.2)	5.00 (4.40-5.60)	10.8 (10.2-11.3)	21.9 (19.8-23.2)	1355
40–59 years	12.3 (11.9-12.7)	5.40 (4.70-5.90)	12.4 (12.1-12.9)	26.7 (25.1-28.1)	1337
60 years and older	15.2 (14.7-15.8)	6.10 (5.70-6.70)	15.3 (14.7-16.1)	35.4 (34.1-37.6)	1496
Females					
Total, 3 years and older	14.1 (13.7-14.5)	5.80 (5.60-6.20)	14.3 (13.8-14.7)	32.9 (31.2-34.5)	8165
3–5 years	18.8 (18.0-19.7)	10.3 (8.30-11.6)	18.7 (17.5-19.1)	33.5 (31.0-36.6)	382
6–11 years	18.5 (18.0-19.1)	10.0 (9.30-10.7)	18.6 (17.8-19.0)	33.4 (30.0-37.4)	935
12–19 years	12.7 (12.2-13.3)	6.20 (5.70-6.60)	12.8 (12.3-13.5)	24.8 (22.2-28.1)	2163
20–39 years	12.1 (11.6-12.6)	5.40 (5.10-5.60)	12.0 (11.4-12.8)	28.7 (26.2-30.8)	1829
40–59 years	13.2 (12.7-13.8)	5.50 (5.10-6.20)	13.4 (12.7-14.0)	30.2 (27.5-34.1)	1337
60 years and older	18.1 (17.3-18.8)	7.40 (6.80-7.80)	18.2 (17.3-18.9)	43.0 (39.8-45.6)	1519

Table 1.1.b. Serum folate: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	12.4 (11.9-12.9)	5.70 (5.30-6.20)	12.5 (12.0-12.9)	26.3 (24.8-28.1)	4695
3–5 years	18.1 (17.1-19.2)	10.9 (9.90-11.5)	17.7 (16.7-18.7)	33.6 (28.6-36.8)	266
6–11 years	17.7 (17.1-18.4)	10.4 (9.60-11.0)	17.3 (16.7-17.9)	31.0 (28.8-34.8)	652
12–19 years	12.4 (12.0-12.8)	6.60 (6.10-6.90)	12.6 (12.0-13.2)	22.4 (21.7-24.0)	1637
20–39 years	10.5 (9.96-11.0)	5.00 (4.20-5.60)	10.3 (9.80-11.0)	20.1 (19.4-21.9)	866
40–59 years	11.8 (11.1-12.5)	5.90 (5.10-6.50)	11.9 (11.2-12.4)	23.8 (20.6-28.0)	634
60 years and older	14.4 (13.6-15.2)	6.00 (5.00-6.90)	14.8 (13.5-15.8)	34.1 (30.2-38.7)	640
Males					
Total, 3 years and older	12.0 (11.4-12.5)	5.50 (4.80-6.20)	12.1 (11.4-12.6)	25.3 (23.5-27.4)	2293
3–5 years	17.7 (16.6-18.9)	10.5† (9.70-11.6)	17.4 (16.1-18.5)	34.0† (27.1-44.8)	139
6–11 years	17.6 (16.7-18.5)	10.1 (9.00-11.0)	17.5 (16.4-18.4)	32.1 (26.2-42.0)	338
12–19 years	12.5 (12.0-13.1)	6.40 (5.80-7.00)	12.6 (12.0-13.3)	24.1 (22.1-26.3)	811
20–39 years	9.85 (9.24-10.5)	4.50 (3.80-5.60)	9.80 (9.20-10.6)	19.3 (17.2-20.0)	383
40–59 years	11.6 (10.8-12.5)	5.80 (5.10-6.60)	11.7 (10.7-12.6)	22.0 (18.4-28.7)	301
60 years and older	13.5 (12.5-14.5)	6.20 (5.00-7.10)	13.2 (12.2-14.8)	29.8 (24.0-48.3)	321
Females					
Total, 3 years and older	12.9 (12.4-13.4)	5.90 (5.70-6.40)	13.0 (12.6-13.7)	27.2 (25.6-28.8)	2402
3–5 years	18.5 (17.1-20.0)	11.0† (9.60-12.0)	18.3 (16.9-19.0)	31.6† (27.4-36.6)	127
6–11 years	17.9 (17.2-18.6)	10.5 (9.60-11.7)	17.3 (16.6-18.2)	30.8 (28.8-32.1)	314
12–19 years	12.2 (11.8-12.7)	6.60 (6.10-7.00)	12.5 (11.8-13.3)	21.6 (19.8-22.4)	826
20–39 years	11.2 (10.7-11.8)	5.20 (4.90-5.90)	11.0 (10.3-11.7)	22.3 (20.0-27.6)	483
40–59 years	11.9 (11.1-12.8)	5.90 (4.60-6.50)	12.0 (11.1-12.5)	25.4 (21.4-26.6)	333
60 years and older	15.2 (14.3-16.2)	6.10 (5.00-7.20)	15.8 (14.4-16.7)	36.0 (31.5-39.6)	319

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.1.c. Serum folate: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	11.3 (10.9-11.8)	5.10 (4.60-5.30)	11.1 (10.6-11.6)	25.5 (23.9-27.1)	3716
3–5 years	16.9 (16.0-17.8)	9.80 (8.70-10.5)	16.2 (15.1-17.8)	34.8 (28.2-39.3)	235
6–11 years	16.9 (16.2-17.6)	9.60 (8.80-10.6)	16.4 (15.8-17.4)	31.8 (28.0-39.5)	604
12–19 years	10.9 (10.5-11.4)	5.30 (5.00-5.70)	11.0 (10.5-11.4)	19.8 (19.0-21.0)	1256
20–39 years	9.73 (9.18-10.3)	5.10 (4.50-5.40)	9.60 (9.10-10.4)	19.8 (18.7-21.4)	593
40–59 years	10.3 (9.86-10.8)	4.40 (4.10-5.10)	10.1 (9.60-10.8)	22.7 (19.4-26.0)	541
60 years and older	12.7 (11.6-13.8)	4.80 (4.20-5.40)	12.2 (11.0-14.0)	38.1 (31.1-43.3)	487
Males					
Total, 3 years and older	10.9 (10.5-11.3)	4.80 (4.40-5.10)	10.8 (10.5-11.3)	22.7 (21.2-25.0)	1822
3–5 years	16.6 (15.3-17.9)	9.00† (7.50-10.6)	15.6 (14.4-17.2)	36.5† (26.1-55.9)	122
6–11 years	17.0 (16.3-17.8)	9.60 (8.80-10.8)	16.6 (15.9-17.6)	31.6 (26.8-39.5)	305
12–19 years	11.0 (10.5-11.5)	5.10 (4.60-5.80)	11.2 (10.5-11.7)	20.1 (19.2-22.2)	640
20–39 years	9.17 (8.63-9.74)	4.50 (3.50-5.10)	9.50 (8.40-10.2)	17.4 (16.3-19.5)	249
40–59 years	9.69 (9.20-10.2)	4.20 (3.00-4.70)	9.80 (9.20-10.2)	19.2 (17.8-20.6)	274
60 years and older	11.3 (10.3-12.4)	4.60 (3.90-5.20)	11.3 (9.90-12.6)	33.8 (20.0-40.4)	232
Females					
Total, 3 years and older	11.7 (11.1-12.3)	5.40 (4.80-5.70)	11.2 (10.7-11.9)	27.4 (25.1-30.4)	1894
3–5 years	17.2 (15.8-18.8)	10.2† (7.80-10.9)	17.2 (15.2-18.8)	30.9† (27.1-36.3)	113
6–11 years	16.7 (16.0-17.5)	9.60 (7.90-10.5)	16.3 (15.5-17.3)	32.5 (27.1-38.4)	299
12–19 years	10.8 (10.3-11.4)	5.40 (5.00-5.80)	10.8 (10.3-11.3)	19.4 (18.3-21.0)	616
20–39 years	10.2 (9.49-10.9)	5.40 (4.50-5.70)	9.70 (9.20-10.7)	21.4 (19.2-24.0)	344
40–59 years	10.9 (10.2-11.7)	4.70 (3.50-5.90)	10.6 (9.50-12.1)	24.8 (19.6-29.2)	267
60 years and older	13.6 (12.2-15.2)	5.10 (3.80-6.60)	12.7 (11.6-14.9)	39.5 (30.5-48.0)	255

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.1.d. Serum folate: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	14.1 (13.6-14.6)	6.00 (5.70-6.30)	14.2 (13.7-14.8)	32.0 (30.9-33.3)	6147
3–5 years	19.6 (18.3-21.1)	10.1† (8.30-12.3)	18.9 (17.8-20.2)	38.0† (31.5-48.9)	219
6–11 years	18.7 (17.9-19.5)	9.70 (8.90-10.8)	18.8 (17.9-19.5)	34.2 (31.6-37.8)	494
12–19 years	13.3 (12.8-13.9)	6.20 (5.70-6.70)	13.6 (13.1-14.3)	26.5 (24.0-27.6)	1073
20–39 years	11.9 (11.4-12.6)	5.50 (4.80-5.90)	12.2 (11.2-12.9)	26.3 (24.0-29.1)	1381
40–59 years	13.3 (12.7-13.8)	5.60 (5.20-6.10)	13.3 (12.9-14.0)	29.8 (27.4-31.0)	1276
60 years and older	17.4 (16.8-18.0)	7.20 (6.60-7.60)	17.8 (16.9-18.4)	41.0 (37.4-43.5)	1704
Males					
Total, 3 years and older	13.3 (12.9-13.9)	6.00 (5.60-6.30)	13.6 (13.0-14.1)	29.4 (28.1-30.6)	3013
3–5 years	19.2 (17.2-21.4)	9.00† (7.80-11.1)	18.7 (16.3-19.9)	42.0† (29.9-57.6)	116
6–11 years	18.2 (17.0-19.5)	8.90 (7.60-11.0)	18.0 (16.8-19.2)	34.7 (29.7-38.0)	260
12–19 years	13.0 (12.4-13.7)	6.20 (5.60-6.80)	13.4 (12.8-13.9)	26.0 (22.8-27.3)	536
20–39 years	11.3 (10.6-12.0)	5.40 (4.40-6.10)	11.3 (10.4-12.4)	23.0 (20.2-24.5)	577
40–59 years	12.7 (12.2-13.3)	5.70 (5.20-6.40)	13.0 (12.3-13.5)	27.3 (25.4-28.8)	666
60 years and older	15.8 (15.1-16.5)	6.30 (6.10-7.30)	16.0 (15.2-17.0)	35.9 (33.6-37.6)	858
Females					
Total, 3 years and older	14.9 (14.3-15.4)	6.10 (5.80-6.50)	15.1 (14.5-15.7)	34.2 (32.4-35.8)	3134
3–5 years	20.1 (18.8-21.5)	11.6† (8.30-14.1)	19.1 (18.4-21.6)	33.5† (28.9-39.0)	103
6–11 years	19.2 (18.3-20.1)	10.2 (8.90-11.1)	19.4 (18.8-20.2)	33.6 (29.4-40.3)	234
12–19 years	13.7 (12.9-14.5)	6.40 (5.20-7.10)	13.9 (13.2-14.7)	26.6 (23.0-31.6)	537
20–39 years	12.6 (12.0-13.4)	5.60 (5.10-5.90)	13.0 (11.8-13.7)	30.4 (26.3-32.4)	804
40–59 years	13.8 (13.1-14.6)	5.70 (5.10-6.30)	13.9 (12.9-15.1)	31.0 (28.7-35.0)	610
60 years and older	18.8 (18.0-19.7)	7.70 (7.20-8.60)	18.9 (18.0-19.8)	43.6 (40.0-46.1)	846

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.2.a. Red blood cell (RBC) folate: Total population

Geometric mean and selected percentiles of RBC concentrations (in ng/mL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	280 (273-287)	154 (149-159)	276 (270-282)	526 (510-541)	16102
3–5 years	288 (281-296)	192 (184-203)	286 (278-293)	464 (403-512)	840
6–11 years	280 (273-287)	186 (178-192)	277 (269-284)	431 (413-482)	1938
12–19 years	244 (237-251)	150 (145-155)	240 (234-246)	411 (393-436)	4362
20–39 years	255 (248-262)	142 (135-149)	252 (241-261)	452 (437-474)	3195
40–59 years	291 (283-299)	159 (151-167)	289 (282-297)	538 (500-576)	2709
60 years and older	338 (330-345)	169 (160-178)	341 (331-351)	667 (634-688)	3058
Males					
Total, 3 years and older	272 (265-279)	153 (148-159)	268 (260-275)	494 (480-515)	7827
3–5 years	291 (278-304)	192 (180-206)	287 (277-300)	477 (394-559)	438
6–11 years	287 (279-295)	201 (189-209)	280 (272-288)	448 (423-504)	989
12–19 years	240 (232-249)	150 (142-159)	238 (232-245)	398 (372-436)	2179
20–39 years	246 (238-254)	146 (139-151)	245 (235-256)	418 (395-440)	1358
40–59 years	282 (274-291)	157 (148-168)	280 (271-291)	516 (481-545)	1349
60 years and older	325 (314-337)	159 (147-170)	324 (310-339)	644 (593-702)	1514
Females					
Total, 3 years and older	288 (281-295)	155 (149-161)	285 (278-292)	552 (531-573)	8275
3–5 years	286 (277-295)	190 (177-201)	287 (276-293)	441 (386-519)	402
6–11 years	272 (264-280)	178 (171-185)	271 (261-281)	402 (385-469)	949
12–19 years	247 (239-255)	148 (145-155)	244 (235-251)	422 (386-476)	2183
20–39 years	264 (256-274)	140 (132-152)	261 (251-273)	492 (455-540)	1837
40–59 years	300 (288-312)	164 (151-174)	297 (285-309)	565 (505-595)	1360
60 years and older	347 (340-355)	176 (163-185)	353 (339-364)	673 (634-698)	1544

Table 1.2.b. Red blood cell (RBC) folate: Mexican Americans

Geometric mean and selected percentiles of RBC concentrations (in ng/mL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	258 (251-265)	155 (146-161)	254 (248-261)	456 (435-473)	4726
3–5 years	289 (280-298)	201 (194-210)	278 (270-289)	458 (403-524)	273
6–11 years	282 (276-288)	197 (180-211)	276 (270-282)	444 (402-492)	658
12–19 years	245 (239-252)	156 (145-164)	241 (237-248)	408 (381-428)	1642
20–39 years	239 (231-248)	140 (126-149)	235 (229-243)	423 (392-443)	870
40–59 years	273 (263-283)	167 (160-172)	267 (255-275)	496 (454-552)	634
60 years and older	301 (285-317)	161 (141-180)	291 (275-314)	590 (534-711)	649
Males					
Total, 3 years and older	250 (242-258)	145 (133-155)	251 (241-257)	430 (401-457)	2306
3–5 years	297 (284-311)	210† (196-220)	283 (270-299)	514† (401-599)	144
6–11 years	287 (280-295)	201 (185-214)	283 (274-292)	443 (383-511)	339
12–19 years	241 (234-248)	155 (141-166)	238 (233-246)	376 (356-406)	813
20–39 years	227 (215-239)	129 (114-147)	225 (211-237)	392 (351-435)	385
40–59 years	263 (252-275)	165 (152-171)	265 (251-278)	432 (392-498)	302
60 years and older	293 (269-318)	152 (133-190)	285 (266-299)	567 (525-702)	323
Females					
Total, 3 years and older	268 (260-275)	159 (155-168)	260 (251-266)	488 (457-517)	2420
3–5 years	279 (267-292)	188† (182-203)	272 (259-289)	418† (371-458)	129
6–11 years	276 (268-285)	194 (173-212)	268 (263-275)	434 (384-492)	319
12–19 years	250 (242-258)	157 (145-167)	243 (237-250)	434 (393-486)	829
20–39 years	255 (246-265)	152 (141-159)	250 (233-260)	436 (421-512)	485
40–59 years	284 (269-299)	171 (163-181)	269 (248-291)	538 (464-624)	332
60 years and older	308 (295-321)	168 (154-184)	305 (280-318)	600 (532-785)	326

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.2.c. Red blood cell (RBC) folate: Non-Hispanic blacks

Geometric mean and selected percentiles of RBC concentrations (in ng/mL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	221 (216-226)	123 (120-129)	220 (214-224)	383 (370-399)	3783
3–5 years	247 (240-254)	166 (159-180)	244 (235-251)	364 (326-411)	248
6–11 years	238 (232-243)	161 (151-172)	240 (233-247)	336 (322-350)	623
12–19 years	200 (196-205)	123 (117-129)	203 (197-209)	310 (295-320)	1265
20–39 years	209 (202-216)	117 (113-124)	209 (201-215)	361 (340-385)	598
40–59 years	222 (215-230)	120 (111-130)	222 (213-231)	396 (367-427)	553
60 years and older	254 (243-267)	125 (110-136)	255 (240-267)	535 (476-590)	496
Males					
Total, 3 years and older	216 (210-222)	122 (116-132)	219 (212-226)	360 (341-372)	1856
3–5 years	246 (235-257)	168† (145-188)	244 (234-254)	364† (314-508)	130
6–11 years	243 (237-250)	161 (153-178)	248 (238-255)	334 (313-361)	316
12–19 years	203 (198-209)	124 (116-131)	208 (202-214)	310 (292-327)	645
20–39 years	203 (194-211)	118 (101-135)	207 (197-214)	322 (302-350)	249
40–59 years	211 (202-221)	121 (104-132)	211 (194-226)	364 (348-396)	277
60 years and older	244 (229-260)	117 (103-134)	248 (227-266)	460 (403-592)	239
Females					
Total, 3 years and older	225 (219-231)	124 (117-130)	221 (216-226)	411 (378-453)	1927
3–5 years	248 (238-258)	165† (159-181)	244 (233-258)	379† (319-453)	118
6–11 years	232 (224-240)	158 (132-177)	230 (221-242)	336 (319-369)	307
12–19 years	197 (192-202)	124 (111-131)	197 (189-201)	303 (291-320)	620
20–39 years	214 (205-223)	119 (113-127)	210 (200-220)	379 (352-445)	349
40–59 years	233 (222-244)	122 (109-141)	233 (220-247)	409 (370-512)	276
60 years and older	262 (246-279)	127 (104-151)	262 (241-277)	553 (496-599)	257

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.2.d. Red blood cell (RBC) folate: Non-Hispanic whites

Geometric mean and selected percentiles of RBC concentrations (in ng/mL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	297 (289-304)	166 (160-172)	292 (284-299)	551 (536-570)	6210
3–5 years	303 (289-318)	204 (180-231)	300 (290-309)	474 (390-546)	231
6–11 years	292 (283-301)	189 (183-207)	290 (282-296)	464 (422-519)	498
12–19 years	257 (249-265)	160 (152-164)	253 (246-261)	436 (400-458)	1083
20–39 years	268 (257-279)	150 (135-165)	265 (252-278)	475 (449-524)	1383
40–59 years	305 (296-313)	173 (166-180)	302 (293-309)	545 (506-597)	1291
60 years and older	352 (342-361)	182 (170-193)	355 (344-365)	674 (639-702)	1724
Males					
Total, 3 years and older	287 (279-296)	165 (158-173)	281 (272-291)	523 (501-544)	3037
3–5 years	308 (286-332)	204† (165-231)	310 (290-324)	512† (403-634)	120
6–11 years	300 (289-311)	211 (189-225)	290 (276-299)	473 (422-533)	263
12–19 years	251 (241-261)	158 (145-164)	246 (238-256)	410 (372-454)	538
20–39 years	258 (247-269)	157 (147-165)	256 (241-270)	432 (402-463)	578
40–59 years	295 (286-304)	171 (157-180)	292 (280-303)	527 (491-601)	672
60 years and older	339 (325-355)	170 (158-190)	342 (322-359)	660 (601-717)	866
Females					
Total, 3 years and older	306 (297-315)	167 (159-174)	302 (293-310)	580 (551-604)	3173
3–5 years	298 (285-311)	201† (189-236)	294 (279-307)	436† (382-546)	111
6–11 years	283 (273-294)	182 (173-192)	290 (277-298)	453 (381-508)	235
12–19 years	264 (253-275)	160 (149-167)	262 (250-270)	451 (395-539)	545
20–39 years	278 (265-293)	143 (130-167)	278 (261-293)	548 (490-591)	805
40–59 years	315 (300-330)	176 (165-190)	308 (295-327)	570 (503-611)	619
60 years and older	361 (354-369)	191 (182-201)	364 (351-372)	680 (639-711)	858

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.3.a. Serum vitamin B12: Total population

Geometric mean and selected percentiles of serum concentrations (in pg/mL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	488 (483-494)	237 (234-242)	485 (477-492)	1000 (977-1030)	15914
3–5 years	783 (745-822)	446 (425-475)	788 (741-823)	1380 (1300-1520)	800
6–11 years	692 (672-712)	369 (344-410)	700 (682-718)	1260 (1190-1310)	1907
12–19 years	505 (496-515)	267 (254-279)	510 (499-523)	941 (912-979)	4331
20–39 years	446 (439-453)	233 (222-238)	446 (438-455)	812 (787-843)	3185
40–59 years	461 (453-469)	233 (224-241)	452 (442-460)	919 (883-973)	2676
60 years and older	478 (466-489)	225 (212-233)	474 (467-485)	1010 (976-1060)	3015
Males					
Total, 3 years and older	488 (480-497)	248 (240-258)	485 (477-494)	961 (922-993)	7741
3–5 years	763 (715-814)	432 (373-468)	756 (699-824)	1450 (1250-1650)	417
6–11 years	690 (667-715)	368 (344-393)	697 (673-718)	1270 (1200-1330)	972
12–19 years	507 (493-522)	278 (254-297)	512 (494-528)	920 (892-952)	2165
20–39 years	458 (446-470)	243 (231-263)	460 (445-475)	795 (766-826)	1355
40–59 years	458 (447-469)	241 (226-256)	452 (438-460)	847 (792-898)	1337
60 years and older	451 (439-464)	224 (204-236)	456 (439-469)	907 (859-1000)	1495
Females					
Total, 3 years and older	488 (482-494)	232 (226-237)	483 (475-492)	1040 (1010-1080)	8173
3–5 years	806 (762-852)	475 (446-514)	804 (755-859)	1340 (1270-1440)	383
6–11 years	694 (668-720)	382 (338-425)	700 (676-731)	1250 (1110-1310)	935
12–19 years	504 (494-514)	256 (241-267)	509 (495-525)	966 (936-1000)	2166
20–39 years	435 (427-443)	222 (210-232)	433 (418-447)	839 (784-913)	1830
40–59 years	463 (448-479)	223 (201-238)	453 (435-473)	1000 (920-1120)	1339
60 years and older	499 (482-515)	227 (209-237)	494 (479-510)	1060 (994-1140)	1520

Table 1.3.b. Serum vitamin B12: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in pg/mL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	532 (513-553)	260 (249-273)	514 (493-531)	1120 (1060-1200)	4695
3–5 years	821 (784-860)	447 (402-526)	809 (764-870)	1470 (1330-1530)	266
6–11 years	701 (672-731)	415 (390-447)	705 (676-731)	1190 (1090-1270)	652
12–19 years	507 (491-523)	268 (249-288)	504 (494-519)	883 (847-920)	1637
20–39 years	477 (452-504)	242 (213-260)	453 (437-469)	1010 (875-1180)	866
40–59 years	518 (491-546)	264 (258-295)	475 (452-514)	1100 (947-1500)	634
60 years and older	497 (464-532)	215 (203-237)	482 (454-514)	1090 (969-1460)	640
Males					
Total, 3 years and older	507 (486-529)	263 (245-278)	494 (473-516)	999 (936-1100)	2293
3–5 years	798 (744-855)	428† (351-553)	779 (704-833)	1490† (1250-2310)	139
6–11 years	690 (646-738)	411 (379-455)	694 (659-729)	1190 (1040-1370)	338
12–19 years	489 (472-507)	264 (242-292)	488 (479-501)	849 (808-896)	811
20–39 years	454 (423-489)	249 (200-279)	452 (423-468)	771 (731-858)	383
40–59 years	486 (465-507)	292 (264-308)	469 (429-514)	891 (792-1390)	301
60 years and older	451 (414-491)	206 (162-238)	444 (410-473)	1070 (911-1250)	321
Females					
Total, 3 years and older	562 (536-589)	257 (241-269)	533 (514-552)	1200 (1120-1360)	2402
3–5 years	848 (799-901)	451† (408-548)	853 (775-933)	1390† (1200-1520)	127
6–11 years	713 (681-747)	424 (382-475)	711 (689-746)	1160 (1080-1280)	314
12–19 years	527 (505-549)	277 (254-296)	525 (504-534)	915 (870-939)	826
20–39 years	506 (463-553)	232 (202-257)	461 (444-482)	1190 (1040-1720)	483
40–59 years	553 (507-603)	258 (214-277)	491 (461-528)	1310 (1000-4570)	333
60 years and older	540 (494-592)	235 (196-271)	525 (484-581)	1180 (965-2170)	319

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.3.c. Serum vitamin B12: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in pg/mL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	568 (558-579)	273 (263-289)	569 (556-583)	1180 (1150-1220)	3712
3–5 years	867 (829-906)	486 (403-567)	859 (815-929)	1540 (1330-1700)	234
6–11 years	803 (775-832)	413 (375-452)	812 (786-845)	1460 (1320-1630)	603
12–19 years	585 (569-602)	298 (274-313)	588 (566-609)	1150 (1070-1230)	1254
20–39 years	508 (491-525)	261 (233-289)	511 (492-530)	939 (864-977)	593
40–59 years	525 (506-545)	263 (251-277)	522 (502-553)	1110 (1020-1190)	541
60 years and older	542 (511-576)	246 (224-280)	560 (506-605)	1190 (1030-1410)	487
Males					
Total, 3 years and older	558 (543-574)	270 (254-291)	563 (545-575)	1150 (1090-1230)	1818
3–5 years	861 (799-928)	479† (361-558)	859 (791-931)	1650† (1320-1880)	121
6–11 years	780 (744-818)	413 (368-478)	775 (752-822)	1390 (1250-1520)	304
12–19 years	561 (540-583)	295 (256-324)	567 (535-602)	1000 (952-1080)	638
20–39 years	511 (483-541)	253 (228-296)	518 (492-549)	939 (838-1170)	249
40–59 years	507 (485-531)	261 (245-294)	507 (477-551)	1020 (888-1140)	274
60 years and older	493 (458-531)	239 (215-269)	481 (458-542)	1030 (910-1320)	232
Females					
Total, 3 years and older	577 (566-589)	277 (264-291)	576 (560-590)	1200 (1160-1260)	1894
3–5 years	873 (815-934)	564† (419-611)	857 (804-953)	1430† (1250-1560)	113
6–11 years	827 (791-865)	409 (373-452)	854 (803-891)	1490 (1320-1930)	299
12–19 years	611 (592-630)	302 (270-315)	607 (584-634)	1280 (1160-1460)	616
20–39 years	505 (485-526)	271 (238-301)	505 (476-530)	911 (814-975)	344
40–59 years	542 (516-568)	263 (228-287)	538 (507-575)	1160 (1100-1250)	267
60 years and older	577 (539-617)	249 (219-300)	607 (554-647)	1260 (1080-1630)	255

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.3.d. Serum vitamin B12: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in pg/mL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	472 (465-479)	235 (230-238)	471 (461-479)	938 (904-976)	6150
3–5 years	728 (679-781)	440† (389-471)	730 (659-795)	1300† (1110-1510)	219
6–11 years	662 (639-686)	350 (336-385)	680 (660-699)	1170 (1060-1280)	494
12–19 years	493 (478-508)	265 (244-276)	503 (483-523)	918 (883-963)	1072
20–39 years	431 (422-441)	228 (216-236)	434 (422-450)	763 (741-800)	1382
40–59 years	449 (440-457)	228 (218-238)	440 (428-456)	882 (831-934)	1279
60 years and older	473 (460-486)	226 (209-236)	471 (462-480)	1000 (954-1060)	1704
Males					
Total, 3 years and older	477 (466-487)	244 (236-256)	474 (463-486)	897 (868-944)	3011
3–5 years	701 (635-773)	424† (303-471)	682 (612-778)	1200† (1070-1590)	116
6–11 years	666 (634-699)	344 (310-369)	679 (647-713)	1250 (1080-1430)	260
12–19 years	500 (479-522)	279 (253-299)	509 (482-532)	903 (846-935)	534
20–39 years	451 (436-468)	245 (233-271)	454 (436-475)	762 (721-811)	577
40–59 years	452 (439-465)	236 (220-251)	445 (429-461)	817 (772-883)	667
60 years and older	452 (438-467)	226 (204-244)	457 (439-471)	893 (836-986)	857
Females					
Total, 3 years and older	467 (459-475)	226 (215-234)	467 (453-478)	976 (930-1010)	3139
3–5 years	760 (703-820)	471† (424-517)	754 (690-820)	1310† (1100-1510)	103
6–11 years	657 (627-689)	378 (336-425)	679 (632-701)	1090 (976-1250)	234
12–19 years	486 (470-502)	248 (236-267)	497 (470-523)	940 (870-1000)	538
20–39 years	413 (403-423)	216 (206-227)	412 (398-424)	758 (736-859)	805
40–59 years	445 (428-463)	218 (192-236)	434 (413-459)	920 (853-1060)	612
60 years and older	490 (472-508)	227 (199-238)	482 (470-502)	1060 (983-1170)	847

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.4.a. Plasma homocysteine: Total population

Geometric mean and selected percentiles of plasma concentrations (in µmol/L) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	7.36 (7.26-7.46)	3.92 (3.83-4.02)	7.36 (7.25-7.47)	13.6 (13.3-14.1)	16071
3–5 years	4.26 (4.15-4.37)	2.84 (2.70-3.04)	4.24 (4.17-4.38)	6.16 (5.81-6.40)	830
6–11 years	4.53 (4.44-4.63)	3.06 (2.93-3.23)	4.51 (4.42-4.60)	6.74 (6.53-6.97)	1933
12–19 years	5.98 (5.87-6.10)	3.82 (3.65-3.95)	5.90 (5.79-6.03)	9.57 (9.34-9.91)	4357
20–39 years	7.25 (7.15-7.36)	4.37 (4.21-4.53)	7.21 (7.12-7.31)	12.0 (11.6-12.4)	3194
40–59 years	8.28 (8.17-8.38)	5.25 (5.17-5.35)	8.13 (8.02-8.23)	13.4 (12.8-14.1)	2703
60 years and older	10.0 (9.80-10.3)	6.20 (6.12-6.32)	9.67 (9.40-9.93)	18.4 (17.6-19.0)	3054
Males					
Total, 3 years and older	7.92 (7.81-8.03)	4.14 (4.02-4.23)	8.06 (7.92-8.17)	14.3 (13.8-14.7)	7811
3–5 years	4.35 (4.23-4.48)	3.05 (2.69-3.31)	4.31 (4.20-4.48)	6.16 (5.82-6.32)	432
6–11 years	4.60 (4.48-4.71)	3.08 (2.91-3.26)	4.57 (4.48-4.70)	6.90 (6.47-7.23)	988
12–19 years	6.35 (6.21-6.49)	3.96 (3.74-4.23)	6.24 (6.14-6.40)	9.96 (9.54-10.9)	2177
20–39 years	8.21 (8.06-8.36)	5.58 (5.37-5.74)	8.07 (7.87-8.20)	12.8 (12.1-13.8)	1358
40–59 years	9.10 (8.94-9.26)	6.20 (5.99-6.50)	8.90 (8.70-9.13)	14.0 (13.0-14.7)	1345
60 years and older	10.7 (10.5-10.9)	6.85 (6.53-7.09)	10.4 (10.1-10.7)	18.5 (17.6-19.0)	1511
Females					
Total, 3 years and older	6.87 (6.76-6.98)	3.76 (3.65-3.87)	6.79 (6.67-6.88)	12.9 (12.5-13.3)	8260
3–5 years	4.16 (4.01-4.32)	2.74 (2.60-3.01)	4.22 (4.03-4.37)	6.16 (5.76-6.53)	398
6–11 years	4.47 (4.36-4.58)	3.04 (2.91-3.23)	4.45 (4.27-4.59)	6.58 (6.18-7.02)	945
12–19 years	5.62 (5.48-5.77)	3.65 (3.46-3.90)	5.58 (5.42-5.73)	8.84 (8.28-9.57)	2180
20–39 years	6.43 (6.30-6.57)	3.85 (3.64-4.08)	6.42 (6.25-6.55)	10.4 (9.81-11.4)	1836
40–59 years	7.56 (7.43-7.69)	4.94 (4.75-5.05)	7.36 (7.20-7.52)	12.9 (12.3-13.4)	1358
60 years and older	9.58 (9.29-9.87)	6.07 (5.93-6.18)	9.12 (8.90-9.37)	18.2 (16.9-19.4)	1543

Table 1.4.b. Plasma homocysteine: Mexican Americans

Geometric mean and selected percentiles of plasma concentrations (in µmol/L) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	6.35 (6.18-6.52)	3.54 (3.45-3.62)	6.35 (6.14-6.51)	11.6 (11.2-12.0)	4725
3–5 years	4.10 (3.92-4.29)	2.84 (2.66-3.11)	4.09 (3.84-4.33)	5.80 (5.37-6.41)	271
6–11 years	4.45 (4.34-4.56)	3.04 (2.82-3.25)	4.43 (4.30-4.61)	6.47 (6.18-6.60)	656
12–19 years	5.73 (5.58-5.90)	3.74 (3.59-3.92)	5.65 (5.47-5.85)	9.06 (8.59-9.54)	1643
20–39 years	6.77 (6.62-6.93)	4.08 (3.88-4.24)	6.80 (6.60-6.93)	11.8 (10.9-12.5)	870
40–59 years	7.66 (7.38-7.94)	4.79 (4.47-5.08)	7.48 (7.18-7.89)	11.7 (11.3-12.4)	634
60 years and older	9.57 (9.03-10.1)	5.63 (5.35-6.21)	9.34 (8.61-10.1)	17.7 (16.1-19.4)	651
Males					
Total, 3 years and older	6.98 (6.81-7.17)	3.76 (3.60-3.87)	7.02 (6.87-7.20)	12.4 (11.9-12.8)	2305
3–5 years	4.13 (3.97-4.29)	2.69† (2.60-3.20)	4.11 (3.84-4.48)	5.68† (5.26-6.40)	142
6–11 years	4.59 (4.47-4.71)	3.04 (2.80-3.37)	4.62 (4.42-4.77)	6.56 (6.42-7.11)	339
12–19 years	6.23 (6.07-6.40)	4.10 (3.92-4.22)	6.23 (6.01-6.42)	9.84 (9.07-10.7)	814
20–39 years	7.77 (7.54-8.02)	5.01 (4.66-5.32)	7.43 (7.18-7.76)	12.8 (11.9-14.8)	386
40–59 years	8.52 (8.17-8.89)	5.63 (5.27-6.22)	8.41 (8.04-8.91)	12.0 (11.4-14.5)	301
60 years and older	10.1 (9.53-10.7)	6.34 (5.58-6.73)	10.1 (9.19-10.6)	18.7 (16.5-20.3)	323
Females					
Total, 3 years and older	5.72 (5.53-5.92)	3.43 (3.30-3.56)	5.65 (5.47-5.80)	10.0 (9.26-11.2)	2420
3–5 years	4.07 (3.78-4.39)	3.06† (2.72-3.23)	4.01 (3.69-4.31)	5.83† (4.89-8.23)	129
6–11 years	4.31 (4.18-4.44)	3.04 (2.82-3.23)	4.28 (4.12-4.46)	5.91 (5.77-6.38)	317
12–19 years	5.24 (5.07-5.40)	3.48 (3.31-3.69)	5.19 (5.01-5.41)	8.05 (7.65-8.31)	829
20–39 years	5.75 (5.60-5.90)	3.66 (3.51-3.90)	5.79 (5.52-5.93)	8.56 (8.15-9.20)	484
40–59 years	6.86 (6.54-7.19)	4.40 (3.92-4.82)	6.68 (6.35-7.08)	11.2 (9.70-13.7)	333
60 years and older	9.16 (8.46-9.92)	5.44 (5.14-5.88)	8.84 (8.01-9.97)	17.2 (15.0-21.6)	328

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.4.c. Plasma homocysteine: Non-Hispanic blacks

Geometric mean and selected percentiles of plasma concentrations (in µmol/L) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	7.14 (6.95-7.33)	3.72 (3.58-3.84)	7.07 (6.84-7.29)	14.3 (13.3-14.9)	3777
3–5 years	4.16 (4.01-4.32)	2.82 (2.67-3.08)	4.08 (3.91-4.34)	6.18 (5.81-6.43)	246
6–11 years	4.43 (4.29-4.57)	2.99 (2.84-3.21)	4.42 (4.29-4.57)	6.43 (6.23-6.75)	621
12–19 years	5.96 (5.83-6.10)	3.73 (3.57-3.92)	5.92 (5.78-6.05)	9.66 (9.34-10.1)	1265
20–39 years	7.22 (7.03-7.42)	4.33 (4.12-4.43)	7.22 (7.00-7.46)	11.9 (11.3-12.8)	597
40–59 years	8.71 (8.33-9.09)	5.27 (4.87-5.66)	8.43 (8.08-8.83)	15.3 (13.7-18.8)	552
60 years and older	10.9 (10.5-11.3)	6.39 (6.12-6.67)	10.2 (9.86-10.8)	21.3 (18.9-25.9)	496
Males					
Total, 3 years and older	7.68 (7.43-7.92)	3.83 (3.72-4.00)	7.77 (7.52-8.04)	15.2 (14.6-15.9)	1853
3–5 years	4.38 (4.17-4.60)	3.05† (2.68-3.34)	4.27 (4.06-4.61)	6.38† (5.79-6.57)	127
6–11 years	4.53 (4.38-4.69)	2.99 (2.81-3.39)	4.53 (4.38-4.64)	6.51 (6.23-6.80)	314
12–19 years	6.37 (6.22-6.52)	3.87 (3.69-4.08)	6.32 (6.16-6.44)	10.4 (9.70-11.0)	646
20–39 years	8.46 (8.18-8.74)	5.54 (5.34-5.91)	8.22 (7.96-8.59)	14.3 (11.9-15.5)	249
40–59 years	9.49 (9.03-9.97)	6.04 (5.32-6.45)	9.20 (8.62-9.54)	18.1 (14.7-20.2)	278
60 years and older	11.5 (11.0-12.0)	6.83 (6.13-7.33)	11.0 (10.2-11.9)	21.3 (18.4-25.9)	239
Females					
Total, 3 years and older	6.71 (6.50-6.94)	3.60 (3.50-3.76)	6.59 (6.38-6.78)	12.8 (12.2-13.7)	1924
3–5 years	3.93 (3.72-4.16)	2.72† (2.54-2.97)	3.85 (3.58-4.29)	5.85† (5.13-6.39)	119
6–11 years	4.33 (4.18-4.47)	2.94 (2.71-3.21)	4.33 (4.18-4.47)	6.39 (5.90-6.81)	307
12–19 years	5.58 (5.41-5.75)	3.65 (3.46-3.82)	5.62 (5.45-5.77)	8.51 (7.92-9.32)	619
20–39 years	6.41 (6.18-6.64)	4.07 (3.70-4.33)	6.42 (6.18-6.75)	9.75 (9.08-10.0)	348
40–59 years	8.07 (7.67-8.50)	4.91 (4.63-5.33)	7.72 (7.38-8.48)	13.3 (11.7-19.2)	274
60 years and older	10.6 (10.1-11.1)	6.20 (5.89-6.62)	9.92 (9.55-10.5)	22.5 (17.5-27.7)	257

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.4.d. Plasma homocysteine: Non-Hispanic whites

Geometric mean and selected percentiles of plasma concentrations (in µmol/L) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	7.59 (7.47-7.71)	4.07 (3.97-4.19)	7.60 (7.48-7.74)	14.0 (13.4-14.4)	6192
3–5 years	4.30 (4.14-4.45)	2.74 (2.64-3.19)	4.28 (4.19-4.49)	6.19 (5.74-6.90)	229
6–11 years	4.56 (4.44-4.69)	3.14 (2.94-3.26)	4.51 (4.40-4.68)	6.94 (6.60-7.13)	497
12–19 years	5.99 (5.86-6.12)	3.83 (3.59-4.03)	5.89 (5.76-6.07)	9.54 (9.23-10.2)	1078
20–39 years	7.36 (7.24-7.49)	4.66 (4.37-4.83)	7.33 (7.16-7.49)	12.0 (11.5-12.4)	1383
40–59 years	8.31 (8.19-8.42)	5.30 (5.18-5.44)	8.17 (8.03-8.28)	13.4 (12.5-14.1)	1286
60 years and older	10.0 (9.74-10.3)	6.22 (6.12-6.44)	9.63 (9.33-9.92)	18.2 (17.4-19.0)	1719
Males					
Total, 3 years and older	8.12 (7.99-8.25)	4.25 (4.15-4.38)	8.23 (8.11-8.38)	14.3 (13.9-14.8)	3026
3–5 years	4.39 (4.18-4.61)	3.10† (2.44-3.48)	4.28 (4.20-4.56)	6.14† (5.65-7.22)	120
6–11 years	4.62 (4.49-4.75)	3.15 (2.94-3.31)	4.55 (4.41-4.76)	6.91 (6.47-7.23)	264
12–19 years	6.28 (6.11-6.46)	3.95 (3.64-4.25)	6.19 (6.00-6.36)	9.72 (9.38-11.4)	534
20–39 years	8.21 (8.03-8.41)	5.62 (5.37-5.81)	8.10 (7.84-8.28)	12.4 (11.7-12.9)	577
40–59 years	9.10 (8.92-9.28)	6.31 (5.99-6.56)	8.91 (8.68-9.18)	13.8 (12.7-14.4)	668
60 years and older	10.7 (10.4-11.0)	6.88 (6.53-7.25)	10.3 (10.0-10.7)	18.2 (17.3-19.0)	863
Females					
Total, 3 years and older	7.11 (6.97-7.25)	3.89 (3.69-4.07)	7.01 (6.89-7.14)	13.4 (12.8-14.2)	3166
3–5 years	4.20 (3.97-4.44)	2.71† (2.06-3.19)	4.25 (4.04-4.59)	6.17† (5.58-6.90)	109
6–11 years	4.50 (4.33-4.68)	3.11 (2.91-3.30)	4.47 (4.19-4.73)	6.94 (6.16-7.35)	233
12–19 years	5.70 (5.52-5.88)	3.68 (3.43-3.97)	5.63 (5.40-5.84)	9.09 (8.36-10.2)	544
20–39 years	6.61 (6.45-6.78)	3.90 (3.63-4.32)	6.52 (6.37-6.72)	11.2 (9.87-12.0)	806
40–59 years	7.57 (7.40-7.75)	4.97 (4.67-5.13)	7.36 (7.18-7.57)	12.9 (11.7-14.0)	618
60 years and older	9.53 (9.19-9.89)	6.04 (5.82-6.19)	9.09 (8.78-9.31)	18.2 (16.6-19.8)	856

† Estimate is subject to greater uncertainty due to small cell size.

Table 1.5.a. Plasma methylmalonic acid: Total population

Geometric mean and selected percentiles of plasma concentrations (in µmol/L) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	.131 (.129-.134)	.070 (.060-.070)	.120 (.120-.130)	.290 (.280-.300)	16048
3–5 years	.120 (.116-.124)	.060 (.060-.070)	.120 (.110-.120)	.230 (.200-.250)	829
6–11 years	.121 (.117-.125)	.070 (.060-.070)	.120 (.110-.120)	.210 (.190-.220)	1929
12–19 years	.116 (.113-.120)	.050 (.050-.060)	.110 (.100-.110)	.230 (.210-.240)	4352
20–39 years	.122 (.119-.125)	.060 (.060-.070)	.110 (.110-.120)	.260 (.240-.270)	3189
40–59 years	.132 (.129-.134)	.060 (.060-.070)	.120 (.120-.130)	.250 (.240-.270)	2701
60 years and older	.171 (.166-.176)	.080 (.070-.080)	.160 (.150-.160)	.450 (.410-.530)	3048
Males					
Total, 3 years and older	.135 (.132-.138)	.070 (.060-.070)	.130 (.120-.130)	.280 (.270-.300)	7799
3–5 years	.123 (.118-.129)	.060 (.060-.070)	.110 (.110-.120)	.230 (.200-.280)	432
6–11 years	.125 (.120-.130)	.060 (.060-.070)	.110 (.110-.120)	.200 (.180-.220)	986
12–19 years	.122 (.118-.126)	.070 (.060-.070)	.120 (.110-.120)	.230 (.220-.270)	2175
20–39 years	.128 (.123-.132)	.060 (.060-.070)	.130 (.120-.130)	.250 (.230-.290)	1355
40–59 years	.136 (.132-.140)	.080 (.070-.080)	.130 (.120-.130)	.270 (.240-.300)	1343
60 years and older	.173 (.168-.178)	.070 (.070-.080)	.160 (.150-.160)	.450 (.420-.500)	1508
Females					
Total, 3 years and older	.128 (.126-.131)	.070 (.060-.070)	.110 (.110-.120)	.280 (.260-.280)	8249
3–5 years	.116 (.111-.122)	.060 (.060-.070)	.110 (.110-.120)	.200 (.180-.250)	397
6–11 years	.117 (.112-.123)	.070 (.060-.070)	.110 (.110-.120)	.190 (.180-.200)	943
12–19 years	.111 (.107-.116)	.050 (.050-.060)	.100 (.100-.110)	.220 (.200-.260)	2177
20–39 years	.117 (.114-.120)	.050 (.050-.060)	.100 (.100-.110)	.260 (.230-.270)	1834
40–59 years	.127 (.124-.131)	.060 (.060-.070)	.110 (.110-.120)	.250 (.230-.300)	1358
60 years and older	.170 (.164-.177)	.070 (.070-.080)	.150 (.140-.150)	.460 (.380-.570)	1540

Table 1.5.b. Plasma methylmalonic acid: Mexican Americans

Geometric mean and selected percentiles of plasma concentrations (in µmol/L) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	.111 (.108-.113)	.050 (.050-.060)	.110 (.100-.110)	.220 (.220-.240)	4726
3–5 years	.108 (.103-.112)	.070 (.060-.070)	.110 (.100-.110)	.180 (.170-.210)	271
6–11 years	.104 (.100-.109)	.060 (<LOD-.060)	.100 (.090-.100)	.180 (.160-.190)	656
12–19 years	.104 (.102-.107)	.060 (.050-.060)	.100 (.090-.100)	.190 (.180-.220)	1644
20–39 years	.108 (.103-.113)	.050 (<LOD-.060)	.100 (.090-.100)	.230 (.210-.270)	870
40–59 years	.116 (.112-.120)	.060 (.050-.060)	.110 (.100-.110)	.230 (.220-.270)	634
60 years and older	.150 (.145-.155)	.060 (.060-.080)	.130 (.120-.130)	.440 (.400-.530)	651
Males					
Total, 3 years and older	.117 (.114-.121)	.060 (<LOD-.060)	.100 (.100-.110)	.250 (.230-.280)	2305
3–5 years	.108 (.102-.115)	.060† (.050-.080)	.100 (.100-.110)	.180† (.160-.210)	142
6–11 years	.104 (.099-.109)	.050 (<LOD-.070)	.110 (.100-.110)	.170 (.150-.200)	339
12–19 years	.111 (.107-.115)	.050 (<LOD-.060)	.110 (.100-.110)	.210 (.190-.230)	814
20–39 years	.118 (.112-.125)	.060 (<LOD-.060)	.110 (.100-.110)	.280 (.230-.390)	385
40–59 years	.125 (.119-.132)	.070 (.060-.070)	.110 (.110-.120)	.260 (.220-.350)	301
60 years and older	.151 (.141-.162)	.070 (.060-.080)	.140 (.130-.150)	.500 (.330-.630)	324
Females					
Total, 3 years and older	.104 (.102-.106)	.050 (.050-.060)	.095 (.090-.100)	.210 (.190-.220)	2421
3–5 years	.107 (.100-.114)	.060† (<LOD-.070)	.110 (.100-.120)	.170† (.160-.210)	129
6–11 years	.105 (.100-.111)	.070 (.060-.070)	.100 (.090-.100)	.170 (.150-.200)	317
12–19 years	.097 (.095-.100)	.060 (.050-.060)	.100 (.090-.100)	.170 (.170-.200)	830
20–39 years	.097 (.093-.103)	< LOD	.100 (.090-.100)	.170 (.160-.210)	485
40–59 years	.107 (.102-.112)	.060 (.050-.060)	.090 (.090-.100)	.190 (.180-.220)	333
60 years and older	.148 (.140-.157)	.070 (<LOD-.080)	.120 (.120-.130)	.430 (.380-.560)	327

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 1.5.c. Plasma methylmalonic acid: Non-Hispanic blacks

Geometric mean and selected percentiles of plasma concentrations (in µmol/L) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	.110 (.107-.114)	.050 (.050-.060)	.100 (.100-.110)	.220 (.210-.240)	3768
3–5 years	.102 (.097-.107)	.060 (<LOD-.060)	.090 (.090-.100)	.170 (.160-.200)	245
6–11 years	.103 (.099-.107)	.070 (.060-.070)	.100 (.090-.100)	.170 (.150-.190)	619
12–19 years	.101 (.097-.105)	.050 (.050-.060)	.100 (.090-.100)	.180 (.180-.200)	1264
20–39 years	.101 (.097-.106)	.060 (.050-.060)	.100 (.090-.100)	.180 (.160-.220)	596
40–59 years	.115 (.109-.122)	.060 (<LOD-.060)	.110 (.100-.110)	.230 (.190-.270)	551
60 years and older	.156 (.148-.165)	.070 (.070-.080)	.140 (.130-.140)	.400 (.310-.500)	493
Males					
Total, 3 years and older	.115 (.111-.119)	.050 (.050-.060)	.100 (.100-.110)	.230 (.220-.260)	1846
3–5 years	.103 (.096-.110)	.060† (<LOD-.060)	.090 (.090-.110)	.180† (.150-.230)	127
6–11 years	.104 (.100-.109)	.060 (<LOD-.060)	.100 (.090-.100)	.160 (.150-.190)	312
12–19 years	.107 (.102-.112)	.060 (<LOD-.060)	.100 (.090-.100)	.190 (.180-.240)	645
20–39 years	.110 (.103-.119)	.060 (<LOD-.070)	.100 (.100-.110)	.220 (.170-.260)	248
40–59 years	.119 (.111-.128)	< LOD	.120 (.110-.120)	.250 (.200-.290)	277
60 years and older	.155 (.143-.167)	.070 (.050-.070)	.140 (.120-.150)	.450 (.310-.560)	237
Females					
Total, 3 years and older	.107 (.104-.110)	.050 (.050-.060)	.090 (.090-.100)	.220 (.200-.230)	1922
3–5 years	.101 (.094-.109)	.050† (<LOD-.070)	.100 (.090-.100)	.150† (.130-.190)	118
6–11 years	.102 (.097-.107)	.060 (.060-.070)	.100 (.090-.100)	.170 (.150-.200)	307
12–19 years	.095 (.090-.100)	< LOD	.080 (.080-.090)	.170 (.160-.180)	619
20–39 years	.095 (.092-.099)	.060 (.050-.060)	.080 (.080-.090)	.160 (.140-.180)	348
40–59 years	.112 (.104-.121)	.050 (<LOD-.070)	.110 (.100-.110)	.210 (.170-.230)	274
60 years and older	.157 (.147-.168)	.080 (.070-.080)	.140 (.120-.140)	.390 (.270-.620)	256

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 1.5.d. Plasma methylmalonic acid: Non-Hispanic whites

Geometric mean and selected percentiles of plasma concentrations (in µmol/L) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	.139 (.136-.142)	.080 (.070-.080)	.130 (.120-.130)	.290 (.280-.300)	6178
3–5 years	.129 (.123-.136)	.080 (.070-.080)	.120 (.110-.120)	.240 (.210-.270)	229
6–11 years	.130 (.124-.137)	.070 (.070-.080)	.130 (.110-.130)	.230 (.200-.270)	495
12–19 years	.124 (.120-.128)	.070 (.060-.070)	.110 (.110-.120)	.230 (.220-.280)	1073
20–39 years	.130 (.126-.133)	.070 (.060-.070)	.120 (.120-.130)	.250 (.230-.270)	1380
40–59 years	.136 (.132-.139)	.070 (.070-.080)	.130 (.120-.130)	.250 (.240-.280)	1285
60 years and older	.174 (.168-.179)	.090 (.080-.090)	.160 (.150-.160)	.450 (.380-.530)	1716
Males					
Total, 3 years and older	.141 (.138-.145)	.080 (.070-.080)	.140 (.130-.140)	.280 (.270-.300)	3021
3–5 years	.136 (.127-.146)	.080† (.050-.080)	.130 (.120-.140)	.250† (.210-.340)	120
6–11 years	.134 (.126-.143)	.080 (.060-.080)	.120 (.110-.130)	.240 (.200-.310)	264
12–19 years	.129 (.124-.134)	.060 (.060-.070)	.110 (.110-.120)	.240 (.220-.280)	533
20–39 years	.132 (.127-.138)	.060 (.060-.070)	.130 (.120-.130)	.250 (.230-.290)	576
40–59 years	.139 (.134-.144)	.070 (.070-.080)	.120 (.120-.130)	.270 (.240-.300)	667
60 years and older	.174 (.168-.180)	.090 (.080-.100)	.170 (.160-.170)	.440 (.380-.490)	861
Females					
Total, 3 years and older	.137 (.134-.140)	.080 (.070-.080)	.120 (.120-.130)	.290 (.280-.310)	3157
3–5 years	.122 (.113-.132)	.070† (.070-.090)	.120 (.110-.120)	.200† (.160-.250)	109
6–11 years	.125 (.117-.134)	.070 (.060-.080)	.110 (.110-.130)	.210 (.180-.270)	231
12–19 years	.119 (.114-.125)	.070 (.060-.070)	.100 (.100-.110)	.230 (.200-.300)	540
20–39 years	.127 (.123-.131)	.060 (.060-.070)	.110 (.110-.120)	.260 (.250-.280)	804
40–59 years	.132 (.128-.137)	.080 (.070-.080)	.130 (.120-.130)	.250 (.220-.300)	618
60 years and older	.173 (.166-.181)	.090 (.080-.090)	.160 (.150-.160)	.450 (.370-.570)	855

† Estimate is subject to greater uncertainty due to small cell size.

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2

Fat-Soluble Vitamins & Micronutrients

Vitamins A and E and Carotenoids

- Vitamin A
- Vitamin E
- *gamma*-Tocopherol
- *alpha*-Carotene
- *trans-beta*-Carotene
- *beta*-Cryptoxanthin
- Lutein/zeaxanthin
- *trans*-Lycopene

Vitamin D

- 25-Hydroxyvitamin D

Fat-Soluble Vitamins & Micronutrients:

Vitamins A and E and Carotenoids

Vitamins A (retinol) and E (tocopherol) and the carotenoids are fat-soluble micronutrients that are found in many foods, including some vegetables, fruits, meats, and animal products. Fish-liver oils, liver, egg yolks, butter, and cream are known for their higher content of vitamin A. Nuts and seeds are particularly rich sources of vitamin E (Thomas 2006). At least 700 carotenoids—fat-soluble red and yellow pigments—are found in nature (Britton 2004). Americans consume 40–50 of these carotenoids, primarily in fruits and vegetables (Khachik 1992), and smaller amounts in poultry products, including egg yolks, and in seafoods (Boylston 2007). Six major carotenoids are found in human serum: *alpha*-carotene, *beta*-carotene, *beta*-cryptoxanthin, lutein, *trans*-lycopene, and zeaxanthin. Major carotene sources are orange-colored fruits and vegetables such as carrots, pumpkins, and mangos. Lutein and zeaxanthin are also found in dark green leafy vegetables, where any orange coloring is overshadowed by chlorophyll. *Trans*-Lycopene is obtained primarily from tomato and tomato products. For information on the carotenoid content of U.S. foods, see the 1998 carotenoid database created by the U.S. Department of Agriculture and the Nutrition Coordinating Center at the University of Minnesota (http://www.nal.usda.gov/fnic/foodcomp/Data/car98/car98.html).

Vitamin A, found in foods that come from animal sources, is called preformed vitamin A. Some carotenoids found in colorful fruits and vegetables are called provitamin A; they are metabolized in the body to vitamin A. Among the carotenoids, *beta*-carotene, a retinol dimer, has the most significant provitamin A activity. Because of limitations in the body's ability to absorb and metabolize vitamin A, approximately 12 micrograms (µg) of dietary *beta*-carotene are needed to equal 1 µg of retinol. Other provitamin A carotenoids, such as *alpha*-carotene and *beta*-cryptoxanthin, are half as active as *beta*-carotene (Institute of Medicine 2000). The bioconversion of carotenoids to vitamin A is highly variable from person to person (Krinsky 2005). Vitamin E activity is derived from at least eight naturally occurring tocopherols, the most potent of which is *alpha*-tocopherol. Other less active forms of vitamin E are plentiful in the U.S. diet, with *gamma*-tocopherol being the predominant form.

The absorption of fat-soluble micronutrients from the gastrointestinal tract depends on processes responsible for fat absorption or metabolism. Thus, people with conditions resulting in fat malabsorption (e.g., celiac disease, Crohn's disease, pancreatic disorders) can develop vitamin A deficiency over time. Vitamin A also has interactions with other nutrients. Iron and zinc deficiency can affect vitamin A metabolism and transport of vitamin A stores from the liver to body tissues (Institute of Medicine 2001). The absorption of carotenoids from foods is highly dependent on cooking techniques that break down plant cell walls and release carotenoids and also on the availability of dietary fat to enhance carotenoid uptake (Krinsky 2005). The liver regulates the concentration of vitamin A in the circulation by releasing stored retinyl esters as needed; only when liver reserves are nearly exhausted does serum vitamin A fall into the deficient range (Napoli 2006). The variation in serum carotenoid concentrations among people in the United States is relatively large, primarily reflecting wide-ranging differences in dietary intake (Lacher 2005). Plasma concentrations of tocopherols vary widely among healthy individuals and are highly correlated with plasma lipid concentrations (Ford 1999; Ford 2006).

Inadequate or excessive intake of vitamins A or E can lead to various disorders. For example, vitamin A deficiency is considered to be the main cause of childhood blindness (Roodhooft 2002), a rare condition in the United States. Prominent signs of vitamin A deficiency include night blindness, corneal thinning, and conjunctival metaplasia. Vitamin A is also essential for proper immune function, epithelial growth and repair, bone growth, reproduction, and normal embryonic and fetal development (West 2006). Acute toxicity, resulting from single or short-term large doses of preformed vitamin A, is characterized by nausea, vomiting, headache, vertigo, blurred vision, increased cerebrospinal fluid pressure, and lack of muscular coordination. Central nervous system effects, liver abnormalities, bone and skin changes, and other nonspecific adverse effects can be indicative of chronic hypervitaminosis A. Consuming excess amounts of vitamin A during early pregnancy may lead to serious birth defects (Institute of Medicine 2001). The U.S. Food and Drug Administration (FDA) currently recommends that pregnant women obtain vitamin A from foods containing *beta*-carotene (U.S. Food and Drug Administration 1995).

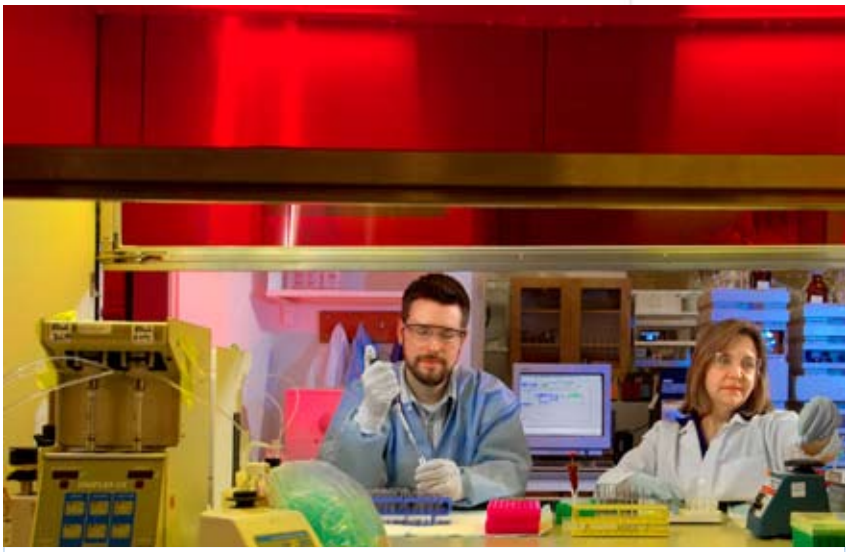
Carotenoids are considered among the best biological markers for fruit and vegetable intake. The strongest dietary predictors of serum carotenoid concentrations are fruits (for sources of *beta*-cryptoxanthin), carrots and root vegetables (for sources of carotenes), and tomato products (for sources of *trans*-lycopene) (Al-Delaimy 2005). Research studies have shown inconsistencies in the relation between carotenoid intake and protection from cancer. Carotenoids in foods, even when consumed over long periods and in large amounts, are not known to produce adverse health effects. However, results of intervention studies of smokers who used 20-30 milligrams (mg) of *beta*-carotene per day showed that this group had more lung cancers than placebo-treated groups (Redlich 1998; Albanes 1996).

Vitamin E deficiency occurs only rarely in people, and overt deficiency symptoms in people consuming low-vitamin E diets have never been described (Institute of Medicine 2000). The main manifestation of vitamin E deficiency is peripheral neuropathy characterized by the degeneration of the large-caliber axons of sensory neurons

(Institute of Medicine 2000). The upper limit (UL) for vitamin E intake (1000 mg/day) was based on hemorrhagic effects; however, a causal association between excess *alpha*-tocopherol intake in apparently healthy individuals and adverse health outcomes has not consistently been shown (Institute of Medicine 2000). Studies evaluating tocopherols to reduce the risk for cardiovascular disease demonstrated inconsistent findings (Agency for Healthcare Research and Quality 2003). The American Heart Association currently advises that antioxidant supplements (such as vitamins E and C and *beta*-carotene) should not be used for primary or secondary prevention of cardiovascular disease (Lichtenstein 2006). Nevertheless, the American Heart Association recommends consuming food sources of antioxidant nutrients, principally from a variety of plant-derived foods such as fruits, vegetables, whole grains, and vegetable oils.

The National Academy of Sciences has established dietary-requirement intake values for vitamins A and E by determining the adequate intake (AI) for infants and the recommended dietary allowance (RDA) for older age groups (Institute of Medicine 2000 and 2001). The RDA for vitamin A for adults is 900 µg/day of retinol equivalents; for children, the RDA ranges from 300–700 µg/day. For infants (aged 0–12 months), the AI is set at 400–500 µg/day of retinol equivalents. For adults, the RDA for vitamin E is 15 mg/day of *alpha*-tocopherol; for children (1–18 years), the RDA ranges from 6 mg to 15 mg/day. There is no RDA for other forms of vitamin E such as *gamma*-tocopherol. Although no quantitative recommendations are available for the intake of carotenoids, existing recommendations support increased consumption of carotenoid-rich fruits and vegetables. Current public health guidelines advise that people consume 5 to 13 servings of fruits and vegetables a day, depending on caloric need, to ensure adequate nutrient intake (U.S. Department of Health and Human Services and U.S. Department of Agriculture 2005).

Clinical laboratories typically use conventional units for serum concentrations of these fat-soluble micronutrients (µg per deciliter [dL]). Conversion factors to international system (SI) units are 1 µg/dL = 0.0349 micromole per liter (µmol/L) for vitamin A and 1 µg/dL = 0.02322 µmol/L for vitamin E. Depending on its molecular weight, each carotenoid has a specific conversion factor.



Chemists perform extraction of fat-soluble vitamins from serum.

The diagnosis of vitamin A or E deficiency is supported by measuring these concentrations in the body. Vitamin A deficiency can be diagnosed in a number of ways. People with serum concentrations of retinol of less than 20 µg/dL are considered vitamin A deficient, and those with serum concentrations of less than 10 µg/dL are considered severely deficient (West 2006). Carotenoid deficiency has no defined serum

concentrations. The laboratory diagnosis of vitamin E deficiency is based on serum concentrations of *alpha*-tocopherol (less than 500 µg/dL or less than 0.8 mg of *alpha*-tocopherol per gram of total lipids) (Beers 2006). Such concentrations are associated with in vitro hydrogen peroxide-induced red blood cell lysis, not with clinical deficiency symptoms (Institute of Medicine 2000). Among most laboratories participating in an external quality assurance program, standardized high performance liquid chromatography (HPLC) methods for measuring fat-soluble micronutrients show consistent agreement of values (Duewer 2000).

For more information on these fat-soluble micronutrients, see the Institute of Medicine's Dietary Reference Intake reports (Institute of Medicine 2000 and 2001), the vitamin fact sheets from the National Institutes of Health, Office of Dietary Supplements (http://ods.od.nih.gov/Health_Information/Vitamin_and_Mineral_Supplement_Fact_Sheets.aspx), as well as information from the American Society for Nutrition (http://jn.nutrition.org/nutinfo/).

Since 1971, various fat-soluble micronutrients have been measured in the serum of NHANES participants. In NHANES III (1988–1994), clinically low concentrations of serum retinol were uncommon in U.S. residents aged 4 years and older, although racial/ethnic and socioeconomic differences existed (Ballew 2001). Variations in serum carotenoid concentrations by ethnicity and sex were found for adults, children, and adolescents (Ford 2000; Ford 2002). Ford et al. also found sociodemographic variations in serum concentrations of *alpha*-tocopherol among U.S. adults in NHANES III (1999) and *alpha*- and *gamma*-tocopherol in NHANES 1999–2000 (2006). Application of the most common cut-off value for serum *alpha*-tocopherol concentrations in NHANES 1999–2000 (500 µg/dL), resulted in a low prevalence of vitamin E deficiency, despite the fact that the U.S. Department of Agriculture (USDA) estimated dietary intakes of vitamin E were low and that most of the U.S. population (> 90 percent) did not meet dietary recommendations either in 1999–2000 (Ahuja 2004) or in 2001–2002 (Moshfegh 2005). However, the USDA report is based on intakes from food only and does not include dietary supplements. Furthermore, in NHANES only *alpha*-tocopherol is estimated for assessing dietary vitamin E intake. In NHANES 2001–2002, 44 percent of survey participants had an estimated dietary intake (from food only) of vitamin A (including carotenoids) that was less than the vitamin A estimated average requirement (EAR) (Moshfegh 2005). Low dietary intakes of certain micronutrients without widespread manifestation of deficiency suggest the need for further evaluations to determine whether improved estimates are necessary, either in the nutrient tables or in dietary intake.

Selected Observations and Highlights

The following sample observations are taken from the tables of 1999–2002 (for vitamins A and E) or 2001–2002 data (for all carotenoids) contained in this report. Statements about categorical differences between demographic groups noted below are based on non-overlapping confidence limits from univariate analysis without adjusting for demographic variables (e.g., age, sex, race/ethnicity) or other determinants of these blood concentrations (e.g., dietary intake, supplement usage, smoking, BMI). A multivariate analysis may alter the size and statistical significance of these categorical differences. Furthermore, additional significant differences of smaller magnitude may be present despite their lack of mention here (e.g., if confidence limits slightly overlap or if differences are unobservable before covariate adjustment has occurred). For a selection of citations of descriptive NHANES papers related to these biochemical indicators of diet and nutrition, see Appendix E.

General Observations

- Serum vitamin A and E concentrations are lower in children and adolescents than in adults.
- Serum *beta*-carotene concentrations are higher in older people (≥ 60 years), whereas serum *alpha*-carotene and lutein/zeaxanthin concentrations are higher in middle-aged and older people compared with people in younger age groups.
- Serum *beta*-cryptoxanthin concentrations are higher in children than in adolescents or adults.
- Serum *trans*-lycopene and *gamma*-tocopherol concentrations are lower in young children and older people than in people in other age groups.
- Serum *alpha*-carotene and lutein/zeaxanthin concentrations are lower in adolescents, whereas serum *beta*-carotene concentrations are lower in adolescents and in adults 20–39 years old than in people in other age groups.
- Females have lower concentrations of serum vitamin A and *trans*-lycopene than do males. Females have higher concentrations of serum vitamin E and *beta*-carotene than do males.
- Non-Hispanic blacks and Mexican Americans have lower serum concentrations of vitamin A than do non-Hispanic whites.
- Non-Hispanic blacks have lower serum concentrations of vitamin E than do Mexican Americans, who have lower serum concentrations of vitamin E than do non-Hispanic whites.
- Non-Hispanic blacks have higher serum concentrations of *gamma*-tocopherol than do Mexican Americans and non-Hispanic whites.

- Non-Hispanic blacks have lower serum concentrations of *alpha*-carotene than do non-Hispanic whites or Mexican Americans.
- Non-Hispanic whites have lower serum concentrations of *beta*-cryptoxanthin than do non-Hispanic blacks, who have lower serum concentrations of *beta*-cryptoxanthin than do Mexican Americans.
- Non-Hispanic blacks have higher serum concentrations of *trans*-lycopene than do Mexican Americans.

Highlights

The majority of the U.S. population (> 95 percent) has adequate serum concentrations of vitamin A (≥ 20 µg/dL) and vitamin E (≥ 500 µg/dL).

Table 2.1.a. Serum vitamin A: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	53.5 (52.7-54.3)	30.9 (30.3-31.7)	54.5 (53.6-55.4)	87.0 (85.8-88.4)	15819
3–5 years	33.1 (32.6-33.7)	22.7 (21.4-24.4)	33.7 (33.0-34.4)	46.5 (44.1-47.8)	782
6–11 years	36.3 (35.7-37.0)	26.0 (24.8-26.3)	36.4 (35.7-37.1)	51.2 (49.4-52.6)	1880
12–19 years	47.0 (46.3-47.6)	30.8 (30.1-31.4)	47.4 (46.6-48.0)	70.6 (68.9-72.1)	4317
20–39 years	53.6 (52.6-54.6)	33.6 (32.5-34.6)	54.6 (53.5-55.6)	82.3 (80.3-83.8)	3177
40–59 years	59.7 (58.8-60.6)	37.1 (35.0-38.7)	60.6 (59.4-61.4)	92.6 (88.9-95.2)	2665
60 years and older	63.8 (62.9-64.7)	40.2 (38.1-41.4)	64.5 (63.2-65.3)	98.8 (95.6-102)	2998
Males					
Total, 3 years and older	56.3 (55.3-57.3)	31.7 (30.8-32.9)	58.1 (56.9-59.3)	88.7 (86.5-91.2)	7701
3–5 years	32.9 (32.1-33.7)	21.9 (17.1-25.0)	33.9 (33.0-35.0)	45.4 (43.2-47.5)	410
6–11 years	36.1 (35.2-37.1)	26.0 (24.5-26.5)	36.1 (35.3-37.1)	51.3 (49.4-52.6)	956
12–19 years	49.1 (48.2-50.1)	32.1 (30.9-33.8)	49.8 (48.8-50.9)	71.3 (69.3-72.9)	2164
20–39 years	58.4 (57.5-59.4)	40.3 (39.0-41.6)	59.0 (58.0-60.1)	83.5 (80.9-85.5)	1349
40–59 years	64.6 (63.3-65.9)	42.4 (40.4-44.3)	66.0 (65.0-67.7)	95.3 (92.8-98.4)	1332
60 years and older	65.4 (63.9-66.9)	41.2 (38.7-42.7)	66.1 (64.6-68.2)	101 (96.4-106)	1490
Females					
Total, 3 years and older	50.9 (50.1-51.7)	30.3 (29.4-31.1)	50.9 (50.1-51.8)	85.2 (83.3-87.2)	8118
3–5 years	33.4 (32.7-34.1)	24.1 (22.2-25.3)	33.1 (32.5-34.5)	47.1 (44.7-49.7)	372
6–11 years	36.5 (35.8-37.2)	26.2 (24.7-26.9)	36.7 (36.1-37.5)	50.4 (49.0-52.2)	924
12–19 years	44.8 (43.9-45.6)	29.7 (29.0-30.9)	44.7 (43.5-45.9)	68.8 (66.0-71.9)	2153
20–39 years	49.2 (48.1-50.4)	30.7 (29.7-31.8)	49.1 (47.3-50.7)	80.8 (78.0-82.4)	1828
40–59 years	55.3 (54.3-56.3)	34.4 (32.4-35.4)	55.5 (54.2-56.4)	87.3 (84.8-91.3)	1333
60 years and older	62.6 (61.6-63.6)	39.4 (36.2-41.4)	63.0 (62.0-64.4)	96.8 (92.0-101)	1508

Table 2.1.b. Serum vitamin A: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	46.8 (46.0-47.7)	28.1 (27.2-28.9)	47.1 (46.0-48.1)	75.6 (73.7-77.8)	4662
3–5 years	31.6 (30.7-32.6)	22.6 (21.7-23.8)	31.9 (30.2-33.7)	43.2 (40.4-45.6)	261
6–11 years	35.4 (34.8-36.0)	24.6 (23.8-26.2)	35.6 (34.9-36.2)	48.9 (47.2-50.8)	644
12–19 years	44.8 (44.2-45.5)	30.7 (28.7-31.9)	45.0 (44.1-45.8)	64.6 (63.6-65.9)	1626
20–39 years	50.6 (49.6-51.6)	31.9 (29.8-33.5)	50.9 (49.0-52.8)	75.2 (73.8-77.8)	866
40–59 years	52.8 (51.4-54.3)	32.5 (30.4-35.0)	53.9 (52.4-55.3)	83.7 (78.8-87.4)	628
60 years and older	55.9 (52.9-59.2)	34.0 (31.2-36.5)	55.3 (52.2-59.9)	91.0 (82.4-107)	637
Males					
Total, 3 years and older	50.6 (49.7-51.6)	29.8 (28.8-30.5)	51.7 (50.5-53.2)	79.1 (77.0-82.4)	2277
3–5 years	32.5 (30.6-34.5)	22.4† (20.1-25.0)	32.9 (30.7-34.5)	45.2† (41.1-51.2)	136
6–11 years	35.4 (34.6-36.2)	24.6 (23.2-27.1)	35.4 (34.5-36.2)	49.2 (45.9-51.3)	333
12–19 years	48.1 (47.1-49.1)	33.7 (32.1-34.9)	48.3 (47.0-49.7)	67.8 (65.6-69.7)	807
20–39 years	56.6 (55.3-57.9)	39.3 (37.4-41.9)	57.5 (55.8-59.1)	78.3 (75.2-86.5)	382
40–59 years	57.9 (55.9-59.9)	36.3 (32.4-40.4)	57.9 (56.1-60.2)	87.4 (83.0-95.3)	298
60 years and older	57.0 (54.3-60.0)	35.3 (33.1-37.1)	55.5 (52.9-61.3)	93.4 (79.8-118)	321
Females					
Total, 3 years and older	43.0 (42.1-43.9)	27.0 (26.1-27.8)	42.6 (41.5-43.6)	69.8 (65.7-73.1)	2385
3–5 years	30.8 (29.4-32.2)	22.6† (20.3-24.7)	30.4 (27.9-33.3)	40.0† (38.9-43.7)	125
6–11 years	35.3 (34.4-36.3)	23.8 (23.1-26.5)	35.9 (34.7-36.7)	48.6 (47.2-51.2)	311
12–19 years	41.5 (40.8-42.3)	28.4 (26.9-30.8)	41.1 (40.5-41.5)	60.3 (57.6-62.2)	819
20–39 years	44.3 (43.1-45.5)	28.7 (26.4-30.7)	44.6 (42.8-46.3)	69.1 (63.4-72.8)	484
40–59 years	48.1 (46.4-49.9)	30.6 (25.7-34.1)	48.1 (46.4-50.1)	74.7 (68.3-77.1)	330
60 years and older	55.0 (51.2-59.0)	31.8 (27.8-39.3)	54.8 (51.3-59.9)	90.0 (82.9-99.0)	316

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.1.c. Serum vitamin A: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	46.0 (45.1-47.0)	27.3 (26.3-27.9)	45.7 (44.4-47.1)	79.3 (75.9-81.6)	3680
3–5 years	31.8 (30.6-33.1)	21.6 (19.3-23.9)	32.1 (30.8-33.3)	44.6 (41.6-47.9)	226
6–11 years	35.0 (34.1-35.9)	23.7 (21.9-25.6)	35.1 (34.0-36.5)	50.5 (48.2-52.2)	591
12–19 years	41.4 (40.6-42.2)	27.9 (26.7-28.6)	41.7 (40.6-42.6)	61.9 (60.2-64.1)	1252
20–39 years	46.1 (44.8-47.5)	28.4 (27.6-30.7)	46.8 (45.2-48.5)	72.0 (67.7-74.6)	590
40–59 years	52.2 (50.4-54.1)	30.6 (27.3-34.0)	52.1 (50.6-54.0)	87.3 (80.6-95.6)	540
60 years and older	58.6 (56.6-60.6)	33.5 (31.2-36.7)	59.0 (56.8-60.4)	102 (93.4-117)	481
Males					
Total, 3 years and older	48.5 (47.6-49.5)	27.9 (26.9-28.7)	49.6 (48.5-50.7)	80.7 (77.6-84.3)	1806
3–5 years	32.7 (31.2-34.2)	22.6† (19.3-24.9)	32.7 (31.0-34.6)	45.4† (41.9-53.6)	119
6–11 years	34.5 (33.5-35.5)	24.2 (20.8-25.5)	34.4 (33.2-35.6)	50.7 (47.2-54.3)	297
12–19 years	43.7 (42.7-44.6)	28.7 (28.0-30.0)	43.5 (42.4-44.6)	64.8 (62.6-67.5)	640
20–39 years	51.7 (50.1-53.4)	34.3 (28.8-37.8)	53.2 (51.2-55.2)	74.8 (70.3-79.6)	246
40–59 years	56.3 (53.8-58.9)	34.4 (30.2-38.1)	56.3 (53.1-59.3)	92.9 (80.8-107)	274
60 years and older	59.3 (56.1-62.7)	34.9 (30.0-39.9)	58.5 (53.5-62.8)	106 (87.7-144)	230
Females					
Total, 3 years and older	44.0 (42.7-45.3)	26.7 (25.5-27.9)	42.9 (41.9-43.9)	75.6 (72.6-80.4)	1874
3–5 years	30.9 (29.3-32.6)	19.5† (16.1-23.6)	31.7 (29.9-33.1)	42.7† (38.6-45.7)	107
6–11 years	35.5 (34.3-36.7)	23.6 (21.5-26.7)	36.0 (34.3-37.6)	50.4 (48.0-52.2)	294
12–19 years	39.2 (38.3-40.1)	26.0 (24.5-27.5)	39.5 (38.5-40.7)	56.8 (54.5-59.0)	612
20–39 years	42.3 (40.4-44.2)	27.6 (24.7-29.1)	41.7 (39.8-43.8)	66.3 (62.0-72.4)	344
40–59 years	48.9 (46.5-51.4)	29.3 (25.2-31.5)	47.7 (44.5-51.1)	82.0 (74.4-92.0)	266
60 years and older	58.1 (55.3-61.1)	32.9 (30.2-36.8)	59.4 (56.8-61.2)	97.8 (86.7-115)	251

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.1.d. Serum vitamin A: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	56.3 (55.3-57.4)	33.1 (32.1-34.2)	57.3 (56.2-58.8)	88.9 (87.4-90.9)	6128
3–5 years	34.0 (33.1-34.8)	24.0† (21.4-25.8)	34.2 (33.0-35.7)	47.2† (44.1-49.7)	217
6–11 years	36.8 (35.9-37.7)	26.5 (25.4-28.3)	36.7 (35.8-37.9)	51.3 (49.0-52.7)	489
12–19 years	49.0 (47.9-50.0)	32.6 (31.3-34.2)	49.0 (48.0-50.0)	72.9 (70.9-75.0)	1073
20–39 years	56.1 (54.8-57.4)	36.1 (34.6-37.6)	57.0 (55.0-58.7)	83.9 (81.9-86.8)	1377
40–59 years	62.0 (60.9-63.1)	40.1 (38.1-42.0)	63.1 (61.5-64.3)	93.5 (90.3-96.2)	1276
60 years and older	65.2 (64.3-66.2)	41.6 (40.1-43.1)	65.5 (64.4-67.5)	99.1 (96.1-102)	1696
Males					
Total, 3 years and older	58.9 (57.6-60.2)	33.6 (32.0-35.1)	60.8 (59.3-62.9)	91.4 (88.7-93.5)	3001
3–5 years	33.4 (32.3-34.4)	21.4† (17.1-25.8)	34.4 (32.7-36.6)	45.6† (41.4-47.8)	115
6–11 years	36.6 (35.2-38.0)	26.2 (24.3-28.6)	36.4 (35.1-38.4)	52.2 (48.6-53.0)	257
12–19 years	50.6 (49.3-51.9)	32.4 (30.5-36.0)	51.0 (49.8-52.3)	72.9 (70.0-74.9)	535
20–39 years	60.4 (59.1-61.7)	41.7 (40.5-43.1)	60.4 (59.2-63.0)	84.8 (81.6-87.5)	575
40–59 years	66.6 (65.1-68.1)	44.5 (42.5-47.8)	68.2 (66.3-69.8)	96.2 (92.9-99.9)	665
60 years and older	66.8 (65.2-68.4)	42.0 (40.4-44.6)	67.9 (65.3-70.1)	101 (96.6-105)	854
Females					
Total, 3 years and older	54.0 (52.9-55.2)	32.6 (31.6-34.1)	54.5 (52.8-55.8)	87.5 (85.9-89.4)	3127
3–5 years	34.7 (33.3-36.1)	26.2† (24.0-27.8)	34.0 (32.5-36.3)	49.1† (45.9-51.8)	102
6–11 years	37.0 (36.0-38.0)	26.2 (24.7-28.4)	36.8 (36.0-38.0)	50.2 (48.1-54.0)	232
12–19 years	47.3 (46.0-48.6)	33.2 (31.2-34.3)	46.9 (45.3-47.9)	72.1 (68.3-76.8)	538
20–39 years	52.2 (50.5-54.0)	34.1 (30.9-35.9)	51.7 (49.9-54.8)	83.1 (80.5-87.3)	802
40–59 years	57.7 (56.5-58.8)	36.0 (34.6-39.2)	57.2 (56.0-58.4)	88.8 (86.1-94.8)	611
60 years and older	64.1 (62.9-65.2)	41.4 (39.0-43.5)	64.5 (62.5-65.6)	97.4 (92.0-102)	842

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.2.a. Serum vitamin E: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	1090 (1070-1110)	615 (604-626)	1030 (1010-1050)	2380 (2300-2480)	15766
3–5 years	800 (777-824)	567 (547-593)	782 (758-813)	1160 (1110-1310)	777
6–11 years	794 (779-810)	556 (546-570)	790 (772-812)	1130 (1090-1180)	1873
12–19 years	762 (750-774)	532 (518-548)	753 (741-766)	1140 (1100-1200)	4314
20–39 years	991 (977-1010)	629 (618-645)	963 (943-980)	1740 (1650-1800)	3168
40–59 years	1300 (1280-1330)	774 (743-792)	1250 (1220-1280)	2620 (2470-2760)	2655
60 years and older	1530 (1500-1560)	808 (771-850)	1480 (1440-1520)	3220 (3010-3330)	2979
Males					
Total, 3 years and older	1070 (1040-1090)	605 (593-617)	1010 (984-1030)	2280 (2170-2380)	7673
3–5 years	796 (768-825)	569 (556-594)	791 (759-823)	1110 (1030-1300)	406
6–11 years	789 (770-809)	554 (543-576)	785 (760-815)	1130 (1040-1210)	951
12–19 years	749 (731-767)	521 (503-544)	739 (724-757)	1120 (1060-1200)	2163
20–39 years	993 (972-1020)	625 (611-646)	969 (940-985)	1750 (1660-1880)	1344
40–59 years	1310 (1270-1350)	752 (724-776)	1250 (1220-1280)	2570 (2390-2830)	1328
60 years and older	1420 (1380-1450)	769 (727-803)	1370 (1330-1400)	2850 (2740-3010)	1481
Females					
Total, 3 years and older	1120 (1100-1140)	626 (612-640)	1050 (1030-1070)	2480 (2350-2620)	8093
3–5 years	804 (772-838)	560 (513-602)	774 (750-812)	1270 (1120-1460)	371
6–11 years	801 (779-822)	560 (542-587)	799 (775-820)	1140 (1090-1190)	922
12–19 years	776 (763-788)	548 (539-556)	769 (756-784)	1160 (1110-1210)	2151
20–39 years	990 (974-1010)	630 (615-654)	955 (933-978)	1700 (1620-1830)	1824
40–59 years	1300 (1260-1340)	797 (744-820)	1240 (1200-1280)	2670 (2360-2970)	1327
60 years and older	1620 (1580-1660)	860 (819-889)	1590 (1530-1650)	3370 (3170-3550)	1498

Table 2.2.b. Serum vitamin E: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	967 (944-990)	587 (572-602)	919 (904-938)	1800 (1720-1950)	4662
3–5 years	768 (748-788)	569 (514-593)	762 (737-787)	1050 (980-1110)	261
6–11 years	770 (758-782)	555 (538-573)	765 (746-780)	1090 (1050-1110)	640
12–19 years	754 (744-764)	516 (503-531)	744 (729-758)	1150 (1110-1200)	1628
20–39 years	987 (954-1020)	642 (605-667)	959 (931-983)	1680 (1550-1780)	867
40–59 years	1260 (1210-1310)	757 (720-804)	1230 (1160-1280)	2250 (2070-2620)	629
60 years and older	1380 (1320-1440)	762 (696-810)	1310 (1260-1390)	2810 (2610-3350)	637
Males					
Total, 3 years and older	968 (943-995)	580 (564-590)	922 (902-943)	1810 (1690-2010)	2277
3–5 years	766 (736-797)	567† (530-608)	749 (719-784)	1070† (971-1230)	135
6–11 years	768 (748-789)	544 (532-577)	758 (736-785)	1070 (1030-1160)	331
12–19 years	741 (723-759)	503 (490-516)	733 (718-753)	1110 (1080-1150)	808
20–39 years	999 (954-1050)	617 (587-662)	964 (923-1020)	1650 (1530-1920)	383
40–59 years	1300 (1210-1400)	790 (707-860)	1250 (1160-1340)	2370 (2060-3340)	299
60 years and older	1280 (1220-1350)	729 (651-799)	1230 (1200-1300)	2610 (2080-3530)	321
Females					
Total, 3 years and older	965 (939-992)	593 (574-616)	915 (898-939)	1780 (1690-1980)	2385
3–5 years	770 (740-800)	577† (495-594)	780 (735-819)	992† (953-1110)	126
6–11 years	772 (756-789)	558 (526-586)	768 (744-790)	1090 (1040-1170)	309
12–19 years	769 (761-777)	539 (529-551)	757 (732-778)	1220 (1130-1260)	820
20–39 years	972 (945-1000)	651 (592-675)	947 (921-981)	1670 (1480-1750)	484
40–59 years	1220 (1170-1260)	739 (715-795)	1190 (1130-1260)	2100 (1810-2400)	330
60 years and older	1470 (1380-1570)	780 (587-929)	1400 (1330-1470)	2850 (2670-3490)	316

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.2.c. Serum vitamin E: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	917 (897-936)	579 (564-595)	884 (865-903)	1700 (1620-1820)	3670
3–5 years	761 (736-787)	560† (511-586)	748 (728-768)	1120† (1080-1170)	222
6–11 years	769 (752-786)	548 (521-583)	765 (745-789)	1070 (1010-1120)	592
12–19 years	728 (714-741)	530 (512-542)	721 (707-740)	1030 (1010-1060)	1249
20–39 years	879 (860-899)	607 (567-627)	867 (840-895)	1390 (1300-1470)	589
40–59 years	1090 (1050-1120)	686 (636-712)	1040 (1010-1070)	2250 (1840-2390)	539
60 years and older	1200 (1140-1250)	692 (655-736)	1150 (1090-1190)	2280 (2070-2780)	479
Males					
Total, 3 years and older	888 (866-912)	573 (554-589)	864 (842-883)	1620 (1450-1770)	1802
3–5 years	761 (725-798)	550† (497-614)	749 (702-782)	1100† (989-1130)	117
6–11 years	780 (763-797)	565 (531-580)	772 (757-811)	1080 (1010-1160)	297
12–19 years	722 (706-738)	528 (506-539)	716 (701-732)	1020 (975-1050)	639
20–39 years	870 (834-908)	614 (567-643)	863 (809-900)	1340 (1200-1560)	246
40–59 years	1040 (995-1080)	636 (579-707)	1010 (971-1070)	1850 (1620-2250)	274
60 years and older	1110 (1060-1170)	655 (582-721)	1070 (1020-1140)	2180 (1910-2390)	229
Females					
Total, 3 years and older	942 (916-968)	588 (560-609)	907 (884-923)	1800 (1640-2080)	1868
3–5 years	761 (731-792)	545† (491-586)	748 (713-800)	1150† (1010-1240)	105
6–11 years	757 (732-783)	536 (505-588)	757 (726-788)	1010 (982-1120)	295
12–19 years	734 (719-748)	534 (503-560)	733 (706-758)	1050 (1000-1100)	610
20–39 years	886 (863-909)	605 (519-626)	877 (839-907)	1450 (1300-1510)	343
40–59 years	1130 (1090-1180)	712 (679-780)	1050 (1020-1090)	2410 (2020-2700)	265
60 years and older	1250 (1180-1330)	727 (686-815)	1180 (1140-1270)	2690 (1930-3650)	250

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.2.d. Serum vitamin E: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	1150 (1130-1180)	638 (620-652)	1090 (1050-1120)	2530 (2440-2630)	6085
3–5 years	822 (782-865)	567† (547-622)	803 (757-853)	1240† (1110-1460)	216
6–11 years	804 (782-826)	556 (545-577)	800 (772-825)	1150 (1090-1230)	485
12–19 years	774 (757-791)	543 (526-556)	763 (744-777)	1180 (1100-1250)	1071
20–39 years	1010 (991-1030)	646 (619-665)	978 (957-994)	1780 (1660-1930)	1368
40–59 years	1340 (1310-1370)	796 (770-820)	1280 (1250-1310)	2670 (2500-2980)	1266
60 years and older	1580 (1540-1610)	831 (795-868)	1530 (1500-1580)	3300 (3070-3460)	1679
Males					
Total, 3 years and older	1120 (1090-1150)	619 (598-643)	1060 (1020-1100)	2420 (2300-2540)	2977
3–5 years	819 (773-867)	576† (556-622)	818 (751-860)	1100† (1010-1470)	114
6–11 years	788 (759-818)	550 (502-575)	779 (746-825)	1130 (1030-1220)	254
12–19 years	758 (731-785)	532 (509-556)	742 (724-771)	1150 (1040-1300)	534
20–39 years	1010 (974-1040)	637 (607-669)	976 (939-1000)	1850 (1620-2060)	569
40–59 years	1350 (1310-1400)	774 (728-810)	1280 (1250-1330)	2630 (2470-3150)	660
60 years and older	1450 (1410-1500)	779 (734-815)	1400 (1370-1440)	2880 (2750-3240)	846
Females					
Total, 3 years and older	1180 (1150-1210)	654 (639-670)	1120 (1090-1160)	2640 (2490-2770)	3108
3–5 years	826 (770-886)	564† (430-662)	776 (742-874)	1440† (1150-1520)	102
6–11 years	822 (793-852)	557 (530-603)	811 (781-851)	1150 (1100-1400)	231
12–19 years	791 (773-810)	554 (537-568)	781 (761-811)	1180 (1110-1250)	537
20–39 years	1020 (996-1030)	647 (623-682)	982 (951-1010)	1760 (1620-1930)	799
40–59 years	1330 (1290-1380)	818 (783-852)	1280 (1230-1320)	2690 (2360-3090)	606
60 years and older	1680 (1630-1730)	884 (853-924)	1660 (1600-1740)	3460 (3230-3760)	833

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.3.a. Serum *gamma*-tocopherol: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	198 (190-206)	65.7 (61.0-71.0)	212 (204-221)	462 (438-482)	14738
3–5 years	176 (162-192)	63.0 (52.0-83.5)	186 (170-199)	364 (340-407)	730
6–11 years	207 (198-217)	97.8 (92.0-105)	217 (206-225)	389 (363-428)	1730
12–19 years	197 (190-204)	100 (93.0-108)	201 (192-208)	372 (359-386)	4009
20–39 years	206 (198-215)	83.0 (71.7-89.2)	219 (208-227)	442 (427-468)	3005
40–59 years	205 (194-218)	60.0 (55.0-68.0)	225 (213-238)	530 (478-568)	2491
60 years and older	174 (165-184)	47.8 (46.0-51.0)	190 (177-203)	496 (462-531)	2773
Males					
Total, 3 years and older	199 (191-208)	65.1 (59.0-72.0)	212 (204-221)	466 (442-481)	7169
3–5 years	167 (151-184)	58.6 (42.8-89.0)	178 (165-193)	340 (298-400)	380
6–11 years	201 (190-213)	92.0 (81.0-104)	213 (195-225)	366 (361-408)	870
12–19 years	193 (186-200)	98.1 (91.0-108)	193 (187-201)	371 (341-390)	2005
20–39 years	208 (200-217)	75.5 (66.0-88.5)	223 (210-233)	473 (436-481)	1279
40–59 years	214 (200-228)	61.0 (57.0-72.0)	230 (216-248)	548 (499-608)	1253
60 years and older	169 (160-180)	43.9 (40.0-47.8)	191 (176-200)	463 (427-510)	1382
Females					
Total, 3 years and older	197 (189-205)	65.8 (62.0-71.0)	213 (202-221)	457 (433-484)	7569
3–5 years	188 (172-205)	72.0 (56.0-95.9)	195 (176-215)	385 (328-446)	350
6–11 years	214 (203-226)	106 (95.0-117)	221 (206-238)	408 (361-473)	860
12–19 years	202 (194-211)	102 (89.0-111)	208 (198-219)	373 (357-391)	2004
20–39 years	203 (193-214)	85.0 (75.0-91.4)	216 (202-226)	424 (410-440)	1726
40–59 years	198 (186-210)	57.2 (51.0-67.0)	221 (206-233)	505 (453-559)	1238
60 years and older	178 (167-189)	51.3 (47.1-55.2)	189 (175-207)	508 (482-542)	1391

Table 2.3.b. Serum *gamma*-tocopherol: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	206 (199-214)	92.0 (87.9-99.0)	211 (203-218)	437 (404-466)	3983
3–5 years	180 (168-192)	93.0 (82.2-109)	185 (175-200)	318 (287-370)	224
6–11 years	219 (210-229)	112 (99.9-122)	226 (217-239)	419 (372-456)	546
12–19 years	203 (197-209)	108 (103-117)	206 (197-214)	370 (349-394)	1399
20–39 years	196 (185-208)	91.0 (84.0-99.6)	199 (187-213)	397 (363-456)	771
40–59 years	232 (220-244)	88.9 (74.0-104)	235 (220-251)	544 (469-631)	535
60 years and older	209 (194-225)	67.0 (56.0-80.7)	231 (205-254)	496 (449-527)	508
Males					
Total, 3 years and older	206 (198-215)	93.0 (84.0-101)	211 (203-217)	448 (402-473)	1937
3–5 years	180 (167-194)	93.5† (82.2-112)	183 (173-195)	312† (283-340)	115
6–11 years	222 (210-234)	116 (105-124)	221 (212-242)	440 (364-483)	272
12–19 years	198 (190-207)	106 (98.0-116)	201 (192-212)	367 (332-398)	691
20–39 years	197 (183-211)	91.5 (72.0-102)	199 (183-214)	408 (371-469)	346
40–59 years	234 (214-256)	78.0 (58.0-103)	246 (219-267)	544 (456-659)	258
60 years and older	212 (189-237)	66.0 (47.0-85.0)	237 (211-274)	443 (371-527)	255
Females					
Total, 3 years and older	206 (198-215)	92.0 (86.0-101)	212 (201-224)	428 (399-460)	2046
3–5 years	180 (161-201)	88.3† (45.0-116)	196 (160-209)	355† (252-392)	109
6–11 years	217 (204-231)	105 (83.5-123)	228 (216-243)	401 (361-452)	274
12–19 years	209 (200-218)	113 (105-123)	210 (194-226)	372 (338-418)	708
20–39 years	195 (183-209)	90.0 (76.0-102)	200 (186-216)	349 (336-418)	425
40–59 years	229 (216-243)	89.3 (74.0-105)	230 (216-250)	494 (460-640)	277
60 years and older	206 (189-225)	70.0 (52.9-80.0)	226 (183-252)	515 (462-683)	253

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.3.c. Serum *gamma*-tocopherol: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	223 (215-232)	97.9 (86.0-106)	235 (223-245)	444 (427-458)	3578
3–5 years	188 (174-203)	90.0† (75.0-109)	196 (182-209)	336† (309-367)	220
6–11 years	218 (207-230)	116 (104-124)	221 (206-237)	393 (365-441)	569
12–19 years	208 (202-215)	109 (101-121)	212 (204-218)	356 (334-384)	1217
20–39 years	222 (209-236)	98.5 (86.0-115)	234 (213-253)	426 (394-452)	571
40–59 years	234 (223-247)	84.4 (65.0-111)	257 (241-271)	470 (440-508)	529
60 years and older	238 (223-254)	69.0 (54.0-90.0)	270 (256-282)	515 (492-575)	472
Males					
Total, 3 years and older	214 (205-224)	97.1 (80.4-109)	222 (212-233)	417 (402-442)	1756
3–5 years	189 (171-207)	83.5† (63.0-119)	194 (180-211)	331† (287-364)	116
6–11 years	213 (201-224)	107 (93.0-120)	213 (201-229)	386 (365-427)	288
12–19 years	202 (194-209)	104 (95.0-118)	206 (195-215)	351 (321-386)	620
20–39 years	215 (199-231)	98.5 (80.3-115)	226 (202-248)	404 (370-450)	237
40–59 years	224 (206-243)	84.0 (44.7-130)	249 (219-268)	418 (393-553)	267
60 years and older	223 (206-242)	69.0 (54.0-103)	248 (214-265)	511 (449-583)	228
Females					
Total, 3 years and older	231 (221-242)	97.9 (84.4-109)	244 (230-257)	460 (437-480)	1822
3–5 years	188 (167-210)	78.0† (74.0-111)	195 (167-220)	356† (314-380)	104
6–11 years	224 (209-240)	124 (114-138)	224 (210-247)	393 (351-455)	281
12–19 years	216 (207-225)	122 (104-132)	215 (206-226)	369 (338-428)	597
20–39 years	229 (212-247)	98.0 (79.0-124)	245 (212-270)	435 (390-469)	334
40–59 years	244 (226-264)	84.4 (70.6-109)	271 (244-293)	478 (440-559)	262
60 years and older	249 (229-270)	61.8 (45.2-91.0)	282 (265-304)	524 (492-583)	244

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.3.d. Serum *gamma*-tocopherol: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 3 years and older	194 (184-205)	60.0 (55.0-65.0)	211 (200-221)	473 (444-499)	5877
3–5 years	176 (155-199)	56.0† (42.8-83.0)	188 (162-215)	366† (329-441)	211
6–11 years	204 (192-218)	90.9 (82.2-102)	215 (199-231)	408 (359-484)	469
12–19 years	195 (185-204)	94.9 (88.0-103)	199 (188-210)	375 (357-393)	1036
20–39 years	207 (196-219)	77.4 (65.6-88.9)	221 (208-232)	453 (430-477)	1326
40–59 years	199 (185-215)	57.0 (51.0-64.8)	221 (203-235)	532 (481-573)	1217
60 years and older	170 (160-180)	46.7 (44.9-50.7)	186 (170-198)	498 (460-537)	1618
Males					
Total, 3 years and older	196 (186-208)	59.0 (51.0-67.0)	212 (202-224)	473 (446-502)	2885
3–5 years	164 (142-189)	47.1† (22.5-89.0)	186 (153-199)	355† (298-489)	112
6–11 years	195 (180-211)	82.2 (78.0-97.7)	212 (174-230)	365 (327-408)	246
12–19 years	191 (181-201)	94.3 (86.0-108)	189 (183-200)	378 (340-399)	519
20–39 years	211 (198-224)	71.0 (51.2-89.2)	230 (214-242)	473 (441-484)	554
40–59 years	209 (192-227)	59.0 (53.0-69.6)	226 (211-249)	548 (471-617)	635
60 years and older	165 (154-177)	42.8 (39.8-46.7)	186 (170-197)	463 (426-520)	819
Females					
Total, 3 years and older	192 (182-203)	61.9 (56.9-65.6)	209 (196-221)	478 (439-506)	2992
3–5 years	190 (164-220)	58.0† (52.0-96.0)	204 (164-241)	388† (313-482)	99
6–11 years	216 (199-234)	99.0† (87.0-112)	221 (197-248)	418† (361-555)	223
12–19 years	199 (186-212)	95.1 (82.0-108)	207 (188-224)	367 (345-402)	517
20–39 years	204 (190-218)	84.0 (65.0-97.0)	217 (199-227)	428 (406-478)	772
40–59 years	190 (174-207)	51.0 (43.8-60.2)	213 (187-230)	511 (452-572)	582
60 years and older	173 (161-186)	51.3 (47.0-55.9)	185 (167-203)	525 (479-546)	799

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.4.a. Serum *alpha*-carotene: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	2.48 (2.23-2.76)	.700 (<LOD-.800)	2.36 (2.10-2.70)	8.50 (7.40-9.30)	8359
3–5 years	2.41 (2.13-2.74)	.800 (<LOD-1.00)	2.20 (1.90-2.50)	8.50 (7.00-10.3)	430
6–11 years	2.24 (2.00-2.51)	.800 (.800-.900)	2.00 (1.80-2.30)	6.10 (5.20-7.70)	1014
12–19 years	1.68 (1.52-1.86)	< LOD	1.40 (1.30-1.60)	5.10 (4.40-6.20)	2206
20–39 years	2.22 (1.93-2.56)	< LOD	2.20 (1.90-2.50)	7.80 (6.70-8.80)	1716
40–59 years	2.98 (2.60-3.42)	.800 (.700-1.00)	2.80 (2.50-3.30)	10.7 (8.60-13.0)	1470
60 years and older	3.08 (2.74-3.46)	.800 (<LOD-1.00)	3.10 (2.70-3.60)	9.10 (8.60-9.80)	1523
Males					
Total, 3 years and older	2.22 (1.98-2.49)	< LOD	2.10 (1.90-2.30)	7.20 (6.30-8.60)	4052
3–5 years	2.29 (1.91-2.74)	.700 (<LOD-.800)	2.00 (1.70-2.40)	7.20 (5.00-11.1)	217
6–11 years	2.28 (1.96-2.65)	.800 (.800-1.00)	2.00 (1.80-2.40)	6.60 (5.00-8.50)	507
12–19 years	1.55 (1.38-1.75)	< LOD	1.40 (1.20-1.60)	4.40 (3.80-6.00)	1092
20–39 years	1.99 (1.72-2.31)	< LOD	1.80 (1.50-2.10)	6.90 (5.60-8.60)	724
40–59 years	2.53 (2.17-2.95)	.800 (<LOD-.900)	2.40 (2.00-2.90)	8.60 (6.30-11.3)	763
60 years and older	2.81 (2.48-3.18)	.800 (<LOD-.900)	2.90 (2.50-3.50)	8.40 (7.40-9.30)	749
Females					
Total, 3 years and older	2.75 (2.47-3.07)	.700 (<LOD-.900)	2.70 (2.30-3.00)	9.20 (8.20-10.5)	4307
3–5 years	2.55 (1.99-3.26)	.700 (<LOD-1.50)	2.30 (1.80-3.10)	9.70 (7.10-12.4)	213
6–11 years	2.20 (1.97-2.45)	.800 (.800-.900)	2.10 (1.80-2.30)	5.80 (4.90-6.50)	507
12–19 years	1.83 (1.63-2.04)	< LOD	1.70 (1.50-2.00)	5.40 (4.60-6.90)	1114
20–39 years	2.45 (2.10-2.86)	< LOD	2.30 (1.90-2.70)	8.10 (6.80-9.20)	992
40–59 years	3.55 (3.10-4.06)	1.10 (.900-1.30)	3.40 (2.90-3.70)	12.4 (10.5-15.8)	707
60 years and older	3.30 (2.87-3.79)	1.00 (.800-1.20)	3.20 (2.80-3.90)	9.70 (8.70-10.4)	774

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.

Table 2.4.b. Serum *alpha*-carotene: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	2.72 (2.39-3.10)	1.00 (.900-1.10)	2.50 (2.30-2.80)	7.40 (6.30-8.90)	2116
3–5 years	2.56 (2.12-3.08)	1.00 (.800-1.50)	2.20 (2.10-2.50)	6.40 (4.50-9.00)	126
6–11 years	2.43 (2.12-2.79)	.900 (.800-1.10)	2.20 (2.00-2.70)	5.40 (4.70-6.70)	290
12–19 years	1.90 (1.71-2.11)	.700 (<LOD-.800)	1.70 (1.50-2.10)	5.30 (3.90-6.40)	696
20–39 years	2.92 (2.48-3.43)	1.00 (.800-1.30)	2.80 (2.50-3.40)	8.00 (6.60-9.10)	460
40–59 years	3.39 (2.71-4.24)	1.10 (.900-1.40)	3.30 (2.60-4.10)	8.70 (7.20-14.3)	289
60 years and older	3.04 (2.35-3.94)	.900 (<LOD-1.30)	2.90 (2.30-4.00)	8.90 (6.20-13.7)	255
Males					
Total, 3 years and older	2.46 (2.13-2.83)	.800 (.700-1.00)	2.44 (2.20-2.70)	6.60 (5.30-8.00)	1019
3–5 years	2.37 (1.70-3.32)	.800† (<LOD-1.50)	2.20 (1.70-2.80)	5.90† (2.90-12.1)	62
6–11 years	2.39 (1.89-3.03)	.800 (.700-1.00)	2.20 (1.70-2.90)	5.50 (3.90-8.40)	140
12–19 years	1.69 (1.48-1.92)	.700 (<LOD-.800)	1.50 (1.30-1.90)	4.20 (3.30-6.20)	330
20–39 years	2.51 (2.06-3.06)	.800 (<LOD-1.10)	2.60 (2.10-3.10)	6.70 (5.20-7.90)	213
40–59 years	3.33 (2.61-4.23)	1.20 (.800-1.70)	3.20 (2.50-4.10)	8.10 (5.90-13.2)	149
60 years and older	2.49 (1.83-3.38)	.700 (<LOD-1.10)	2.60 (1.90-3.00)	7.00 (5.50-9.10)	125
Females					
Total, 3 years and older	3.04 (2.66-3.48)	1.00 (.900-1.20)	2.80 (2.50-3.30)	8.50 (7.10-10.8)	1097
3–5 years	2.75 (2.28-3.32)	1.20† (<LOD-1.60)	2.40 (2.00-3.10)	6.00† (4.20-9.00)	64
6–11 years	2.48 (2.16-2.85)	1.20 (.900-1.50)	2.30 (1.90-3.00)	5.00 (4.00-6.00)	150
12–19 years	2.16 (1.92-2.43)	.800 (.700-.900)	2.00 (1.60-2.50)	5.80 (4.40-7.30)	366
20–39 years	3.45 (2.87-4.15)	1.20 (.900-1.40)	3.20 (2.60-4.30)	9.10 (8.00-12.7)	247
40–59 years	3.46 (2.66-4.49)	.900 (.700-1.40)	3.30 (2.40-4.80)	10.8 (8.00-14.8)	140
60 years and older	3.58 (2.63-4.86)	1.30 (.900-1.80)	3.60 (2.40-4.80)	11.5 (6.00-15.2)	130

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 2.4.c. Serum *alpha*-carotene: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	1.77 (1.51-2.08)	< LOD	1.60 (1.30-1.90)	6.10 (4.80-8.20)	1992
3–5 years	1.75 (1.40-2.17)	< LOD	1.40 (1.10-1.80)	5.00 (3.20-13.9)	128
6–11 years	1.92 (1.69-2.19)	.900 (.800-1.00)	1.70 (1.40-1.90)	4.30 (3.50-5.60)	340
12–19 years	1.38 (1.20-1.59)	< LOD	1.20 (1.10-1.50)	3.90 (2.80-5.30)	671
20–39 years	1.71 (1.27-2.29)	< LOD	1.50 (1.10-2.10)	5.80 (3.90-11.4)	319
40–59 years	1.88 (1.65-2.13)	< LOD	1.80 (1.50-2.00)	7.20 (6.10-9.70)	291
60 years and older	2.22 (1.70-2.90)	< LOD	2.00 (1.40-2.70)	9.30 (4.90-15.1)	243
Males					
Total, 3 years and older	1.65 (1.38-1.96)	< LOD	1.40 (1.20-1.80)	5.80 (4.20-7.40)	984
3–5 years	1.54 (1.18-2.02)	< LOD†	1.30 (1.00-1.90)	3.90† (2.20-13.9)	64
6–11 years	2.08 (1.82-2.36)	.900 (.800-1.20)	1.90 (1.70-2.20)	4.60 (3.50-6.60)	175
12–19 years	1.32 (1.11-1.57)	< LOD	1.10 (1.00-1.34)	3.30 (2.70-5.50)	340
20–39 years	1.55 (1.07-2.24)	< LOD	1.40 (.900-2.30)	6.10 (3.40-9.60)	132
40–59 years	1.71 (1.44-2.03)	< LOD	1.80 (1.20-2.10)	6.60 (4.50-8.40)	154
60 years and older	1.94 (1.56-2.43)	< LOD	1.50 (1.30-2.40)	6.70 (4.20-12.5)	119
Females					
Total, 3 years and older	1.88 (1.58-2.23)	< LOD	1.70 (1.40-1.90)	6.50 (4.90-9.40)	1008
3–5 years	1.98 (1.52-2.60)	< LOD†	1.70 (1.30-2.20)	6.00† (3.20-33.8)	64
6–11 years	1.76 (1.40-2.22)	.700 (<LOD-.900)	1.60 (1.30-1.90)	3.70 (2.60-8.30)	165
12–19 years	1.45 (1.27-1.65)	< LOD	1.30 (1.10-1.60)	4.00 (2.90-5.50)	331
20–39 years	1.83 (1.33-2.50)	< LOD	1.80 (1.10-2.20)	5.30 (3.90-11.5)	187
40–59 years	2.04 (1.69-2.46)	< LOD	1.70 (1.50-2.10)	7.90 (5.90-13.8)	137
60 years and older	2.44 (1.71-3.47)	< LOD	2.10 (1.40-3.20)	9.40 (5.90-17.6)	124

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 2.4.d. Serum *alpha*-carotene: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	2.57 (2.25-2.94)	.800 (<LOD-.900)	2.40 (2.10-2.90)	8.80 (7.70-10.2)	3583
3–5 years	2.46 (1.95-3.11)	.800 (<LOD-1.40)	2.10 (1.70-3.00)	8.50 (5.60-11.1)	133
6–11 years	2.29 (1.98-2.65)	.700 (<LOD-.900)	2.20 (1.80-2.50)	6.50 (4.90-10.2)	301
12–19 years	1.69 (1.48-1.93)	< LOD	1.40 (1.20-1.70)	5.30 (4.40-6.50)	656
20–39 years	2.17 (1.86-2.55)	< LOD	2.00 (1.60-2.30)	8.10 (6.30-9.20)	772
40–59 years	3.12 (2.66-3.67)	.900 (.800-1.20)	2.90 (2.50-3.40)	11.3 (8.60-14.2)	777
60 years and older	3.16 (2.78-3.58)	.900 (<LOD-1.00)	3.30 (2.80-3.80)	9.20 (8.50-9.90)	944
Males					
Total, 3 years and older	2.28 (1.99-2.62)	< LOD	2.10 (1.90-2.60)	7.80 (6.30-9.20)	1739
3–5 years	2.44 (1.99-2.98)	1.00† (<LOD-1.30)	2.20 (1.70-2.50)	8.50† (4.40-11.3)	72
6–11 years	2.35 (1.87-2.96)	.900 (<LOD-1.10)	2.00 (1.60-2.70)	8.10 (4.40-13.4)	157
12–19 years	1.53 (1.31-1.79)	< LOD	1.30 (1.10-1.70)	4.40 (3.80-6.20)	323
20–39 years	1.95 (1.66-2.28)	< LOD	1.90 (1.50-2.10)	7.30 (5.20-8.90)	312
40–59 years	2.59 (2.16-3.11)	.800 (<LOD-.900)	2.50 (2.00-3.00)	8.80 (5.70-12.0)	407
60 years and older	2.86 (2.47-3.32)	.800 (<LOD-.900)	3.00 (2.30-3.70)	8.40 (7.40-9.80)	468
Females					
Total, 3 years and older	2.89 (2.49-3.35)	.700 (<LOD-.900)	2.90 (2.40-3.20)	9.70 (8.30-11.5)	1844
3–5 years	2.49 (1.49-4.17)	< LOD†	2.20 (1.50-4.70)	8.50† (5.40-14.7)	61
6–11 years	2.22 (1.97-2.50)	.700 (<LOD-.900)	2.20 (1.80-2.60)	6.00 (4.40-8.40)	144
12–19 years	1.86 (1.58-2.19)	< LOD	1.70 (1.50-2.20)	5.90 (4.80-7.50)	333
20–39 years	2.40 (2.00-2.89)	< LOD	2.30 (1.80-2.80)	8.30 (7.20-10.5)	460
40–59 years	3.83 (3.26-4.51)	1.20 (.900-1.40)	3.60 (3.10-4.50)	12.7 (10.4-17.0)	370
60 years and older	3.40 (2.92-3.96)	1.10 (.800-1.30)	3.37 (2.90-4.10)	9.50 (8.60-10.5)	476

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 2.5.a. Serum *trans-beta*-carotene: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	12.2 (11.5-13.0)	4.30 (4.10-4.70)	11.9 (11.3-12.5)	34.3 (31.7-37.4)	8358
3–5 years	13.6 (12.6-14.6)	5.80 (4.90-7.10)	13.5 (12.1-15.3)	31.1 (27.5-35.9)	429
6–11 years	13.3 (12.7-13.9)	6.50 (6.10-6.90)	13.2 (12.6-13.9)	27.0 (23.3-29.8)	1012
12–19 years	9.69 (9.20-10.2)	4.20 (3.90-4.70)	9.60 (9.00-10.4)	21.6 (20.1-23.7)	2206
20–39 years	10.3 (9.38-11.2)	3.70 (3.30-4.20)	9.90 (9.10-10.9)	29.0 (25.7-32.8)	1716
40–59 years	13.3 (12.1-14.7)	4.20 (3.70-4.90)	12.9 (12.0-14.2)	42.8 (35.3-49.8)	1471
60 years and older	16.5 (14.9-18.3)	5.50 (4.40-6.10)	17.6 (15.3-19.6)	46.0 (41.5-50.9)	1524
Males					
Total, 3 years and older	10.9 (10.2-11.7)	3.90 (3.60-4.30)	11.0 (10.3-11.7)	30.2 (26.8-33.0)	4053
3–5 years	13.3 (11.7-15.2)	5.60 (5.00-6.80)	14.2 (11.9-16.1)	30.1 (23.8-44.8)	216
6–11 years	13.5 (12.4-14.7)	6.50 (6.10-7.10)	13.4 (11.9-14.7)	26.4 (23.0-31.3)	507
12–19 years	9.27 (8.57-10.0)	4.10 (3.80-4.40)	9.10 (8.30-10.2)	20.1 (18.8-22.0)	1092
20–39 years	9.07 (8.24-10.0)	3.40 (2.90-4.10)	8.80 (7.90-9.80)	24.6 (21.3-29.6)	724
40–59 years	11.3 (10.2-12.7)	3.70 (3.30-4.10)	11.6 (10.2-12.6)	33.0 (27.0-43.9)	764
60 years and older	14.5 (13.0-16.2)	4.30 (3.60-5.20)	15.5 (13.6-17.3)	42.2 (35.0-47.0)	750
Females					
Total, 3 years and older	13.6 (12.7-14.6)	5.10 (4.70-5.50)	13.0 (12.2-14.2)	38.2 (35.3-41.4)	4305
3–5 years	13.8 (12.1-15.7)	5.80 (4.30-7.90)	12.6 (10.9-15.7)	32.6 (24.6-55.1)	213
6–11 years	13.0 (12.3-13.7)	6.30 (5.70-7.10)	12.6 (12.0-13.5)	28.0 (22.3-31.3)	505
12–19 years	10.1 (9.53-10.8)	4.50 (3.90-5.30)	10.3 (9.60-11.0)	23.3 (20.3-26.4)	1114
20–39 years	11.4 (10.3-12.6)	4.20 (3.50-4.80)	10.8 (9.50-12.3)	32.1 (28.9-37.0)	992
40–59 years	15.8 (14.1-17.8)	5.50 (4.70-5.90)	15.1 (13.4-17.1)	49.9 (39.1-63.2)	707
60 years and older	18.1 (16.0-20.6)	6.00 (5.00-7.60)	19.0 (16.9-21.8)	48.1 (42.6-55.8)	774

Table 2.5.b. Serum *trans-beta*-carotene: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	12.5 (11.7-13.4)	4.70 (4.20-5.50)	12.8 (11.7-13.9)	31.0 (28.4-33.6)	2116
3–5 years	13.9 (11.7-16.5)	7.10 (4.80-9.70)	13.0 (10.9-16.1)	24.3 (22.0-29.0)	126
6–11 years	13.4 (12.4-14.4)	6.60 (5.70-7.60)	13.6 (12.1-14.9)	28.2 (24.2-30.8)	289
12–19 years	10.0 (9.53-10.5)	4.50 (4.10-4.80)	10.2 (9.60-10.6)	21.8 (19.3-25.4)	696
20–39 years	12.4 (11.2-13.7)	4.30 (3.70-5.70)	13.0 (10.8-14.5)	30.6 (27.0-34.1)	460
40–59 years	13.8 (11.7-16.4)	4.30 (3.70-5.70)	13.9 (11.1-17.4)	37.7 (33.1-45.6)	289
60 years and older	14.6 (12.7-16.7)	4.10 (3.20-5.00)	15.8 (13.2-17.6)	39.1 (35.5-52.1)	256
Males					
Total, 3 years and older	11.3 (10.4-12.3)	4.20 (3.80-5.10)	11.4 (9.90-13.2)	28.0 (25.2-29.4)	1020
3–5 years	13.8 (10.4-18.4)	7.20† (4.80-10.6)	12.6 (9.70-17.3)	24.1† (17.4-41.5)	62
6–11 years	13.0 (11.4-14.9)	5.80 (4.70-7.70)	13.4 (10.0-16.4)	24.6 (22.0-31.4)	140
12–19 years	8.98 (8.36-9.65)	4.20 (3.80-4.70)	9.10 (7.90-10.0)	18.9 (17.0-20.9)	330
20–39 years	10.6 (9.13-12.3)	3.90 (3.00-5.20)	11.1 (9.00-13.5)	25.8 (22.4-29.4)	213
40–59 years	13.3 (11.4-15.6)	4.30 (3.60-6.50)	13.0 (10.2-17.1)	33.9 (28.6-45.6)	149
60 years and older	11.8 (9.61-14.5)	3.60 (1.90-5.50)	12.6 (9.20-16.5)	37.3 (27.6-58.4)	126
Females					
Total, 3 years and older	14.1 (13.0-15.2)	5.60 (5.00-6.10)	14.2 (13.3-15.0)	33.9 (29.2-40.8)	1096
3–5 years	14.0 (12.0-16.4)	6.70† (4.60-9.70)	13.0 (10.2-20.1)	25.1† (21.9-32.6)	64
6–11 years	13.7 (12.5-15.1)	7.00 (5.70-8.40)	13.7 (12.0-14.7)	26.5 (22.1-33.5)	149
12–19 years	11.3 (10.3-12.3)	4.70 (4.10-5.90)	11.4 (10.1-12.7)	25.4 (21.6-29.7)	366
20–39 years	14.8 (12.7-17.1)	5.70 (3.70-7.60)	14.8 (13.0-17.4)	36.7 (27.4-48.1)	247
40–59 years	14.4 (11.3-18.4)	4.30 (3.10-5.70)	14.4 (10.9-20.4)	39.3 (29.3-64.9)	140
60 years and older	17.3 (14.0-21.3)	4.20 (3.30-8.30)	18.4 (13.9-21.6)	40.1 (36.1-52.1)	130

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.5.c. Serum *trans-beta*-carotene: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	10.8 (9.96-11.8)	4.00 (3.40-4.50)	10.8 (10.0-11.5)	28.7 (25.8-33.0)	1992
3–5 years	11.5 (10.3-12.9)	5.10 (4.00-6.00)	11.3 (10.0-13.4)	24.6 (18.9-31.4)	128
6–11 years	12.9 (12.1-13.6)	6.50 (5.90-7.40)	12.4 (11.5-12.9)	27.7 (22.7-31.8)	340
12–19 years	9.64 (8.86-10.5)	4.40 (4.00-5.00)	9.70 (8.70-10.7)	20.5 (18.4-23.4)	671
20–39 years	9.62 (7.80-11.9)	3.50 (2.90-4.50)	9.50 (7.50-12.3)	25.6 (17.6-37.0)	319
40–59 years	10.3 (9.20-11.6)	3.00 (2.50-4.20)	10.4 (9.10-11.4)	30.5 (24.5-39.4)	291
60 years and older	16.6 (13.8-19.9)	5.00 (4.10-6.80)	17.0 (14.4-20.9)	46.6 (36.0-65.7)	243
Males					
Total, 3 years and older	10.1 (9.24-11.0)	4.10 (3.20-4.50)	10.3 (9.60-11.2)	25.6 (22.4-28.7)	984
3–5 years	11.3 (9.60-13.2)	5.10† (4.60-7.00)	12.0 (8.30-14.3)	22.7† (16.0-30.1)	64
6–11 years	14.4 (13.0-16.0)	7.40 (6.30-8.40)	13.5 (12.7-15.5)	28.7 (22.7-35.1)	175
12–19 years	9.20 (8.22-10.3)	4.20 (3.30-5.20)	9.40 (8.30-10.8)	20.1 (17.6-22.5)	340
20–39 years	8.88 (6.97-11.3)	3.40 (2.90-4.40)	9.10 (6.60-11.7)	23.6 (14.8-34.0)	132
40–59 years	9.09 (7.95-10.4)	2.90 (1.90-4.10)	9.60 (8.00-10.9)	25.8 (18.6-37.1)	154
60 years and older	13.0 (10.6-15.9)	3.80 (3.20-5.00)	14.1 (10.8-17.0)	42.1 (26.8-51.3)	119
Females					
Total, 3 years and older	11.5 (10.4-12.7)	4.00 (3.50-4.80)	11.2 (10.3-12.7)	32.5 (27.1-38.2)	1008
3–5 years	11.8 (9.69-14.3)	4.60† (3.60-6.50)	11.4 (9.20-14.4)	31.1† (16.5-57.7)	64
6–11 years	11.3 (9.51-13.5)	5.80 (5.10-6.60)	10.5 (9.30-12.5)	21.7 (17.0-35.5)	165
12–19 years	10.1 (9.10-11.2)	4.70 (4.30-5.40)	10.0 (8.50-11.3)	20.9 (18.3-26.2)	331
20–39 years	10.2 (7.98-12.9)	3.50 (2.80-4.90)	10.0 (7.50-13.6)	27.3 (17.6-42.6)	187
40–59 years	11.6 (9.90-13.7)	3.00 (2.10-5.60)	12.2 (9.50-15.3)	37.1 (26.1-45.6)	137
60 years and older	19.6 (15.1-25.3)	6.80 (3.00-11.9)	19.7 (15.2-25.2)	51.7 (36.9-93.4)	124

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.5.d. Serum *trans-beta*-carotene: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	12.6 (11.6-13.7)	4.50 (4.10-5.00)	12.1 (11.4-13.1)	36.4 (32.8-40.6)	3582
3–5 years	14.0 (12.2-16.0)	6.10 (4.20-7.90)	14.7 (11.7-16.7)	30.9 (26.1-36.4)	132
6–11 years	13.6 (12.5-14.8)	6.80 (5.70-8.20)	13.4 (12.0-14.9)	27.9 (22.7-31.1)	300
12–19 years	9.69 (8.94-10.5)	4.20 (3.60-4.90)	9.30 (8.60-10.5)	22.0 (19.6-24.9)	656
20–39 years	10.1 (8.99-11.3)	3.90 (3.20-4.60)	9.50 (8.60-10.7)	29.0 (23.7-36.2)	772
40–59 years	13.9 (12.5-15.5)	4.70 (4.00-5.30)	13.5 (12.2-14.7)	44.4 (35.2-55.1)	778
60 years and older	16.5 (14.7-18.5)	5.50 (4.30-6.40)	17.6 (15.1-19.9)	45.8 (40.8-51.5)	944
Males					
Total, 3 years and older	11.2 (10.3-12.3)	3.90 (3.50-4.30)	11.3 (10.2-12.1)	32.1 (27.9-36.2)	1739
3–5 years	14.1 (12.2-16.2)	5.60† (3.80-6.80)	15.0 (11.9-16.6)	31.4† (23.8-46.0)	71
6–11 years	13.8 (12.2-15.7)	6.70 (5.60-8.40)	13.8 (11.9-15.9)	25.8 (22.1-33.0)	157
12–19 years	9.28 (8.36-10.3)	4.00 (3.50-4.60)	9.00 (8.00-10.3)	20.3 (18.4-24.0)	323
20–39 years	9.02 (8.00-10.2)	3.80 (3.10-4.60)	8.60 (7.70-9.50)	26.4 (19.3-33.6)	312
40–59 years	11.7 (10.5-13.2)	3.80 (3.40-4.30)	11.9 (10.2-12.9)	35.0 (28.4-44.4)	408
60 years and older	14.7 (13.0-16.7)	4.50 (3.40-5.70)	15.6 (13.7-17.9)	43.0 (35.2-50.9)	468
Females					
Total, 3 years and older	14.0 (12.7-15.5)	5.10 (4.70-5.70)	13.5 (12.1-15.1)	40.1 (36.0-45.1)	1843
3–5 years	13.8 (10.4-18.4)	7.60† (3.20-9.50)	12.8 (9.60-17.3)	30.6† (17.1-73.7)	61
6–11 years	13.3 (12.1-14.7)	6.70 (5.30-8.00)	12.8 (11.8-15.1)	28.6 (21.5-31.3)	143
12–19 years	10.1 (9.16-11.2)	4.50 (3.50-5.70)	10.0 (8.60-11.5)	24.2 (19.4-30.0)	333
20–39 years	11.1 (9.78-12.6)	4.30 (3.40-5.00)	10.4 (9.10-12.1)	32.8 (27.4-39.8)	460
40–59 years	16.8 (14.5-19.4)	5.70 (5.30-6.60)	15.7 (13.8-18.4)	54.7 (40.2-76.2)	370
60 years and older	18.0 (15.7-20.7)	5.70 (4.80-7.60)	19.0 (16.8-23.0)	48.1 (41.1-56.3)	476

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.6.a. Serum *beta*-cryptoxanthin: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	7.51 (7.12-7.93)	3.20 (3.00-3.50)	7.50 (7.00-7.90)	17.8 (16.5-19.2)	8317
3–5 years	9.43 (8.40-10.6)	4.10 (3.30-5.50)	9.00 (7.80-10.5)	22.8 (18.3-27.8)	427
6–11 years	9.40 (8.71-10.2)	4.60 (4.10-5.10)	9.10 (8.20-10.1)	20.0 (17.0-22.9)	1006
12–19 years	7.63 (7.20-8.09)	3.70 (3.40-4.00)	7.50 (7.00-8.00)	15.8 (14.4-17.6)	2199
20–39 years	7.11 (6.57-7.69)	3.10 (2.80-3.50)	6.80 (6.30-7.50)	17.1 (15.2-19.3)	1707
40–59 years	7.28 (6.75-7.86)	3.00 (2.70-3.40)	7.10 (6.70-7.80)	17.4 (15.3-19.7)	1459
60 years and older	7.44 (6.84-8.09)	2.80 (2.50-3.20)	7.70 (7.00-8.30)	18.6 (17.5-19.6)	1519
Males					
Total, 3 years and older	7.35 (6.96-7.77)	3.14 (2.80-3.40)	7.50 (6.90-7.90)	17.1 (16.0-18.5)	4032
3–5 years	9.80 (8.43-11.4)	4.20 (3.20-5.60)	9.60 (7.90-11.8)	22.8 (15.6-31.9)	217
6–11 years	9.63 (8.84-10.5)	5.00 (4.10-5.50)	9.30 (8.40-10.2)	21.2 (16.5-25.9)	503
12–19 years	7.64 (7.14-8.19)	3.70 (3.30-4.20)	7.50 (7.00-8.10)	15.5 (14.2-17.7)	1085
20–39 years	7.15 (6.49-7.88)	3.20 (2.80-3.50)	7.10 (6.10-8.00)	16.8 (15.2-19.8)	723
40–59 years	6.98 (6.57-7.42)	2.90 (2.50-3.30)	7.00 (6.50-7.60)	16.1 (14.6-18.5)	756
60 years and older	6.64 (6.02-7.31)	2.40 (1.90-2.90)	7.00 (6.00-7.60)	16.7 (15.8-17.7)	748
Females					
Total, 3 years and older	7.67 (7.23-8.12)	3.40 (3.10-3.50)	7.50 (7.00-7.90)	18.2 (16.7-19.7)	4285
3–5 years	9.07 (7.79-10.6)	3.90 (3.00-5.30)	8.20 (6.40-10.4)	23.3 (17.3-32.1)	210
6–11 years	9.15 (8.21-10.2)	4.30 (4.00-4.80)	8.70 (7.80-10.7)	18.4 (16.1-21.6)	503
12–19 years	7.61 (7.10-8.16)	3.70 (3.40-4.00)	7.50 (7.00-8.00)	16.0 (14.3-17.5)	1114
20–39 years	7.07 (6.50-7.70)	3.10 (2.60-3.50)	6.70 (6.10-7.50)	17.5 (14.6-19.6)	984
40–59 years	7.61 (6.88-8.43)	3.10 (2.80-3.50)	7.30 (6.70-8.10)	18.5 (15.4-21.9)	703
60 years and older	8.10 (7.41-8.86)	3.10 (2.70-3.50)	8.20 (7.40-8.80)	20.1 (18.1-22.7)	771

Table 2.6.b. Serum *beta*-cryptoxanthin: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	12.1 (11.1-13.1)	5.10 (4.80-5.70)	12.1 (10.8-13.5)	27.1 (25.0-29.8)	2114
3–5 years	11.0 (9.50-12.8)	5.20 (4.20-6.70)	10.3 (9.10-12.3)	23.6 (18.8-42.0)	126
6–11 years	11.9 (10.6-13.3)	6.20 (5.30-7.10)	11.1 (10.0-13.4)	24.1 (19.9-28.7)	290
12–19 years	9.72 (9.07-10.4)	4.80 (4.20-5.40)	9.70 (9.00-10.5)	19.8 (17.2-21.4)	696
20–39 years	13.4 (11.9-15.1)	5.60 (4.90-6.80)	14.0 (11.6-15.9)	30.0 (26.9-33.7)	460
40–59 years	12.2 (10.4-14.3)	4.70 (3.80-5.80)	12.7 (10.4-15.2)	27.3 (23.2-36.9)	287
60 years and older	11.0 (9.19-13.2)	3.70 (3.20-4.50)	11.1 (9.20-13.4)	28.5 (21.2-37.1)	255
Males					
Total, 3 years and older	11.8 (10.7-13.1)	5.20 (4.70-5.70)	11.7 (10.4-13.4)	26.6 (23.8-29.9)	1018
3–5 years	11.1 (8.25-14.8)	5.50† (3.60-6.90)	10.3 (6.80-15.9)	22.8† (14.1-43.1)	62
6–11 years	11.6 (10.2-13.0)	5.60 (4.90-7.20)	10.9 (9.70-12.6)	24.1 (19.9-28.7)	140
12–19 years	9.32 (8.39-10.4)	4.70 (3.50-5.50)	9.34 (8.10-10.8)	18.5 (15.2-22.2)	330
20–39 years	12.9 (11.3-14.8)	5.30 (4.80-7.00)	13.4 (10.6-15.4)	29.8 (24.1-35.1)	213
40–59 years	12.9 (10.7-15.6)	5.10 (3.20-7.50)	13.1 (9.70-18.4)	28.7 (24.1-38.3)	147
60 years and older	9.87 (8.17-11.9)	3.50 (2.40-4.40)	10.8 (8.40-13.2)	23.9 (16.7-37.1)	126
Females					
Total, 3 years and older	12.3 (11.4-13.3)	5.30 (4.90-6.00)	12.2 (10.9-13.9)	27.7 (25.3-32.1)	1096
3–5 years	11.0 (9.59-12.6)	4.70† (3.20-7.50)	9.90 (7.70-12.7)	25.7† (17.7-44.1)	64
6–11 years	12.2 (10.7-14.0)	6.80 (5.30-7.30)	11.4 (9.50-14.3)	25.4 (19.1-28.8)	150
12–19 years	10.2 (9.61-10.8)	5.10 (4.50-5.80)	10.0 (9.40-10.7)	20.8 (18.8-22.5)	366
20–39 years	13.9 (12.1-16.1)	6.00 (4.80-7.10)	14.6 (11.3-17.6)	32.2 (26.1-37.6)	247
40–59 years	11.5 (9.71-13.7)	4.50 (3.80-5.80)	11.9 (10.1-13.8)	26.5 (18.8-42.9)	140
60 years and older	12.0 (9.47-15.3)	4.30 (3.20-6.10)	11.7 (8.50-17.3)	29.7 (21.2-43.4)	129

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.6.c. Serum *beta*-cryptoxanthin: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	8.13 (7.50-8.81)	3.90 (3.40-4.20)	7.90 (7.40-8.50)	18.0 (15.7-20.7)	1987
3–5 years	10.9 (9.72-12.2)	5.80 (5.30-6.30)	10.2 (8.30-12.7)	20.9 (16.7-23.5)	128
6–11 years	12.0 (10.7-13.4)	6.50 (5.50-7.90)	11.8 (9.90-13.9)	23.0 (20.4-26.3)	338
12–19 years	8.94 (8.44-9.47)	4.70 (4.40-5.10)	8.80 (8.30-9.30)	16.6 (14.9-17.6)	670
20–39 years	7.60 (6.69-8.63)	4.00 (3.60-4.30)	7.00 (6.20-8.20)	15.4 (12.7-21.9)	318
40–59 years	6.79 (6.35-7.26)	3.10 (2.90-3.50)	6.60 (6.10-7.50)	15.5 (13.2-18.8)	290
60 years and older	7.89 (6.22-10.0)	3.00 (2.30-3.40)	7.80 (5.70-10.2)	20.5 (15.7-29.6)	243
Males					
Total, 3 years and older	8.26 (7.59-8.99)	4.00 (3.50-4.30)	8.10 (7.30-9.10)	17.8 (15.7-20.4)	982
3–5 years	10.7 (9.29-12.3)	5.90† (5.30-6.40)	10.2 (8.70-12.6)	20.1† (16.1-22.7)	64
6–11 years	12.7 (11.2-14.4)	6.70 (5.60-8.30)	12.8 (10.9-14.2)	23.1 (18.6-30.9)	174
12–19 years	8.91 (8.29-9.58)	5.00 (4.50-5.40)	8.90 (8.20-9.30)	16.3 (14.4-18.8)	339
20–39 years	8.00 (6.63-9.67)	4.00 (2.80-5.00)	7.80 (5.70-10.2)	15.9 (13.9-21.9)	132
40–59 years	6.69 (6.09-7.34)	3.30 (2.90-3.70)	6.50 (5.80-7.30)	14.8 (12.1-19.1)	154
60 years and older	7.02 (5.69-8.66)	3.10 (2.20-3.50)	6.80 (5.70-8.20)	15.7 (9.30-27.1)	119
Females					
Total, 3 years and older	8.02 (7.38-8.73)	3.70 (3.30-4.10)	7.80 (7.20-8.30)	18.0 (15.3-21.6)	1005
3–5 years	11.1 (9.30-13.2)	5.60† (5.00-6.40)	10.6 (7.70-14.9)	20.9† (15.4-53.1)	64
6–11 years	11.3 (9.47-13.4)	6.30 (4.40-7.70)	11.0 (8.50-13.8)	21.6 (14.7-28.4)	164
12–19 years	8.97 (8.48-9.49)	4.60 (4.00-5.00)	8.90 (8.60-9.80)	17.0 (15.2-17.7)	331
20–39 years	7.33 (6.38-8.42)	3.80 (3.40-4.30)	6.30 (6.10-7.30)	15.3 (10.8-24.6)	186
40–59 years	6.89 (6.31-7.52)	3.20 (2.50-3.70)	6.70 (5.90-7.80)	16.1 (12.9-19.1)	136
60 years and older	8.55 (6.37-11.5)	2.70 (2.30-4.10)	8.80 (5.10-13.9)	23.0 (16.5-34.7)	124

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.6.d. Serum *beta*-cryptoxanthin: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	6.84 (6.47-7.24)	3.00 (2.70-3.30)	6.80 (6.30-7.20)	15.6 (14.6-16.9)	3552
3–5 years	8.53 (7.14-10.2)	3.90 (2.80-5.50)	7.90 (6.40-10.4)	19.8 (14.4-31.9)	130
6–11 years	8.49 (7.67-9.38)	4.20 (3.80-4.90)	8.30 (7.40-9.10)	16.6 (14.6-21.8)	296
12–19 years	6.87 (6.41-7.36)	3.30 (2.80-3.80)	6.60 (6.10-7.00)	14.3 (12.5-16.6)	651
20–39 years	6.16 (5.63-6.73)	2.90 (2.60-3.40)	5.90 (5.40-6.50)	13.3 (11.1-16.4)	765
40–59 years	6.87 (6.39-7.38)	2.90 (2.70-3.30)	6.80 (6.20-7.40)	15.6 (13.9-18.0)	770
60 years and older	7.14 (6.56-7.76)	2.70 (2.30-3.20)	7.50 (6.70-8.10)	17.6 (16.4-19.1)	940
Males					
Total, 3 years and older	6.64 (6.31-6.99)	2.90 (2.60-3.30)	6.50 (6.20-7.00)	14.7 (13.8-16.1)	1724
3–5 years	9.29 (7.45-11.6)	3.80† (2.20-6.10)	8.90 (6.50-11.3)	23.9† (12.1-56.4)	72
6–11 years	8.68 (7.70-9.77)	4.10 (3.70-5.10)	8.30 (7.40-9.20)	18.4 (13.8-26.3)	155
12–19 years	6.80 (6.30-7.33)	3.20 (2.80-3.60)	6.60 (6.10-7.40)	14.0 (11.8-16.6)	318
20–39 years	6.23 (5.54-7.01)	3.10 (2.70-3.50)	6.00 (5.40-6.70)	13.3 (10.8-16.5)	311
40–59 years	6.50 (6.17-6.84)	2.80 (2.35-3.30)	6.50 (5.90-7.10)	14.3 (12.5-16.0)	402
60 years and older	6.34 (5.77-6.96)	2.10 (1.90-2.60)	6.80 (5.70-7.60)	16.2 (15.2-17.2)	466
Females					
Total, 3 years and older	7.04 (6.57-7.55)	3.10 (2.90-3.40)	6.80 (6.30-7.40)	16.4 (14.8-18.4)	1828
3–5 years	7.73 (5.91-10.1)	3.90† (2.00-5.70)	7.10 (5.30-11.3)	15.0† (11.7-33.0)	58
6–11 years	8.27 (6.92-9.87)	4.10 (3.50-4.90)	8.20 (6.40-10.9)	15.4 (13.5-18.7)	141
12–19 years	6.93 (6.33-7.59)	3.50 (3.00-4.00)	6.60 (6.00-7.10)	14.5 (12.7-16.9)	333
20–39 years	6.09 (5.54-6.70)	2.80 (2.40-3.40)	6.00 (5.40-6.60)	13.5 (10.8-17.8)	454
40–59 years	7.29 (6.52-8.16)	3.10 (2.90-3.70)	7.00 (6.10-7.90)	17.5 (13.5-22.2)	368
60 years and older	7.82 (7.06-8.66)	3.20 (2.70-3.60)	8.00 (7.30-8.60)	19.5 (16.9-21.6)	474

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.7.a. Serum lutein/zeaxanthin: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	13.0 (12.5-13.6)	7.00 (6.60-7.30)	12.8 (12.2-13.5)	25.0 (24.0-25.8)	8353
3–5 years	12.5 (11.8-13.2)	7.30 (7.00-7.90)	12.5 (12.0-13.4)	20.7 (18.5-22.7)	430
6–11 years	12.5 (11.9-13.2)	7.60 (7.00-8.20)	12.4 (11.6-13.2)	20.3 (19.1-21.8)	1014
12–19 years	10.4 (9.91-11.0)	6.10 (5.70-6.60)	10.4 (9.80-11.1)	17.8 (16.5-19.1)	2205
20–39 years	12.1 (11.5-12.9)	6.30 (6.00-6.80)	12.0 (11.2-12.8)	23.0 (21.7-24.4)	1714
40–59 years	14.4 (13.6-15.2)	7.70 (7.40-8.30)	14.2 (13.5-15.0)	27.3 (25.5-29.6)	1468
60 years and older	15.2 (14.3-16.2)	7.60 (7.00-8.30)	15.3 (14.3-16.5)	30.0 (27.3-32.5)	1522
Males					
Total, 3 years and older	13.0 (12.5-13.5)	7.00 (6.70-7.30)	13.0 (12.4-13.6)	24.9 (23.5-26.0)	4049
3–5 years	12.2 (11.0-13.5)	7.30 (6.40-8.00)	12.1 (10.8-13.8)	19.5 (18.2-21.8)	217
6–11 years	12.6 (11.7-13.4)	7.70 (6.40-8.60)	12.5 (11.5-13.5)	21.3 (19.4-24.6)	507
12–19 years	10.3 (9.71-10.9)	5.90 (5.30-6.30)	10.2 (9.60-10.9)	17.7 (16.5-18.9)	1091
20–39 years	12.4 (11.7-13.1)	6.70 (6.20-7.10)	12.4 (11.2-13.2)	22.8 (21.6-24.5)	724
40–59 years	14.5 (13.8-15.3)	7.90 (7.30-8.50)	14.5 (13.7-15.5)	27.6 (25.5-30.4)	761
60 years and older	14.5 (13.4-15.8)	7.30 (6.30-8.50)	14.7 (13.3-16.4)	28.5 (24.9-32.0)	749
Females					
Total, 3 years and older	13.1 (12.5-13.7)	6.80 (6.50-7.10)	12.7 (12.2-13.5)	25.0 (24.1-25.9)	4304
3–5 years	12.8 (11.6-14.1)	7.50 (6.40-8.10)	12.6 (11.8-13.8)	21.4 (17.6-26.5)	213
6–11 years	12.5 (11.9-13.2)	7.90 (7.00-8.90)	12.2 (11.5-13.3)	19.4 (18.0-20.7)	507
12–19 years	10.6 (9.95-11.3)	6.50 (5.60-7.00)	10.4 (9.90-11.3)	17.9 (16.5-20.2)	1114
20–39 years	11.9 (11.1-12.8)	6.20 (5.80-6.90)	11.6 (10.7-12.5)	23.0 (20.8-25.1)	990
40–59 years	14.2 (13.2-15.2)	7.60 (7.10-8.40)	13.9 (13.0-14.7)	26.8 (24.8-30.2)	707
60 years and older	15.8 (14.9-16.7)	8.00 (7.10-8.70)	15.7 (14.6-17.5)	32.0 (27.6-33.7)	773

Table 2.7.b. Serum lutein/zeaxanthin: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	13.7 (13.3-14.1)	7.70 (7.30-8.10)	13.5 (13.1-14.0)	24.1 (23.0-25.1)	2114
3–5 years	12.5 (11.3-13.9)	7.20 (5.80-9.70)	12.5 (11.8-13.8)	19.1 (16.9-22.5)	126
6–11 years	12.4 (11.5-13.2)	8.00 (6.40-9.20)	12.2 (11.6-12.8)	19.2 (17.2-21.2)	290
12–19 years	10.8 (10.4-11.1)	6.70 (6.00-6.80)	10.6 (10.2-11.0)	18.0 (16.7-18.9)	696
20–39 years	14.4 (13.5-15.4)	8.10 (7.10-8.60)	14.9 (13.8-15.9)	24.4 (23.0-25.7)	460
40–59 years	15.7 (14.3-17.1)	8.90 (8.20-9.50)	15.5 (13.9-16.7)	28.4 (23.9-32.9)	287
60 years and older	15.8 (15.0-16.7)	8.00 (6.00-9.70)	16.0 (14.4-17.4)	32.5 (27.3-34.3)	255
Males					
Total, 3 years and older	14.1 (13.6-14.6)	8.10 (7.40-8.40)	14.2 (13.7-14.6)	24.1 (22.6-26.1)	1018
3–5 years	12.8 (10.6-15.4)	6.70† (5.30-10.8)	13.1 (11.3-15.4)	19.1† (15.9-25.7)	62
6–11 years	12.2 (11.2-13.2)	8.20 (6.30-9.30)	12.3 (11.4-12.9)	19.1 (15.7-22.5)	140
12–19 years	10.7 (10.1-11.3)	6.60 (5.70-7.00)	10.4 (9.60-11.4)	18.2 (15.6-20.1)	330
20–39 years	15.0 (14.0-15.9)	8.60 (7.30-9.90)	15.8 (14.4-16.5)	23.9 (22.1-26.2)	213
40–59 years	17.4 (15.7-19.3)	9.50 (8.90-11.4)	17.3 (14.8-19.9)	31.6 (26.6-36.4)	147
60 years and older	15.3 (14.0-16.6)	7.70 (5.70-9.80)	14.9 (13.4-17.4)	29.5 (25.8-37.9)	126
Females					
Total, 3 years and older	13.2 (12.8-13.6)	7.40 (6.90-7.70)	13.0 (12.5-13.5)	23.9 (21.9-25.1)	1096
3–5 years	12.3 (10.8-14.0)	6.70† (5.00-10.0)	12.4 (9.90-14.9)	18.5† (16.0-22.5)	64
6–11 years	12.6 (11.7-13.6)	8.30 (6.40-9.30)	12.4 (11.6-13.5)	19.2 (16.6-24.2)	150
12–19 years	10.9 (10.4-11.4)	6.80 (6.10-7.40)	10.9 (10.2-11.3)	17.5 (16.2-19.7)	366
20–39 years	13.8 (12.7-15.0)	7.30 (6.60-8.20)	13.8 (12.2-15.8)	24.9 (23.8-26.5)	247
40–59 years	14.0 (12.5-15.6)	8.20 (6.80-9.10)	13.9 (12.3-15.9)	22.7 (18.7-30.8)	140
60 years and older	16.3 (15.2-17.6)	8.60 (6.00-11.3)	16.0 (13.8-19.0)	32.5 (26.4-34.3)	129

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.7.c. Serum lutein/zeaxanthin: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	14.3 (13.2-15.5)	8.10 (7.30-8.80)	14.2 (12.8-15.5)	26.1 (24.1-28.5)	1992
3–5 years	15.4 (14.0-17.1)	9.80 (8.50-11.2)	15.3 (13.0-18.2)	24.5 (19.6-32.5)	128
6–11 years	15.3 (14.4-16.3)	9.50 (8.50-10.3)	15.7 (14.7-16.6)	24.7 (22.4-25.3)	340
12–19 years	12.5 (11.6-13.5)	7.80 (7.20-8.50)	12.5 (11.4-13.7)	19.6 (17.9-22.2)	671
20–39 years	13.3 (11.9-14.8)	7.50 (6.70-8.10)	12.8 (11.4-14.4)	25.3 (21.8-28.6)	319
40–59 years	14.9 (13.6-16.4)	8.60 (7.00-9.40)	15.5 (13.2-17.2)	28.2 (24.7-31.2)	291
60 years and older	17.6 (15.1-20.5)	9.10 (7.30-11.2)	17.7 (14.7-21.5)	33.7 (29.7-36.5)	243
Males					
Total, 3 years and older	14.5 (13.4-15.7)	8.00 (7.40-9.00)	14.6 (13.4-15.8)	26.2 (24.1-28.5)	984
3–5 years	15.4 (13.4-17.7)	10.6† (8.50-12.7)	14.5 (13.0-18.4)	21.8† (18.5-34.3)	64
6–11 years	16.4 (15.2-17.7)	10.1 (8.90-11.4)	16.4 (15.6-17.2)	25.1 (23.9-27.0)	175
12–19 years	12.3 (11.5-13.0)	7.80 (7.50-8.30)	12.0 (11.4-13.3)	19.6 (18.2-20.8)	340
20–39 years	13.8 (12.0-15.8)	7.50 (6.80-8.40)	13.5 (11.0-15.6)	25.9 (21.9-29.8)	132
40–59 years	15.1 (13.5-17.0)	8.60 (7.10-9.70)	15.5 (13.5-17.5)	28.7 (24.2-31.2)	154
60 years and older	16.1 (14.2-18.1)	7.50 (5.80-10.4)	16.0 (14.7-18.4)	29.6 (22.7-38.9)	119
Females					
Total, 3 years and older	14.1 (12.9-15.5)	8.10 (7.10-8.80)	13.9 (12.2-15.4)	26.0 (23.3-29.5)	1008
3–5 years	15.5 (12.9-18.5)	9.40† (7.90-11.8)	15.6 (12.3-18.2)	25.7† (19.3-37.1)	64
6–11 years	14.2 (12.8-15.9)	8.90 (7.40-10.1)	14.8 (12.3-16.1)	21.8 (19.2-25.3)	165
12–19 years	12.8 (11.5-14.2)	8.10 (6.80-9.40)	12.8 (11.3-14.4)	20.4 (17.6-24.2)	331
20–39 years	12.9 (11.4-14.6)	7.10 (6.30-8.10)	12.7 (11.3-14.3)	23.3 (19.5-28.9)	187
40–59 years	14.7 (13.2-16.3)	8.70 (6.20-9.60)	14.2 (12.5-17.1)	27.4 (22.1-33.3)	137
60 years and older	18.8 (15.5-22.7)	9.40 (8.00-12.2)	19.3 (14.4-25.4)	35.0 (31.0-36.7)	124

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.7.d. Serum lutein/zeaxanthin: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	12.6 (11.9-13.2)	6.80 (6.40-7.10)	12.4 (11.6-13.1)	24.1 (22.5-25.7)	3580
3–5 years	11.5 (10.8-12.3)	7.20 (6.40-7.60)	11.8 (10.4-12.8)	17.7 (16.9-21.4)	133
6–11 years	11.7 (10.9-12.6)	7.20 (6.70-7.90)	11.4 (10.8-12.4)	18.7 (17.0-21.8)	301
12–19 years	9.87 (9.21-10.6)	5.90 (5.20-6.40)	9.80 (9.10-10.5)	16.8 (15.2-19.3)	656
20–39 years	11.3 (10.6-12.1)	6.00 (5.70-6.50)	11.3 (10.3-12.4)	21.2 (19.3-22.9)	770
40–59 years	13.8 (13.0-14.8)	7.50 (7.10-7.80)	13.7 (13.1-14.4)	26.3 (24.1-28.5)	777
60 years and older	14.7 (13.8-15.7)	7.40 (6.80-8.10)	14.9 (13.5-16.4)	28.0 (25.6-31.7)	943
Males					
Total, 3 years and older	12.5 (11.9-13.1)	6.80 (6.30-7.10)	12.5 (11.7-13.2)	23.9 (22.0-26.0)	1738
3–5 years	11.2 (9.93-12.6)	7.10† (6.20-7.70)	10.7 (9.00-13.5)	17.1† (15.2-21.7)	72
6–11 years	11.7 (10.6-13.0)	7.10 (5.70-8.30)	11.3 (10.2-13.0)	19.6 (17.2-25.5)	157
12–19 years	9.65 (9.05-10.3)	5.50 (4.90-6.20)	9.60 (9.10-10.2)	16.7 (15.5-18.7)	323
20–39 years	11.6 (10.7-12.6)	6.20 (5.70-6.90)	11.7 (10.6-13.0)	20.7 (17.7-23.7)	312
40–59 years	13.9 (13.2-14.8)	7.70 (7.10-8.50)	13.9 (13.3-14.9)	26.8 (24.9-28.3)	407
60 years and older	13.9 (12.8-15.2)	7.30 (6.20-8.10)	14.1 (12.6-16.0)	26.1 (24.2-28.9)	467
Females					
Total, 3 years and older	12.6 (11.9-13.4)	6.60 (6.20-7.00)	12.2 (11.6-13.0)	24.4 (22.8-25.8)	1842
3–5 years	11.9 (10.6-13.5)	7.30† (4.30-8.30)	12.6 (10.8-13.8)	18.4† (15.2-23.2)	61
6–11 years	11.7 (11.0-12.5)	7.50 (6.60-8.10)	11.5 (10.9-12.3)	17.9 (15.5-20.2)	144
12–19 years	10.1 (9.25-11.0)	6.10 (5.00-6.70)	10.1 (9.10-10.7)	16.8 (14.8-20.8)	333
20–39 years	11.1 (10.2-12.0)	5.90 (5.60-6.60)	10.6 (9.50-12.0)	21.4 (18.4-23.3)	458
40–59 years	13.7 (12.6-15.0)	7.40 (6.50-8.00)	13.5 (12.3-14.3)	26.4 (23.4-31.6)	370
60 years and older	15.4 (14.4-16.4)	7.70 (6.70-8.70)	15.5 (14.0-17.4)	30.4 (25.8-34.3)	476

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.8.a. Serum *trans*-lycopene: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	20.5 (19.8-21.1)	10.5 (10.0-11.0)	22.0 (21.2-22.8)	37.5 (36.1-38.6)	8348
3–5 years	16.1 (15.2-17.1)	7.90 (7.30-8.90)	17.4 (16.2-18.1)	30.7 (28.5-32.8)	427
6–11 years	21.6 (20.7-22.5)	11.4 (10.4-12.7)	22.7 (21.4-23.7)	36.0 (35.0-37.2)	1012
12–19 years	21.6 (21.1-22.1)	12.8 (11.9-13.6)	22.3 (21.8-22.8)	36.1 (35.1-37.5)	2205
20–39 years	22.7 (21.5-23.9)	12.5 (11.7-13.8)	23.7 (22.5-24.8)	39.1 (37.6-41.0)	1714
40–59 years	21.1 (20.1-22.1)	10.7 (9.80-11.7)	22.6 (21.3-24.1)	38.1 (36.6-39.8)	1468
60 years and older	15.4 (14.6-16.3)	6.70 (5.70-7.30)	17.1 (15.9-17.9)	33.4 (31.5-34.5)	1522
Males					
Total, 3 years and older	21.2 (20.5-22.0)	10.8 (10.3-11.3)	23.1 (22.2-24.0)	39.0 (37.4-40.6)	4048
3–5 years	16.0 (14.9-17.2)	7.80 (7.10-9.00)	17.7 (16.0-19.1)	28.4 (27.1-30.9)	216
6–11 years	21.7 (20.4-23.1)	11.5 (9.40-13.3)	23.0 (21.2-25.0)	36.4 (34.1-40.1)	507
12–19 years	22.5 (21.8-23.2)	13.4 (12.4-14.0)	23.5 (22.5-24.5)	37.5 (35.3-39.8)	1091
20–39 years	24.2 (22.6-25.9)	13.8 (11.7-15.0)	25.0 (23.6-26.3)	42.1 (39.1-45.2)	724
40–59 years	21.7 (20.4-23.2)	11.1 (9.20-11.9)	23.7 (21.9-25.5)	39.8 (37.5-41.7)	761
60 years and older	15.2 (14.1-16.4)	6.30 (5.60-7.50)	16.8 (15.5-17.9)	33.2 (30.5-36.0)	749
Females					
Total, 3 years and older	19.7 (19.1-20.4)	10.3 (9.70-10.9)	21.1 (20.1-21.9)	35.6 (34.3-36.7)	4300
3–5 years	16.2 (14.6-18.1)	8.00 (6.20-10.3)	16.6 (14.9-18.6)	32.5 (29.1-34.3)	211
6–11 years	21.5 (20.6-22.4)	10.7 (9.70-13.0)	22.2 (20.6-23.3)	35.5 (34.1-37.3)	505
12–19 years	20.6 (20.0-21.3)	12.3 (11.5-13.1)	21.4 (20.0-22.2)	34.8 (32.1-36.3)	1114
20–39 years	21.3 (20.2-22.5)	12.2 (10.5-13.6)	22.3 (21.2-23.6)	36.7 (33.8-39.3)	990
40–59 years	20.4 (19.4-21.4)	10.7 (9.30-12.1)	21.8 (20.9-22.8)	36.5 (34.4-37.8)	707
60 years and older	15.6 (14.5-16.9)	6.70 (5.60-7.50)	17.3 (15.7-18.6)	33.3 (30.6-34.5)	773

Table 2.8.b. Serum *trans*-lycopene: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	19.7 (18.9-20.5)	10.6 (9.90-11.6)	20.6 (19.8-21.5)	34.6 (33.0-36.0)	2111
3–5 years	15.0 (12.9-17.4)	7.30 (5.80-9.20)	15.7 (12.5-19.4)	30.4 (23.0-39.8)	124
6–11 years	19.7 (18.3-21.3)	10.5 (9.20-13.1)	20.5 (18.7-22.5)	33.7 (29.6-36.1)	289
12–19 years	20.4 (19.4-21.4)	12.3 (11.2-13.4)	20.7 (19.6-22.0)	32.9 (30.4-36.2)	696
20–39 years	21.4 (20.1-22.8)	12.1 (11.2-13.6)	21.7 (20.6-22.5)	36.0 (33.1-39.9)	460
40–59 years	19.1 (17.5-20.9)	10.2 (8.70-11.3)	20.0 (17.9-22.3)	34.4 (29.9-39.1)	287
60 years and older	13.9 (11.7-16.6)	6.20 (2.20-9.60)	15.3 (13.1-17.7)	30.1 (26.6-31.6)	255
Males					
Total, 3 years and older	20.4 (19.6-21.2)	11.4 (10.2-12.0)	21.3 (20.6-21.9)	35.9 (32.7-39.4)	1018
3–5 years	15.2 (13.3-17.2)	8.60† (1.80-11.3)	15.7 (12.4-18.1)	28.5† (23.8-33.3)	62
6–11 years	20.8 (18.5-23.4)	12.6 (8.70-14.7)	20.6 (19.2-24.1)	33.4 (28.4-45.7)	140
12–19 years	21.1 (20.2-22.0)	12.9 (11.6-13.9)	21.5 (20.4-22.6)	34.6 (30.3-39.4)	330
20–39 years	22.0 (20.7-23.5)	12.4 (11.2-14.1)	22.2 (20.7-23.6)	39.1 (33.0-43.7)	213
40–59 years	20.0 (17.9-22.3)	10.2 (8.90-11.8)	20.9 (16.8-24.5)	35.5 (30.2-43.3)	147
60 years and older	13.0 (10.4-16.3)	5.20 (.800-7.50)	14.2 (10.6-17.7)	27.8 (24.0-31.4)	126
Females					
Total, 3 years and older	19.0 (18.0-20.0)	10.2 (9.10-11.3)	20.0 (18.6-21.4)	33.7 (31.6-34.9)	1093
3–5 years	14.8 (11.0-19.8)	6.70† (4.30-9.50)	15.0 (9.50-22.8)	32.7† (20.3-37.9)	62
6–11 years	18.7 (16.8-20.7)	9.90 (9.10-11.0)	20.0 (16.9-22.9)	33.2 (28.6-35.4)	149
12–19 years	19.6 (18.4-20.9)	11.7 (10.2-13.6)	19.8 (18.3-21.2)	31.7 (29.7-35.9)	366
20–39 years	20.6 (18.9-22.5)	11.6 (10.3-13.2)	21.3 (19.0-22.7)	34.8 (30.1-37.6)	247
40–59 years	18.2 (16.4-20.2)	9.10 (5.30-13.2)	19.3 (17.9-20.8)	30.5 (28.2-36.9)	140
60 years and older	14.7 (12.1-18.0)	6.80 (1.90-10.3)	15.8 (13.7-20.7)	30.5 (24.4-36.1)	129

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.8.c. Serum *trans*-lycopene: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	21.6 (21.0-22.3)	10.9 (10.1-11.7)	23.4 (22.1-24.2)	40.1 (37.9-42.2)	1992
3–5 years	20.8 (18.3-23.6)	10.9 (8.90-13.4)	20.8 (18.6-24.9)	40.9 (28.5-54.9)	128
6–11 years	25.9 (24.1-27.9)	15.0 (13.1-16.8)	27.1 (24.1-29.6)	42.1 (36.7-47.1)	340
12–19 years	24.7 (23.6-25.8)	13.9 (12.4-16.0)	25.4 (24.0-27.0)	41.0 (38.4-43.0)	671
20–39 years	24.3 (23.3-25.4)	13.1 (12.4-14.6)	25.2 (23.5-26.8)	41.6 (39.0-46.9)	319
40–59 years	19.0 (17.7-20.5)	8.70 (6.20-11.3)	20.6 (19.6-22.0)	35.9 (34.4-41.3)	291
60 years and older	14.1 (12.9-15.4)	5.40 (4.50-7.10)	14.5 (13.3-16.7)	31.4 (28.8-34.1)	243
Males					
Total, 3 years and older	22.3 (21.4-23.2)	10.7 (9.90-12.4)	23.8 (22.8-24.6)	41.2 (37.4-44.1)	984
3–5 years	21.6 (18.2-25.5)	9.90† (5.10-15.1)	23.8 (19.3-27.0)	41.7† (30.5-57.7)	64
6–11 years	27.1 (24.3-30.1)	15.9 (13.0-18.5)	28.0 (23.9-32.2)	44.0 (36.4-49.1)	175
12–19 years	25.1 (23.9-26.4)	15.2 (13.4-16.7)	25.9 (24.4-27.6)	40.1 (36.8-44.6)	340
20–39 years	25.6 (24.4-26.9)	14.2 (12.5-16.2)	26.5 (23.8-28.1)	45.3 (37.4-56.2)	132
40–59 years	19.4 (17.8-21.0)	9.20 (6.20-11.2)	21.3 (19.3-22.7)	35.7 (32.4-41.2)	154
60 years and older	13.5 (11.8-15.4)	5.40 (4.30-7.10)	14.0 (11.4-16.4)	30.9 (26.2-34.9)	119
Females					
Total, 3 years and older	21.1 (20.2-22.0)	11.0 (10.1-11.6)	22.6 (20.9-24.2)	39.7 (37.1-41.3)	1008
3–5 years	20.0 (17.2-23.2)	11.1† (7.60-14.4)	19.6 (15.7-25.5)	40.9† (26.3-44.6)	64
6–11 years	24.7 (22.7-26.9)	13.8 (11.7-16.8)	25.9 (23.6-28.2)	39.2 (35.2-44.8)	165
12–19 years	24.3 (22.7-26.0)	12.5 (11.3-15.8)	25.2 (22.7-27.6)	41.0 (38.8-44.4)	331
20–39 years	23.5 (22.1-25.0)	13.0 (11.8-14.6)	24.4 (22.1-26.6)	39.7 (37.1-46.5)	187
40–59 years	18.7 (16.9-20.7)	7.90 (5.40-11.9)	19.9 (17.7-22.0)	36.2 (30.9-43.9)	137
60 years and older	14.5 (12.8-16.5)	5.60 (4.50-8.20)	14.8 (12.5-18.6)	31.4 (28.0-34.1)	124

† Estimate is subject to greater uncertainty due to small cell size.

Table 2.8.d. Serum *trans*-lycopene: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 3 years and older	20.7 (19.9-21.4)	10.8 (10.2-11.4)	22.1 (21.0-23.2)	37.6 (36.3-38.7)	3578
3–5 years	15.4 (14.0-17.0)	7.90 (6.20-9.30)	16.6 (14.8-17.9)	27.5 (25.3-31.2)	132
6–11 years	21.5 (20.2-22.9)	11.4 (9.70-13.2)	22.2 (20.6-23.6)	35.8 (33.3-37.8)	300
12–19 years	21.1 (20.5-21.8)	12.8 (11.5-13.8)	21.9 (20.8-22.6)	35.3 (34.0-36.8)	656
20–39 years	22.9 (21.3-24.6)	13.1 (11.7-14.2)	24.2 (22.8-25.7)	39.6 (37.7-42.1)	770
40–59 years	21.9 (20.7-23.1)	11.8 (10.3-13.4)	23.2 (21.3-24.9)	38.5 (36.8-40.0)	777
60 years and older	16.1 (15.2-17.0)	7.00 (6.20-7.70)	17.8 (16.4-18.6)	33.9 (31.7-35.9)	943
Males					
Total, 3 years and older	21.4 (20.5-22.4)	11.0 (9.90-11.6)	23.5 (22.3-24.5)	39.5 (37.9-40.9)	1737
3–5 years	14.4 (12.6-16.5)	7.80† (4.40-9.50)	16.4 (14.3-19.1)	27.4† (24.7-30.9)	71
6–11 years	21.7 (19.9-23.6)	12.2 (9.40-14.1)	22.2 (20.3-25.2)	36.0 (32.0-40.1)	157
12–19 years	22.1 (21.2-23.1)	12.9 (11.5-14.0)	23.2 (21.4-24.6)	37.0 (34.3-40.2)	323
20–39 years	24.8 (22.4-27.3)	13.9 (11.1-16.6)	25.8 (23.9-28.9)	42.4 (38.8-45.6)	312
40–59 years	22.6 (21.0-24.2)	11.4 (9.20-13.5)	24.5 (22.4-26.9)	40.0 (37.9-42.9)	407
60 years and older	15.7 (14.6-17.0)	6.90 (5.80-7.70)	17.5 (15.7-18.6)	33.8 (30.6-37.6)	467
Females					
Total, 3 years and older	19.9 (19.2-20.7)	10.6 (9.90-11.4)	21.1 (20.1-22.1)	35.4 (33.9-36.7)	1841
3–5 years	16.6 (14.7-18.8)	8.70† (6.20-13.1)	16.6 (14.7-18.9)	26.8† (22.8-31.8)	61
6–11 years	21.3 (19.8-22.9)	11.0 (9.40-13.8)	21.7 (20.0-23.7)	34.2 (32.5-38.0)	143
12–19 years	20.2 (19.4-21.0)	12.6 (11.0-13.9)	21.3 (19.4-22.2)	32.4 (28.9-35.8)	333
20–39 years	21.3 (19.8-23.0)	12.3 (9.40-14.3)	22.4 (20.9-24.1)	36.5 (33.1-39.6)	458
40–59 years	21.2 (20.2-22.3)	12.6 (10.7-13.7)	22.0 (20.7-23.5)	36.6 (34.0-37.8)	370
60 years and older	16.4 (15.1-17.7)	6.90 (5.70-8.40)	17.9 (15.9-19.0)	33.8 (31.4-36.1)	476

† Estimate is subject to greater uncertainty due to small cell size.

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Fat-Soluble Vitamins & Micronutrients:

Vitamin D

Vitamin D (calciferol) comprises a group of fat soluble seco-sterols found naturally only in a few foods, such as fish-liver oils, fatty fish, mushrooms, egg yolks, and liver. The two major physiologically relevant forms of vitamin D are D_2 (ergocalciferol) and D_3 (cholecalciferol). Vitamin D_3 is photosynthesized in the skin of vertebrates by the action of solar ultraviolet (UV) B radiation on 7-dehydrocholesterol (Fieser 1959). Vitamin D_2 is produced by UV irradiation of ergosterol, which occurs in molds, yeast, and higher-order plants. Under conditions of regular sun exposure, dietary vitamin D intake is of minor importance. However, latitude, season, aging, sunscreen use, and skin pigmentation influence the production of vitamin D_3 by the skin (Institute of Medicine 1997). Most of the dietary intake of vitamin D comes from fortified milk products and other fortified foods such as breakfast cereals and orange juice (Institute of Medicine 1997). Both vitamin D_2 and D_3 are used in nonprescription vitamin D supplements, but vitamin D_2 is the form available by prescription in the United States (Holick 2007).

Vitamin D without a subscript represents either D_2 or D_3 or both and is biologically inert. Vitamin D from the skin or diet is only short-lived in circulation (with a half-life of 1–2 days), as it is either stored in fat cells or metabolized in the liver (Mawer 1972). In circulation, vitamin D is bound to vitamin D-binding protein and transported to the liver, where it is converted to 25-hydroxyvitamin D [25(OH)D] (DeLuca 1984). This major circulating form of vitamin D is a good reflection of cumulative effects of exposure to sunlight and dietary intake of vitamin D (Haddad 1973; Holick 1995) and is therefore used by clinicians to determine vitamin D status. To be biologically activated at physiologic concentrations, 25(OH)D must be converted in the kidneys to 1,25-dihydroxyvitamin D [$1,25(OH)_2D$], which is thought to be responsible for most, if not all, of the biologic functions of vitamin D (DeLuca 1988; Reichel 1989). The production of 25(OH)D in the liver and of $1,25(OH)_2D$ in the kidney is tightly regulated. In the liver, vitamin D-25-hydroxylase is down-regulated by vitamin D and its metabolites, thereby limiting any increase in the circulating concentration of 25(OH)D following intakes or following production of vitamin D after exposure to sunlight. In the kidney, in response to serum calcium and phosphorus concentrations, the production of $1,25(OH)_2D$ is regulated through the action of parathyroid hormone (PTH) (DeLuca 1988; Reichel 1989).

Active vitamin D functions as a hormone, and its main biologic function in people is to maintain serum calcium and phosphorus concentrations within the normal range by enhancing the efficiency of the small intestine to absorb these minerals from the diet (DeLuca 1988; Reichel 1989). When dietary calcium intake is inadequate to satisfy the body's calcium requirement, $1,25(OH)_2D$, along with PTH, mobilizes calcium stores from the bone. In the kidney, $1,25(OH)_2D$ increases calcium reabsorption by the distal renal tubules. Apart from these traditional calcium-related actions, $1,25(OH)_2D$ and its synthetic analogs are increasingly recognized for their potent antiproliferative, prodifferentiative, and immunomodulatory activities (Nagpal 2005).

Vitamin D deficiency is characterized by inadequate mineralization or by demineralization of the skeleton. Among children, vitamin D deficiency is a common cause of bone deformities known as rickets. Vitamin D deficiency in adults leads to a mineralization defect in the skeleton, causing osteomalacia, and induces secondary hyperparathyroidism with consequent bone loss and osteoporosis. Potential roles for vitamin D beyond bone health, such as effects on muscle strength, the risk for cancer and for type 2 diabetes, are currently being studied. The Agency for Healthcare Research and Quality recently reviewed the effectiveness and safety of vitamin D on outcomes related to bone health (Cranney 2007). The report suggests that vitamin D supplementation has positive effects on bone health in postmenopausal women and older men.

Still, what constitutes the optimal intake of vitamin D remains a matter of some disagreement. Current recommendations from the Institute of Medicine (1997) call for 200 international units (IU) [5.0 micrograms (µg)] of vitamin D daily from birth through age 50, 400 IU (10 µg) for those aged 51–70 years, and 600 IU (15 µg) for those older than 70 years. According to the Dietary Guidelines for Americans (U.S. Department of Health and Human Services and U.S. Department of Agriculture 2005) older adults, people with dark skin, and people exposed to insufficient UV B radiation should consume extra vitamin D from vitamin D-fortified foods or supplements. The American Cancer Society Guidelines on Nutrition and Physical Activity for Cancer Prevention echo this recommendation (Kushi 2006). Some experts say that optimal amounts for all adults are closer to 800–1000 IU (20–25 µg) daily (Vieth 2007; Bischoff-Ferrari 2006; Dawson-Hughes 2005). The tolerable upper intake level for vitamin D is 2000 IU (50 µg) per day in North America and in Europe; however, some scientists are calling for an upward revision (Hathcock 2007; Vieth 2006).

Some clinical laboratories use conventional units for 25(OH)D (nanogram per milliliter [ng/mL]) whereas other laboratories use international system (SI) units (nanomole per liter [nmol/L]). The conversion factor to SI units is: 1 ng/mL = 2.496 nmol/L.

No common definition exists for adequate vitamin D status measured as 25(OH)D serum concentrations (Dawson-Hughes 2005). The Institute of Medicine (1997) defined vitamin D deficiency as serum 25(OH)D concentrations of less than 11 ng/mL (27.5 nmol/L) for neonates, infants, and young children. Because the lower limit of the normal range can be as low as 8 ng/mL (20 nmol/L) and as high as 15 ng/mL (37.5 nmol/L), depending on the geographic location, vitamin D deficiency has been

defined as a concentration of less than 12 ng/mL (mid-range between 8 and 15 ng/mL) for adults (Institute of Medicine 1997). More recently, some scientists have suggested that the criteria used to define adequate status should be revised upwards; serum 25(OH)D concentrations between 20 ng/mL (50 nmol/L) and 32 ng/mL (80 nmol/L) have been defined as sufficient (Hollis 2005; Dawson-Hughes 2005; Bischoff-Ferrari 2006; Norman 2007). A common definition for high serum vitamin D concentrations is also lacking. The Institute of Medicine (1997) used serum calcium concentrations greater than 11 milligrams per deciliter (mg/dL) for assessing the potential for increased risk of harm associated with high vitamin D intakes. To date, however, no evidence has surfaced of adverse effects with serum 25(OH)D concentrations as high as 56 ng/mL (140 nmol/L) in healthy individuals (Vieth 1999).

Different assays measure serum 25(OH)D, and at times large variations occur among methods and even between laboratories using the same method (Singh 2008; Binkley 2004; Carter 2004). Standard reference materials (SRMs) for serum 25(OH)D are currently under development by the U.S. National Institute of Standards and Technology (U.S. NIST) (http://www.cstl.nist.gov/projects/fy06/food0683904.pdf). Improvement in the agreement between laboratories and methods is expected as laboratories begin to use the SRMs.

Medical technologist checks samples for vitamin D analysis.

For more information about vitamin D, see the Institute of Medicine's Dietary Reference Intake reports (Institute of Medicine 1997), fact sheets from the National Institutes of Health, Office of Dietary Supplements (http://ods.od.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx), as well as information from the American Society for Nutrition (http://jn.nutrition.org/nutinfo/).

Since 1988, NHANES has monitored the vitamin D status of the U.S. population. By design, this survey collects information and biological samples in the summer from people living at higher latitudes and in the winter from people living at lower latitudes. Because the different racial and ethnic groups are not evenly distributed across all geographic regions in the United States, the season-latitude structure of the survey can affect comparisons by race or ethnicity. In two seasonal subpopulations from NHANES III (1988–1994), Looker et al. (2002) showed that in the winter and lower latitude subpopulation, 1–5 percent and 25–57 percent had 25(OH)D concentrations less than 10 ng/mL (25 nmol/L) and less than 25 ng/mL (62.5 nmol/L), respectively. In the summer and higher latitude subpopulation, 1–3 percent and 21–49 percent had 25(OH)D concentrations below these cutoffs. Mean

25(OH)D concentrations were highest in non-Hispanic whites, intermediate in Mexican Americans, and lowest in non-Hispanic blacks. Nesby-O'Dell et al. (2002) restricted the analysis of NHANES III data to African-American and white women of reproductive age and found the prevalence of hypovitaminosis [25(OH)D concentrations < 15 ng/mL (37.5 nmol/L)] to be 42.2 percent among African Americans and 4.2 percent among whites.

Selected Observations and Highlights

The following sample observations and figures are taken from the tables of 2001–2002 data contained in this report. Statements about categorical differences between demographic groups noted below are based on non-overlapping confidence limits from univariate analysis without adjusting for demographic variables (e.g., age, sex, race/ethnicity) or other determinants of these blood concentrations (e.g., dietary intake, supplement usage, smoking, BMI). A multivariate analysis may alter the size and statistical significance of these categorical differences. Furthermore, additional significant differences of smaller magnitude may be present despite their lack of mention here (e.g., if confidence limits slightly overlap or if differences are unobservable before covariate adjustment has occurred). For a selection of citations of descriptive NHANES papers related to these biochemical indicators of diet and nutrition, see Appendix E.

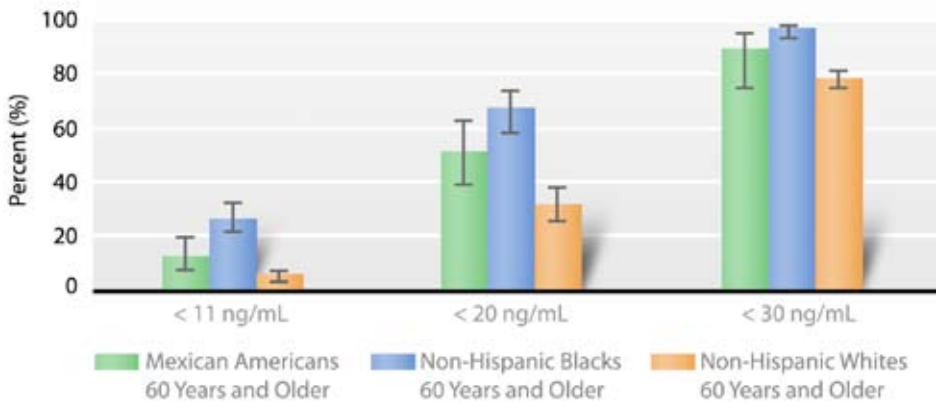
General Observations

- Serum 25(OH)D concentrations are similar throughout all age groups, except that children 6–11 years of age have higher concentrations than do people in other age groups.
- Non-Hispanic whites have higher concentrations of 25(OH)D than do Mexican Americans, who themselves have higher concentrations than do non-Hispanic blacks.
- Approximately 10 percent of the population has concentrations of 25(OH)D that are less than 11 ng/mL. The values at the 10th percentile vary greatly by racial-ethnic group, with non-Hispanic blacks having the highest prevalence of low 25(OH)D concentrations.

Highlights

Because of the current disagreement regarding appropriate criteria by which to define adequate status on the basis of serum 25(OH)D concentrations, the figure below presents prevalence estimates for older people (≥ 60 years) for three cut-off values: 11 ng/mL, 20 ng/mL, and 30 ng/mL. Regardless of the cut-off value, non-Hispanic blacks have the highest prevalence of low serum 25(OH)D concentrations (Fig. 2.a).

Figure 2.a



Prevalence estimates (95 percent confidence intervals) of serum 25-hydroxyvitamin D among U.S. persons 60 years and older by race/ethnicity, National Health and Nutrition Examination Survey, 2001–2002. Prevalence estimates shown here are not part of the tables displayed in this report; rather, the data were analyzed separately to generate this figure.

Table 2.9.a. Serum 25-hydroxyvitamin D: Total population

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	21.9 (21.0-22.7)	11.0 (11.0-12.0)	22.0 (22.0-23.0)	35.0 (33.0-36.0)	7807
6–11 years	25.5 (24.2-26.9)	17.0 (16.0-19.0)	26.0 (24.0-27.0)	35.0 (32.0-39.0)	991
12–19 years	22.0 (21.0-23.1)	13.0 (11.0-14.0)	23.0 (22.0-24.0)	35.0 (33.0-35.0)	2167
20–39 years	21.6 (20.7-22.6)	11.0 (11.0-12.0)	22.0 (22.0-24.0)	35.0 (33.0-38.0)	1691
40–59 years	21.6 (20.6-22.6)	11.0 (11.0-13.0)	22.0 (22.0-23.0)	34.0 (32.0-36.0)	1449
60 years and older	21.0 (20.0-22.1)	12.0 (10.0-12.0)	22.0 (21.0-24.0)	33.0 (32.0-34.0)	1509
Males					
Total, 6 years and older	22.6 (21.8-23.4)	13.0 (13.0-14.0)	24.0 (23.0-24.0)	34.0 (33.0-36.0)	3782
6–11 years	26.1 (24.5-27.9)	18.0 (17.0-20.0)	26.0 (24.0-27.0)	38.0 (33.0-44.0)	497
12–19 years	23.1 (21.9-24.3)	13.0 (11.0-16.0)	24.0 (22.0-25.0)	35.0 (34.0-37.0)	1068
20–39 years	22.2 (21.4-23.1)	13.0 (11.0-14.0)	23.0 (21.0-24.0)	34.0 (32.0-37.0)	709
40–59 years	22.3 (21.2-23.5)	12.0 (11.0-14.0)	22.0 (22.0-23.0)	33.0 (32.0-37.0)	762
60 years and older	21.5 (20.7-22.5)	13.0 (11.0-14.0)	22.0 (21.0-24.0)	32.0 (31.0-33.0)	746
Females					
Total, 6 years and older	21.2 (20.2-22.2)	10.0 (9.00-12.0)	23.0 (22.0-23.0)	34.0 (33.0-36.0)	4025
6–11 years	24.9 (23.6-26.3)	17.0 (15.0-19.0)	26.0 (24.0-27.0)	35.0 (32.0-37.0)	494
12–19 years	21.0 (20.0-22.0)	11.0 (9.00-13.0)	22.0 (20.0-22.0)	33.0 (32.0-35.0)	1099
20–39 years	21.1 (19.9-22.4)	10.0 (9.00-12.0)	22.0 (21.0-24.0)	37.0 (32.0-40.0)	982
40–59 years	20.8 (19.6-22.1)	10.0 (9.00-12.0)	23.0 (21.0-24.0)	34.0 (32.0-35.0)	687
60 years and older	20.6 (19.3-22.0)	11.0 (10.0-12.0)	22.0 (20.0-23.0)	34.0 (33.0-36.0)	763

Table 2.9.b. Serum 25-hydroxyvitamin D: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	19.6 (18.5-20.7)	11.0 (10.0-12.0)	20.0 (19.0-22.0)	29.0 (28.0-32.0)	1961
6–11 years	22.6 (21.7-23.6)	17.0 (15.0-17.0)	22.0 (22.0-24.0)	30.0 (28.0-32.0)	283
12–19 years	19.7 (18.5-21.0)	12.0 (11.0-14.0)	20.0 (18.0-21.0)	29.0 (27.0-32.0)	687
20–39 years	19.5 (18.2-20.9)	12.0 (10.0-13.0)	20.0 (18.0-21.0)	31.0 (27.0-33.0)	452
40–59 years	18.1 (16.5-19.8)	10.0 (8.00-11.0)	20.0 (18.0-21.0)	28.0 (24.0-33.0)	286
60 years and older	18.3 (15.9-21.1)	10.0 (8.00-11.0)	18.0 (16.0-21.0)	29.0 (24.0-36.0)	253
Males					
Total, 6 years and older	20.6 (19.4-21.8)	13.0 (11.0-13.0)	21.0 (19.0-22.0)	30.0 (27.0-32.0)	942
6–11 years	22.8 (21.8-23.9)	17.0 (15.0-18.0)	22.0 (22.0-24.0)	28.0 (26.0-31.0)	138
12–19 years	21.1 (19.7-22.7)	13.0 (11.0-15.0)	21.0 (19.0-24.0)	29.0 (27.0-33.0)	323
20–39 years	20.1 (18.7-21.7)	12.0 (10.0-13.0)	20.0 (19.0-22.0)	31.0 (26.0-34.0)	208
40–59 years	19.9 (18.3-21.7)	12.0 (9.00-14.0)	21.0 (19.0-22.0)	28.0 (25.0-33.0)	148
60 years and older	19.5 (16.6-22.9)	9.00 (6.00-11.0)	21.0 (16.0-25.0)	31.0 (25.0-39.0)	125
Females					
Total, 6 years and older	18.6 (17.5-19.7)	10.0 (10.0-11.0)	18.0 (17.0-20.0)	29.0 (27.0-31.0)	1019
6–11 years	22.4 (21.4-23.5)	17.0 (15.0-18.0)	22.0 (20.0-23.0)	30.0 (28.0-33.0)	145
12–19 years	18.3 (17.0-19.6)	11.0 (9.00-14.0)	18.0 (17.0-20.0)	26.0 (25.0-28.0)	364
20–39 years	18.8 (17.3-20.4)	10.0 (9.00-12.0)	18.0 (17.0-21.0)	31.0 (27.0-33.0)	244
40–59 years	16.3 (14.5-18.3)	8.00 (7.00-10.0)	18.0 (14.0-20.0)	25.0 (22.0-33.0)	138
60 years and older	17.4 (14.7-20.7)	10.0 (7.00-12.0)	18.0 (16.0-21.0)	27.0 (22.0-30.0)	128

Table 2.9.c. Serum 25-hydroxyvitamin D: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	13.0 (12.5-13.6)	7.00 (6.00-7.00)	13.0 (13.0-14.0)	22.0 (22.0-23.0)	1821
6–11 years	18.7 (17.7-19.8)	11.0 (10.0-14.0)	19.0 (18.0-19.0)	25.0 (24.0-27.0)	334
12–19 years	13.2 (12.4-14.0)	7.00 (7.00-8.00)	14.0 (13.0-14.0)	22.0 (20.0-23.0)	653
20–39 years	11.6 (11.0-12.2)	7.00 (6.00-7.00)	12.0 (11.0-12.0)	20.0 (17.0-22.0)	312
40–59 years	12.2 (11.4-13.0)	5.00 (5.00-6.00)	12.0 (11.0-14.0)	23.0 (21.0-24.0)	285
60 years and older	14.6 (13.4-15.9)	6.00 (6.00-7.00)	14.0 (13.0-17.0)	28.0 (24.0-29.0)	237
Males					
Total, 6 years and older	14.2 (13.4-15.0)	7.00 (7.00-8.00)	14.0 (13.0-15.0)	23.0 (22.0-25.0)	898
6–11 years	19.8 (18.5-21.2)	12.0 (10.0-15.0)	20.0 (18.0-21.0)	27.0 (26.0-29.0)	172
12–19 years	14.6 (13.5-15.7)	7.00 (6.00-9.00)	14.0 (13.0-16.0)	22.0 (22.0-25.0)	328
20–39 years	12.7 (11.6-13.8)	7.00 (7.00-8.00)	13.0 (11.0-15.0)	20.0 (19.0-23.0)	127
40–59 years	13.2 (12.1-14.5)	5.00 (5.00-6.00)	13.0 (11.0-15.0)	23.0 (21.0-24.0)	154
60 years and older	14.6 (13.7-15.6)	7.00 (6.00-9.00)	15.0 (13.0-17.0)	26.0 (22.0-29.0)	117
Females					
Total, 6 years and older	12.2 (11.5-12.8)	7.00 (6.00-7.00)	12.0 (12.0-13.0)	22.0 (22.0-24.0)	923
6–11 years	17.5 (16.1-19.1)	11.0 (9.00-14.0)	18.0 (16.0-19.0)	25.0 (23.0-26.0)	162
12–19 years	11.9 (11.1-12.8)	7.00 (5.00-7.00)	11.0 (11.0-12.0)	21.0 (18.0-24.0)	325
20–39 years	11.0 (10.2-11.7)	6.00 (3.00-7.00)	11.0 (10.0-11.0)	19.0 (16.0-23.0)	185
40–59 years	11.3 (10.2-12.5)	5.00 (5.00-6.00)	10.0 (9.00-12.0)	21.0 (17.0-26.0)	131
60 years and older	14.6 (12.5-17.0)	6.00 (3.00-7.00)	14.0 (12.0-17.0)	26.0 (21.0-31.0)	120

Table 2.9.d. Serum 25-hydroxyvitamin D: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	24.3 (23.5-25.2)	15.0 (14.0-16.0)	25.0 (24.0-25.0)	37.0 (34.0-38.0)	3416
6–11 years	28.5 (26.6-30.5)	21.0 (19.0-22.0)	28.0 (26.0-29.0)	39.0 (33.0-45.0)	294
12–19 years	25.8 (25.0-26.6)	17.0 (16.0-18.0)	25.0 (25.0-26.0)	36.0 (35.0-38.0)	648
20–39 years	25.2 (24.4-26.1)	17.0 (15.0-18.0)	26.0 (25.0-26.0)	38.0 (36.0-42.0)	766
40–59 years	23.7 (22.6-24.9)	13.0 (12.0-15.0)	25.0 (23.0-26.0)	36.0 (33.0-38.0)	768
60 years and older	22.0 (20.9-23.3)	13.0 (11.0-14.0)	23.0 (21.0-24.0)	34.0 (32.0-34.0)	940
Males					
Total, 6 years and older	24.8 (23.8-25.8)	15.0 (14.0-17.0)	26.0 (24.0-26.0)	37.0 (34.0-39.0)	1655
6–11 years	29.1 (26.9-31.4)	22.0 (19.0-24.0)	28.0 (26.0-31.0)	39.0 (35.0-46.0)	152
12–19 years	26.7 (25.4-28.1)	20.0 (17.0-20.0)	27.0 (25.0-28.0)	38.0 (35.0-41.0)	320
20–39 years	25.0 (24.0-26.0)	16.0 (14.0-18.0)	25.0 (23.0-26.0)	36.0 (33.0-39.0)	309
40–59 years	24.2 (22.9-25.7)	14.0 (14.0-16.0)	25.0 (22.0-26.0)	37.0 (33.0-38.0)	406
60 years and older	22.6 (21.6-23.7)	13.0 (12.0-15.0)	23.0 (23.0-25.0)	33.0 (31.0-34.0)	468
Females					
Total, 6 years and older	23.9 (23.0-24.9)	13.0 (13.0-15.0)	25.0 (24.0-25.0)	37.0 (34.0-39.0)	1761
6–11 years	27.8 (25.8-30.0)	21.0 (19.0-22.0)	27.0 (26.0-29.0)	38.0 (33.0-44.0)	142
12–19 years	25.0 (24.3-25.7)	16.0 (14.0-18.0)	26.0 (24.0-27.0)	36.0 (34.0-38.0)	328
20–39 years	25.5 (24.1-26.9)	15.0 (14.0-18.0)	25.0 (24.0-27.0)	39.0 (35.0-44.0)	457
40–59 years	23.1 (22.0-24.2)	12.0 (10.0-13.0)	25.0 (23.0-26.0)	34.0 (33.0-37.0)	362
60 years and older	21.6 (20.1-23.1)	11.0 (10.0-13.0)	23.0 (21.0-24.0)	35.0 (33.0-36.0)	472

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3

Iron-Status Indicators

- Ferritin
- Iron
- Total iron-binding capacity
- Transferrin saturation
- Protoporphyrin

Iron-Status Indicators

Iron functions as a component of proteins and enzymes. Almost two-thirds of the iron in the body (approximately 2.5 grams of iron) is found in hemoglobin, the protein in red blood cells that carries oxygen to tissues, and about 15 percent is in the myoglobin of muscle tissue. The average American diet provides 10–15 milligrams (mg) of iron daily in the form of heme and nonheme iron. Heme iron is found in animal foods that originally contained hemoglobin and myoglobin, such as red meat, fish, and poultry. Nonheme iron is found in plant foods, such as lentils and beans, and also is provided in iron-enriched and iron-fortified foods. Although heme iron is absorbed better than nonheme iron, most dietary iron is nonheme iron (Miret 2003). Each day the body absorbs approximately 1–2 mg of iron to compensate for the 1–2 mg of iron that the (nonmenstruating) body loses (Institute of Medicine 2001).

Transporting iron from one organ to another is accomplished by the reversible binding of iron to the transport protein, transferrin, which will then form a complex with a highly specific transferrin receptor (TfR) located on the plasma membrane surfaces of cells. Intracellular iron availability is regulated through the increased expression of cellular TfR concentration by iron-deficient cells. Ferritin is the major iron-storage compound: its production increases in cells as iron supplies increase. Although all cells are capable of storing iron, the liver, spleen, and bone marrow cells are primary iron-storage sites in people (Institute of Medicine 2001).

Iron deficiency and iron overload are the two major disorders of iron metabolism. Iron-deficiency anemia is the most severe form of iron deficiency. It is linked to many adverse consequences of iron deficiency, such as reduced physical capacity (Haas 2001) and poor pregnancy outcomes (Schorr 1994). Iron deficiency without anemia, however, has been linked to negative effects on cognitive development among infants and adolescents (Grantham-McGregor 2001; Beard 1999). Iron overload is the accumulation of excess iron in body tissues, and it usually occurs as a result of a genetic predisposition to absorb iron in excess of normal but can also be caused by excessive ingestion of iron supplements or multiple blood transfusions (Pietrangelo 2004). In advanced stages of iron overload

disease (hemochromatosis), the iron accumulates in the parenchymal cells of several organs, but particularly the liver, followed by the heart and pancreas; this condition can lead to organ dysfunction and even death (Pietrangelo 2004).

The Recommended Dietary Allowance (RDA) for all age groups of men and postmenopausal women is 8 mg per day; the RDA for premenopausal women is 18 mg per day. The Tolerable Upper Uptake Level for adults is 45 mg per day of iron, a level based on gastrointestinal distress as an adverse effect (Institute of Medicine 2001).

Clinical laboratories typically use conventional units for iron-status indicators: iron, total iron-binding capacity (TIBC), and erythrocyte protoporphyrin (EPP) are calculated in micrograms per deciliter (µg/dL), ferritin in nanograms per milliliter (ng/mL). Conversion factors to international system (SI) units are as follows: 1 µg/dL = 0.179 micromole per liter (µmol/L) for iron and TIBC, 1 µg/dL = 0.01777 µmol/L for EPP, and 1 ng/mL = 2.247 picomole (pmol)/L for ferritin.

Medical technologist places samples for ferritin measurement into a clinical analyzer.

Several methods are used to measure iron and related analytes. Serum iron concentration measures the amount of ferric iron (Fe^{3+}) bound mainly to serum transferrin but does not include the divalent iron contained in serum as hemoglobin. Serum iron concentration is decreased in many people with iron-deficiency anemia and in people with chronic inflammatory disorders. Elevated concentrations of serum iron occur in iron-loading disorders such as hemochromatosis. Serum iron is not, however, a good indicator of iron stores and is not a sensitive measure of iron deficiency, partly because of daily fluctuations. For enhanced utility, serum iron measurements are used in conjunction with TIBC measurements. Normally, because only about one third of the iron-binding sites of transferrin are occupied by Fe^{3+}, serum transferrin has considerable reserve iron-binding capacity. TIBC is a measurement of serum transferrin after saturation of all available binding sites with reagent iron. Concentrations of serum TIBC vary with the type of iron-metabolism disorder. For example, in iron deficiency TIBC is often increased, and in chronic inflammatory disorders, malignancies, and hemochromatosis, it is often decreased. The ratio of serum iron to TIBC is called transferrin saturation. Low iron values in conjunction with elevated TIBC values (or specifically measured transferrin concentrations), yielding less than 16 percent transferrin saturation, generally indicate iron-deficiency anemia (World Health Organization 2001). Transferrin saturation values in excess of 60 percent may be indicative of hemochromatosis or iron overload (World Health Organization 2001).

Ferritin is present in the blood in very low concentrations. Plasma ferritin is in equilibrium with body stores, and its concentration declines early in the development of iron deficiency. Low serum ferritin concentrations thus are sensitive indicators of iron deficiency. Ferritin is also an acute-phase protein; acute and chronic diseases can result in increased ferritin concentration, potentially masking an iron-deficiency diagnosis. The generally accepted cut-off level for serum ferritin below which iron stores are considered to be depleted is 15 ng/mL for people aged 5 years and older and 12 ng/mL for people younger than 5 years of age (World Health Organization 2001).

Finally, when iron delivery to the bone marrow is not sufficient for maintaining the incorporation of iron into newly synthesized globin and porphyrin protein, EPP concentrations increase. Yet EPP is not useful to distinguish iron deficiency from infection and also elevates in response to lead poisoning (Roels 1975). As a result, the measurement of EPP is most useful in settings where iron deficiency levels are common and where infections, lead poisoning, and other forms of anemia are rare. The generally accepted cut-off level for EPP is 80 µg/dL red blood cells for people aged 5 years and older and 70 µg/dL red blood cells for children younger than 5 years of age (World Health Organization 2001).

For more information about iron, see the Institute of Medicine's Dietary Reference Intake reports (Institute of Medicine 2001), fact sheets from the National Institutes of Health, Office of Dietary Supplements (http://ods.od.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx), and information from the American Society for Nutrition (http://jn.nutrition.org/nutinfo/).

Three national health objectives for Healthy People 2010 relate to iron deficiency reduction: Objective 19–12 (reduce iron deficiency among young children and females of childbearing age), Objective 19–13 (reduce anemia among low-income pregnant females in their third trimester), and Objective 19–14 (reduce iron deficiency among pregnant females) (U.S. Department of Health and Human Services 2000).

To address the changing epidemiology of iron deficiency in the United States, CDC staff, in consultation with outside experts, developed recommendations in 1998 for use by primary health-care providers to prevent, detect, and treat iron deficiency (U.S. Centers for Disease Control and Prevention 1998). Since the inception of NHANES in 1971, monitoring the iron status of the U.S. population has been an important component. To provide the best possible assessment of this element, each NHANES has included a battery of hematologic and biochemical indicators of iron status (Looker 1995). Since NHANES II (1976–1980), models that employ multiple biochemical iron-status indicators have been used to define iron deficiency in the population (Pilch 1984). The three-indicator model, using serum ferritin, transferrin saturation, and erythrocyte protoporphyrin, was developed in 1980 and applied to NHANES III (1988–1994) as well as to the other most recent surveys that became continuous beginning in 1999.

Reference data for hematologic and iron-related analytes were published for NHANES II (Fulwood 1982) and NHANES III (Hollowell, 2005). Prevalence estimates of iron deficiency using the three-indicator model were similar in NHANES III (Looker 1997) and in NHANES 1999–2000 (Looker 2002). In NHANES 1999–2000, the estimated prevalence of iron deficiency was greatest among toddlers aged 1–2 years (7 percent) and adolescent and adult females aged 12–49 years (9 percent to 16 percent). The prevalence of iron deficiency was approximately two times higher among non-Hispanic black and Mexican-American females (19 percent to 22 percent) than among non-Hispanic white females (10 percent). Across all age and sex groups in the United States, iron-deficiency anemia has an estimated prevalence of less than 5 percent.

Selected Observations and Highlights

The following example observations and figures are taken from the tables of 1999–2002 data (for ferritin) and 1999–2000 data (for all other iron-status indicators) contained in this report. Statements about categorical differences between demographic groups noted below are based on non-overlapping confidence limits from univariate analysis without adjusting for demographic variables (e.g., age, sex, race/ethnicity) or other determinants of these blood concentrations (e.g., dietary intake, supplement usage, smoking, BMI). A multivariate analysis may alter the size and statistical significance of these categorical differences. Furthermore, additional significant differences of smaller magnitude may be present despite their lack of mention here (e.g., if confidence limits slightly overlap or if differences are not statistically significant before covariate adjustment has occurred). For a selection of citations of descriptive NHANES papers related to these biochemical indicators of diet and nutrition, see Appendix E.

General Observations

- Among all age groups, 1–5 year-old children have the lowest ferritin concentrations. Children up to age 11 have lower transferrin saturation levels than do adolescents or adults.
- Women 12 years and older are more likely to be defined as iron deficient than are men. These women have lower concentrations of serum ferritin, lower transferrin saturation, and higher EPP concentrations.
- Mexican Americans have lower serum ferritin and higher EPP concentrations than do either non-Hispanic whites or non-Hispanic blacks.

- Non-Hispanic blacks have lower serum transferrin saturation levels than do non-Hispanic whites.
- Mexican-American and non-Hispanic white children (aged 1–5 years) have lower serum ferritin concentrations than do non-Hispanic black children.
- Mexican-American children (aged 1–5 years) have higher EPP concentrations than do non-Hispanic black or non-Hispanic white children.
- Mexican-American women of childbearing age (aged 20–39 years) have lower serum ferritin concentrations than do non-Hispanic white women. Concentrations for non-Hispanic black women of childbearing age fall between those of Mexican-American and non-Hispanic white women.
- Non-Hispanic black women of childbearing age (aged 20–39 years) have lower serum transferrin saturation levels than do non-Hispanic white women. Serum transferrin saturation levels for Mexican-American women of childbearing age fall between levels for non-Hispanic white and Mexican-American women of childbearing age.

Highlights

Because children and women have lower serum ferritin and transferrin saturation levels than do men and older people (≥ 60 years), children and women are at greater risk for iron deficiency.

Two minority groups, non-Hispanic blacks and Mexican Americans, typically are at greater risk for iron deficiency than are non-Hispanic whites.

At least 5 percent of persons in each age group, except for older people (≥ 60 years), have low serum ferritin concentrations (< 12 ng/mL for children younger than 5 years and < 15 ng/mL for people aged 5 years and older) that are consistent with depleted iron storage.

At least 10 percent of persons in each age group have low transferrin saturation levels (< 16 percent), which are indicative of iron deficiency.

Table 3.1.a. Serum ferritin: Total population

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for the total U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 1 year and older	60.2 (58.3-62.1)	9.00 (9.00-10.0)	62.0 (59.0-64.0)	343 (329-359)	16656
1–5 years	21.5 (20.3-22.9)	6.00 (3.00-8.00)	21.0 (20.0-23.0)	62.0 (53.0-77.0)	1523
6–11 years	29.8 (28.1-31.5)	11.0 (11.0-13.0)	30.0 (28.0-31.0)	74.0 (67.0-83.0)	1909
12–19 years	32.8 (31.4-34.3)	8.00 (6.00-9.00)	34.0 (32.0-35.0)	115 (103-125)	4340
20–39 years	62.2 (58.9-65.6)	8.00 (7.00-10.0)	71.0 (66.0-76.0)	301 (272-321)	3186
40–59 years	80.8 (76.7-85.0)	9.00 (7.00-11.0)	93.0 (88.0-96.0)	404 (379-433)	2680
60 years and older	101 (95.5-107)	19.0 (16.0-22.0)	105 (97.0-112)	481 (434-518)	3018
Males					
Total, 1 year and older	93.0 (89.3-96.8)	16.0 (15.0-17.0)	101 (97.0-107)	416 (391-439)	8142
1–5 years	20.2 (18.7-21.7)	3.00 (3.00-6.00)	20.0 (19.0-22.0)	62.0 (50.0-79.0)	805
6–11 years	29.7 (27.3-32.3)	11.0 (9.00-12.0)	31.0 (29.0-32.0)	73.0 (64.0-83.0)	972
12–19 years	44.3 (41.6-47.1)	15.0 (13.0-17.0)	42.0 (40.0-45.0)	142 (125-154)	2172
20–39 years	129 (122-137)	41.0 (34.0-46.0)	134 (125-142)	382 (344-406)	1356
40–59 years	145 (135-157)	32.0 (24.0-42.0)	150 (138-168)	500 (434-574)	1340
60 years and older	127 (118-136)	21.0 (18.0-24.0)	134 (125-147)	552 (493-623)	1497
Females					
Total, 1 year and older	39.7 (38.1-41.4)	6.00 (6.00-8.00)	39.0 (37.0-41.0)	213 (198-228)	8514
1–5 years	23.2 (21.8-24.8)	7.00 (5.00-9.00)	23.0 (22.0-25.0)	69.0 (52.0-88.0)	718
6–11 years	29.9 (28.2-31.7)	12.0 (10.0-14.0)	30.0 (27.0-31.0)	76.0 (67.0-83.0)	937
12–19 years	24.0 (22.7-25.3)	5.00 (3.00-7.00)	26.0 (24.0-27.0)	76.0 (70.0-85.0)	2168
20–39 years	30.4 (28.6-32.4)	< LOD	32.0 (30.0-35.0)	126 (110-146)	1830
40–59 years	45.6 (42.8-48.6)	4.00 (3.00-6.00)	53.0 (46.0-57.0)	228 (201-243)	1340
60 years and older	84.9 (79.7-90.4)	15.0 (14.0-21.0)	86.0 (80.0-93.0)	391 (349-445)	1521

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.

Table 3.1.b. Serum ferritin: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for Mexican Americans in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 1 year and older	46.6 (43.4-50.1)	7.00 (6.00-8.00)	44.0 (40.0-47.0)	298 (265-334)	4946
1–5 years	19.0 (18.2-19.9)	5.00 (3.00-7.00)	19.0 (18.0-20.0)	48.0 (45.0-54.0)	515
6–11 years	27.7 (26.1-29.5)	12.0 (10.0-13.0)	27.0 (25.0-28.0)	70.0 (59.0-81.0)	651
12–19 years	29.9 (28.1-31.8)	6.00 (3.00-7.00)	32.0 (29.0-34.0)	114 (101-122)	1639
20–39 years	56.8 (51.9-62.2)	6.00 (3.00-8.00)	67.0 (60.0-74.0)	300 (256-336)	867
40–59 years	76.0 (67.5-85.6)	< LOD	97.0 (81.0-111)	463 (409-589)	634
60 years and older	100 (91.8-110)	18.0 (12.0-24.0)	102 (90.0-120)	433 (342-568)	640
Males					
Total, 1 year and older	77.1 (72.9-81.6)	14.0 (13.0-16.0)	85.0 (77.0-91.0)	373 (317-408)	2422
1–5 years	19.0 (18.0-20.0)	5.00 (3.00-7.00)	19.0 (18.0-21.0)	48.0 (42.0-59.0)	268
6–11 years	28.4 (26.3-30.7)	12.0 (11.0-14.0)	27.0 (25.0-29.0)	70.0 (56.0-88.0)	337
12–19 years	43.2 (40.5-46.2)	14.0 (10.0-16.0)	42.0 (40.0-46.0)	131 (121-143)	812
20–39 years	121 (112-131)	39.0 (31.0-51.0)	122 (111-134)	349 (298-395)	383
40–59 years	160 (142-180)	44.0 (33.0-53.0)	159 (142-177)	646 (457-959)	301
60 years and older	122 (105-143)	19.0 (13.0-28.0)	136 (102-162)	569 (364-831)	321
Females					
Total, 1 year and older	26.9 (24.2-30.0)	< LOD	27.0 (24.0-29.0)	161 (123-201)	2524
1–5 years	19.1 (17.6-20.8)	5.00 (3.00-8.00)	20.0 (17.0-20.0)	47.0 (44.0-56.0)	247
6–11 years	27.0 (24.7-29.6)	12.0 (8.00-14.0)	27.0 (24.0-29.0)	68.0 (59.0-84.0)	314
12–19 years	20.0 (18.3-21.9)	< LOD	22.0 (19.0-24.0)	69.0 (59.0-77.0)	827
20–39 years	23.3 (20.6-26.3)	< LOD	24.0 (22.0-26.0)	98.0 (78.0-144)	484
40–59 years	35.2 (29.2-42.4)	< LOD	38.0 (32.0-44.0)	293 (195-385)	333
60 years and older	84.6 (76.6-93.4)	17.0 (11.0-24.0)	87.0 (76.0-100)	324 (237-375)	319

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.

Table 3.1.c. Serum ferritin: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic blacks in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 1 year and older	59.2 (55.6-62.9)	8.00 (6.00-10.0)	58.0 (54.0-62.0)	381 (342-423)	3898
1–5 years	25.9 (23.9-28.1)	8.00 (5.00-10.0)	25.0 (24.0-28.0)	73.0 (62.0-98.0)	415
6–11 years	36.8 (34.7-39.0)	15.0 (13.0-17.0)	36.0 (34.0-38.0)	86.0 (78.0-91.0)	604
12–19 years	32.9 (31.3-34.6)	7.00 (6.00-10.0)	33.0 (31.0-36.0)	122 (110-132)	1258
20–39 years	54.4 (48.0-61.6)	< LOD	63.0 (56.0-73.0)	313 (266-368)	592
40–59 years	96.9 (86.7-108)	7.00 (6.00-12.0)	111 (100-129)	482 (425-642)	543
60 years and older	133 (118-150)	22.0 (18.0-31.0)	141 (125-162)	613 (509-724)	486
Males					
Total, 1 year and older	92.8 (87.2-98.8)	17.0 (16.0-19.0)	98.0 (90.0-108)	452 (420-494)	1917
1–5 years	24.6 (21.8-27.7)	7.00† (3.00-10.0)	24.0 (21.0-27.0)	69.0† (57.0-122)	215
6–11 years	36.1 (33.6-38.7)	16.0 (13.0-18.0)	34.0 (31.0-38.0)	79.0 (75.0-90.0)	304
12–19 years	44.1 (42.1-46.1)	14.0 (12.0-16.0)	43.0 (40.0-46.0)	146 (128-171)	642
20–39 years	137 (126-150)	35.0 (24.0-52.0)	150 (137-161)	381 (325-450)	249
40–59 years	176 (156-199)	42.0 (30.0-53.0)	178 (157-206)	642 (494-984)	275
60 years and older	159 (135-186)	26.0 (18.0-34.0)	173 (132-204)	710 (521-851)	232
Females					
Total, 1 year and older	40.1 (36.5-44.2)	6.00 (3.00-7.00)	40.0 (37.0-42.0)	267 (246-297)	1981
1–5 years	27.5 (25.0-30.2)	10.0† (7.00-12.0)	26.0 (24.0-30.0)	73.0† (56.0-96.0)	200
6–11 years	37.6 (34.8-40.6)	16.0 (12.0-17.0)	37.0 (33.0-41.0)	88.0 (73.0-107)	300
12–19 years	24.5 (22.3-26.8)	3.00 (3.00-6.00)	24.0 (22.0-29.0)	91.0 (78.0-104)	616
20–39 years	26.6 (22.0-32.2)	< LOD	31.0 (24.0-34.0)	142 (102-232)	343
40–59 years	57.4 (50.1-65.8)	6.00 (3.00-6.00)	61.0 (52.0-75.0)	343 (255-481)	268
60 years and older	118 (101-138)	21.0 (8.00-30.0)	131 (107-151)	534 (396-613)	254

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 3.1.d. Serum ferritin: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic whites in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		5th	50th	95th	
Males and Females					
Total, 1 year and older	63.0 (60.4-65.6)	11.0 (10.0-11.0)	65.0 (63.0-69.0)	343 (327-357)	6360
1–5 years	21.3 (19.2-23.6)	5.00 (3.00-8.00)	21.0 (19.0-23.0)	61.0 (46.0-80.0)	420
6–11 years	28.4 (26.0-31.1)	10.0 (9.00-12.0)	30.0 (27.0-32.0)	69.0 (59.0-83.0)	496
12–19 years	32.9 (31.0-34.8)	8.00 (7.00-11.0)	34.0 (31.0-36.0)	107 (95.0-122)	1075
20–39 years	64.3 (59.6-69.5)	9.00 (7.00-12.0)	74.0 (66.0-81.0)	293 (261-328)	1382
40–59 years	79.8 (75.7-84.1)	10.0 (9.00-12.0)	91.0 (85.0-96.0)	386 (349-406)	1280
60 years and older	97.9 (92.2-104)	17.0 (15.0-21.0)	102 (94.0-110)	448 (393-503)	1707
Males					
Total, 1 year and older	96.0 (91.4-101)	16.0 (14.0-18.0)	107 (99.0-115)	414 (391-435)	3127
1–5 years	19.4 (17.3-21.8)	< LOD	19.0 (17.0-21.0)	61.0 (42.0-79.0)	226
6–11 years	28.4 (24.8-32.6)	11.0 (9.00-14.0)	29.0 (27.0-33.0)	68.0 (50.0-97.0)	261
12–19 years	42.9 (39.7-46.4)	14.0 (10.0-17.0)	43.0 (39.0-46.0)	127 (111-143)	536
20–39 years	131 (121-141)	43.0 (32.0-49.0)	135 (124-144)	382 (331-416)	577
40–59 years	139 (127-153)	31.0 (18.0-39.0)	144 (132-168)	453 (409-517)	668
60 years and older	125 (116-135)	20.0 (18.0-25.0)	135 (122-148)	531 (471-601)	859
Females					
Total, 1 year and older	41.7 (39.5-44.0)	8.00 (6.00-9.00)	41.0 (39.0-44.0)	205 (193-227)	3233
1–5 years	23.6 (20.9-26.8)	8.00† (5.00-11.0)	24.0 (20.0-26.0)	59.0† (42.0-98.0)	194
6–11 years	28.4 (25.9-31.2)	10.0 (9.00-14.0)	28.0 (25.0-31.0)	73.0 (56.0-83.0)	235
12–19 years	24.8 (23.0-26.6)	7.00 (3.00-8.00)	26.0 (25.0-28.0)	71.0 (61.0-85.0)	539
20–39 years	32.0 (29.1-35.2)	5.00 (3.00-8.00)	34.0 (29.0-40.0)	127 (108-149)	805
40–59 years	45.2 (41.8-48.8)	6.00 (3.00-8.00)	51.0 (45.0-57.0)	206 (181-235)	612
60 years and older	80.7 (75.7-86.1)	16.0 (13.0-22.0)	83.0 (77.0-89.0)	353 (296-391)	848

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 3.2.a. Serum iron: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	81.2 (79.5-83.0)	45.0 (42.0-46.0)	85.0 (84.0-87.0)	137 (134-139)	7877
1–5 years	65.2 (62.0-68.4)	31.0 (27.0-35.0)	70.0 (64.0-79.0)	115 (110-124)	704
6–11 years	71.5 (68.2-75.0)	39.0 (34.0-41.0)	76.0 (69.0-82.0)	126 (117-131)	887
12–19 years	82.1 (79.7-84.7)	45.0 (42.0-47.0)	87.0 (83.0-89.0)	141 (133-145)	2127
20–39 years	84.5 (81.3-87.8)	45.0 (41.0-48.0)	88.0 (86.0-93.0)	146 (139-154)	1470
40–59 years	83.3 (80.3-86.4)	50.0 (46.0-52.0)	87.0 (83.0-92.0)	135 (131-139)	1199
60 years and older	82.0 (78.5-85.8)	49.0 (44.0-54.0)	83.0 (80.0-86.0)	132 (126-139)	1490
Males					
Total, 1 year and older	88.1 (86.1-90.0)	51.0 (49.0-54.0)	92.0 (89.0-94.0)	144 (141-147)	3879
1–5 years	64.9 (61.3-68.7)	33.0 (26.0-38.0)	67.0 (65.0-73.0)	116 (103-125)	388
6–11 years	69.6 (65.9-73.5)	38.0 (31.0-41.0)	75.0 (67.0-81.0)	115 (105-129)	463
12–19 years	92.0 (86.3-98.0)	52.0 (43.0-59.0)	96.0 (91.0-100)	150 (139-161)	1080
20–39 years	93.8 (91.4-96.3)	60.0 (56.0-63.0)	94.0 (92.0-98.0)	154 (141-163)	632
40–59 years	93.7 (89.1-98.6)	56.0 (52.0-63.0)	97.0 (92.0-103)	141 (137-148)	570
60 years and older	86.6 (83.2-90.0)	52.0 (44.0-56.0)	88.0 (85.0-91.0)	145 (137-154)	746
Females					
Total, 1 year and older	75.1 (73.3-76.9)	39.0 (37.0-43.0)	79.0 (77.0-81.0)	130 (124-135)	3998
1–5 years	65.5 (58.8-72.9)	30.0 (24.0-37.0)	76.0 (60.0-85.0)	114 (108-128)	316
6–11 years	73.8 (66.9-81.4)	37.0 (27.0-46.0)	76.0 (67.0-87.0)	133 (111-148)	424
12–19 years	72.9 (69.0-77.0)	40.0 (36.0-42.0)	77.0 (71.0-81.0)	128 (116-135)	1047
20–39 years	76.2 (72.0-80.6)	36.0 (33.0-41.0)	82.0 (74.0-87.0)	137 (128-151)	838
40–59 years	74.7 (71.6-77.9)	44.0 (38.0-48.0)	78.0 (71.0-83.0)	125 (115-134)	629
60 years and older	78.5 (73.9-83.5)	49.0 (40.0-54.0)	80.0 (76.0-85.0)	125 (114-133)	744

Table 3.2.b. Serum iron: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	80.1 (77.7-82.6)	40.0 (38.0-44.0)	84.0 (81.0-87.0)	139 (136-147)	2710
1–5 years	62.3 (56.6-68.6)	28.0 (21.0-35.0)	70.0 (60.0-79.0)	120 (111-135)	277
6–11 years	71.2 (65.8-77.1)	41.0 (34.0-45.0)	75.0 (68.0-83.0)	117 (110-133)	361
12–19 years	83.3 (79.3-87.4)	44.0 (38.0-48.0)	89.0 (83.0-93.0)	143 (138-148)	938
20–39 years	85.1 (80.1-90.4)	43.0 (37.0-51.0)	88.0 (80.0-97.0)	149 (138-162)	407
40–59 years	85.1 (81.7-88.6)	47.0 (41.0-52.0)	89.0 (83.0-96.0)	147 (131-162)	344
60 years and older	82.1 (76.7-87.7)	48.0 (42.0-52.0)	85.0 (77.0-95.0)	134 (130-139)	383
Males					
Total, 1 year and older	90.0 (86.1-94.1)	49.0 (45.0-55.0)	96.0 (90.0-99.0)	153 (143-162)	1348
1–5 years	61.6 (54.7-69.4)	28.0 (21.0-35.0)	65.0 (57.0-75.0)	120 (97.0-148)	152
6–11 years	71.4 (63.3-80.6)	42.0 (32.0-49.0)	74.0 (66.0-84.0)	115 (100-134)	198
12–19 years	94.1 (90.8-97.6)	53.0 (49.0-58.0)	97.0 (92.0-103)	156 (150-162)	481
20–39 years	102 (96.5-109)	62.0 (56.0-69.0)	107 (101-111)	162 (150-176)	170
40–59 years	101 (93.9-108)	62.0 (50.0-76.0)	102 (93.0-112)	151 (133-178)	152
60 years and older	87.3 (81.9-93.0)	44.0 (30.0-60.0)	95.0 (82.0-102)	141 (130-155)	195
Females					
Total, 1 year and older	70.8 (67.7-74.1)	36.0 (33.0-38.0)	76.0 (71.0-79.0)	127 (117-132)	1362
1–5 years	63.3 (56.3-71.1)	26.0 (16.0-37.0)	74.0 (58.0-86.0)	117 (105-138)	125
6–11 years	71.1 (64.4-78.4)	38.0 (22.0-51.0)	79.0 (70.0-84.0)	118 (110-129)	163
12–19 years	74.2 (66.6-82.7)	36.0 (30.0-46.0)	79.0 (71.0-87.0)	127 (96.0-144)	457
20–39 years	69.2 (61.3-78.1)	35.0 (30.0-41.0)	75.0 (66.0-84.0)	124 (111-129)	237
40–59 years	72.6 (68.4-77.0)	36.0 (27.0-47.0)	73.0 (66.0-83.0)	130 (116-154)	192
60 years and older	77.4 (70.5-85.1)	48.0 (37.0-57.0)	78.0 (72.0-86.0)	123 (109-137)	188

Table 3.2.c. Serum iron: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	71.7 (69.0-74.6)	38.0 (35.0-39.0)	75.0 (71.0-80.0)	122 (119-130)	1784
1–5 years	67.2 (60.0-75.3)	37.0 (30.0-50.0)	69.0 (62.0-80.0)	109 (96.0-125)	172
6–11 years	71.5 (67.2-76.1)	40.0 (34.0-48.0)	77.0 (73.0-80.0)	117 (103-124)	261
12–19 years	73.5 (68.0-79.4)	39.0 (33.0-42.0)	79.0 (71.0-84.0)	127 (118-138)	584
20–39 years	74.1 (70.0-78.5)	35.0 (31.0-41.0)	81.0 (74.0-83.0)	133 (122-147)	274
40–59 years	71.5 (66.6-76.8)	39.0 (34.0-45.0)	71.0 (66.0-80.0)	126 (112-139)	251
60 years and older	65.4 (61.5-69.5)	33.0 (30.0-40.0)	67.0 (65.0-72.0)	109 (99.0-119)	242
Males					
Total, 1 year and older	80.4 (76.3-84.7)	47.0 (39.0-52.0)	82.0 (78.0-85.0)	132 (121-141)	875
1–5 years	68.4 (60.4-77.6)	37.0† (33.0-40.0)	69.0 (58.0-80.0)	110† (88.0-149)	93
6–11 years	71.4 (65.7-77.6)	37.0 (28.0-50.0)	79.0 (73.0-84.0)	117 (103-122)	129
12–19 years	82.2 (77.7-86.9)	46.0 (41.0-54.0)	89.0 (82.0-94.0)	132 (121-138)	301
20–39 years	88.4 (82.2-95.0)	57.0 (44.0-67.0)	91.0 (82.0-98.0)	137 (120-153)	117
40–59 years	80.4 (71.8-90.1)	50.0 (31.0-55.0)	80.0 (70.0-94.0)	136 (119-157)	122
60 years and older	73.0 (66.1-80.5)	35.0 (32.0-54.0)	72.0 (64.0-81.0)	119 (101-141)	113
Females					
Total, 1 year and older	64.7 (62.1-67.4)	33.0 (30.0-36.0)	67.0 (65.0-70.0)	118 (110-122)	909
1–5 years	65.8 (56.5-76.7)	33.0† (21.0-54.0)	71.0 (60.0-82.0)	103† (97.0-123)	79
6–11 years	71.6 (66.3-77.3)	40.0 (27.0-49.0)	76.0 (69.0-80.0)	119 (101-128)	132
12–19 years	65.3 (57.6-74.1)	34.0 (22.0-40.0)	69.0 (60.0-81.0)	123 (108-135)	283
20–39 years	63.9 (59.3-68.9)	30.0 (20.0-33.0)	67.0 (61.0-77.0)	123 (112-159)	157
40–59 years	64.7 (58.2-71.9)	36.0 (31.0-45.0)	67.0 (60.0-71.0)	106 (91.0-115)	129
60 years and older	60.3 (57.3-63.3)	35.0 (29.0-40.0)	65.0 (58.0-68.0)	103 (86.0-116)	129

† Estimate is subject to greater uncertainty due to small cell size.

Table 3.2.d. Serum iron: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	84.0 (81.8-86.2)	47.0 (45.0-51.0)	88.0 (86.0-89.0)	139 (135-141)	2645
1–5 years	68.5 (63.2-74.3)	35.0 (25.0-44.0)	76.0 (66.0-85.0)	117 (109-132)	170
6–11 years	72.6 (67.2-78.5)	37.0 (30.0-41.0)	80.0 (66.0-90.0)	131 (113-146)	191
12–19 years	85.2 (81.2-89.4)	45.0 (40.0-51.0)	89.0 (85.0-91.0)	145 (137-153)	419
20–39 years	87.3 (81.7-93.3)	46.0 (41.0-56.0)	90.0 (85.0-96.0)	148 (139-158)	609
40–59 years	85.9 (82.0-90.0)	51.0 (48.0-54.0)	90.0 (85.0-96.0)	135 (129-140)	496
60 years and older	84.0 (80.4-87.8)	51.0 (47.0-56.0)	86.0 (84.0-90.0)	132 (127-139)	760
Males					
Total, 1 year and older	89.9 (86.9-92.9)	53.0 (50.0-56.0)	93.0 (90.0-96.0)	146 (141-151)	1315
1–5 years	67.7 (59.9-76.4)	33.0† (21.0-45.0)	72.0 (64.0-85.0)	118† (100-149)	91
6–11 years	70.0 (63.9-76.7)	32.0† (29.0-41.0)	79.0 (66.0-87.0)	115† (101-141)	101
12–19 years	94.4 (85.3-104)	52.0 (42.0-64.0)	97.0 (89.0-108)	161 (145-173)	214
20–39 years	94.8 (91.7-98.0)	60.0 (52.0-64.0)	95.0 (92.0-101)	154 (141-169)	265
40–59 years	95.3 (88.6-103)	59.0 (53.0-65.0)	98.0 (92.0-106)	140 (132-147)	254
60 years and older	87.6 (83.9-91.6)	53.0 (47.0-58.0)	88.0 (85.0-92.0)	146 (136-155)	390
Females					
Total, 1 year and older	78.5 (76.2-80.9)	43.0 (40.0-46.0)	84.0 (80.0-87.0)	132 (124-141)	1330
1–5 years	69.5 (62.4-77.5)	35.0† (25.0-40.0)	82.0 (58.0-88.0)	116† (108-132)	79
6–11 years	75.8 (64.4-89.1)	38.0† (24.0-50.0)	80.0 (60.0-99.0)	136† (118-155)	90
12–19 years	75.8 (68.3-84.1)	42.0 (36.0-46.0)	80.0 (69.0-87.0)	127 (115-144)	205
20–39 years	80.4 (72.7-89.0)	41.0 (29.0-47.0)	88.0 (74.0-96.0)	144 (130-161)	344
40–59 years	77.6 (74.6-80.6)	46.0 (39.0-51.0)	80.0 (72.0-85.0)	126 (113-135)	242
60 years and older	81.1 (76.2-86.3)	51.0 (43.0-58.0)	83.0 (79.0-87.0)	125 (113-135)	370

† Estimate is subject to greater uncertainty due to small cell size.

Table 3.3.a. Serum total iron-binding capacity: Total population

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for the total U.S. population, aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	366 (360-371)	297 (292-304)	367 (359-374)	447 (441-453)	7847
1–5 years	371 (359-383)	309 (286-322)	374 (361-384)	446 (434-454)	699
6–11 years	369 (361-378)	312 (295-320)	372 (361-380)	438 (423-444)	883
12–19 years	383 (374-391)	312 (301-328)	385 (377-392)	461 (451-471)	2124
20–39 years	365 (359-371)	299 (289-306)	363 (357-371)	450 (446-459)	1468
40–59 years	364 (359-370)	298 (291-305)	364 (354-373)	441 (433-453)	1195
60 years and older	353 (347-358)	284 (276-290)	355 (347-361)	437 (424-450)	1478
Males					
Total, 1 year and older	356 (349-364)	294 (287-300)	358 (351-365)	431 (421-438)	3860
1–5 years	375 (363-387)	306 (276-327)	379 (363-390)	449 (429-477)	385
6–11 years	364 (351-377)	304 (281-323)	366 (357-381)	426 (408-442)	460
12–19 years	374 (366-383)	313 (297-329)	379 (367-386)	448 (436-461)	1076
20–39 years	349 (341-357)	293 (282-298)	350 (342-358)	416 (402-432)	631
40–59 years	357 (350-364)	294 (289-302)	357 (351-365)	425 (409-436)	567
60 years and older	345 (337-353)	283 (269-288)	348 (338-357)	431 (409-446)	741
Females					
Total, 1 year and older	375 (370-381)	305 (298-309)	377 (369-383)	460 (454-465)	3987
1–5 years	366 (352-381)	307 (271-321)	369 (351-386)	439 (424-447)	314
6–11 years	375 (367-383)	312 (305-320)	374 (370-387)	441 (427-453)	423
12–19 years	391 (382-402)	312 (302-335)	393 (383-401)	475 (456-491)	1048
20–39 years	382 (375-390)	308 (303-316)	383 (374-397)	477 (463-485)	837
40–59 years	371 (365-378)	300 (290-310)	373 (360-384)	450 (442-466)	628
60 years and older	359 (354-364)	289 (282-296)	361 (354-371)	439 (424-457)	737

Table 3.3.b. Serum total iron-binding capacity: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for Mexican Americans in the U.S. population, aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	373 (363-384)	303 (288-314)	375 (366-385)	455 (438-478)	2707
1–5 years	378 (370-387)	316 (303-323)	377 (368-390)	453 (444-476)	274
6–11 years	379 (371-388)	320 (308-327)	385 (372-395)	441 (433-451)	361
12–19 years	396 (380-413)	328 (316-336)	395 (386-408)	486 (447-551)	938
20–39 years	370 (357-384)	299 (277-319)	375 (354-387)	457 (426-485)	407
40–59 years	365 (359-370)	291 (275-308)	367 (358-372)	439 (431-476)	344
60 years and older	345 (334-357)	277 (263-290)	350 (338-363)	415 (405-434)	383
Males					
Total, 1 year and older	365 (356-375)	301 (282-314)	370 (357-380)	437 (427-449)	1345
1–5 years	382 (370-394)	318 (299-329)	387 (368-396)	456 (436-492)	150
6–11 years	382 (371-393)	324 (313-337)	386 (366-403)	441 (425-452)	198
12–19 years	383 (374-392)	319 (304-330)	388 (381-395)	460 (448-469)	480
20–39 years	359 (344-374)	300 (275-319)	361 (348-380)	428 (411-442)	170
40–59 years	353 (345-361)	281 (270-305)	357 (347-367)	417 (403-437)	152
60 years and older	339 (327-352)	276 (250-288)	345 (324-362)	409 (383-434)	195
Females					
Total, 1 year and older	382 (370-395)	308 (293-318)	384 (373-393)	476 (449-504)	1362
1–5 years	374 (360-389)	316 (301-334)	368 (355-392)	449 (422-473)	124
6–11 years	376 (368-384)	315 (305-325)	383 (370-391)	449 (430-456)	163
12–19 years	409 (383-437)	337 (325-345)	405 (384-428)	529 (436-579)	458
20–39 years	384 (366-402)	301 (275-325)	383 (371-404)	485 (452-526)	237
40–59 years	376 (365-388)	299 (284-311)	374 (361-390)	475 (438-496)	192
60 years and older	351 (337-366)	276 (245-304)	354 (343-365)	421 (408-451)	188

Table 3.3.c. Serum total iron-binding capacity: Non-Hispanic blacks

[Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population, aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	354 (349-359)	287 (282-293)	354 (346-360)	435 (427-443)	1774
1–5 years	370 (363-377)	315 (306-334)	365 (360-375)	435 (415-455)	172
6–11 years	366 (362-371)	316 (303-327)	367 (360-375)	427 (418-434)	257
12–19 years	374 (368-379)	312 (301-321)	375 (370-380)	447 (432-460)	582
20–39 years	356 (346-366)	288 (273-301)	346 (341-360)	444 (428-475)	273
40–59 years	342 (332-353)	276 (262-286)	346 (331-359)	426 (409-443)	249
60 years and older	323 (315-331)	259 (242-271)	322 (315-330)	401 (380-435)	241
Males					
Total, 1 year and older	342 (337-348)	283 (266-291)	344 (340-349)	414 (407-421)	868
1–5 years	368 (358-378)	320† (295-340)	367 (359-381)	416† (401-435)	93
6–11 years	365 (358-372)	318 (306-328)	364 (355-374)	423 (409-431)	126
12–19 years	365 (360-371)	307 (293-317)	369 (360-376)	432 (416-450)	299
20–39 years	331 (320-342)	265 (253-288)	331 (314-344)	401 (367-428)	117
40–59 years	333 (319-347)	266 (222-296)	333 (313-362)	405 (384-423)	120
60 years and older	324 (317-331)	259 (232-282)	325 (313-338)	397 (375-421)	113
Females					
Total, 1 year and older	364 (359-370)	290 (283-298)	364 (354-375)	447 (441-457)	906
1–5 years	372 (360-384)	315† (286-334)	362 (351-382)	475† (415-481)	79
6–11 years	368 (359-376)	311 (295-329)	371 (353-384)	432 (417-443)	131
12–19 years	382 (374-391)	321 (304-328)	382 (372-390)	456 (433-487)	283
20–39 years	379 (370-387)	309 (293-319)	379 (362-398)	478 (436-496)	156
40–59 years	351 (337-365)	275 (262-296)	352 (338-368)	442 (414-448)	129
60 years and older	323 (310-336)	254 (235-276)	321 (306-333)	406 (375-450)	128

† Estimate is subject to greater uncertainty due to small cell size.

Table 3.3.d. Serum total iron-binding capacity: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in µg/dL) for non-Hispanic whites in the U.S. population, aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	367 (361-373)	300 (294-307)	367 (359-375)	448 (441-454)	2630
1–5 years	368 (349-387)	305 (265-331)	377 (351-394)	442 (424-451)	168
6–11 years	372 (363-382)	313 (304-321)	372 (359-388)	442 (413-467)	191
12–19 years	379 (368-391)	311 (293-328)	384 (374-395)	461 (448-474)	418
20–39 years	367 (362-371)	299 (291-307)	365 (359-374)	450 (442-463)	608
40–59 years	369 (362-376)	302 (294-314)	367 (354-379)	444 (433-458)	494
60 years and older	357 (351-362)	288 (284-293)	358 (349-368)	438 (427-454)	751
Males					
Total, 1 year and older	358 (350-366)	295 (286-302)	357 (350-366)	433 (419-442)	1306
1–5 years	370 (355-386)	301† (253-331)	379 (348-398)	446† (411-473)	90
6–11 years	364 (345-384)	304† (269-326)	367 (352-388)	426† (397-475)	101
12–19 years	372 (362-384)	310 (285-332)	377 (361-385)	447 (436-464)	213
20–39 years	351 (342-360)	296 (282-304)	352 (345-362)	418 (401-442)	264
40–59 years	364 (355-372)	301 (290-319)	362 (352-370)	426 (419-442)	253
60 years and older	347 (339-356)	284 (271-289)	348 (338-358)	434 (414-447)	385
Females					
Total, 1 year and older	376 (370-382)	306 (300-311)	378 (370-386)	461 (453-471)	1324
1–5 years	365 (338-395)	304† (201-336)	372 (334-401)	436† (398-457)	78
6–11 years	382 (374-391)	317† (313-338)	374 (370-393)	444† (427-467)	90
12–19 years	387 (375-400)	311 (295-335)	391 (378-403)	471 (450-479)	205
20–39 years	383 (375-391)	307 (303-316)	383 (367-401)	478 (454-495)	344
40–59 years	374 (365-384)	302 (289-317)	376 (355-389)	454 (440-479)	241
60 years and older	365 (360-370)	293 (287-307)	369 (359-376)	450 (424-471)	366

† Estimate is subject to greater uncertainty due to small cell size.

Table 3.4.a. Serum transferrin saturation: Total population

Geometric mean and selected percentiles of serum concentrations (in %) for the total U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	22.2 (21.6-22.9)	12.0 (11.4-12.5)	23.5 (22.8-24.1)	38.8 (37.8-40.4)	7845
1–5 years	17.6 (16.7-18.6)	8.20 (7.30-9.20)	19.4 (16.8-20.8)	32.9 (29.7-35.3)	697
6–11 years	19.4 (18.4-20.5)	10.4 (9.40-11.2)	21.1 (18.9-22.4)	34.4 (32.0-35.8)	883
12–19 years	21.5 (20.6-22.4)	11.3 (10.2-12.3)	22.5 (21.5-23.4)	38.7 (36.0-41.4)	2124
20–39 years	23.1 (22.2-24.2)	12.3 (11.2-12.7)	24.5 (23.4-25.5)	42.0 (40.0-44.2)	1468
40–59 years	22.9 (22.0-23.9)	13.1 (12.3-14.1)	23.8 (22.7-25.3)	38.6 (36.4-40.5)	1195
60 years and older	23.2 (22.2-24.3)	13.3 (12.4-14.3)	24.2 (23.1-25.1)	38.4 (36.8-39.6)	1478
Males					
Total, 1 year and older	24.7 (23.9-25.6)	14.0 (13.3-14.5)	25.8 (24.8-26.5)	41.8 (40.2-43.8)	3858
1–5 years	17.4 (16.5-18.3)	8.30 (6.80-9.80)	18.3 (16.6-19.8)	32.4 (29.0-34.6)	383
6–11 years	19.1 (17.7-20.7)	10.6 (8.80-11.7)	21.2 (18.9-22.4)	32.2 (28.4-35.5)	460
12–19 years	24.5 (22.9-26.2)	13.3 (11.5-14.5)	25.8 (24.3-26.9)	42.8 (36.3-50.4)	1076
20–39 years	26.9 (26.1-27.7)	16.3 (14.7-17.4)	27.1 (25.7-28.4)	45.9 (43.7-48.8)	631
40–59 years	26.2 (24.7-27.8)	16.0 (14.3-17.9)	26.8 (25.4-28.9)	41.6 (39.8-43.2)	567
60 years and older	25.1 (24.0-26.3)	14.5 (13.3-15.4)	25.9 (24.7-27.3)	41.7 (39.4-43.8)	741
Females					
Total, 1 year and older	20.1 (19.5-20.7)	10.4 (9.60-11.3)	21.3 (20.9-21.7)	35.8 (33.6-38.4)	3987
1–5 years	17.9 (15.9-20.1)	7.70 (5.90-10.4)	20.2 (16.2-23.2)	34.1 (29.2-37.1)	314
6–11 years	19.7 (17.8-21.7)	10.1 (8.30-12.2)	21.1 (17.9-23.8)	36.1 (32.6-38.8)	423
12–19 years	18.8 (17.6-20.0)	9.90 (9.10-10.9)	19.8 (18.4-20.9)	32.9 (31.0-36.6)	1048
20–39 years	20.0 (18.8-21.2)	9.00 (7.90-11.1)	21.4 (19.8-23.3)	38.4 (35.0-41.1)	837
40–59 years	20.2 (19.3-21.1)	11.5 (9.20-13.1)	21.5 (20.5-22.5)	34.8 (32.0-37.6)	628
60 years and older	21.7 (20.5-23.0)	12.8 (11.1-14.2)	22.3 (21.1-23.6)	35.4 (31.8-37.9)	737

Table 3.4.b. Serum transferrin saturation: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in %) for Mexican Americans in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	21.5 (20.5-22.5)	10.5 (9.90-11.4)	22.9 (21.6-24.0)	39.3 (37.0-41.2)	2707
1–5 years	16.6 (14.9-18.4)	7.20 (5.40-9.10)	18.3 (16.5-20.1)	32.9 (28.0-38.8)	274
6–11 years	18.8 (17.5-20.2)	10.7 (8.70-12.2)	19.9 (18.5-21.4)	30.8 (28.9-33.1)	361
12–19 years	21.1 (20.2-22.0)	10.6 (9.70-12.0)	22.0 (20.7-22.2)	38.6 (36.4-40.3)	938
20–39 years	23.0 (21.2-24.9)	12.1 (9.30-13.6)	24.2 (21.9-26.9)	41.2 (38.2-48.1)	407
40–59 years	23.4 (22.5-24.2)	12.5 (10.4-15.1)	24.7 (23.3-26.4)	41.1 (37.0-44.2)	344
60 years and older	23.6 (21.9-25.6)	13.2 (11.9-14.9)	24.0 (20.8-27.9)	41.4 (38.0-43.1)	383
Males					
Total, 1 year and older	24.6 (23.1-26.2)	13.2 (12.1-14.4)	25.8 (24.2-27.5)	43.7 (40.0-48.1)	1345
1–5 years	16.2 (14.2-18.5)	6.90 (5.10-8.60)	17.0 (15.0-19.8)	32.9 (25.6-41.5)	150
6–11 years	18.7 (16.8-20.8)	10.8 (8.60-12.9)	19.5 (18.2-21.3)	29.6 (27.4-34.2)	198
12–19 years	24.6 (23.3-26.0)	13.3 (12.1-14.9)	25.9 (24.3-27.3)	41.0 (38.7-44.1)	480
20–39 years	28.4 (26.0-30.9)	16.6 (14.6-19.5)	28.6 (25.0-33.0)	49.5 (41.8-56.0)	170
40–59 years	28.6 (26.8-30.5)	18.4 (14.1-21.2)	28.4 (26.7-30.8)	44.6 (40.9-49.3)	152
60 years and older	25.6 (23.9-27.5)	13.3 (10.4-16.3)	27.4 (23.2-30.4)	43.8 (38.5-49.0)	195
Females					
Total, 1 year and older	18.6 (17.5-19.7)	8.90 (8.00-10.0)	20.1 (18.9-21.2)	33.2 (31.0-35.8)	1362
1–5 years	17.1 (15.5-18.9)	6.80 (5.20-9.70)	19.8 (16.5-22.7)	33.4 (28.0-37.1)	124
6–11 years	18.9 (17.1-20.9)	10.4 (5.80-13.2)	20.3 (18.8-21.8)	30.8 (29.3-31.7)	163
12–19 years	18.2 (17.1-19.5)	8.70 (7.50-10.3)	19.7 (18.1-21.3)	33.4 (30.2-36.3)	458
20–39 years	18.1 (15.9-20.7)	8.10 (6.80-10.4)	19.0 (16.7-21.9)	32.5 (29.5-38.1)	237
40–59 years	19.3 (18.0-20.7)	8.90 (6.40-12.3)	20.6 (18.5-23.9)	34.1 (31.7-41.0)	192
60 years and older	21.9 (19.8-24.2)	12.8 (11.8-15.1)	23.0 (19.8-24.2)	35.0 (31.9-41.4)	188

Table 3.4.c. Serum transferrin saturation: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in %) for non-Hispanic blacks in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	20.3 (19.5-21.2)	9.90 (9.30-10.8)	21.6 (20.5-22.7)	36.5 (34.4-39.0)	1773
1–5 years	18.3 (16.4-20.3)	10.2 (8.20-12.5)	19.0 (16.1-21.6)	30.7 (26.6-38.1)	171
6–11 years	19.6 (18.3-21.0)	10.8 (8.60-12.7)	21.3 (19.6-22.3)	31.0 (29.4-34.4)	257
12–19 years	19.7 (18.2-21.3)	10.0 (8.80-11.3)	21.3 (20.0-22.7)	34.9 (32.2-38.3)	582
20–39 years	20.8 (19.4-22.4)	8.90 (7.50-10.7)	22.1 (20.4-24.9)	38.4 (35.3-44.2)	273
40–59 years	20.9 (19.3-22.6)	10.7 (8.50-12.9)	21.4 (19.3-23.2)	37.6 (34.3-42.1)	249
60 years and older	20.2 (18.9-21.6)	11.4 (9.40-12.9)	21.2 (19.6-22.5)	34.9 (30.6-39.0)	241
Males					
Total, 1 year and older	23.5 (22.4-24.8)	13.6 (12.5-14.7)	24.5 (22.5-26.1)	39.3 (36.2-41.8)	867
1–5 years	18.7 (16.6-21.2)	10.4† (9.00-12.4)	19.0 (15.5-22.5)	30.2† (24.6-40.8)	92
6–11 years	19.7 (17.8-21.7)	10.4 (7.90-13.7)	21.7 (18.9-24.0)	30.1 (28.0-34.3)	126
12–19 years	22.5 (21.3-23.8)	12.2 (11.1-14.4)	24.2 (22.4-25.6)	36.5 (33.6-39.3)	299
20–39 years	26.7 (24.8-28.8)	17.4 (14.3-19.8)	27.1 (24.9-30.1)	40.3 (35.7-45.8)	117
40–59 years	24.2 (21.7-27.0)	13.9 (10.9-16.3)	23.9 (21.4-28.0)	42.2 (37.1-46.8)	120
60 years and older	22.6 (20.8-24.4)	12.9 (11.4-15.8)	22.4 (20.6-24.3)	38.1 (32.1-41.6)	113
Females					
Total, 1 year and older	17.8 (16.9-18.7)	8.60 (7.40-9.30)	19.2 (17.9-20.2)	34.3 (31.6-36.0)	906
1–5 years	17.7 (15.2-20.6)	9.40† (5.30-12.7)	19.4 (14.7-21.8)	29.4† (26.4-38.1)	79
6–11 years	19.5 (17.8-21.3)	11.5 (6.70-14.1)	21.0 (18.7-22.5)	32.7 (29.4-35.3)	131
12–19 years	17.1 (14.9-19.5)	8.10 (5.50-10.8)	18.9 (15.5-21.5)	32.3 (28.2-37.0)	283
20–39 years	16.9 (15.5-18.4)	7.30 (5.40-8.70)	18.0 (15.9-20.1)	37.4 (33.1-41.7)	156
40–59 years	18.5 (16.3-20.9)	9.90 (6.90-12.0)	19.9 (17.1-21.8)	31.5 (27.1-35.0)	129
60 years and older	18.6 (17.2-20.0)	9.40 (8.70-11.8)	19.9 (17.8-21.7)	31.3 (28.5-35.0)	128

† Estimate is subject to greater uncertainty due to small cell size.

Table 3.4.d. Serum transferrin saturation: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in %) for non-Hispanic whites in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	22.9 (22.0-23.8)	12.6 (11.7-13.2)	24.0 (23.2-24.9)	39.6 (38.3-41.5)	2629
1–5 years	18.7 (16.9-20.6)	9.20 (6.80-11.4)	20.8 (16.5-23.9)	34.0 (29.2-36.7)	167
6–11 years	19.5 (17.9-21.2)	9.90 (8.50-11.6)	21.2 (17.0-23.2)	35.7 (32.0-38.8)	191
12–19 years	22.4 (21.1-23.8)	11.6 (10.2-13.2)	23.2 (21.8-24.1)	41.4 (36.3-44.8)	418
20–39 years	23.8 (22.3-25.5)	12.7 (10.9-14.6)	25.1 (23.5-26.3)	43.5 (40.9-45.2)	608
40–59 years	23.4 (22.0-24.8)	14.0 (12.8-15.1)	24.1 (22.8-25.8)	38.6 (35.6-41.5)	494
60 years and older	23.5 (22.3-24.7)	13.6 (12.4-14.7)	24.5 (23.3-25.6)	38.5 (36.8-39.4)	751
Males					
Total, 1 year and older	25.1 (23.9-26.4)	14.4 (13.3-15.3)	25.9 (24.5-27.1)	43.0 (40.2-45.2)	1305
1–5 years	18.5 (16.4-20.8)	9.10† (6.80-12.3)	20.1 (16.5-23.1)	33.2† (28.8-36.7)	89
6–11 years	19.2 (17.1-21.7)	9.90† (6.10-11.7)	21.6 (17.5-23.4)	32.4† (28.7-36.4)	101
12–19 years	25.3 (22.8-28.0)	13.4 (11.3-14.5)	26.0 (23.0-29.0)	45.2 (38.4-57.1)	213
20–39 years	27.0 (26.2-27.9)	16.4 (14.5-18.0)	26.7 (25.2-28.8)	46.3 (44.1-48.9)	264
40–59 years	26.2 (24.0-28.6)	16.1 (14.1-18.5)	26.2 (24.6-29.2)	40.5 (38.6-43.8)	253
60 years and older	25.3 (24.0-26.7)	14.2 (13.0-15.9)	26.1 (25.0-27.8)	41.9 (39.2-45.4)	385
Females					
Total, 1 year and older	20.9 (20.1-21.7)	11.5 (10.4-12.4)	22.0 (21.1-22.9)	36.6 (34.0-39.2)	1324
1–5 years	19.0 (16.4-21.9)	9.20† (5.10-11.9)	21.1 (15.4-24.5)	34.2† (29.7-41.2)	78
6–11 years	19.8 (16.8-23.4)	10.2† (6.60-12.8)	21.1 (15.3-26.2)	38.4† (34.7-40.6)	90
12–19 years	19.6 (17.4-22.0)	10.1 (9.00-13.6)	19.9 (18.1-22.6)	33.0 (30.7-38.7)	205
20–39 years	21.1 (18.9-23.5)	10.9 (7.80-13.0)	23.0 (19.4-26.3)	39.2 (35.0-42.6)	344
40–59 years	20.8 (19.9-21.7)	12.4 (10.9-13.8)	21.9 (20.4-22.9)	35.6 (31.5-41.0)	241
60 years and older	22.1 (20.8-23.5)	13.1 (11.4-14.8)	22.8 (21.3-24.4)	36.1 (31.8-38.4)	366

† Estimate is subject to greater uncertainty due to small cell size.

Table 3.5.a. Erythrocyte protoporphyrin: Total population

Geometric mean and selected percentiles of red blood cell concentrations (in µg/dL) for the total U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	47.6 (46.7-48.6)	33.0 (32.0-33.0)	46.0 (44.0-47.0)	72.0 (70.0-73.0)	7985
1–5 years	47.8 (45.9-49.9)	32.0 (31.0-34.0)	45.0 (42.0-48.0)	69.0 (67.0-72.0)	728
6–11 years	45.2 (42.7-47.8)	31.0 (29.0-34.0)	45.0 (42.0-48.0)	65.0 (60.0-72.0)	905
12–19 years	46.0 (44.5-47.5)	33.0 (31.0-34.0)	45.0 (43.0-46.0)	70.0 (67.0-73.0)	2139
20–39 years	46.7 (45.5-47.9)	31.0 (30.0-32.0)	44.0 (42.0-44.0)	72.0 (69.0-76.0)	1477
40–59 years	48.3 (47.3-49.3)	34.0 (32.0-35.0)	45.0 (44.0-47.0)	71.0 (67.0-75.0)	1217
60 years and older	51.1 (50.1-52.1)	33.0 (32.0-34.0)	48.0 (48.0-50.0)	76.0 (73.0-80.0)	1519
Males					
Total, 1 year and older	42.9 (41.9-44.0)	30.0 (30.0-32.0)	41.0 (40.0-43.0)	59.0 (58.0-61.0)	3926
1–5 years	47.2 (45.0-49.5)	31.0 (30.0-34.0)	46.0 (43.0-49.0)	68.0 (64.0-73.0)	401
6–11 years	44.1 (41.4-47.0)	31.0 (28.0-33.0)	43.0 (41.0-47.0)	61.0 (54.0-72.0)	473
12–19 years	41.6 (40.0-43.2)	30.0 (29.0-32.0)	41.0 (39.0-42.0)	56.0 (53.0-59.0)	1082
20–39 years	40.5 (38.8-42.2)	30.0 (28.0-31.0)	39.0 (37.0-40.0)	58.0 (54.0-61.0)	634
40–59 years	43.1 (42.2-44.2)	32.0 (30.0-33.0)	41.0 (40.0-42.0)	57.0 (55.0-61.0)	578
60 years and older	47.2 (46.3-48.1)	32.0 (32.0-34.0)	45.0 (43.0-46.0)	71.0 (66.0-76.0)	758
Females					
Total, 1 year and older	52.7 (51.5-53.9)	35.0 (34.0-37.0)	49.0 (48.0-51.0)	79.0 (77.0-82.0)	4059
1–5 years	48.6 (45.3-52.2)	34.0 (31.0-36.0)	45.0 (42.0-50.0)	71.0 (66.0-77.0)	327
6–11 years	46.4 (43.5-49.4)	32.0 (30.0-35.0)	46.0 (42.0-48.0)	68.0 (62.0-75.0)	432
12–19 years	51.1 (49.2-53.0)	34.0 (32.0-37.0)	49.0 (47.0-51.0)	76.0 (71.0-81.0)	1057
20–39 years	53.8 (52.5-55.0)	36.0 (36.0-37.0)	49.0 (49.0-51.0)	83.0 (78.0-89.0)	843
40–59 years	53.6 (51.3-56.0)	36.0 (34.0-37.0)	51.0 (48.0-52.0)	83.0 (74.0-93.0)	639
60 years and older	54.4 (52.5-56.5)	37.0 (34.0-38.0)	52.0 (49.0-55.0)	80.0 (75.0-85.0)	761

Table 3.5.b. Erythrocyte protoporphyrin: Mexican Americans

Geometric mean and selected percentiles of red blood cell concentrations (in µg/dL) for Mexican Americans in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	52.3 (50.8-53.9)	35.0 (33.0-36.0)	49.0 (48.0-51.0)	84.0 (80.0-88.0)	2741
1–5 years	53.6 (50.5-56.9)	38.0 (35.0-40.0)	50.0 (48.0-52.0)	79.0 (71.0-94.0)	283
6–11 years	51.8 (49.6-54.1)	34.0 (33.0-38.0)	49.0 (47.0-53.0)	81.0 (73.0-87.0)	368
12–19 years	53.9 (50.6-57.5)	35.0 (34.0-37.0)	50.0 (48.0-52.0)	89.0 (73.0-116)	942
20–39 years	50.6 (47.7-53.7)	32.0 (32.0-36.0)	47.0 (45.0-51.0)	80.0 (71.0-93.0)	410
40–59 years	53.8 (52.0-55.8)	34.0 (33.0-36.0)	52.0 (48.0-55.0)	88.0 (79.0-94.0)	345
60 years and older	53.1 (50.8-55.4)	34.0 (33.0-37.0)	51.0 (47.0-54.0)	82.0 (77.0-86.0)	393
Males					
Total, 1 year and older	46.6 (45.1-48.1)	31.0 (29.0-33.0)	45.0 (43.0-46.0)	69.0 (66.0-71.0)	1361
1–5 years	55.4 (51.6-59.5)	39.0 (34.0-40.0)	52.0 (47.0-53.0)	84.0 (72.0-120)	156
6–11 years	50.6 (47.6-53.8)	37.0 (33.0-40.0)	48.0 (46.0-53.0)	73.0 (62.0-90.0)	200
12–19 years	47.5 (46.1-48.9)	33.0 (31.0-36.0)	45.0 (43.0-46.0)	70.0 (66.0-74.0)	482
20–39 years	42.7 (40.6-44.8)	31.0 (27.0-34.0)	41.0 (40.0-43.0)	61.0 (54.0-66.0)	172
40–59 years	45.9 (43.8-48.2)	32.0 (29.0-35.0)	44.0 (41.0-47.0)	66.0 (61.0-78.0)	153
60 years and older	47.7 (45.4-50.2)	33.0 (29.0-35.0)	46.0 (41.0-49.0)	73.0 (67.0-86.0)	198
Females					
Total, 1 year and older	59.2 (57.0-61.5)	38.0 (37.0-40.0)	56.0 (54.0-58.0)	96.0 (88.0-108)	1380
1–5 years	51.4 (47.8-55.3)	37.0 (31.0-41.0)	48.0 (45.0-53.0)	71.0 (64.0-88.0)	127
6–11 years	53.2 (50.8-55.7)	34.0 (33.0-38.0)	51.0 (48.0-54.0)	86.0 (73.0-89.0)	168
12–19 years	60.8 (55.0-67.1)	40.0 (38.0-42.0)	57.0 (53.0-61.0)	110 (69.0-127)	460
20–39 years	61.3 (56.1-67.0)	39.0 (36.0-42.0)	58.0 (52.0-63.0)	101 (81.0-138)	238
40–59 years	62.5 (60.3-64.8)	37.0 (34.0-41.0)	60.0 (56.0-64.0)	100 (90.0-119)	192
60 years and older	58.5 (55.6-61.5)	39.0 (36.0-41.0)	56.0 (53.0-59.0)	85.0 (80.0-97.0)	195

Table 3.5.c. Erythrocyte protoporphyrin: Non-Hispanic blacks

Geometric mean and selected percentiles of red blood cell concentrations (in µg/dL) for non-Hispanic blacks in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	47.4 (45.8-49.1)	31.0 (30.0-33.0)	44.0 (43.0-47.0)	72.0 (69.0-75.0)	1817
1–5 years	45.4 (43.1-47.8)	31.0 (28.0-33.0)	45.0 (42.0-48.0)	61.0 (57.0-68.0)	180
6–11 years	44.9 (42.7-47.2)	30.0 (29.0-31.0)	44.0 (42.0-46.0)	63.0 (58.0-71.0)	270
12–19 years	45.2 (43.0-47.5)	31.0 (28.0-32.0)	42.0 (40.0-44.0)	67.0 (63.0-75.0)	587
20–39 years	48.0 (44.9-51.3)	32.0 (29.0-34.0)	45.0 (40.0-49.0)	76.0 (67.0-84.0)	277
40–59 years	48.3 (46.0-50.7)	32.0 (31.0-34.0)	46.0 (43.0-48.0)	71.0 (62.0-93.0)	255
60 years and older	51.0 (48.2-54.0)	34.0 (32.0-38.0)	48.0 (45.0-51.0)	78.0 (70.0-86.0)	248
Males					
Total, 1 year and older	41.9 (40.1-43.9)	29.0 (28.0-32.0)	41.0 (39.0-43.0)	58.0 (56.0-62.0)	890
1–5 years	45.4 (42.7-48.3)	31.0† (28.0-36.0)	46.0 (39.0-49.0)	61.0† (53.0-68.0)	98
6–11 years	43.4 (41.6-45.3)	30.0 (27.0-32.0)	43.0 (40.0-45.0)	60.0 (56.0-70.0)	134
12–19 years	40.5 (39.0-42.1)	29.0 (28.0-31.0)	39.0 (37.0-40.0)	57.0 (51.0-63.0)	301
20–39 years	39.3 (36.2-42.7)	29.0 (26.0-32.0)	38.0 (34.0-40.0)	54.0 (45.0-67.0)	117
40–59 years	42.7 (40.7-44.8)	30.0 (27.0-32.0)	42.0 (38.0-43.0)	57.0 (52.0-63.0)	123
60 years and older	47.5 (43.9-51.4)	32.0 (26.0-36.0)	46.0 (41.0-50.0)	71.0 (62.0-80.0)	117
Females					
Total, 1 year and older	53.0 (51.1-54.8)	34.0 (33.0-37.0)	50.0 (48.0-53.0)	82.0 (77.0-88.0)	927
1–5 years	45.4 (42.0-49.0)	31.0† (28.0-33.0)	43.0 (39.0-49.0)	68.0† (58.0-79.0)	82
6–11 years	46.5 (42.6-50.8)	30.0 (29.0-33.0)	45.0 (41.0-49.0)	72.0 (62.0-76.0)	136
12–19 years	50.7 (46.2-55.6)	35.0 (32.0-37.0)	46.0 (44.0-50.0)	79.0 (65.0-94.0)	286
20–39 years	56.6 (52.7-60.7)	37.0 (33.0-39.0)	54.0 (51.0-58.0)	82.0 (71.0-104)	160
40–59 years	53.6 (49.4-58.3)	34.0 (31.0-37.0)	53.0 (48.0-56.0)	84.0 (70.0-99.0)	132
60 years and older	53.8 (50.5-57.3)	36.0 (34.0-39.0)	51.0 (46.0-52.0)	82.0 (70.0-105)	131

† Estimate is subject to greater uncertainty due to small cell size.

Table 3.5.d. Erythrocyte protoporphyrin: Non-Hispanic whites

Geometric mean and selected percentiles of red blood cell concentrations (in µg/dL) for non-Hispanic whites in the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 1 year and older	46.3 (45.4-47.3)	31.0 (30.0-32.0)	43.0 (43.0-45.0)	68.0 (66.0-70.0)	2674
1–5 years	45.8 (43.0-48.8)	31.0 (30.0-34.0)	44.0 (40.0-47.0)	67.0 (60.0-72.0)	177
6–11 years	43.3 (39.7-47.2)	31.0 (27.0-34.0)	43.0 (40.0-46.0)	61.0 (53.0-73.0)	192
12–19 years	44.2 (42.1-46.3)	32.0 (29.0-33.0)	44.0 (41.0-45.0)	62.0 (58.0-72.0)	423
20–39 years	45.1 (43.5-46.8)	32.0 (30.0-32.0)	44.0 (42.0-44.0)	69.0 (61.0-73.0)	610
40–59 years	46.7 (45.8-47.6)	34.0 (32.0-35.0)	45.0 (43.0-46.0)	66.0 (63.0-71.0)	502
60 years and older	50.3 (49.5-51.0)	34.0 (32.0-34.0)	48.0 (47.0-50.0)	75.0 (72.0-78.0)	770
Males					
Total, 1 year and older	42.0 (40.8-43.2)	30.0 (30.0-32.0)	41.0 (40.0-42.0)	58.0 (56.0-60.0)	1330
1–5 years	44.1 (41.3-47.0)	31.0† (28.0-33.0)	44.0 (40.0-47.0)	64.0† (55.0-67.0)	95
6–11 years	41.9 (37.8-46.5)	29.0† (26.0-33.0)	41.0 (39.0-45.0)	61.0† (49.0-72.0)	103
12–19 years	40.7 (38.1-43.5)	28.0 (26.0-32.0)	41.0 (37.0-43.0)	54.0 (49.0-59.0)	215
20–39 years	39.1 (37.5-40.9)	29.0 (25.0-30.0)	37.0 (35.0-39.0)	53.0 (49.0-59.0)	265
40–59 years	42.7 (41.3-44.2)	32.0 (28.0-34.0)	41.0 (40.0-43.0)	56.0 (52.0-60.0)	258
60 years and older	46.4 (45.3-47.4)	33.0 (32.0-34.0)	43.0 (42.0-45.0)	67.0 (64.0-74.0)	394
Females					
Total, 1 year and older	51.0 (49.7-52.3)	35.0 (34.0-37.0)	47.0 (46.0-49.0)	75.0 (73.0-80.0)	1344
1–5 years	47.9 (42.0-54.7)	34.0† (31.0-36.0)	42.0 (38.0-49.0)	69.0† (60.0-93.0)	82
6–11 years	45.0 (40.8-49.5)	32.0† (29.0-35.0)	44.0 (39.0-50.0)	60.0† (55.0-77.0)	89
12–19 years	48.4 (46.0-50.9)	33.0 (32.0-37.0)	47.0 (45.0-50.0)	73.0 (67.0-77.0)	208
20–39 years	51.9 (49.2-54.8)	36.0 (34.0-39.0)	48.0 (47.0-49.0)	81.0 (72.0-99.0)	345
40–59 years	51.0 (48.8-53.3)	36.0 (34.0-37.0)	49.0 (45.0-52.0)	74.0 (68.0-83.0)	244
60 years and older	53.7 (51.8-55.7)	36.0 (34.0-39.0)	52.0 (49.0-56.0)	79.0 (73.0-84.0)	376

† Estimate is subject to greater uncertainty due to small cell size.

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4

Trace Elements

- Iodine
- Selenium

Trace Elements:
Iodine

Iodine, a trace element found in soil, is an essential component of the thyroid hormones involved in regulating the body's metabolic processes. Iodized salt and seafood are the major dietary sources of iodine. In the United States, salt is iodized with potassium iodide at 100 parts per million (76 milligram [mg] of iodine per kilogram [kg] of salt). Iodized salt is chosen by about 50–60 percent of the U.S. population (Institute of Medicine 2001). Still, most ingested salt comes from processed food (approximately 70 percent), which is typically not iodized in either the United States or in Canada (The Public Health Committee of the American Thyroid Association 2006).

For the thyroid to synthesize thyroid hormones, iodine is essential. Iodine deficiency disorders include mental retardation, hypothyroidism, goiter, cretinism, and varying degrees of other growth and developmental abnormalities. Iodine deficiency is the most preventable cause of mental retardation in the world (World Health Organization 2007). Thyroid enlargement (goiter) is usually the earliest clinical feature of iodine deficiency. Thyroid hormone is particularly important in the development of the central nervous system during the fetal and early postnatal periods. In areas where iodized salt is common, iodine deficiency is rare.

The median intake of iodine from food in the United States is approximately 240 to 300 micrograms (µg) per day for men and 190 to 210 µg/day for women, largely owing to the iodization of salt (Institute of Medicine 2001). Iodine deficiency develops when iodide intake is less than 20 µg/day (Beers 2006). Most dietary iodine absorbed in the body eventually appears in the urine; thus, urinary iodine excretion is recommended for assessing recent dietary iodine intake worldwide (World Health Organization 2007).

Excess iodine intake may also result in goiter, as well as in hyper- or hypothyroidism. High iodine intake has also been associated with increased risk for thyroid papillary cancer (Institute of Medicine 2001). For most people, iodine intake from usual foods and supplements is unlikely to exceed the tolerable upper intake level (1,100 µg/day).

The Institute of Medicine recommends iodine intake at 150 µg per day for nonpregnant adults, 220 µg per day for pregnant women and 290 µg per day during lactation (Institute of Medicine 2001).

World Health Organization (WHO) categories for median urinary iodine concentrations in school-age children and adults (excluding pregnant and lactating women) are widely used to define iodine intake and nutrition status for populations (World Health Organization 2007) (Table 4.a). An additional adequacy criterion is that not more than 20 percent of samples from children and non-pregnant women are below 50 nanograms per milliliter (ng/mL) of iodine.

Table 4.a Epidemiological criteria for assessing iodine nutrition based on median urinary iodine concentrations of school-age children (≥ 6 years)*

Median Urinary Iodine (ng/mL)	Iodine Intake	Iodine Status
< 20	Insufficient	Severe iodine deficiency
20–49	Insufficient	Moderate iodine deficiency
50–99	Insufficient	Mild iodine deficiency
100–199	Adequate	Adequate iodine nutrition
200–299	Above requirements	Likely to provide adequate intake for pregnant/lactating women but may pose a slight risk of more than adequate intake in the overall population
> 300	Excessive	Risk for adverse health consequences (e.g., iodine-induced hyperthyroidism, autoimmune thyroid diseases)

*Applies to adults but not to pregnant and lactating women

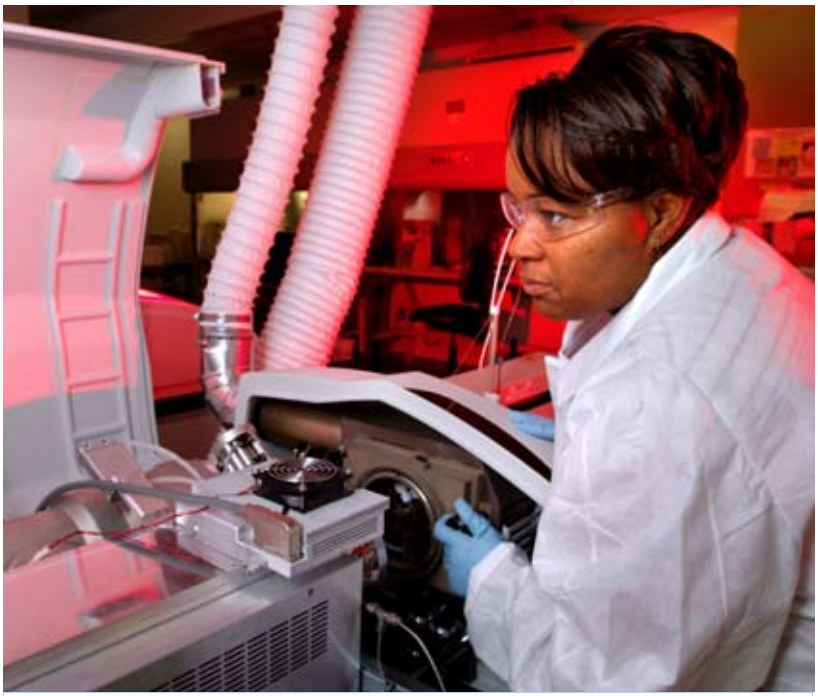
Note that these categories are useful for classifying population risk but are not categories to define individual risk for adverse health outcomes. The large day-to-day variations in urine iodine excretion, even among individuals with stable iodine intake, tend to offset one another when the sample includes an adequately large number (50–100 people per site) of representative individuals (Borak 2005).

For pregnant women, median urinary iodine concentrations of 150–249 ng/mL represent adequate iodine intake (World Health Organization 2007).

The Public Health Committee of the American Thyroid Association (2006) has recommended that until additional physiologic data are available to determine the appropriate requirements during pregnancy and lactation, iodine supplementation (150 µg/day) is appropriate for these two life stages in the United States and in

Canada. This decision was based on data for pregnant women from NHANES III and NHANES 2001–2002: median urinary iodine concentrations were lower than recommended during NHANES III (141 ng/mL) and within the recommended range during NHANES 2001–2002 (173 ng/mL), but 95 percent confidence intervals ranged from 75 to 229 ng/mL (Caldwell 2005).

For more information about iodine, see the Institute of Medicine's Dietary Reference Intake report (Institute of Medicine 2001) as well as information from the American Society for Nutrition (http://jn.nutrition.org/nutinfo/).



Chemist performs maintenance on instrumentation used to measure urinary iodine.

Since 1971, NHANES has measured urinary iodine. The NHANES III survey (1988–1994) showed a sizable decrease in urinary iodine concentrations compared with concentrations measured during NHANES I (1971–1974) (Hollowell 1998). This decline may have been due to the dairy industry's effort in the mid-1980s to reduce the iodine residue in milk from feed supplements and iodophor sanitizing agents (Pennington 1996). Decreased concentrations of iodine in fruit-flavored breakfast cereals—the industry's response to a ban on erythrosine (an iodine-containing food dye)—could also have contributed to the decline in urinary iodine concentrations (Pennington 1996). Since 2000, urinary iodine has been measured in the continuous NHANES survey. CDC uses a new method, involving inductively coupled plasma mass spectrometry (ICP-MS), to make these measurements (Caldwell 2003). This method has been compared with the established Sandell-Kolthoff spectrophotometric method used in NHANES III (Pino 1998). The two methods strongly correlate ($r^2 = 0.98$), and the average difference between them is not statistically significant (Caldwell 2003). When CDC laboratory scientists used this new method to measure urinary iodine concentrations in NHANES 2000 (U.S. Centers for Disease Control and Prevention 2000) and NHANES 2001–2002 (Caldwell 2005), they found that the U.S. median urinary iodine concentration had stabilized since the initial drop that had occurred from NHANES I to NHANES III. This finding confirms the stability of the U.S. iodine intake and continued adequate iodine nutrition for the country generally.

Selected Observations and Highlights

The following example observations and figures are taken from the uncorrected tables of 2001–2002 data contained in this report. Statements about categorical differences between demographic groups noted below are based on non-overlapping confidence limits from univariate analysis without adjusting for demographic variables (i.e., age, sex, race/ethnicity) or other determinants of these urine concentrations (i.e., dietary intake, supplement usage, smoking, BMI). A multivariate analysis may alter the size and statistical significance of these categorical differences. Furthermore, additional significant differences of smaller magnitude may be present despite their lack of mention here (e.g., if confidence limits slightly overlap or if differences are not statistically significant before covariate adjustment has occurred). For a selection of citations of descriptive NHANES papers related to these biochemical indicators of diet and nutrition, see Appendix E.

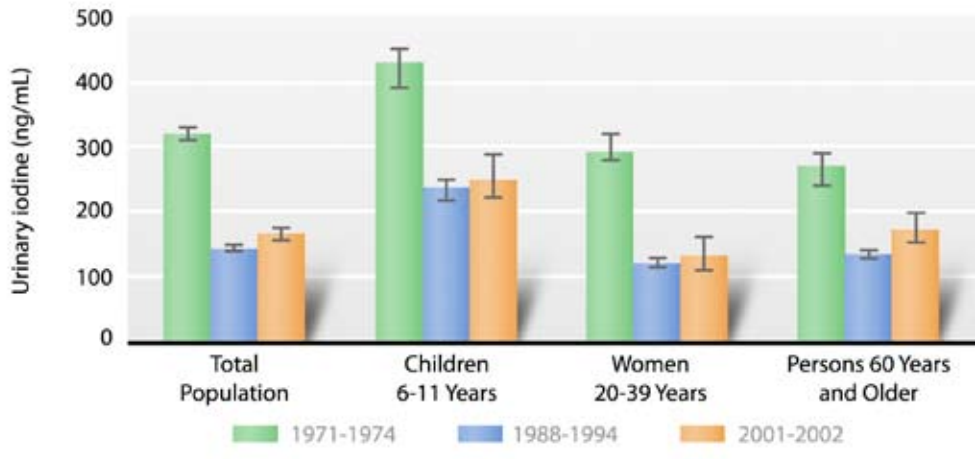
General Observations

- Children (aged 6–11 years) have higher urinary iodine concentrations than people in any other age group.
- Females have lower urinary iodine concentrations than males.

Highlights

After a sharp decline that occurred from 1971–1988, from 1988–2002 median concentrations of urinary iodine appear to have stabilized in various population subgroups (Fig 4.a). This finding has been shown previously (Caldwell 2005).

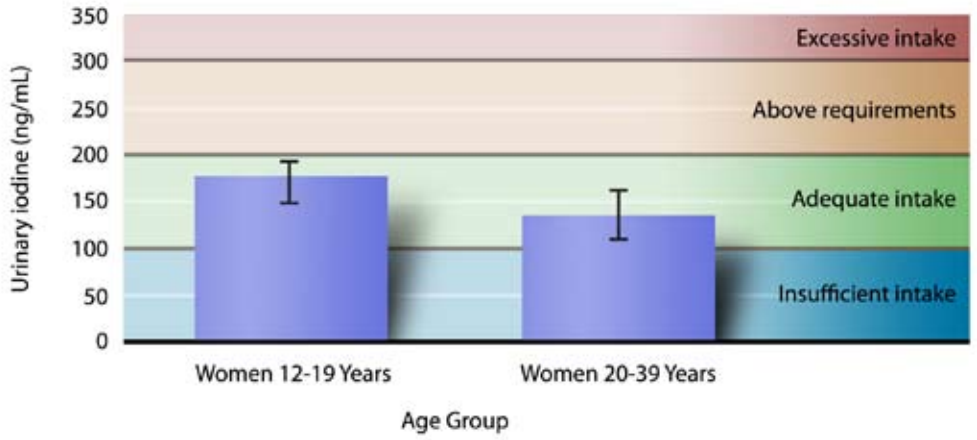
Figure 4.a



Median concentrations (95 percent confidence intervals) of urinary iodine in the U.S. population, aged 6 years and older, and in population subgroups, National Health and Nutrition Examination Survey, 1971–2002. Data shown for NHANES 1971–1974 and 1988–1994 are not part of the tables displayed in this report but were analyzed separately to generate this figure.

On the basis of median urinary iodine concentrations, the iodine intake of women of childbearing age appears adequate (Fig 4.b). Appropriate consideration should be given, however, to the higher intake recommendation for pregnant women (World Health Organization 2007).

Figure 4.b



Median concentrations (95 percent confidence intervals) of urinary iodine among women of childbearing age, National Health and Nutrition Examination Survey, 2001–2002.

Table 4.1.a. Urinary iodine: Total population

Geometric mean and selected percentiles of urine concentrations (in ng/mL) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	162 (152-172)	44.0 (41.0-49.0)	167 (158-176)	503 (466-543)	2837
6–11 years	235 (208-266)	78.0 (61.0-89.0)	249 (221-289)	682 (571-737)	374
12–19 years	192 (178-207)	58.0 (42.0-68.0)	206 (189-214)	594 (511-693)	831
20–39 years	148 (132-166)	49.0 (34.0-58.0)	153 (136-175)	429 (356-482)	627
40–59 years	140 (121-162)	37.0 (25.0-45.0)	142 (118-169)	478 (403-577)	496
60 years and older	177 (156-200)	57.0 (49.0-65.0)	173 (152-199)	524 (440-633)	509
Males					
Total, 6 years and older	192 (178-208)	64.0 (54.0-73.0)	197 (179-209)	542 (478-619)	1333
6–11 years	250 (213-294)	86.0 (55.0-126)	266 (223-316)	682 (498-864)	185
12–19 years	238 (214-265)	75.0 (67.0-104)	234 (210-271)	639 (545-896)	386
20–39 years	176 (155-200)	63.0 (48.0-89.0)	178 (143-213)	425 (345-479)	271
40–59 years	169 (147-194)	44.0 (35.0-71.0)	172 (149-207)	496 (391-596)	255
60 years and older	211 (172-258)	75.0 (40.0-102)	202 (163-249)	615 (417-904)	236
Females					
Total, 6 years and older	137 (127-148)	37.0 (31.0-43.0)	140 (127-157)	458 (421-516)	1504
6–11 years	220 (182-267)	64.0 (44.0-88.0)	239 (185-293)	638 (524-738)	189
12–19 years	154 (137-173)	40.0 (28.0-62.0)	174 (148-193)	454 (368-587)	445
20–39 years	127 (105-153)	34.0 (23.0-53.0)	133 (108-162)	425 (314-507)	356
40–59 years	115 (93.2-141)	28.0 (22.0-36.0)	111 (78.0-146)	456 (292-695)	241
60 years and older	155 (135-177)	51.0 (44.0-62.0)	156 (117-189)	440 (349-550)	273

Table 4.1.b. Urinary iodine: Mexican Americans

Geometric mean and selected percentiles of urine concentrations (in ng/mL) for Mexican Americans in the U.S. population, age 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	176 (163-189)	56.0 (45.0-60.0)	186 (167-205)	487 (442-518)	720
6–11 years	241 (210-277)	95.0 (62.0-150)	231 (193-297)	621 (487-699)	112
12–19 years	179 (161-198)	56.0 (40.0-72.0)	190 (160-213)	524 (392-583)	266
20–39 years	168 (142-198)	50.0 (40.0-66.0)	173 (141-218)	442 (375-534)	166
40–59 years	156 (124-197)	31.0† (14.0-74.0)	169 (146-215)	472† (380-700)	90
60 years and older	152 (131-176)	56.0† (36.0-75.0)	156 (115-203)	427† (303-477)	86
Males					
Total, 6 years and older	201 (173-233)	60.0 (43.0-79.0)	203 (172-236)	524 (442-792)	325
6–11 years	246 (190-318)	76.0† (42.0-138)	246 (174-374)	677† (469-926)	53
12–19 years	190 (163-221)	58.0 (33.0-100)	198 (153-226)	511 (344-583)	113
20–39 years	195 (146-261)	58.0† (28.0-79.0)	197 (137-255)	495† (374-1170)	75
40–59 years	191 (134-274)	37.0† (15.0-146)	193 (154-311)	453† (346-713)	48
60 years and older	209 (165-265)	82.0† (13.0-161)	203 (154-345)	455† (324-1210)	36
Females					
Total, 6 years and older	151 (136-168)	45.0 (31.0-60.0)	169 (137-202)	441 (370-480)	395
6–11 years	237 (193-290)	107† (79.0-150)	218 (179-297)	510† (370-656)	59
12–19 years	167 (143-194)	46.0 (32.0-62.0)	189 (146-213)	506 (351-676)	153
20–39 years	140 (109-179)	40.0† (22.0-69.0)	167 (97.0-247)	331† (294-480)	91
40–59 years	123 (85.4-178)	22.0† (7.00-58.0)	125 (86.0-178)	433† (186-532)	42
60 years and older	120 (94.1-154)	51.0† (28.0-61.0)	111 (82.0-158)	299† (158-521)	50

† Estimate is subject to greater uncertainty due to small cell size.

Table 4.1.c. Urinary iodine: Non-Hispanic blacks

Geometric mean and selected percentiles of urine concentrations (in ng/mL) for non-Hispanic blacks in the U.S. population, age 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	156 (137-178)	54.0 (45.0-65.0)	143 (124-173)	478 (402-608)	670
6–11 years	247 (201-302)	97.0 (67.0-138)	257 (175-311)	600 (467-954)	121
12–19 years	183 (151-221)	62.0 (43.0-78.0)	172 (156-200)	555 (384-695)	248
20–39 years	145 (117-181)	58.0 (31.0-95.0)	134 (106-169)	398 (306-478)	121
40–59 years	136 (99.7-185)	44.0† (31.0-57.0)	120 (82.0-197)	627† (275-923)	106
60 years and older	127 (91.6-176)	40.0† (18.0-64.0)	112 (94.0-129)	268† (213-525)	74
Males					
Total, 6 years and older	161 (143-181)	55.0 (39.0-68.0)	156 (134-173)	540 (414-681)	325
6–11 years	259 (201-334)	90.0† (53.0-149)	240 (175-318)	932† (496-1100)	61
12–19 years	201 (162-249)	65.0 (50.0-101)	186 (161-214)	624 (381-873)	120
20–39 years	161 (127-204)	69.0† (23.0-126)	149 (127-183)	459† (242-745)	57
40–59 years	120 (83.6-171)	31.0† (11.0-65.0)	113 (76.0-180)	594† (180-1010)	55
60 years and older	120 (79.4-183)	45.0† (25.0-99.0)	119 (56.0-232)	320† (156-525)	32
Females					
Total, 6 years and older	153 (128-182)	53.0 (41.0-60.0)	135 (108-174)	449 (352-608)	345
6–11 years	234 (177-309)	97.0† (73.0-138)	257 (143-334)	531† (424-744)	60
12–19 years	167 (134-207)	38.0 (32.0-68.0)	168 (146-186)	487 (366-670)	128
20–39 years	135 (103-176)	53.0† (47.0-86.0)	121 (92.0-176)	340† (201-471)	64
40–59 years	152 (104-223)	50.0† (36.0-65.0)	124 (65.0-352)	702† (350-994)	51
60 years and older	132 (69.1-252)	30.0† (16.0-73.0)	104 (66.0-200)	255† (208-1780)	42

† Estimate is subject to greater uncertainty due to small cell size.

Table 4.1.d. Urinary iodine: Non-Hispanic whites

Geometric mean and selected percentiles of urine concentrations (in ng/mL) for non-Hispanic whites in the U.S. population, age 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	163 (150-176)	44.0 (40.0-49.0)	169 (158-179)	511 (468-569)	1222
6–11 years	229 (195-270)	61.0† (44.0-92.0)	266 (206-327)	682† (516-738)	111
12–19 years	205 (182-231)	59.0 (41.0-81.0)	214 (192-240)	619 (537-769)	248
20–39 years	148 (125-176)	47.0 (27.0-63.0)	157 (133-185)	421 (324-507)	280
40–59 years	139 (115-168)	35.0 (23.0-45.0)	138 (107-169)	480 (387-659)	258
60 years and older	185 (161-211)	56.0 (48.0-68.0)	186 (163-200)	552 (435-670)	325
Males					
Total, 6 years and older	199 (180-221)	64.0 (51.0-78.0)	204 (187-219)	548 (470-653)	575
6–11 years	247 (192-319)	92.0† (37.0-139)	271 (206-320)	682† (389-864)	57
12–19 years	279 (246-316)	97.0 (67.0-150)	280 (223-344)	696 (586-1020)	116
20–39 years	179 (149-215)	63.0 (44.0-95.0)	181 (136-247)	407 (323-468)	112
40–59 years	174 (146-206)	43.0 (35.0-75.0)	172 (141-212)	477 (389-659)	132
60 years and older	224 (178-282)	80.0 (40.0-107)	212 (168-271)	633 (417-1040)	158
Females					
Total, 6 years and older	135 (122-149)	35.0 (28.0-43.0)	140 (122-157)	473 (419-569)	647
6–11 years	211 (153-291)	58.0† (24.0-124)	225 (129-399)	689† (451-895)	54
12–19 years	153 (126-185)	40.0 (21.0-62.0)	175 (127-194)	454 (323-740)	132
20–39 years	126 (95.4-166)	28.0 (20.0-53.0)	133 (96.0-169)	425 (303-576)	168
40–59 years	110 (83.1-144)	28.0 (22.0-36.0)	96.0 (67.0-152)	480 (265-873)	126
60 years and older	159 (140-181)	52.0 (43.0-65.0)	158 (121-194)	444 (365-634)	167

† Estimate is subject to greater uncertainty due to small cell size.

Table 4.1.e. Urinary iodine: Total population (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	163 (153-173)	64.5 (59.5-68.3)	151 (141-165)	437 (406-470)	2835
6–11 years	273 (246-304)	116 (101-131)	257 (219-321)	699 (608-817)	374
12–19 years	149 (137-161)	66.7 (59.9-70.2)	138 (129-146)	364 (297-479)	830
20–39 years	135 (127-143)	56.7 (51.2-63.7)	128 (116-136)	346 (307-431)	627
40–59 years	151 (130-175)	59.5 (52.5-66.3)	141 (119-176)	407 (300-478)	496
60 years and older	216 (192-244)	87.2 (75.8-97.2)	200 (176-230)	518 (452-629)	508
Males					
Total, 6 years and older	156 (143-171)	59.6 (53.1-69.1)	145 (136-161)	415 (368-501)	1333
6–11 years	292 (263-325)	123 (92.0-148)	321 (260-359)	774 (533-963)	185
12–19 years	162 (144-182)	63.8 (58.1-72.5)	151 (136-181)	412 (303-578)	386
20–39 years	131 (122-141)	57.9 (49.7-65.6)	119 (107-136)	341 (273-470)	271
40–59 years	133 (112-158)	52.5 (43.9-60.2)	134 (103-162)	315 (269-423)	255
60 years and older	200 (168-238)	74.8 (57.6-94.9)	190 (145-238)	474 (362-704)	236
Females					
Total, 6 years and older	170 (161-179)	67.6 (63.1-70.5)	158 (146-169)	449 (426-508)	1502
6–11 years	254 (213-303)	109 (95.1-119)	220 (195-298)	631 (481-978)	189
12–19 years	136 (124-149)	66.8 (59.7-71.2)	128 (111-137)	337 (265-434)	444
20–39 years	139 (127-153)	56.1 (48.6-68.2)	133 (116-144)	359 (299-449)	356
40–59 years	171 (148-198)	65.4 (56.0-78.4)	155 (133-186)	436 (392-576)	241
60 years and older	230 (199-265)	96.9 (81.8-113)	207 (179-251)	571 (446-667)	272

Table 4.1.f. Urinary iodine: Mexican Americans (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	164 (152-176)	65.4 (61.8-74.5)	154 (140-178)	424 (344-467)	720
6–11 years	298 (253-350)	135 (104-162)	304 (239-344)	726 (469-939)	112
12–19 years	144 (132-157)	65.2 (53.5-82.7)	132 (119-149)	314 (255-445)	266
20–39 years	146 (127-168)	63.0 (54.9-70.8)	143 (109-175)	328 (248-492)	166
40–59 years	142 (124-164)	62.0† (40.1-83.0)	140 (117-186)	325† (241-479)	90
60 years and older	200 (170-234)	74.3† (61.9-112)	195 (156-245)	452† (391-765)	86
Males					
Total, 6 years and older	157 (137-181)	62.2 (53.8-74.4)	150 (125-182)	428 (308-522)	325
6–11 years	300 (227-395)	141† (93.0-193)	304 (209-375)	766† (459-1090)	53
12–19 years	133 (116-151)	61.1 (49.3-81.4)	123 (108-146)	282 (182-493)	113
20–39 years	144 (115-181)	57.3† (49.4-69.3)	143 (102-182)	328† (202-613)	75
40–59 years	130 (98.3-172)	58.9† (9.93-108)	129 (103-214)	294† (241-405)	48
60 years and older	193 (130-287)	84.0† (60.9-117)	180 (110-342)	452† (245-765)	36
Females					
Total, 6 years and older	172 (154-192)	74.1 (63.2-83.7)	159 (139-184)	428 (339-534)	395
6–11 years	296 (233-375)	130† (90.6-163)	304 (198-373)	726† (428-1070)	59
12–19 years	157 (136-182)	73.9 (60.8-82.9)	141 (119-168)	364 (255-778)	153
20–39 years	147 (123-176)	65.4† (42.9-89.7)	145 (108-190)	316† (210-466)	91
40–59 years	159 (115-218)	70.0† (40.1-119)	143 (95.1-233)	408† (230-705)	42
60 years and older	204 (158-265)	66.3† (58.5-122)	195 (143-257)	437† (331-1110)	50

† Estimate is subject to greater uncertainty due to small cell size.

Table 4.1.g. Urinary iodine: Non-Hispanic blacks (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	113 (103-124)	45.7 (41.3-51.0)	103 (92.5-115)	321 (257-381)	669
6–11 years	209 (161-273)	89.7 (75.5-110)	206 (121-293)	510 (393-775)	121
12–19 years	110 (93.7-128)	45.9 (36.8-58.8)	95.5 (87.7-114)	303 (208-406)	247
20–39 years	94.6 (86.0-104)	42.8 (37.1-55.4)	88.3 (82.4-104)	190 (172-247)	121
40–59 years	101 (82.3-124)	37.9† (23.6-55.9)	98.7 (69.1-130)	339† (218-441)	106
60 years and older	122 (93.7-160)	51.3† (38.8-59.3)	102 (93.5-117)	339† (175-394)	74
Males					
Total, 6 years and older	102 (87.9-119)	37.9 (29.0-48.1)	95.6 (79.1-118)	305 (260-356)	325
6–11 years	208 (148-292)	84.0† (75.0-107)	204 (109-321)	510† (356-802)	61
12–19 years	111 (89.6-138)	44.9 (33.7-60.7)	99.1 (80.0-119)	332 (201-479)	120
20–39 years	90.0 (78.5-103)	37.6† (27.9-53.9)	83.8 (63.3-109)	300† (153-362)	57
40–59 years	74.7 (54.5-102)	26.9† (7.53-54.1)	73.6 (41.3-148)	188† (116-280)	55
60 years and older	105 (85.8-129)	50.6† (35.5-67.1)	97.1 (69.5-134)	211† (126-359)	32
Females					
Total, 6 years and older	123 (111-135)	51.9 (46.3-57.8)	108 (98.7-117)	329 (239-414)	344
6–11 years	211 (152-293)	101† (33.7-124)	214 (120-328)	478† (297-915)	60
12–19 years	108 (94.4-124)	45.9 (36.4-62.9)	94.3 (87.7-106)	257 (189-468)	127
20–39 years	98.2 (82.4-117)	48.6† (37.1-67.5)	90.4 (75.0-115)	184† (157-235)	64
40–59 years	133 (99.2-178)	48.3† (44.6-65.4)	117 (79.3-162)	441† (303-699)	51
60 years and older	136 (83.5-222)	51.3† (38.8-71.8)	107 (94.7-115)	270† (120-9060)	42

† Estimate is subject to greater uncertainty due to small cell size.

Table 4.1.h. Urinary iodine: Non-Hispanic whites (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 2001–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	175 (163-188)	69.2 (64.5-72.4)	164 (151-177)	452 (420-517)	1221
6–11 years	290 (256-328)	121† (98.2-148)	298 (214-366)	738† (570-857)	111
12–19 years	159 (145-175)	70.2 (62.5-75.3)	143 (129-175)	353 (297-578)	248
20–39 years	145 (133-157)	64.5 (52.9-69.7)	133 (121-144)	386 (322-451)	280
40–59 years	159 (133-191)	62.0 (55.9-69.8)	147 (123-191)	416 (315-562)	258
60 years and older	232 (203-265)	102 (84.3-116)	211 (188-249)	567 (455-667)	324
Males					
Total, 6 years and older	167 (149-187)	66.5 (55.6-76.5)	156 (142-175)	432 (371-532)	575
6–11 years	320 (268-383)	134† (98.2-157)	359 (237-379)	785† (404-1200)	57
12–19 years	182 (160-206)	67.4 (57.8-89.1)	180 (143-229)	559 (297-710)	116
20–39 years	139 (122-158)	66.9 (49.7-78.7)	126 (107-145)	352 (228-514)	112
40–59 years	140 (115-171)	54.7 (43.9-64.8)	137 (99.2-179)	369 (276-439)	132
60 years and older	215 (175-264)	81.1 (54.1-116)	197 (159-263)	514 (366-830)	158
Females					
Total, 6 years and older	182 (172-193)	69.6 (65.3-74.3)	169 (158-183)	468 (431-569)	646
6–11 years	260 (201-336)	106† (85.9-132)	215 (167-368)	631† (449-978)	54
12–19 years	140 (121-162)	69.2 (59.7-73.5)	131 (103-148)	328 (264-434)	132
20–39 years	150 (130-172)	62.7 (47.2-69.7)	138 (122-161)	397 (322-451)	168
40–59 years	182 (150-221)	69.6 (60.7-84.5)	177 (122-231)	437 (387-730)	126
60 years and older	246 (209-289)	109 (89.4-132)	212 (192-278)	571 (446-700)	166

† Estimate is subject to greater uncertainty due to small cell size.

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Trace Elements:
Selenium

Selenium is a trace mineral essential to good health. The major dietary source of selenium is plant foods. Selenium concentrations in plants generally reflect the concentration of selenium in soils, but some meats and seafood can also contribute dietary selenium; in the United States, meats and bread are common sources. Depending on foodstuff origin, variation in its selenium content can be between 11- and 72-fold; thus, predicting dietary intake by relying on estimates from nutrient databases is difficult (Keck 2006).

Selenium functions through selenoproteins, several of which are oxidant-defense enzymes. For example, the selenium-dependent glutathione peroxidase defends the body against oxidative stress. Other selenium-associated proteins regulate the action of thyroid hormones and the oxidation-reduction status of vitamin C and other molecules (Institute of Medicine 2000). Most selenium in animal tissues is present as selenomethionine or selenocysteine.

Selenium deficiency in the United States is rare, but it is seen in other countries, most notably in China, where the concentration of selenium in soil is low. In the United States, most cases of selenium depletion or deficiency are associated with severe gastrointestinal problems, such as Crohn's disease, or with the surgical removal of part of the stomach, and are therefore a result of impaired selenium absorption (Kuroki 2003; Rannem 1992; Bjerre 1989).

By itself, selenium deficiency does not usually cause illness. Rather, it can make the body more susceptible to illnesses caused by other nutritional, biochemical, or infectious stresses (Beck 2003). Three specific diseases have been associated with selenium deficiency. Keshan disease occurs only in selenium-deficient children and is associated with an enlarged heart and poor heart function. Kashin-Beck disease is a disorder of the bones and joints of the hands and fingers, elbows, knees, and ankles of children and adolescents. Lastly, myxedematous endemic cretinism, a condition that results in mental retardation, occurs in infants born to mothers deficient in both selenium and iodine (Institute of Medicine 2000).

Chemists review selenium data.

Evidence is limited as to whether intakes of selenium greater than the amount needed to allow full expression of selenoproteins may have chemopreventive effects against cancer. Controlled intervention studies are needed to adequately evaluate selenium as a cancer chemopreventive agent (Institute of Medicine 2000).

Blood concentrations of selenium greater than 1,000 nanograms per milliliter (ng/mL) (12.7 micromoles per liter [µmol/L]) can result in a condition known as selenosis (Koller 1986). Manifestations of selenosis include gastrointestinal upset, hair loss, white blotchy nails, garlic-breath odor, fatigue, irritability, and mild nerve damage (Goldhaber 2003).

The National Academy of Sciences has established an estimated average requirement (EAR) for selenium that is based on the amount needed to maximize plasma glutathione peroxidase activity and prevent Keshan disease. The EAR is the average daily nutrient intake level estimated to meet the requirement of half of the healthy individuals in a particular life stage and sex group. The EAR for selenium for boys and girls 9–13 years old or 14–18 years old is 35 and 45 micrograms (µg) daily, respectively. For healthy children aged 1–3 years or 4–8 years, the currently recommended EAR for selenium is 17 and 23 µg daily, respectively. These values are extrapolated from adult values (Institute of Medicine 2000).

A diagnosis of selenium deficiency is confirmed by measuring concentrations of selenium in serum or plasma. Values less than 70 ng/mL or 0.8 µmol/L suggest synthesis of selenium-associated proteins has not yet reached a plateau and that selenium supplies are limited (Institute of Medicine 2000).

For more information about selenium, see the Institute of Medicine's Dietary Reference Intake report (Institute of Medicine 2000), the selenium fact sheet from the National Institutes of Health, Office of Dietary Supplements (http://ods.od.nih.gov/factsheets/selenium.asp), as well as information from the American Society for Nutrition (http://jn.nutrition.org/nutinfo/).

Using serum selenium concentrations measured in the U.S. population in NHANES III (1988–1994), it appears that the diets of most U.S. residents provide the recommended amounts of selenium (Niskar 2003). The mean and median serum selenium concentrations were 1.58 µmol/L and 1.56 µmol/L, respectively. Serum selenium concentrations differed by age, sex, race, ethnicity, poverty-income ratio, and geographic region. In NHANES 2001–2002, less than 3 percent of survey participants had a dietary intake of selenium below the EAR (Moshfegh 2005).

Selected Observations and Highlights

The following example observations are taken from the tables of 1999-2000 data contained in this report. Only data for children were available for the NHANES survey period covered in this report. Statements about categorical differences between demographic groups noted below are based on non-overlapping confidence limits from univariate analysis without adjusting for demographic variables (i.e., age, sex, race/ethnicity) or other determinants of these blood concentrations (i.e., dietary intake, supplement usage, smoking, BMI). A multivariate analysis may alter the size and statistical significance of these categorical differences. Furthermore, additional significant differences of smaller magnitude may be present despite their lack of mention here (e.g., if confidence limits slightly overlap or if differences are not statistically significant before covariate adjustment has occurred). For a selection of citations of descriptive NHANES papers related to these biochemical indicators of diet and nutrition, see Appendix E.

General Observations

- Younger children (aged 3–5 years) have lower serum selenium concentrations than do older children (aged 6–11 years).
- At least 90 percent of 3–11 year-old children have adequate serum concentrations of selenium.

Highlights

The majority of U.S. children (> 90 percent) have adequate serum concentrations of selenium (≥ 70 ng/mL). No evidence has surfaced of excessive exposure to selenium (> 1,000 ng/mL) in U.S. children.

Table 4.2.a. Serum selenium: Total population

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total,3-11 years	112 (110-114)	93.0 (91.0-96.0)	113 (111-114)	130 (127-133)	1186
3–5 years	107 (104-110)	90.0 (83.0-94.0)	110 (105-112)	128 (124-131)	343
6–11 years	114 (111-116)	95.0 (93.0-102)	113 (111-116)	130 (128-134)	843
Males					
Total,3-11 years	113 (110-116)	94.0 (91.0-98.0)	114 (111-116)	134 (129-137)	626
3–5 years	108 (103-112)	87.0 (64.0-95.0)	108 (104-112)	129 (123-136)	188
6–11 years	115 (111-119)	96.0 (91.0-104)	114 (110-121)	134 (129-137)	438
Females					
Total,3-11 years	111 (108-113)	93.0 (90.0-96.0)	112 (110-116)	128 (126-131)	560
3–5 years	107 (102-111)	89.0 (72.0-96.0)	110 (105-115)	126 (119-131)	155
6–11 years	112 (109-115)	93.0 (89.0-98.0)	113 (109-117)	128 (126-131)	405

Table 4.2.b. Serum selenium: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total,3-11 years	110 (107-113)	93.0 (87.0-96.0)	109 (106-113)	126 (123-131)	477
3–5 years	108 (104-112)	90.0 (83.0-98.0)	107 (103-113)	124 (120-129)	131
6–11 years	111 (108-114)	95.0 (91.0-100)	111 (107-114)	128 (123-133)	346
Males					
Total,3-11 years	111 (108-115)	93.0 (85.0-98.0)	111 (108-114)	129 (125-135)	262
3–5 years	109 (105-113)	87.0† (83.0-99.0)	108 (104-114)	125† (120-135)	71
6–11 years	112 (109-116)	93.0 (87.0-100)	111 (107-115)	133 (126-135)	191
Females					
Total,3-11 years	108 (105-112)	95.0 (89.0-98.0)	108 (105-114)	123 (118-126)	215
3–5 years	106 (100-112)	89.0† (76.0-98.0)	105 (100-112)	123† (116-130)	60
6–11 years	109 (106-112)	96.0 (87.0-99.0)	111 (105-114)	123 (118-132)	155

† Estimate is subject to greater uncertainty due to small cell size.

Table 4.2.c. Serum selenium: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total,3-11 years	107 (104-110)	91.0 (87.0-94.0)	107 (104-111)	124 (120-126)	341
3–5 years	104 (101-107)	91.0† (84.0-94.0)	104 (102-109)	121† (116-125)	98
6–11 years	108 (105-112)	92.0 (87.0-94.0)	108 (105-112)	124 (121-130)	243
Males					
Total,3-11 years	108 (105-112)	91.0 (86.0-94.0)	109 (104-113)	124 (118-130)	173
3–5 years	104 (99.4-109)	83.0† (50.0-91.0)	105 (103-112)	118† (113-131)	56
6–11 years	110 (106-115)	92.0 (86.0-101)	110 (105-115)	126 (119-133)	117
Females					
Total,3-11 years	106 (104-108)	91.0 (87.0-95.0)	107 (103-109)	122 (118-124)	168
3–5 years	105 (101-109)	93.0† (84.0-96.0)	103 (98.0-112)	120† (112-127)	42
6–11 years	106 (104-109)	92.0 (87.0-96.0)	106 (103-110)	121 (118-124)	126

† Estimate is subject to greater uncertainty due to small cell size.

Table 4.2.d. Serum selenium: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total,3-11 years	113 (110-116)	94.0 (90.0-102)	116 (112-118)	130 (127-135)	265
3–5 years	107 (102-113)	87.0† (57.0-103)	114 (105-118)	130† (123-133)	81
6–11 years	115 (111-119)	94.0 (90.0-104)	116 (111-120)	131 (127-136)	184
Males					
Total,3-11 years	113 (109-118)	93.0 (91.0-102)	114 (109-121)	134 (128-137)	140
3–5 years	106 (98.9-114)	87.0† (57.0-99.0)	105 (99.0-122)	125† (123-135)	41
6–11 years	116 (110-122)	102† (84.0-110)	115 (110-123)	134† (129-139)	99
Females					
Total,3-11 years	112 (108-117)	94.0 (80.0-102)	116 (111-119)	130 (126-132)	125
3–5 years	108 (101-117)	80.0† (33.0-107)	114 (107-118)	130† (120-133)	40
6–11 years	114 (109-119)	93.0† (79.0-105)	118 (110-120)	130† (126-135)	85

† Estimate is subject to greater uncertainty due to small cell size.

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5

Isoflavones & Lignans

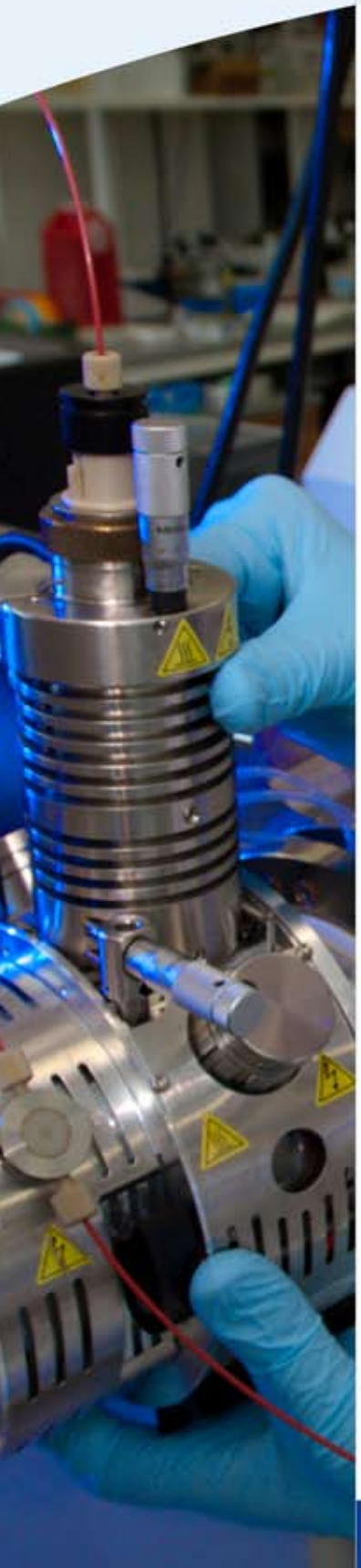
(so-called Phytoestrogens)

Isoflavones

- Genistein
- Daidzein
- Equol
- O-Desmethylangolensin

Lignans

- Enterodiol
- Enterolactone



Isoflavones & Lignans
(so-called Phytoestrogens)

Phytoestrogens are naturally occurring polycyclic phenols found in certain plants that may, when ingested and metabolized, have weak estrogenic effects. Two important groups of phytoestrogens are isoflavones and lignans. The isoflavones considered in this report are daidzein, genistein, O-desmethylangolensin (ODMA), and equol. The lignans considered in this report are enterodiol and enterolactone.

Plant sources of isoflavones include legumes, with the largest contribution coming from soy-based foods. Since soy flour and soy protein isolates may be added to processed meats, meat substitutes, breads, and protein-food bars, these items can be a major source of isoflavones (Grace 2004; Lampe 1999). However, the isoflavone content of soy protein preparations can vary widely and is affected by production techniques (Erdman 2004). Daidzein and genistein are the main soy isoflavones. Kudzu root, used in some dietary supplements, also contains appreciable amounts of daidzein. Naringenin, a precursor to genistein, is found in some citrus fruits. Formononetin and biochanin A are methylated isoflavones found in clovers, which may be used in red clover dietary supplements, and they are metabolized in the body to daidzein and genistein, respectively. Ingested daidzein is further metabolized to ODMA and to equol by intestinal bacteria. Equol, but not ODMA, has estrogenic activity. About 30 percent of adults produce equol and have higher serum equol concentrations after they consume daidzein (Setchell 2003a; Cassidy 2006). This ability to produce equol may be related to an individual's intestinal microflora and influenced by dietary habits (Rowland 2000; Setchell 2006). It is unclear whether the ability to produce equol results in any health-related effects (Vafeiadou 2006).

Lignans include matairesinol and secoisolariciresinol, which are transformed by intestinal bacteria into the estrogenic compounds, enterolactone, and enterodiol, respectively (Cornwell 2004; Rowland 2003). Enterodiol may also convert into enterolactone and vice versa. Lignans are found in flax seeds, whole wheat flour, tea, some fruits, and other cereal grains.

Diet is the source of human exposure to phytoestrogens. The absorption and metabolism of phytoestrogens varies considerably among individuals, which may relate to differences in absorption, enterohepatic circulation, and metabolism by intestinal bacteria. Phytoestrogens are ingested in their naturally occurring *beta*-glycosidic forms. The *beta*-glycosidic forms are hydrolyzed to their aglycones in the intestine, absorbed, and then linked in the intestinal wall and liver with glucuronic acid to make them more water-soluble, a process known as glucuronidation (Doerge 2000; Rowland 2003). The glucuronidated metabolites of isoflavones predominate in blood and urine (Setchell 2001).

Isoflavones are excreted from the body within about 24 hours after ingestion, mainly in urine and, to a lesser extent, in feces (Setchell 2001). Urinary concentrations of daidzein and genistein may not correlate well with the ingested doses, perhaps because of the limited absorption of these isoflavones at higher doses (Setchell 2003b). In contrast, lignan concentrations in plasma and urine concentrations after flax seed consumption increases in a dose-dependent manner (Nesbitt 1999). Equol excretion may depend on diet, the type of intestinal bacteria present, and individual genetic factors (Rowland 2000; Setchell 2002; Setchell 1999).

Generally, phytoestrogens are much less potent than endogenously produced estrogens, but phytoestrogens can be present in much greater quantities (100 to 1000 times the concentration of endogenous estrogens). Additionally, phytoestrogens bind less tightly to steroid-hormone serum-transport proteins than do endogenous estrogens (Nagel 1998). Equol has more potent estrogen activity than its precursor daidzein and has been proposed to be most important in explaining the mechanism of action of isoflavones in disease prevention (Setchell 2002).

In comparison with Western diets, Asian diets typically provide higher intakes of soy-based foods. Some have suggested that the higher isoflavone intake in Asian diets may account for the lower incidence among Asians of menopause-related symptoms and for other associated beneficial health outcomes, such as reduced risk for breast, prostate, and colon cancer; cardiovascular health; and modulation of osteoporosis. A recent evidence report from the Agency for Healthcare Research and Quality (Balk 2005) about the effects of soy on health outcomes reported that there is no conclusive evidence of a dose-response effect of either soy protein or isoflavone on cardiovascular diseases, menopausal symptoms, endocrine function, cancer, bone health, reproductive health, kidney diseases, cognitive function, or glucose metabolism. For reducing low-density lipoprotein concentrations, however, soy protein could possibly have a dose-response effect.

Adverse effects on fertility have been observed in animals that graze on red clover. Results of chronic feeding studies in pregnant animals suggest that high doses of

phytoestrogens alter the fetal hormonal environment (Cornwell 2004). Infants who consume soy-based formula can have plasma concentrations of isoflavones that are 13,000–22,000 times higher than concentrations of endogenous estrogen in infants (Setchell 1997). Yet, studies of children who had been fed soy-based formula as infants and who were followed through adolescence (Klein 1998) and young adulthood (Strom 2001) found no adverse reproductive or endocrine effects. In vitro and animal studies also suggest that soy isoflavones may have immunologic and thyroid effects (Doerge 2002). The Center for the Evaluation of Risks to Human Reproduction of the National Toxicology Program reviewed the developmental and reproductive toxicity of both soy formula and genistein and concluded that available data were inadequate to determine the effects of soy formula on developmental or reproductive toxicity (Rozman 2006a). The expert review panel expressed negligible concern for adverse effects in the general population of consuming dietary sources of genistein: under current exposure conditions, adults would be unlikely to consume sufficient daily levels of genistein to cause adverse reproductive and/or developmental effects (Rozman 2006b).

For more information about soy isoflavones, see the fact sheet from the National Institutes of Health, Office of Dietary Supplements (http://ods.od.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx).

Phytoestrogens have been measured in NHANES since 1999. In NHANES 1999–2000, CDC scientists detected enterolactone in the highest concentration, and daidzein was detected with the highest frequency among the six measured phytoestrogens (Valentin-Blasini 2005). CDC's Third National Report on Human Exposure to Environmental Chemicals has presented geometric means and selected percentiles (50th, 75th, 90th, and 95th) for concentrations of phytoestrogens by age, sex, and race/ethnicity for participants in NHANES 1999–2000 and 2001–2002 (U.S. Centers for Disease Control and Prevention 2005).

Chemist verifies sample for phytoestrogen analysis.

Selected Observations and Highlights

The following example observations are taken from the uncorrected tables of 1999–2002 data contained in this report. Statements about categorical differences between demographic groups noted below are based on non-overlapping confidence limits from univariate analysis without adjusting for demographic variables (i.e., age, sex, race/ethnicity) or other determinants of these urine concentrations (i.e., dietary intake, supplement usage, smoking, BMI). A multivariate analysis may alter the size and statistical significance of these categorical differences. Furthermore, additional significant differences of smaller magnitude may be present despite their lack of mention here (e.g., if confidence limits slightly overlap or if differences are not statistically significant before covariate adjustment has occurred). For a selection of citations of descriptive NHANES papers related to these biochemical indicators of diet and nutrition, see Appendix E.

General Observations

- Urinary isoflavone (genistein, daidzein, equol, and ODMA) concentrations are generally lower in adults than they are in children and adolescents, whereas urinary lignan concentrations either do not differ by age (enterodiol) or show a U-shaped age pattern (enterolactone).
- Males and females have similar phytoestrogen concentrations.
- Non-Hispanic whites have higher equol concentrations than non-Hispanic blacks and Mexican Americans. Mexican Americans have lower ODMA concentrations than non-Hispanic blacks and non-Hispanic whites.

Highlights

Urinary isoflavone and lignan concentrations show only small variations by demographic variables such as age, sex, or race/ethnicity.

Table 5.1.a. Urinary genistein: Total population

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	28.5 (25.5-31.8)	3.27 (2.70-4.17)	28.4 (25.7-30.7)	293 (253-330)	5351
6–11 years	33.8 (29.3-39.1)	5.80 (4.20-7.05)	31.8 (25.2-37.3)	248 (197-328)	727
12–19 years	38.0 (32.2-44.7)	5.60 (4.00-8.20)	34.8 (29.0-41.4)	314 (249-365)	1498
20–39 years	31.3 (26.5-37.0)	3.10 (2.40-4.80)	29.0 (25.8-34.3)	349 (269-437)	1140
40–59 years	23.7 (19.1-29.3)	2.22 (.900-3.40)	24.4 (21.3-29.4)	298 (202-402)	951
60 years and older	24.1 (20.8-28.0)	2.90 (2.20-3.95)	24.2 (20.3-29.8)	227 (155-308)	1035
Males					
Total, 6 years and older	31.1 (26.8-36.2)	3.86 (3.10-5.20)	30.3 (27.6-34.0)	298 (235-341)	2597
6–11 years	34.6 (27.6-43.3)	5.36 (3.30-7.04)	35.2 (24.3-51.0)	218 (146-348)	368
12–19 years	36.3 (28.1-46.8)	6.21 (2.62-10.6)	31.0 (25.6-41.4)	299 (204-363)	736
20–39 years	33.5 (26.5-42.3)	3.16 (2.30-5.39)	30.7 (26.8-35.9)	385 (245-522)	500
40–59 years	26.5 (19.7-35.6)	3.35 (1.32-5.60)	28.4 (20.1-35.7)	281 (195-383)	480
60 years and older	29.8 (24.4-36.6)	4.17 (3.10-5.73)	31.1 (23.7-36.6)	233 (141-335)	513
Females					
Total, 6 years and older	26.1 (23.7-28.8)	2.85 (2.22-3.83)	25.6 (23.5-28.4)	285 (242-353)	2754
6–11 years	33.1 (26.2-41.9)	5.50 (3.75-7.84)	27.0 (21.8-36.1)	272 (197-426)	359
12–19 years	39.8 (34.0-46.7)	5.52 (4.00-8.40)	36.8 (31.3-46.3)	321 (247-445)	762
20–39 years	29.3 (24.0-35.8)	2.99 (1.95-4.86)	27.6 (22.5-36.3)	312 (217-461)	640
40–59 years	21.2 (17.3-26.1)	1.60 (<LOD-3.00)	22.8 (18.7-26.0)	327 (194-495)	471
60 years and older	20.5 (17.3-24.3)	2.50 (1.26-3.51)	20.3 (16.4-25.3)	190 (129-290)	522

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.

Table 5.1.b. Urinary genistein: Mexican Americans

Geometric mean and selected percentiles of urine concentrations (in µg/L) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	29.7 (25.4-34.8)	4.07 (3.40-4.60)	27.4 (23.5-32.5)	294 (216-328)	1498
6–11 years	37.5 (26.3-53.4)	3.78 (1.64-6.00)	42.6 (22.7-63.5)	432 (220-671)	226
12–19 years	32.4 (26.6-39.4)	3.80 (2.50-5.40)	34.2 (27.7-41.1)	314 (216-367)	543
20–39 years	30.7 (22.8-41.3)	4.50 (3.40-5.70)	25.8 (18.5-37.5)	302 (201-427)	301
40–59 years	24.8 (19.7-31.1)	3.60 (2.08-5.62)	25.7 (18.5-34.4)	168 (106-286)	221
60 years and older	20.3 (16.5-25.0)	2.48 (1.06-4.07)	19.0 (13.7-31.1)	190 (113-489)	207
Males					
Total, 6 years and older	33.6 (26.0-43.4)	4.28 (3.10-5.40)	31.6 (24.1-45.0)	324 (294-432)	724
6–11 years	37.7 (23.6-60.3)	3.30 (1.40-7.80)	42.8 (22.4-63.5)	341 (172-830)	117
12–19 years	34.0 (26.5-43.7)	3.67 (2.09-5.70)	39.7 (26.4-54.2)	324 (216-373)	276
20–39 years	37.3 (23.9-58.2)	4.50 (2.70-7.05)	32.3 (19.1-72.9)	406 (244-514)	127
40–59 years	28.7 (20.9-39.4)	4.40† (2.80-8.30)	29.0 (19.5-38.9)	205† (97.3-540)	105
60 years and older	19.1 (12.5-29.4)	2.48† (<LOD-6.30)	16.9 (11.2-31.1)	125† (57.0-614)	99
Females					
Total, 6 years and older	26.0 (23.0-29.4)	3.80 (3.18-4.38)	24.4 (20.7-26.9)	220 (193-309)	774
6–11 years	37.2 (23.9-57.8)	4.60† (<LOD-7.20)	27.4 (19.3-84.7)	523† (220-813)	109
12–19 years	30.6 (23.4-40.1)	3.94 (2.00-6.11)	30.2 (25.0-38.1)	267 (166-492)	267
20–39 years	24.3 (19.0-31.2)	4.32 (3.18-6.30)	20.0 (14.6-26.9)	215 (125-349)	174
40–59 years	21.3 (15.8-28.6)	2.95 (<LOD-5.62)	24.2 (17.0-34.4)	146 (87.3-286)	116
60 years and older	21.4 (14.9-30.6)	1.90† (<LOD-3.80)	23.5 (10.9-38.9)	213† (128-489)	108

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.1.c. Urinary genistein: Non-Hispanic blacks

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	31.5 (25.2-39.3)	3.73 (2.40-5.00)	33.2 (26.8-41.5)	328 (237-393)	1289
6–11 years	42.3 (32.8-54.4)	4.70 (3.50-6.90)	43.7 (32.4-58.0)	417 (272-600)	249
12–19 years	46.7 (37.7-57.9)	7.20 (5.84-10.0)	39.5 (34.4-48.0)	378 (306-467)	451
20–39 years	31.7 (22.9-43.8)	3.70 (1.60-6.30)	34.9 (25.4-49.1)	301 (164-474)	197
40–59 years	24.3 (16.3-36.4)	1.90 (<LOD-5.20)	27.9 (18.5-39.7)	246 (114-402)	210
60 years and older	24.6 (16.8-36.0)	2.79 (1.20-5.40)	23.7 (15.4-34.7)	228 (137-641)	182
Males					
Total, 6 years and older	33.5 (24.7-45.6)	4.60 (2.30-7.21)	36.9 (28.8-49.1)	257 (178-388)	628
6–11 years	45.0 (31.5-64.5)	4.96 (3.33-7.05)	49.6 (34.6-73.9)	387 (205-687)	127
12–19 years	45.8 (36.6-57.4)	7.00 (4.72-10.2)	43.0 (34.6-56.7)	334 (227-445)	212
20–39 years	30.2 (18.1-50.6)	3.80† (<LOD-8.30)	41.5 (24.0-57.2)	252† (104-513)	91
40–59 years	26.7 (16.3-44.0)	3.70† (<LOD-10.0)	30.1 (16.6-50.4)	178† (87.4-367)	109
60 years and older	33.2 (18.3-60.1)	4.70† (<LOD-7.96)	30.3 (15.9-58.6)	276† (108-1120)	89
Females					
Total, 6 years and older	29.8 (24.0-37.1)	3.00 (2.10-4.40)	30.3 (23.3-38.2)	363 (245-472)	661
6–11 years	39.4 (29.0-53.6)	4.74 (1.70-9.70)	34.5 (24.7-50.8)	432 (203-600)	122
12–19 years	47.7 (35.9-63.4)	7.54 (5.90-11.2)	37.4 (29.6-47.6)	394 (233-717)	239
20–39 years	32.8 (22.5-47.8)	2.99† (<LOD-8.40)	34.4 (21.0-50.7)	346† (161-577)	106
40–59 years	22.4 (14.0-35.9)	1.50† (<LOD-4.40)	23.3 (17.1-38.6)	285† (106-495)	101
60 years and older	20.2 (13.1-31.1)	2.30† (<LOD-5.42)	17.4 (10.6-33.3)	228† (105-641)	93

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.1.d. Urinary genistein: Non-Hispanic whites

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	27.1 (24.2-30.4)	2.96 (2.40-3.91)	26.5 (23.9-29.5)	281 (238-330)	2112
6–11 years	31.3 (25.2-38.9)	6.40 (4.20-8.15)	28.4 (22.4-37.3)	217 (155-272)	196
12–19 years	36.4 (29.3-45.3)	5.10 (3.30-9.70)	33.3 (27.9-41.0)	257 (209-331)	375
20–39 years	30.5 (24.0-38.7)	2.80 (1.92-4.86)	27.9 (23.7-34.0)	387 (254-537)	529
40–59 years	23.9 (18.6-30.6)	2.14 (<LOD-3.40)	24.3 (19.7-29.5)	335 (214-466)	434
60 years and older	22.2 (19.0-26.0)	2.74 (1.71-3.98)	22.5 (18.7-27.9)	182 (129-282)	578
Males					
Total, 6 years and older	30.6 (26.1-35.9)	3.90 (2.80-5.60)	29.5 (26.5-33.1)	293 (226-371)	1038
6–11 years	31.0 (22.9-42.0)	6.20† (3.10-8.15)	32.9 (20.6-48.3)	190† (104-257)	101
12–19 years	33.2 (22.9-48.1)	5.09 (2.20-11.5)	28.3 (22.8-38.8)	238 (141-371)	190
20–39 years	32.2 (23.7-43.8)	2.90 (1.90-5.91)	27.9 (23.7-34.3)	413 (229-734)	231
40–59 years	29.1 (21.7-39.1)	3.42 (1.32-5.85)	28.7 (21.7-38.7)	298 (195-447)	225
60 years and older	28.9 (23.0-36.4)	4.17 (3.10-6.00)	29.8 (21.9-36.7)	229 (129-335)	291
Females					
Total, 6 years and older	24.1 (21.6-27.0)	2.59 (1.50-3.20)	23.7 (20.9-26.1)	268 (226-353)	1074
6–11 years	31.7 (21.7-46.3)	6.89† (3.51-10.2)	26.7 (17.3-37.9)	256† (131-500)	95
12–19 years	40.4 (33.6-48.6)	5.10 (3.51-9.13)	37.8 (29.0-53.2)	305 (212-446)	185
20–39 years	28.9 (21.6-38.8)	2.59 (1.40-4.90)	27.0 (18.7-39.0)	330 (206-626)	298
40–59 years	19.6 (14.5-26.6)	.960 (<LOD-2.87)	18.7 (14.3-24.9)	355 (174-627)	209
60 years and older	18.1 (14.8-22.1)	2.20 (1.00-3.75)	18.4 (14.1-24.3)	136 (118-202)	287

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.1.e. Urinary genistein: Total population (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	26.6 (23.7-29.8)	3.78 (3.08-4.46)	24.8 (22.5-27.6)	242 (209-274)	5351
6–11 years	36.7 (31.1-43.4)	6.94 (5.22-8.13)	34.9 (27.6-41.3)	243 (186-292)	727
12–19 years	27.5 (23.3-32.4)	4.36 (3.68-5.09)	24.4 (20.9-30.8)	192 (153-258)	1498
20–39 years	25.1 (21.5-29.2)	3.77 (2.96-4.59)	22.8 (19.1-26.3)	244 (202-318)	1140
40–59 years	23.8 (19.3-29.3)	2.48 (1.17-4.08)	22.3 (18.5-28.7)	270 (196-335)	951
60 years and older	28.9 (25.4-33.0)	4.48 (3.17-5.31)	26.6 (22.4-32.3)	222 (175-285)	1035
Males					
Total, 6 years and older	25.0 (21.4-29.3)	4.02 (3.25-4.74)	23.0 (19.8-26.8)	203 (177-265)	2597
6–11 years	36.5 (28.4-46.8)	6.65 (4.52-8.13)	35.4 (27.1-50.3)	200 (154-286)	368
12–19 years	25.8 (20.4-32.5)	4.23 (3.54-5.09)	22.2 (18.6-31.7)	164 (115-264)	736
20–39 years	23.3 (18.4-29.4)	4.01 (1.99-5.04)	19.0 (15.6-24.7)	227 (170-330)	500
40–59 years	22.0 (16.1-30.0)	3.21 (1.36-4.87)	21.0 (16.1-30.9)	222 (167-334)	480
60 years and older	28.0 (23.6-33.2)	4.74 (3.44-6.19)	27.1 (22.2-33.1)	177 (143-324)	513
Females					
Total, 6 years and older	28.1 (25.3-31.3)	3.50 (2.95-4.23)	26.6 (23.8-29.7)	265 (230-308)	2754
6–11 years	37.0 (28.2-48.6)	7.69 (4.92-9.64)	30.9 (21.9-47.9)	255 (182-488)	359
12–19 years	29.3 (24.9-34.6)	4.65 (3.09-6.00)	28.2 (23.2-33.2)	216 (162-304)	762
20–39 years	27.0 (22.4-32.5)	3.32 (3.01-4.41)	25.8 (21.1-30.3)	265 (192-349)	640
40–59 years	25.6 (21.2-30.8)	2.23 (<LOD-3.81)	24.7 (17.6-36.0)	287 (230-381)	471
60 years and older	29.7 (24.8-35.5)	4.27 (2.52-5.68)	26.6 (21.6-35.0)	252 (191-319)	522

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.

Table 5.1.f. Urinary genistein: Mexican Americans (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	27.6 (24.1-31.6)	3.85 (3.35-4.65)	24.5 (19.7-30.0)	243 (208-279)	1498
6–11 years	48.0 (37.4-61.6)	5.98 (3.95-8.12)	42.4 (31.7-62.9)	601 (317-717)	226
12–19 years	25.5 (21.4-30.4)	3.42 (2.96-4.23)	24.6 (19.7-31.7)	188 (165-254)	543
20–39 years	25.3 (19.5-32.9)	3.79 (3.16-5.11)	19.1 (14.8-32.6)	215 (181-257)	301
40–59 years	24.8 (19.9-31.0)	4.01 (2.88-5.44)	25.6 (18.6-32.8)	176 (124-279)	221
60 years and older	23.4 (18.4-29.6)	3.49 (1.13-5.08)	22.1 (15.8-35.0)	216 (142-329)	207
Males					
Total, 6 years and older	27.7 (22.5-34.1)	4.01 (3.10-5.17)	25.7 (18.7-34.9)	228 (190-285)	724
6–11 years	45.3 (30.6-66.9)	4.29 (2.85-9.69)	40.7 (29.1-66.8)	627 (206-776)	117
12–19 years	25.6 (20.3-32.3)	3.62 (2.22-4.66)	24.7 (18.3-40.4)	185 (165-270)	276
20–39 years	27.5 (18.7-40.3)	3.99 (2.72-5.71)	19.8 (13.5-41.2)	226 (180-323)	127
40–59 years	24.1 (17.7-32.8)	4.91† (3.21-6.44)	25.6 (14.8-34.3)	159† (96.9-335)	105
60 years and older	18.0 (12.2-26.6)	3.05† (<LOD-5.74)	18.5 (10.8-32.4)	135† (50.5-292)	99
Females					
Total, 6 years and older	27.5 (24.0-31.4)	3.72 (3.27-4.42)	23.8 (19.2-26.2)	253 (195-324)	774
6–11 years	51.0 (37.5-69.4)	7.40† (<LOD-9.57)	44.0 (25.1-94.3)	537† (253-926)	109
12–19 years	25.5 (19.4-33.4)	3.42 (2.71-4.65)	24.5 (16.1-36.3)	195 (131-313)	267
20–39 years	23.0 (18.2-29.1)	3.60 (3.20-4.61)	16.8 (13.8-25.5)	205 (119-325)	174
40–59 years	25.6 (19.8-33.2)	3.17 (<LOD-5.96)	24.4 (17.5-33.6)	219 (121-324)	116
60 years and older	29.0 (19.9-42.2)	3.50† (<LOD-11.2)	27.9 (14.7-59.2)	237† (142-408)	108

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.1.g. Urinary genistein: Non-Hispanic blacks (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	21.2 (17.0-26.4)	3.24 (2.52-4.26)	21.1 (17.2-26.1)	192 (154-239)	1289
6–11 years	39.5 (31.0-50.4)	5.59 (3.92-9.81)	38.5 (28.9-51.2)	279 (203-409)	249
12–19 years	26.2 (21.4-32.1)	4.25 (3.54-5.18)	24.9 (20.0-30.8)	224 (138-351)	451
20–39 years	18.0 (12.8-25.3)	2.82 (.344-4.26)	19.0 (13.4-25.6)	186 (95.1-281)	197
40–59 years	16.4 (11.4-23.7)	2.56 (<LOD-4.68)	16.4 (11.5-23.7)	152 (101-217)	210
60 years and older	23.1 (17.0-31.5)	4.13 (2.22-5.31)	20.9 (14.9-30.9)	178 (106-384)	182
Males					
Total, 6 years and older	20.3 (15.1-27.3)	3.24 (1.99-4.68)	20.7 (16.4-28.5)	162 (109-222)	628
6–11 years	41.8 (29.2-59.7)	5.47 (3.10-12.9)	41.3 (28.5-71.2)	274 (165-450)	127
12–19 years	25.0 (20.1-31.0)	3.12 (1.84-5.01)	26.1 (20.0-34.8)	176 (114-260)	212
20–39 years	14.7 (8.72-24.7)	2.82† (<LOD-5.12)	17.2 (10.1-25.6)	103† (53.9-191)	91
40–59 years	16.3 (10.0-26.5)	2.56† (<LOD-5.14)	18.7 (10.4-30.4)	112† (49.6-236)	109
60 years and older	24.7 (14.3-42.4)	4.86† (<LOD-7.14)	20.4 (14.7-32.8)	322† (74.5-783)	89
Females					
Total, 6 years and older	22.1 (17.9-27.1)	3.33 (2.58-4.15)	21.6 (16.5-26.9)	224 (159-317)	661
6–11 years	37.3 (28.2-49.4)	5.59 (2.77-9.59)	31.6 (21.3-54.0)	344 (185-462)	122
12–19 years	27.6 (21.0-36.2)	5.14 (4.13-6.43)	22.9 (16.6-32.3)	261 (130-460)	239
20–39 years	21.2 (14.5-31.1)	3.01† (<LOD-5.56)	23.3 (13.5-30.3)	247† (140-415)	106
40–59 years	16.5 (10.9-25.0)	2.22† (<LOD-4.89)	14.3 (10.6-25.0)	154† (109-247)	101
60 years and older	22.1 (15.5-31.6)	3.95† (<LOD-5.45)	20.0 (13.1-33.8)	178† (90.2-446)	93

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.1.h. Urinary genistein: Non-Hispanic whites (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	27.0 (24.1-30.2)	3.80 (2.98-4.66)	25.6 (22.7-28.8)	242 (207-284)	2112
6–11 years	34.0 (26.7-43.3)	7.20 (4.92-10.4)	31.7 (23.3-40.8)	186 (145-279)	196
12–19 years	27.6 (22.0-34.7)	4.76 (2.77-6.72)	24.1 (20.6-33.0)	166 (130-232)	375
20–39 years	26.6 (21.7-32.5)	3.89 (2.96-4.86)	24.4 (17.5-31.5)	268 (208-348)	529
40–59 years	25.0 (19.6-31.9)	2.47 (<LOD-4.07)	24.2 (18.1-33.2)	287 (204-367)	434
60 years and older	27.7 (24.4-31.4)	4.63 (2.98-6.09)	26.0 (21.9-32.0)	185 (150-274)	578
Males					
Total, 6 years and older	25.9 (22.1-30.4)	4.35 (3.66-5.13)	24.6 (20.6-29.3)	196 (169-284)	1038
6–11 years	34.1 (24.7-47.1)	6.08† (2.28-11.9)	35.3 (18.9-60.1)	168† (115-279)	101
12–19 years	25.2 (17.9-35.5)	4.35 (2.76-6.73)	21.0 (17.0-29.6)	124 (95.4-264)	190
20–39 years	24.5 (18.3-32.7)	4.48 (1.42-5.71)	19.5 (14.8-28.4)	246 (170-365)	231
40–59 years	24.5 (17.9-33.5)	3.32 (1.55-5.13)	22.0 (16.3-35.8)	271 (167-379)	225
60 years and older	27.6 (23.4-32.7)	4.85 (3.73-6.59)	26.8 (20.5-34.3)	170 (111-285)	291
Females					
Total, 6 years and older	28.1 (25.0-31.6)	3.16 (2.45-4.27)	26.6 (22.5-31.3)	274 (230-323)	1074
6–11 years	33.9 (22.4-51.4)	7.69† (4.25-11.6)	27.6 (17.4-41.1)	200† (140-571)	95
12–19 years	30.5 (24.3-38.4)	4.74 (2.59-7.08)	29.8 (21.7-40.1)	203 (141-304)	185
20–39 years	28.8 (22.6-36.7)	3.20 (2.63-4.86)	27.0 (19.6-37.3)	283 (206-357)	298
40–59 years	25.5 (19.2-34.0)	1.62 (<LOD-4.07)	24.2 (15.6-40.4)	323 (220-480)	209
60 years and older	27.8 (22.5-34.2)	4.27 (2.00-6.44)	25.9 (19.9-35.0)	222 (155-319)	287

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.2.a. Urinary daidzein: Total population

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	61.0 (55.2-67.3)	6.75 (5.68-8.00)	59.2 (54.0-66.6)	545 (491-642)	5347
6–11 years	88.1 (78.0-99.4)	15.6 (13.0-19.7)	80.2 (68.2-108)	544 (446-726)	726
12–19 years	89.7 (73.2-110)	10.9 (7.50-16.5)	87.5 (74.3-103)	786 (569-1090)	1497
20–39 years	63.7 (55.6-73.1)	6.59 (5.20-8.10)	57.3 (49.9-70.6)	590 (494-781)	1138
40–59 years	52.3 (43.4-63.1)	5.62 (2.90-7.81)	53.9 (44.2-63.0)	505 (397-725)	951
60 years and older	44.8 (38.9-51.6)	4.80 (2.00-6.70)	44.6 (38.7-54.2)	394 (300-519)	1035
Males					
Total, 6 years and older	64.8 (57.2-73.4)	7.29 (5.62-9.40)	63.0 (57.2-70.9)	542 (470-694)	2595
6–11 years	95.6 (77.5-118)	19.1 (14.4-20.3)	83.6 (56.3-139)	544 (443-745)	368
12–19 years	87.4 (65.2-117)	12.0 (6.72-18.7)	87.5 (71.0-118)	660 (445-1100)	735
20–39 years	64.4 (53.6-77.3)	6.50 (4.00-11.4)	57.0 (48.2-69.8)	663 (494-935)	499
40–59 years	54.8 (43.2-69.4)	5.70 (3.50-7.81)	58.1 (49.5-68.4)	467 (332-774)	480
60 years and older	54.2 (44.6-65.9)	4.89 (2.60-8.70)	57.9 (43.3-78.7)	414 (300-576)	513
Females					
Total, 6 years and older	57.5 (51.9-63.7)	6.41 (5.00-8.00)	56.0 (49.3-62.0)	553 (459-702)	2752
6–11 years	80.7 (66.0-98.8)	13.7 (11.3-19.7)	76.6 (62.3-106)	524 (390-989)	358
12–19 years	92.1 (75.4-112)	10.4 (6.10-16.5)	89.7 (70.2-115)	922 (642-1330)	762
20–39 years	63.1 (51.3-77.7)	7.18 (4.70-8.40)	58.1 (48.2-79.2)	517 (411-987)	639
40–59 years	50.2 (40.5-62.1)	4.40 (1.86-8.22)	46.1 (37.8-61.0)	591 (364-1220)	471
60 years and older	38.7 (32.8-45.7)	4.40 (1.80-6.97)	37.4 (32.0-43.6)	356 (280-461)	522

Table 5.2.b. Urinary daidzein: Mexican Americans

Geometric mean and selected percentiles of urine concentrations (in µg/L) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	55.9 (45.6-68.6)	5.10 (2.41-6.76)	52.5 (43.8-67.4)	618 (513-824)	1495
6–11 years	81.7 (56.7-118)	10.2 (4.39-14.0)	74.5 (43.4-123)	866 (534-1240)	225
12–19 years	71.6 (61.0-84.1)	8.50 (6.30-11.4)	74.6 (56.5-98.5)	595 (475-915)	543
20–39 years	51.9 (36.3-74.2)	3.50 (<LOD-6.82)	47.1 (29.7-68.6)	585 (406-931)	299
40–59 years	46.8 (35.3-62.2)	3.20 (<LOD-6.90)	53.9 (35.8-71.4)	584 (297-980)	221
60 years and older	35.1 (24.7-49.8)	1.96 (<LOD-7.99)	36.3 (27.1-47.3)	366 (182-635)	207
Males					
Total, 6 years and older	62.7 (45.6-86.2)	5.20 (1.80-8.41)	62.9 (45.8-85.0)	745 (515-994)	723
6–11 years	91.4 (61.1-137)	12.7 (4.37-26.6)	84.3 (50.0-123)	896 (505-1240)	117
12–19 years	74.9 (57.6-97.4)	7.50 (4.33-11.7)	81.0 (55.8-117)	664 (498-1100)	276
20–39 years	61.9 (37.0-104)	2.40 (<LOD-9.60)	57.6 (30.1-108)	706 (446-1070)	126
40–59 years	52.5 (33.6-82.1)	5.03† (<LOD-11.2)	56.0 (33.5-92.5)	872† (331-1090)	105
60 years and older	29.1 (16.5-51.3)	< LOD†	31.6 (18.2-47.3)	284† (106-659)	99
Females					
Total, 6 years and older	49.4 (41.1-59.4)	5.40 (1.70-7.52)	45.9 (35.7-54.0)	522 (388-682)	772
6–11 years	72.8 (43.9-121)	6.59† (<LOD-12.5)	60.6 (29.5-195)	824† (514-1420)	108
12–19 years	68.1 (57.5-80.8)	9.70 (6.30-11.8)	69.0 (48.5-93.2)	541 (299-1440)	267
20–39 years	42.2 (28.9-61.6)	4.30 (<LOD-10.7)	35.4 (26.3-51.4)	450 (324-669)	173
40–59 years	41.5 (28.4-60.6)	< LOD	50.1 (26.2-71.4)	302 (213-800)	116
60 years and older	41.0 (25.7-65.5)	2.70† (<LOD-11.2)	37.4 (22.8-76.8)	370† (170-804)	108

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.2.c. Urinary daidzein: Non-Hispanic blacks

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	76.1 (62.0-93.4)	8.10 (5.45-11.1)	88.4 (68.8-106)	628 (491-906)	1288
6–11 years	120 (95.7-151)	12.5 (8.61-17.9)	135 (99.1-172)	1130 (628-1850)	249
12–19 years	119 (98.9-144)	15.1 (10.6-20.4)	118 (98.1-148)	950 (660-1370)	450
20–39 years	77.7 (56.4-107)	9.50 (3.00-12.2)	91.3 (58.1-149)	578 (363-1330)	197
40–59 years	58.7 (40.0-86.2)	6.05 (<LOD-12.1)	66.1 (41.5-96.3)	529 (393-816)	210
60 years and older	45.2 (29.3-69.9)	1.90 (<LOD-6.60)	44.7 (26.5-70.9)	556 (377-1140)	182
Males					
Total, 6 years and older	78.3 (56.9-108)	8.98 (<LOD-14.2)	90.4 (65.6-122)	632 (489-1040)	627
6–11 years	142 (104-194)	16.4 (11.3-24.2)	161 (94.9-244)	1360 (597-1850)	127
12–19 years	123 (101-150)	14.9 (10.5-21.1)	142 (104-183)	1030 (650-1320)	211
20–39 years	74.4 (45.4-122)	8.45† (<LOD-15.0)	86.4 (42.6-198)	582† (305-1340)	91
40–59 years	52.3 (29.5-92.9)	5.80† (<LOD-16.4)	65.5 (31.2-117)	358† (233-594)	109
60 years and older	55.7 (28.3-110)	< LOD†	58.1 (31.0-104)	519† (377-1960)	89
Females					
Total, 6 years and older	74.2 (61.5-89.6)	7.70 (3.61-11.3)	85.9 (66.6-103)	611 (473-856)	661
6–11 years	100 (70.3-144)	10.0 (<LOD-26.2)	107 (79.6-152)	1130 (467-2300)	122
12–19 years	115 (88.3-151)	15.2 (6.80-24.8)	106 (85.2-129)	805 (545-1840)	239
20–39 years	80.4 (57.7-112)	9.50† (2.80-14.3)	98.0 (58.7-155)	465† (331-1400)	106
40–59 years	64.8 (44.8-93.5)	5.70† (<LOD-13.6)	68.8 (37.7-101)	541† (393-1170)	101
60 years and older	39.4 (23.9-64.8)	2.30† (<LOD-5.45)	33.9 (21.6-61.6)	560† (267-1140)	93

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.2.d. Urinary daidzein: Non-Hispanic whites

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	58.4 (53.0-64.3)	6.60 (5.33-8.10)	56.2 (51.5-61.0)	505 (439-636)	2112
6–11 years	83.8 (69.3-101)	16.5 (13.0-20.3)	76.6 (58.9-112)	443 (385-694)	196
12–19 years	84.2 (62.7-113)	9.60 (4.93-16.9)	85.3 (68.3-119)	755 (493-1310)	375
20–39 years	62.0 (52.1-73.8)	6.59 (4.00-9.20)	52.1 (44.3-65.5)	601 (437-987)	529
40–59 years	54.7 (44.4-67.5)	5.70 (3.16-8.00)	54.8 (44.8-62.3)	508 (393-852)	434
60 years and older	41.5 (35.3-48.9)	5.00 (2.00-7.70)	41.7 (36.9-50.6)	337 (235-416)	578
Males					
Total, 6 years and older	63.4 (55.9-71.9)	7.77 (5.80-10.1)	59.0 (53.2-69.8)	505 (418-667)	1038
6–11 years	86.4 (62.7-119)	20.2† (13.0-26.6)	77.7 (43.8-155)	470† (317-694)	101
12–19 years	79.2 (50.9-123)	11.1 (3.70-19.2)	76.9 (53.0-121)	586 (354-1300)	190
20–39 years	59.7 (48.0-74.3)	5.30 (2.00-12.0)	48.9 (37.3-66.9)	663 (362-1410)	231
40–59 years	62.4 (50.6-76.9)	6.30 (5.20-10.1)	58.4 (49.8-71.1)	501 (322-838)	225
60 years and older	53.1 (42.5-66.3)	5.20 (2.90-10.0)	57.2 (42.3-78.2)	377 (273-570)	291
Females					
Total, 6 years and older	54.0 (48.2-60.4)	6.20 (3.63-7.77)	52.0 (44.8-59.2)	505 (432-705)	1074
6–11 years	81.0 (59.0-111)	13.7† (11.6-22.0)	76.6 (58.9-121)	466† (284-1130)	95
12–19 years	90.3 (67.4-121)	9.30 (3.80-18.9)	90.5 (68.3-140)	922 (566-1410)	185
20–39 years	64.3 (49.0-84.4)	6.70 (3.63-9.30)	56.2 (43.1-79.2)	530 (369-1300)	298
40–59 years	48.1 (35.4-65.4)	3.16 (<LOD-10.1)	45.0 (35.4-64.2)	638 (220-1370)	209
60 years and older	34.3 (27.8-42.3)	3.60 (<LOD-7.08)	34.6 (28.5-41.1)	262 (190-398)	287

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.2.e. Urinary daidzein: Total population (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	56.9 (51.4-63.0)	6.67 (5.54-8.00)	56.3 (50.0-64.0)	536 (460-600)	5347
6–11 years	95.6 (83.2-110)	18.4 (14.3-21.2)	88.9 (73.4-112)	635 (494-733)	726
12–19 years	64.8 (52.3-80.3)	8.03 (5.73-10.4)	63.4 (50.0-86.2)	600 (402-797)	1497
20–39 years	51.1 (44.8-58.3)	5.91 (4.85-7.32)	48.8 (41.2-57.7)	523 (390-624)	1138
40–59 years	52.6 (43.7-63.2)	5.54 (3.58-7.49)	51.0 (43.3-65.4)	535 (391-689)	951
60 years and older	53.7 (46.4-62.1)	6.01 (3.90-8.62)	55.5 (43.5-71.3)	389 (308-555)	1035
Males					
Total, 6 years and older	52.1 (45.8-59.3)	5.96 (5.05-7.39)	51.0 (45.2-59.7)	497 (373-601)	2595
6–11 years	101 (80.4-127)	22.7 (14.5-30.1)	88.8 (58.6-143)	553 (447-733)	368
12–19 years	62.0 (47.2-81.5)	9.03 (6.10-10.4)	61.6 (48.6-85.6)	547 (301-921)	735
20–39 years	44.8 (36.8-54.7)	5.36 (3.66-7.20)	41.2 (33.1-47.9)	497 (268-847)	499
40–59 years	45.5 (35.9-57.6)	5.05 (3.28-7.38)	45.2 (32.0-65.0)	478 (263-693)	480
60 years and older	50.9 (41.8-62.0)	4.52 (3.09-7.91)	61.8 (44.2-81.0)	363 (255-659)	513
Females					
Total, 6 years and older	61.9 (55.4-69.1)	7.18 (5.91-9.10)	61.0 (53.3-70.4)	564 (468-628)	2752
6–11 years	90.3 (72.6-112)	14.9 (11.9-19.0)	86.3 (70.8-112)	668 (414-838)	358
12–19 years	67.9 (54.6-84.3)	6.80 (5.25-9.92)	65.1 (48.1-91.9)	628 (478-742)	762
20–39 years	58.1 (47.6-70.9)	6.74 (3.67-9.55)	56.2 (45.0-78.2)	571 (370-783)	639
40–59 years	60.3 (48.0-75.8)	6.58 (3.42-9.23)	62.4 (43.2-75.6)	564 (387-950)	471
60 years and older	56.0 (47.2-66.3)	6.52 (4.52-11.4)	50.9 (39.3-64.8)	451 (312-560)	522

Table 5.2.f. Urinary daidzein: Mexican Americans (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	52.0 (43.7-61.9)	4.81 (3.32-7.03)	48.7 (38.2-65.0)	546 (460-645)	1495
6–11 years	105 (81.0-136)	11.9 (8.98-17.4)	91.1 (65.5-149)	957 (715-1660)	225
12–19 years	56.5 (47.8-66.8)	7.20 (5.28-9.29)	58.1 (45.6-71.6)	511 (358-684)	543
20–39 years	43.0 (31.3-59.0)	3.88 (<LOD-6.82)	35.3 (23.2-57.9)	486 (307-608)	299
40–59 years	46.9 (35.3-62.4)	3.22 (<LOD-6.50)	47.5 (36.0-67.3)	483 (303-708)	221
60 years and older	40.3 (28.2-57.8)	3.97 (<LOD-8.56)	41.0 (27.1-73.4)	343 (223-638)	207
Males					
Total, 6 years and older	51.8 (39.5-68.0)	4.77 (2.90-7.95)	51.0 (38.2-72.0)	585 (471-708)	723
6–11 years	110 (79.0-152)	14.8 (10.2-24.5)	91.1 (57.4-149)	957 (596-1140)	117
12–19 years	56.4 (43.0-73.9)	5.65 (3.59-9.03)	64.9 (39.8-90.0)	614 (358-837)	276
20–39 years	45.8 (28.9-72.6)	3.90 (<LOD-7.95)	40.6 (21.8-91.4)	495 (307-641)	126
40–59 years	44.2 (27.9-69.9)	3.31† (<LOD-9.43)	45.9 (32.2-68.7)	542† (198-1020)	105
60 years and older	27.4 (15.6-48.1)	< LOD†	35.5 (15.0-63.9)	201† (141-458)	99
Females					
Total, 6 years and older	52.2 (44.0-62.0)	4.81 (3.00-8.02)	43.5 (34.1-65.5)	495 (384-600)	772
6–11 years	100 (70.6-142)	8.61† (<LOD-15.7)	103 (55.2-201)	1080† (649-2300)	108
12–19 years	56.6 (47.1-68.0)	8.23 (5.38-9.99)	51.2 (36.9-65.0)	399 (266-684)	267
20–39 years	39.9 (27.9-57.0)	3.50 (<LOD-10.4)	30.6 (22.1-66.4)	384 (271-517)	173
40–59 years	50.1 (36.0-69.6)	< LOD	49.8 (27.9-102)	474 (245-708)	116
60 years and older	55.6 (35.9-86.1)	8.02† (<LOD-12.3)	54.0 (28.9-89.9)	479† (258-984)	108

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.2.g. Urinary daidzein: Non-Hispanic blacks (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	51.3 (42.1-62.4)	5.54 (3.95-7.05)	57.1 (46.5-70.5)	447 (306-599)	1288
6–11 years	113 (91.3-139)	15.4 (10.2-21.8)	109 (83.6-145)	955 (683-1280)	249
12–19 years	67.0 (56.1-80.1)	9.23 (6.59-10.9)	75.7 (54.8-93.7)	561 (317-975)	450
20–39 years	44.2 (32.2-60.8)	5.07 (2.92-7.58)	52.1 (38.4-71.7)	348 (207-541)	197
40–59 years	39.6 (28.3-55.4)	3.95 (<LOD-7.27)	46.5 (26.5-64.1)	272 (215-446)	210
60 years and older	42.5 (29.7-60.7)	2.34 (<LOD-8.65)	40.4 (27.2-79.3)	488 (249-721)	182
Males					
Total, 6 years and older	47.3 (34.8-64.3)	5.07 (<LOD-8.50)	54.1 (40.2-70.2)	472 (297-600)	627
6–11 years	132 (96.4-180)	17.7 (9.66-30.8)	151 (80.0-229)	1050 (661-1300)	127
12–19 years	67.3 (55.8-81.2)	9.03 (4.93-11.3)	80.8 (61.6-106)	499 (370-650)	211
20–39 years	36.1 (22.5-57.7)	5.17† (<LOD-8.50)	41.2 (24.5-70.2)	249† (162-541)	91
40–59 years	31.9 (18.4-55.2)	1.76† (<LOD-10.2)	38.4 (20.4-64.8)	258† (117-696)	109
60 years and older	41.4 (22.1-77.7)	< LOD†	36.0 (23.1-92.3)	562† (214-1370)	89
Females					
Total, 6 years and older	54.9 (46.3-65.0)	6.20 (3.75-8.65)	62.2 (48.7-77.1)	430 (302-639)	661
6–11 years	95.0 (71.7-126)	11.9 (<LOD-20.6)	86.3 (69.7-129)	773 (381-1640)	122
12–19 years	66.7 (51.9-85.8)	9.35 (5.68-12.5)	72.7 (42.1-91.2)	622 (251-1160)	239
20–39 years	51.9 (37.2-72.6)	4.86† (2.92-7.58)	64.6 (47.0-92.1)	372† (207-639)	106
40–59 years	47.6 (35.3-64.2)	6.58† (<LOD-11.1)	48.4 (29.1-70.8)	302† (215-802)	101
60 years and older	43.2 (28.0-66.6)	2.31† (<LOD-10.0)	44.0 (24.3-85.9)	463† (248-828)	93

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.2.h. Urinary daidzein: Non-Hispanic whites (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	58.1 (52.9-64.0)	6.90 (5.66-9.03)	57.8 (51.0-64.2)	506 (413-601)	2112
6–11 years	90.9 (75.0-110)	19.0 (14.3-25.4)	88.3 (70.8-112)	494 (324-710)	196
12–19 years	63.8 (46.5-87.6)	7.18 (4.27-12.2)	63.6 (44.8-96.2)	601 (386-987)	375
20–39 years	54.0 (47.0-62.1)	6.52 (4.85-8.83)	49.8 (39.7-60.4)	579 (384-847)	529
40–59 years	57.4 (47.5-69.3)	6.54 (4.23-9.94)	59.0 (44.1-70.2)	548 (377-807)	434
60 years and older	51.8 (44.0-61.0)	6.01 (3.86-8.87)	53.4 (41.3-69.6)	318 (260-475)	578
Males					
Total, 6 years and older	53.7 (47.4-60.7)	6.62 (5.39-8.80)	54.1 (45.5-63.3)	464 (336-586)	1038
6–11 years	95.0 (70.0-129)	24.9† (14.1-31.9)	88.3 (56.2-152)	425† (302-710)	101
12–19 years	60.2 (39.6-91.4)	9.03 (4.43-12.7)	58.5 (41.9-92.6)	463 (217-1030)	190
20–39 years	45.4 (36.2-56.9)	5.50 (2.82-8.07)	40.4 (29.1-54.6)	497 (248-850)	231
40–59 years	52.5 (43.0-64.0)	6.03 (4.60-9.94)	47.0 (34.5-71.5)	502 (276-723)	225
60 years and older	50.7 (40.7-63.3)	5.14 (3.40-8.87)	61.7 (45.4-80.0)	313 (215-555)	291
Females					
Total, 6 years and older	62.8 (55.9-70.5)	7.48 (5.49-10.5)	60.8 (52.8-70.4)	564 (423-655)	1074
6–11 years	86.6 (62.6-120)	16.5† (11.1-21.2)	86.6 (55.2-113)	655† (275-938)	95
12–19 years	68.2 (48.9-95.0)	6.56 (4.27-9.12)	73.4 (45.1-113)	628 (442-990)	185
20–39 years	64.0 (51.1-80.2)	8.28 (2.74-14.0)	58.0 (44.1-88.7)	607 (384-852)	298
40–59 years	62.7 (46.3-84.9)	6.79 (<LOD-12.6)	65.4 (41.0-79.9)	564 (356-1220)	209
60 years and older	52.6 (42.5-65.1)	6.27 (<LOD-11.3)	49.2 (35.1-66.1)	316 (250-555)	287

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.3.a. Urinary equol: Total population

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	8.77 (7.84-9.81)	< LOD	8.28 (7.21-9.50)	38.5 (33.1-45.2)	4976
6–11 years	11.5 (9.82-13.5)	< LOD	13.4 (10.1-16.1)	45.9 (32.3-59.6)	668
12–19 years	10.4 (9.08-11.9)	< LOD	10.5 (8.70-12.1)	43.1 (35.6-53.1)	1401
20–39 years	8.54 (7.40-9.86)	< LOD	8.16 (6.78-9.80)	37.6 (29.5-47.4)	1043
40–59 years	8.39 (7.24-9.73)	< LOD	7.80 (6.20-9.20)	37.1 (28.7-48.7)	909
60 years and older	7.52 (6.59-8.58)	< LOD	6.68 (5.13-8.20)	34.5 (27.9-41.7)	955
Males					
Total, 6 years and older	9.26 (8.17-10.5)	< LOD	8.70 (7.63-10.3)	39.6 (32.7-48.7)	2417
6–11 years	12.7 (10.1-16.0)	< LOD	13.7 (8.95-17.2)	56.0 (38.3-78.9)	347
12–19 years	10.5 (8.82-12.5)	< LOD	10.4 (8.49-12.9)	43.1 (35.2-56.1)	690
20–39 years	8.68 (7.39-10.2)	< LOD	7.90 (6.40-9.40)	38.2 (29.5-48.9)	454
40–59 years	8.90 (7.47-10.6)	< LOD	9.20 (7.10-10.5)	34.4 (27.4-45.2)	454
60 years and older	8.19 (6.75-9.94)	< LOD	6.83 (5.30-9.68)	35.6 (29.8-46.7)	472
Females					
Total, 6 years and older	8.33 (7.39-9.39)	< LOD	7.89 (6.80-9.17)	37.6 (32.2-42.7)	2559
6–11 years	10.3 (8.60-12.3)	< LOD	12.6 (9.40-15.5)	33.5 (28.0-51.0)	321
12–19 years	10.3 (8.87-11.9)	< LOD	10.5 (8.70-12.1)	42.9 (32.1-58.7)	711
20–39 years	8.40 (6.97-10.1)	< LOD	8.60 (6.50-10.9)	37.5 (25.3-50.9)	589
40–59 years	7.94 (6.53-9.66)	< LOD	6.27 (4.70-8.04)	40.3 (28.5-56.6)	455
60 years and older	7.04 (6.28-7.89)	< LOD	6.56 (4.60-8.13)	30.5 (23.5-43.2)	483

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.

Table 5.3.b. Urinary equol: Mexican Americans

Geometric mean and selected percentiles of urine concentrations (in µg/L) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	6.16 (5.59-6.79)	< LOD	5.20 (4.44-6.05)	25.0 (19.9-31.0)	1405
6–11 years	7.70 (6.18-9.60)	< LOD	6.51 (5.11-9.20)	29.0 (20.7-48.7)	216
12–19 years	7.72 (6.95-8.58)	< LOD	6.90 (5.70-8.10)	33.0 (25.9-44.4)	507
20–39 years	*	< LOD	4.40 (<LOD-5.50)	21.1 (13.7-32.2)	276
40–59 years	6.06 (5.00-7.34)	< LOD	5.10 (4.00-6.44)	21.3 (13.4-39.9)	213
60 years and older	*	< LOD	4.07 (<LOD-5.05)	16.9 (12.9-22.8)	193
Males					
Total, 6 years and older	6.25 (5.48-7.14)	< LOD	5.18 (4.20-6.50)	26.2 (19.1-32.9)	676
6–11 years	8.16 (6.20-10.8)	< LOD	8.53 (4.83-12.8)	29.5 (20.3-48.7)	112
12–19 years	7.31 (6.40-8.35)	< LOD	6.50 (5.50-7.67)	31.0 (19.7-48.6)	256
20–39 years	*	< LOD	4.20 (<LOD-5.49)	20.5 (13.7-32.1)	117
40–59 years	6.91 (5.13-9.30)	< LOD†	6.50 (3.86-9.48)	22.1† (14.0-42.4)	98
60 years and older	*	< LOD†	4.14 (<LOD-5.51)	14.8† (9.20-22.8)	93
Females					
Total, 6 years and older	6.07 (5.49-6.71)	< LOD	5.36 (4.30-6.00)	22.3 (19.1-29.0)	729
6–11 years	7.25 (5.56-9.44)	< LOD†	6.30 (4.96-8.20)	28.6† (18.8-76.3)	104
12–19 years	8.20 (7.23-9.30)	< LOD	7.56 (5.84-8.90)	37.2 (21.3-56.4)	251
20–39 years	5.51 (4.44-6.85)	< LOD	4.99 (3.30-6.60)	16.9 (12.3-35.4)	159
40–59 years	5.32 (4.29-6.59)	< LOD	4.50 (3.50-5.42)	17.3 (10.1-32.7)	115
60 years and older	*	< LOD†	3.88 (<LOD-6.08)	19.0† (8.30-160)	100

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.
* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 5.3.c. Urinary equol: Non-Hispanic blacks

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	6.89 (6.04-7.86)	< LOD	6.09 (4.86-7.50)	28.8 (23.3-34.4)	1196
6–11 years	8.83 (7.19-10.8)	< LOD	9.90 (5.70-13.6)	31.0 (23.5-44.0)	223
12–19 years	9.45 (8.03-11.1)	< LOD	9.90 (7.77-12.0)	40.4 (29.9-51.0)	424
20–39 years	6.93 (5.62-8.55)	< LOD	5.90 (4.40-7.80)	29.6 (21.4-41.4)	178
40–59 years	6.12 (5.16-7.26)	< LOD	5.00 (3.60-7.43)	24.4 (19.4-30.2)	199
60 years and older	*	< LOD	< LOD	18.9 (11.6-27.6)	172
Males					
Total, 6 years and older	7.68 (6.62-8.92)	< LOD	6.90 (5.10-8.50)	31.4 (26.1-39.8)	588
6–11 years	9.56 (7.44-12.3)	< LOD	9.90 (5.49-13.6)	34.4 (30.2-79.5)	120
12–19 years	9.68 (7.99-11.7)	< LOD	10.6 (6.90-13.6)	40.8 (28.4-51.6)	201
20–39 years	7.64 (5.88-9.92)	< LOD†	5.47 (4.20-9.71)	35.6† (21.5-89.9)	80
40–59 years	7.30 (6.02-8.84)	< LOD†	7.40 (5.05-9.00)	26.0† (19.8-35.3)	104
60 years and older	*	< LOD†	< LOD	18.9† (7.60-32.0)	83
Females					
Total, 6 years and older	6.28 (5.36-7.36)	< LOD	5.44 (3.70-7.13)	26.2 (18.9-35.4)	608
6–11 years	8.00 (6.05-10.6)	< LOD†	9.48 (4.10-14.7)	26.2† (19.8-31.8)	103
12–19 years	9.22 (7.50-11.3)	< LOD	9.60 (7.20-11.6)	40.8 (29.9-73.4)	223
20–39 years	6.44 (4.84-8.57)	< LOD†	6.17 (3.50-8.30)	22.9† (14.3-43.4)	98
40–59 years	*	< LOD†	3.80 (<LOD-6.99)	21.2† (13.4-34.1)	95
60 years and older	*	< LOD†	< LOD	20.7† (10.5-43.8)	89

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.
* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 5.3.d. Urinary equol: Non-Hispanic whites

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	9.62 (8.32-11.1)	< LOD	9.49 (7.73-11.2)	41.3 (35.0-48.9)	1955
6–11 years	13.7 (10.7-17.6)	< LOD	15.2 (11.1-19.4)	53.3 (38.5-68.1)	179
12–19 years	11.3 (9.28-13.7)	< LOD	11.7 (9.74-13.6)	45.5 (36.9-58.8)	350
20–39 years	9.66 (7.87-11.9)	< LOD	9.80 (7.63-12.4)	39.0 (29.2-55.1)	486
40–59 years	9.34 (7.68-11.4)	< LOD	9.00 (6.50-10.8)	41.7 (31.7-60.7)	415
60 years and older	7.92 (6.81-9.21)	< LOD	7.30 (5.58-9.40)	34.5 (27.9-41.7)	525
Males					
Total, 6 years and older	10.1 (8.58-11.8)	< LOD	9.86 (8.00-12.2)	44.0 (35.1-53.8)	965
6–11 years	14.6 (10.1-21.2)	< LOD†	15.2 (8.00-26.3)	59.0† (45.9-85.4)	95
12–19 years	11.1 (8.64-14.4)	< LOD	10.9 (7.90-15.2)	48.1 (36.9-81.5)	179
20–39 years	9.81 (7.97-12.1)	< LOD	9.18 (7.60-12.3)	38.6 (29.5-57.5)	214
40–59 years	9.51 (7.58-11.9)	< LOD	9.82 (6.70-12.5)	39.7 (27.4-53.8)	213
60 years and older	8.91 (7.00-11.3)	< LOD	7.51 (5.52-12.4)	36.8 (30.1-46.7)	264
Females					
Total, 6 years and older	9.22 (7.83-10.8)	< LOD	9.00 (7.40-11.1)	39.7 (34.1-45.8)	990
6–11 years	12.7 (9.69-16.7)	< LOD†	15.1 (11.7-19.4)	36.3† (28.6-53.3)	84
12–19 years	11.4 (9.19-14.1)	< LOD	12.1 (9.90-14.1)	39.4 (25.1-61.5)	171
20–39 years	9.51 (7.30-12.4)	< LOD	10.0 (7.11-13.3)	39.0 (26.2-55.1)	272
40–59 years	9.18 (6.95-12.1)	< LOD	7.80 (5.04-9.80)	42.1 (33.3-93.9)	202
60 years and older	7.21 (6.46-8.06)	< LOD	7.26 (4.97-8.67)	28.5 (22.1-38.4)	261

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.3.e. Urinary equol: Total population (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	8.22 (7.38-9.17)	< LOD	7.98 (7.07-9.04)	35.1 (30.3-39.5)	4976
6–11 years	12.4 (10.5-14.7)	< LOD	12.5 (10.3-16.0)	45.6 (33.6-62.8)	668
12–19 years	7.68 (6.80-8.67)	< LOD	7.82 (6.91-8.70)	30.3 (24.3-39.1)	1401
20–39 years	6.90 (6.03-7.89)	< LOD	6.68 (5.68-7.53)	30.3 (25.0-36.3)	1043
40–59 years	8.40 (7.25-9.73)	< LOD	7.88 (6.66-9.16)	37.3 (29.6-46.3)	909
60 years and older	9.02 (7.98-10.2)	< LOD	8.94 (7.32-10.2)	37.8 (27.8-42.4)	955
Males					
Total, 6 years and older	7.39 (6.53-8.36)	< LOD	7.38 (6.30-8.42)	31.1 (27.0-37.8)	2417
6–11 years	13.3 (10.4-16.9)	< LOD	12.7 (8.51-17.5)	48.1 (33.8-93.3)	347
12–19 years	7.55 (6.50-8.77)	< LOD	7.63 (6.45-8.89)	32.2 (25.9-45.3)	690
20–39 years	5.95 (5.04-7.03)	< LOD	5.59 (4.93-6.42)	25.0 (19.7-32.9)	454
40–59 years	7.30 (6.20-8.59)	< LOD	7.53 (6.06-8.81)	27.7 (22.4-39.5)	454
60 years and older	7.69 (6.43-9.20)	< LOD	7.36 (5.50-9.92)	27.9 (22.3-42.4)	472
Females					
Total, 6 years and older	9.10 (8.09-10.2)	< LOD	8.71 (7.60-9.84)	37.8 (32.9-42.5)	2559
6–11 years	11.5 (9.40-14.0)	< LOD	12.3 (10.3-16.3)	37.5 (29.0-50.0)	321
12–19 years	7.82 (6.72-9.10)	< LOD	8.02 (6.97-9.00)	27.0 (23.3-31.7)	711
20–39 years	7.97 (6.78-9.36)	< LOD	7.61 (6.23-9.54)	32.9 (25.6-41.3)	589
40–59 years	9.57 (7.81-11.7)	< LOD	8.63 (6.66-10.0)	46.3 (36.4-67.7)	455
60 years and older	10.2 (9.23-11.3)	< LOD	9.64 (8.27-10.6)	38.8 (27.8-44.8)	483

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.

Table 5.3.f. Urinary equol: Mexican Americans (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	5.77 (5.28-6.31)	< LOD	5.68 (4.95-6.39)	26.3 (22.3-28.8)	1405
6–11 years	9.84 (8.15-11.9)	< LOD	9.32 (7.52-11.9)	37.1 (27.6-47.8)	216
12–19 years	6.19 (5.75-6.65)	< LOD	6.02 (5.42-6.85)	23.4 (19.2-30.2)	507
20–39 years	*	< LOD	4.46 (<LOD-5.96)	18.9 (15.2-23.6)	276
40–59 years	6.12 (5.11-7.34)	< LOD	5.68 (4.55-7.16)	27.6 (18.7-32.6)	213
60 years and older	*	< LOD	5.16 (<LOD-7.14)	21.8 (16.2-33.3)	193
Males					
Total, 6 years and older	5.24 (4.74-5.79)	< LOD	5.05 (4.19-6.31)	21.2 (17.9-24.6)	676
6–11 years	9.88 (7.79-12.5)	< LOD	10.0 (7.61-13.4)	31.4 (22.3-46.6)	112
12–19 years	5.60 (4.95-6.34)	< LOD	5.92 (4.60-6.66)	22.8 (16.2-28.6)	256
20–39 years	*	< LOD	3.66 (<LOD-5.72)	15.2 (10.7-19.9)	117
40–59 years	5.84 (4.35-7.84)	< LOD†	5.46 (3.86-7.32)	27.6† (14.9-36.3)	98
60 years and older	*	< LOD†	3.76 (<LOD-5.42)	14.7† (7.75-34.2)	93
Females					
Total, 6 years and older	6.40 (5.66-7.24)	< LOD	5.99 (5.19-6.97)	29.2 (25.3-35.3)	729
6–11 years	9.80 (7.76-12.4)	< LOD†	9.00 (6.55-11.4)	43.1† (27.9-106)	104
12–19 years	6.89 (6.07-7.82)	< LOD	6.06 (5.10-7.73)	25.2 (19.1-39.0)	251
20–39 years	5.13 (4.19-6.30)	< LOD	5.17 (3.54-6.64)	24.0 (15.7-39.6)	159
40–59 years	6.42 (4.80-8.60)	< LOD	5.68 (4.55-8.65)	27.9 (18.7-41.1)	115
60 years and older	*	< LOD†	6.77 (<LOD-8.26)	25.9† (16.9-51.7)	100

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.
* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 5.3.g. Urinary equol: Non-Hispanic blacks (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	4.68 (4.10-5.34)	< LOD	4.48 (3.70-5.41)	19.1 (16.5-23.3)	1196
6–11 years	8.21 (6.66-10.1)	< LOD	8.40 (6.92-10.6)	33.6 (20.5-45.4)	223
12–19 years	5.35 (4.55-6.28)	< LOD	5.46 (4.72-6.49)	21.0 (17.2-28.1)	424
20–39 years	4.02 (3.23-4.99)	< LOD	3.56 (2.85-4.96)	15.8 (13.0-23.1)	178
40–59 years	4.09 (3.31-5.05)	< LOD	3.64 (2.99-5.00)	17.1 (11.9-22.7)	199
60 years and older	*	< LOD	< LOD	18.8 (12.3-25.7)	172
Males					
Total, 6 years and older	4.66 (3.95-5.50)	< LOD	4.48 (3.48-5.49)	19.5 (16.9-25.2)	588
6–11 years	8.62 (6.68-11.1)	< LOD	8.38 (6.11-12.2)	38.3 (25.6-48.1)	120
12–19 years	5.27 (4.27-6.52)	< LOD	5.49 (4.76-7.37)	20.2 (14.0-33.9)	201
20–39 years	3.82 (2.78-5.23)	< LOD†	3.47 (1.97-4.57)	15.8† (10.5-35.3)	80
40–59 years	4.32 (3.51-5.30)	< LOD†	4.07 (3.28-5.42)	17.3† (11.6-27.0)	104
60 years and older	*	< LOD†	< LOD	12.3† (9.13-22.5)	83
Females					
Total, 6 years and older	4.69 (4.05-5.45)	< LOD	4.48 (3.56-5.75)	18.6 (15.0-24.5)	608
6–11 years	7.74 (5.98-10.0)	< LOD†	8.63 (6.25-10.9)	26.2† (17.1-43.8)	103
12–19 years	5.42 (4.46-6.59)	< LOD	5.44 (4.15-6.94)	24.2 (17.0-32.1)	223
20–39 years	4.18 (3.16-5.53)	< LOD†	3.76 (2.72-5.93)	15.0† (12.3-23.1)	98
40–59 years	*	< LOD†	3.05 (<LOD-5.74)	17.1† (9.11-38.0)	95
60 years and older	*	< LOD†	< LOD	21.2† (12.5-31.3)	89

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.
* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 5.3.h. Urinary equol: Non-Hispanic whites (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	9.61 (8.36-11.0)	< LOD	9.30 (7.93-10.6)	38.7 (32.7-46.3)	1955
6–11 years	14.6 (11.3-18.8)	< LOD	15.1 (11.4-21.4)	51.5 (33.8-99.8)	179
12–19 years	8.77 (7.38-10.4)	< LOD	8.89 (7.38-10.2)	31.9 (25.8-47.4)	350
20–39 years	8.46 (7.10-10.1)	< LOD	8.57 (6.85-10.3)	32.9 (28.0-41.4)	486
40–59 years	9.78 (8.16-11.7)	< LOD	8.78 (7.22-10.4)	44.5 (32.3-55.9)	415
60 years and older	9.85 (8.61-11.3)	< LOD	10.0 (8.48-11.6)	38.0 (27.8-42.8)	525
Males					
Total, 6 years and older	8.44 (7.22-9.86)	< LOD	8.48 (7.07-9.94)	35.8 (28.8-43.3)	965
6–11 years	15.9 (11.1-22.8)	< LOD†	15.8 (8.10-27.0)	64.3† (37.4-120)	95
12–19 years	8.63 (6.94-10.7)	< LOD	8.51 (7.06-10.2)	37.3 (26.8-64.3)	179
20–39 years	7.22 (5.89-8.86)	< LOD	7.02 (5.59-9.20)	28.8 (20.5-37.8)	214
40–59 years	7.97 (6.53-9.72)	< LOD	7.97 (6.66-9.70)	30.2 (22.7-42.3)	213
60 years and older	8.49 (6.91-10.4)	< LOD	8.71 (5.85-12.3)	28.9 (22.3-42.8)	264
Females					
Total, 6 years and older	10.9 (9.38-12.7)	< LOD	10.2 (8.63-12.3)	41.8 (36.4-50.0)	990
6–11 years	13.2 (9.56-18.1)	< LOD†	14.7 (11.6-20.7)	43.3† (28.8-60.7)	84
12–19 years	8.94 (7.23-11.1)	< LOD	9.00 (7.33-11.5)	26.0 (21.5-41.7)	171
20–39 years	9.92 (8.12-12.1)	< LOD	9.54 (7.50-12.7)	36.4 (28.0-55.9)	272
40–59 years	11.9 (9.14-15.5)	< LOD	9.71 (7.33-12.5)	65.3 (37.7-94.0)	202
60 years and older	11.1 (9.88-12.4)	< LOD	10.3 (9.38-12.0)	41.0 (27.8-53.2)	261

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.4.a. Urinary O-desmethylangolensin: Total population

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	4.18 (3.65-4.78)	< LOD	4.00 (3.40-4.74)	98.7 (75.9-122)	5065
6–11 years	5.97 (4.69-7.59)	< LOD	6.50 (4.63-9.68)	105 (59.6-176)	683
12–19 years	5.87 (4.59-7.50)	< LOD	6.47 (4.47-8.60)	122 (99.0-152)	1411
20–39 years	3.59 (2.91-4.43)	< LOD	3.03 (2.50-4.10)	121 (70.1-189)	1085
40–59 years	4.67 (3.64-5.98)	< LOD	4.30 (3.20-5.50)	111 (66.1-160)	896
60 years and older	2.94 (2.39-3.62)	< LOD	3.01 (1.90-4.12)	63.9 (40.3-73.7)	990
Males					
Total, 6 years and older	4.24 (3.58-5.01)	< LOD	4.22 (3.50-5.29)	102 (74.2-137)	2462
6–11 years	6.61 (4.59-9.51)	< LOD	8.40 (3.96-11.3)	121 (52.7-235)	345
12–19 years	6.19 (4.51-8.50)	< LOD	7.00 (4.22-10.6)	105 (74.1-148)	690
20–39 years	3.44 (2.53-4.66)	< LOD	3.00 (2.00-4.47)	135 (53.9-259)	474
40–59 years	4.49 (3.45-5.86)	< LOD	4.50 (2.80-6.30)	108 (57.3-160)	455
60 years and older	3.18 (2.56-3.95)	< LOD	3.60 (2.43-5.57)	58.4 (36.3-85.2)	498
Females					
Total, 6 years and older	4.12 (3.55-4.79)	< LOD	3.90 (3.00-4.56)	93.3 (70.9-128)	2603
6–11 years	5.38 (4.06-7.12)	< LOD	5.10 (3.43-8.80)	88.5 (59.2-161)	338
12–19 years	5.56 (4.09-7.55)	< LOD	5.69 (3.63-7.80)	137 (85.6-195)	721
20–39 years	3.75 (2.85-4.95)	< LOD	3.11 (2.40-4.90)	94.8 (57.2-228)	611
40–59 years	4.84 (3.43-6.82)	< LOD	4.10 (2.83-5.51)	125 (64.9-233)	441
60 years and older	2.77 (2.05-3.73)	< LOD	2.40 (1.50-4.00)	68.0 (33.8-81.6)	492

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.

Table 5.4.b. Urinary O-desmethylangolensin: Mexican Americans

Geometric mean and selected percentiles of urine concentrations (in µg/L) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	2.43 (1.78-3.34)	< LOD	1.80 (1.00-2.84)	86.0 (59.7-105)	1400
6–11 years	3.17 (2.23-4.49)	< LOD	2.84 (1.70-4.04)	61.5 (36.8-129)	212
12–19 years	3.07 (2.35-4.01)	< LOD	2.49 (1.83-3.50)	98.0 (65.2-137)	508
20–39 years	*	< LOD	1.40 (<LOD-3.40)	87.8 (44.2-129)	282
40–59 years	*	< LOD	1.30 (.700-3.60)	95.2 (36.5-191)	209
60 years and older	*	< LOD	.420 (<LOD-2.40)	25.2 (16.0-37.9)	189
Males					
Total, 6 years and older	2.70 (1.77-4.13)	< LOD	2.10 (.800-4.70)	90.9 (66.4-129)	686
6–11 years	3.72 (2.29-6.02)	< LOD†	3.75 (1.60-8.50)	60.2† (29.3-140)	111
12–19 years	3.32 (2.53-4.36)	< LOD	3.20 (2.00-5.02)	86.5 (61.0-144)	262
20–39 years	*	< LOD	1.31 (<LOD-6.54)	97.6 (59.7-189)	122
40–59 years	2.49 (1.48-4.19)	< LOD†	1.30 (.500-4.70)	122† (28.3-237)	100
60 years and older	*	< LOD†	.420 (<LOD-3.30)	17.0† (8.73-34.6)	91
Females					
Total, 6 years and older	2.16 (1.63-2.87)	< LOD	1.62 (.880-2.50)	70.9 (40.6-90.1)	714
6–11 years	2.67 (1.88-3.81)	< LOD†	2.28 (1.44-3.30)	55.0† (20.3-129)	101
12–19 years	2.80 (1.86-4.23)	< LOD	2.40 (1.25-3.60)	98.0 (48.2-152)	246
20–39 years	*	< LOD	1.39 (<LOD-2.83)	57.4 (25.2-88.3)	160
40–59 years	*	< LOD†	1.00 (<LOD-5.20)	86.0† (18.6-191)	109
60 years and older	*	< LOD†	< LOD	33.2† (18.4-150)	98

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.
* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 5.4.c. Urinary O-desmethylangolensin: Non-Hispanic blacks

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	5.54 (4.63-6.64)	< LOD	6.40 (5.10-7.98)	116 (95.5-155)	1219
6–11 years	10.6 (7.78-14.5)	< LOD	13.4 (9.40-22.5)	226 (157-303)	235
12–19 years	10.5 (7.71-14.3)	< LOD	13.2 (8.40-17.8)	165 (131-238)	424
20–39 years	4.69 (2.93-7.51)	< LOD	5.55 (2.66-9.30)	103 (52.4-161)	187
40–59 years	4.42 (2.98-6.55)	< LOD	4.67 (2.40-8.71)	87.6 (58.0-114)	199
60 years and older	3.33 (1.97-5.64)	< LOD	3.04 (1.20-5.70)	99.1 (33.4-357)	174
Males					
Total, 6 years and older	6.36 (4.70-8.59)	< LOD	7.20 (4.80-10.2)	143 (105-177)	590
6–11 years	13.2 (8.14-21.3)	< LOD	22.5 (10.1-39.1)	250 (158-355)	121
12–19 years	12.2 (8.73-17.0)	< LOD	14.5 (7.90-20.7)	171 (136-394)	194
20–39 years	5.91 (3.47-10.1)	< LOD†	5.93 (2.60-14.3)	128† (52.4-308)	85
40–59 years	3.78 (2.07-6.90)	< LOD†	3.50 (1.10-9.30)	99.4† (31.4-120)	103
60 years and older	4.09 (2.10-7.93)	< LOD†	5.30 (1.18-7.60)	77.4† (33.7-255)	87
Females					
Total, 6 years and older	4.94 (4.05-6.02)	< LOD	5.69 (4.50-7.90)	100 (73.8-128)	629
6–11 years	8.38 (5.30-13.2)	< LOD	10.4 (5.53-13.6)	147 (64.2-281)	114
12–19 years	9.07 (5.81-14.2)	< LOD	11.8 (6.64-20.1)	141 (95.1-201)	230
20–39 years	3.92 (2.22-6.93)	< LOD†	4.98 (1.40-9.40)	79.7† (26.6-191)	102
40–59 years	5.04 (2.88-8.81)	< LOD†	5.30 (2.10-13.3)	81.6† (40.2-313)	96
60 years and older	2.89 (1.62-5.16)	< LOD†	2.70 (.700-5.31)	99.1† (21.0-502)	87

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.4.d. Urinary O-desmethylangolensin: Non-Hispanic whites

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	4.25 (3.59-5.04)	< LOD	3.98 (3.30-4.80)	98.7 (72.8-135)	2021
6–11 years	5.98 (4.20-8.50)	< LOD	6.97 (3.43-11.5)	88.0 (45.0-191)	181
12–19 years	6.26 (4.47-8.77)	< LOD	6.50 (4.00-10.0)	122 (76.9-172)	360
20–39 years	3.47 (2.58-4.66)	< LOD	2.80 (2.03-4.40)	129 (61.0-228)	511
40–59 years	5.40 (4.03-7.23)	< LOD	4.56 (3.31-6.40)	137 (76.4-202)	405
60 years and older	2.88 (2.23-3.71)	< LOD	2.83 (1.71-4.20)	58.4 (30.2-78.0)	564
Males					
Total, 6 years and older	4.22 (3.44-5.18)	< LOD	4.12 (3.31-5.40)	96.8 (65.7-137)	995
6–11 years	6.33 (3.52-11.4)	< LOD†	7.20 (3.30-15.7)	88.0† (43.4-311)	90
12–19 years	6.27 (4.21-9.32)	< LOD	6.50 (3.60-13.5)	103 (61.6-148)	181
20–39 years	2.95 (1.95-4.48)	< LOD	2.51 (1.20-4.47)	96.0 (25.2-260)	223
40–59 years	5.35 (4.05-7.06)	< LOD	5.28 (3.31-8.00)	111 (58.4-178)	213
60 years and older	3.27 (2.60-4.12)	< LOD	3.60 (1.90-6.00)	58.4 (29.9-98.9)	288
Females					
Total, 6 years and older	4.29 (3.50-5.25)	< LOD	3.98 (2.79-4.98)	106 (70.6-154)	1026
6–11 years	5.63 (3.55-8.95)	< LOD†	5.90 (2.70-14.3)	72.2† (30.5-176)	91
12–19 years	6.26 (3.92-10.0)	< LOD	6.40 (3.50-11.7)	166 (58.3-367)	179
20–39 years	4.05 (2.76-5.94)	< LOD	3.80 (2.05-5.71)	135 (51.2-250)	288
40–59 years	5.46 (3.47-8.59)	< LOD	4.30 (2.36-6.40)	154 (64.9-322)	192
60 years and older	2.59 (1.81-3.72)	< LOD	2.10 (1.21-4.05)	59.9 (17.7-85.1)	276

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.4.e. Urinary O-desmethylangolensin: Total population (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	3.91 (3.38-4.52)	< LOD	3.74 (3.09-4.50)	87.6 (69.8-108)	5065
6–11 years	6.62 (5.15-8.52)	< LOD	6.64 (4.63-10.6)	93.7 (65.0-144)	683
12–19 years	4.28 (3.25-5.65)	< LOD	4.45 (3.22-6.51)	76.5 (61.6-102)	1411
20–39 years	2.89 (2.33-3.59)	< LOD	2.63 (1.96-3.66)	87.8 (50.8-126)	1085
40–59 years	4.67 (3.70-5.90)	< LOD	3.87 (2.73-5.68)	112 (71.8-155)	896
60 years and older	3.51 (2.81-4.37)	< LOD	3.19 (2.12-4.95)	64.7 (50.8-76.0)	990
Males					
Total, 6 years and older	3.43 (2.85-4.12)	< LOD	3.51 (2.56-4.45)	75.2 (58.5-96.5)	2462
6–11 years	7.12 (4.73-10.7)	< LOD	6.80 (3.59-17.0)	97.8 (56.2-233)	345
12–19 years	4.45 (3.20-6.19)	< LOD	4.71 (3.41-8.02)	70.2 (48.8-115)	690
20–39 years	2.40 (1.73-3.33)	< LOD	2.05 (1.38-3.06)	88.9 (34.3-151)	474
40–59 years	3.76 (2.88-4.92)	< LOD	3.66 (2.46-5.76)	80.3 (53.1-118)	455
60 years and older	2.96 (2.35-3.73)	< LOD	2.92 (1.84-4.68)	51.7 (35.4-64.2)	498
Females					
Total, 6 years and older	4.43 (3.76-5.21)	< LOD	3.92 (3.15-5.00)	98.3 (70.3-140)	2603
6–11 years	6.14 (4.67-8.09)	< LOD	6.61 (4.42-10.5)	88.0 (52.7-158)	338
12–19 years	4.12 (2.97-5.71)	< LOD	3.87 (2.50-5.90)	89.5 (61.4-111)	721
20–39 years	3.45 (2.58-4.61)	< LOD	3.62 (2.28-4.64)	86.0 (43.2-155)	611
40–59 years	5.76 (4.18-7.94)	< LOD	3.90 (2.69-7.27)	147 (85.2-280)	441
60 years and older	4.00 (2.93-5.47)	< LOD	3.40 (1.92-6.17)	69.8 (56.9-109)	492

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.

Table 5.4.f. Urinary O-desmethylangolensin: Mexican Americans (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	2.26 (1.70-3.00)	< LOD	1.69 (1.12-2.67)	58.8 (48.6-87.8)	1400
6–11 years	4.11 (3.09-5.47)	< LOD	3.69 (2.16-7.00)	79.8 (53.6-114)	212
12–19 years	2.43 (1.85-3.19)	< LOD	2.13 (1.55-3.17)	61.5 (47.4-86.3)	508
20–39 years	*	< LOD	1.17 (<LOD-2.67)	56.4 (29.9-103)	282
40–59 years	*	< LOD	1.56 (.805-3.55)	58.8 (27.8-145)	209
60 years and older	*	< LOD	1.03 (<LOD-2.70)	30.4 (21.4-55.3)	189
Males					
Total, 6 years and older	2.23 (1.52-3.27)	< LOD	1.64 (.932-3.90)	61.4 (48.6-93.0)	686
6–11 years	4.52 (2.88-7.09)	< LOD†	4.87 (1.72-8.95)	93.0† (50.2-145)	111
12–19 years	2.50 (1.87-3.35)	< LOD	2.82 (1.54-4.31)	56.1 (37.2-71.2)	262
20–39 years	*	< LOD	1.45 (<LOD-4.56)	60.0 (25.8-113)	122
40–59 years	2.04 (1.26-3.32)	< LOD†	1.42 (.661-4.23)	57.2† (19.6-218)	100
60 years and older	*	< LOD†	.698 (<LOD-3.02)	23.6† (11.1-33.2)	91
Females					
Total, 6 years and older	2.30 (1.77-2.99)	< LOD	1.69 (1.17-2.08)	57.7 (41.7-87.6)	714
6–11 years	3.73 (2.62-5.29)	< LOD†	2.44 (1.68-7.00)	78.3† (27.1-108)	101
12–19 years	2.35 (1.57-3.52)	< LOD	1.78 (1.10-2.78)	68.3 (45.6-115)	246
20–39 years	*	< LOD	1.03 (<LOD-2.15)	41.7 (15.5-87.6)	160
40–59 years	*	< LOD†	1.77 (<LOD-3.90)	76.8† (29.1-145)	109
60 years and older	*	< LOD†	< LOD	55.3† (20.9-970)	98

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.
* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 5.4.g. Urinary O-desmethylangolensin: Non-Hispanic blacks (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	3.73 (3.08-4.51)	< LOD	4.12 (3.20-5.48)	71.9 (54.7-100)	1219
6–11 years	9.94 (7.43-13.3)	< LOD	10.6 (8.27-18.2)	217 (118-305)	235
12–19 years	5.88 (4.34-7.98)	< LOD	7.25 (4.64-10.2)	95.0 (57.0-142)	424
20–39 years	2.68 (1.70-4.23)	< LOD	3.66 (1.67-5.69)	45.4 (26.8-100)	187
40–59 years	2.95 (2.07-4.19)	< LOD	2.93 (1.61-5.48)	60.4 (36.7-81.9)	199
60 years and older	3.11 (1.99-4.85)	< LOD	2.91 (1.64-4.83)	75.6 (47.2-167)	174
Males					
Total, 6 years and older	3.84 (2.85-5.19)	< LOD	4.45 (2.64-7.30)	79.7 (55.2-118)	590
6–11 years	12.3 (7.52-20.0)	< LOD	18.0 (9.43-32.4)	233 (119-363)	121
12–19 years	6.63 (4.79-9.18)	< LOD	7.65 (4.69-11.1)	109 (59.1-198)	194
20–39 years	2.87 (1.70-4.84)	< LOD†	2.95 (1.28-8.61)	42.9† (23.4-100)	85
40–59 years	2.27 (1.24-4.17)	< LOD†	2.18 (.996-5.61)	67.8† (23.2-84.4)	103
60 years and older	3.05 (1.64-5.69)	< LOD†	2.79 (1.12-5.83)	79.7† (26.3-151)	87
Females					
Total, 6 years and older	3.63 (2.96-4.46)	< LOD	4.05 (3.26-5.22)	64.4 (47.0-90.4)	629
6–11 years	7.89 (5.57-11.2)	< LOD	8.27 (4.80-10.9)	104 (62.9-305)	114
12–19 years	5.24 (3.35-8.21)	< LOD	5.83 (3.15-11.1)	71.9 (47.5-142)	230
20–39 years	2.54 (1.45-4.46)	< LOD†	3.36 (1.42-5.69)	42.1† (22.1-185)	102
40–59 years	3.67 (2.23-6.04)	< LOD†	3.61 (1.61-7.58)	54.4† (34.1-147)	96
60 years and older	3.14 (1.90-5.19)	< LOD†	2.91 (1.31-6.30)	75.6† (23.8-359)	87

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.4.h. Urinary O-desmethylangolensin: Non-Hispanic whites (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	4.24 (3.55-5.07)	< LOD	3.78 (3.05-4.95)	97.4 (71.8-125)	2021
6–11 years	6.69 (4.67-9.58)	< LOD	6.80 (3.78-13.6)	85.2 (47.9-190)	181
12–19 years	4.79 (3.27-7.03)	< LOD	4.70 (3.14-8.91)	83.6 (60.3-125)	360
20–39 years	3.01 (2.28-3.98)	< LOD	2.72 (1.89-3.77)	97.4 (50.8-151)	511
40–59 years	5.67 (4.36-7.37)	< LOD	5.32 (2.96-7.96)	136 (71.8-210)	405
60 years and older	3.56 (2.74-4.64)	< LOD	3.17 (1.83-5.45)	64.5 (45.6-83.0)	564
Males					
Total, 6 years and older	3.60 (2.89-4.49)	< LOD	3.51 (2.54-4.68)	76.4 (54.1-102)	995
6–11 years	7.20 (3.84-13.5)	< LOD†	6.80 (2.85-21.3)	90.2† (39.0-407)	90
12–19 years	4.85 (3.15-7.46)	< LOD	4.71 (3.05-13.5)	62.2 (45.9-125)	181
20–39 years	2.24 (1.48-3.39)	< LOD	1.96 (1.27-3.06)	88.2 (23.5-151)	223
40–59 years	4.56 (3.50-5.94)	< LOD	4.91 (2.73-7.08)	96.5 (43.2-161)	213
60 years and older	3.12 (2.43-4.01)	< LOD	3.17 (1.83-5.10)	49.3 (31.6-76.0)	288
Females					
Total, 6 years and older	4.97 (4.04-6.10)	< LOD	4.15 (3.15-6.03)	120 (72.2-153)	1026
6–11 years	6.19 (4.04-9.49)	< LOD†	6.86 (3.85-13.6)	84.7† (37.9-179)	91
12–19 years	4.74 (2.93-7.67)	< LOD	4.64 (2.43-8.27)	98.9 (61.4-292)	179
20–39 years	4.01 (2.77-5.79)	< LOD	4.01 (2.52-5.73)	97.4 (45.6-165)	288
40–59 years	7.07 (4.69-10.7)	< LOD	5.35 (2.45-10.1)	159 (97.6-421)	192
60 years and older	3.96 (2.70-5.81)	< LOD	2.86 (1.64-6.60)	71.5 (49.1-114)	276

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.5.a. Urinary enterodiol: Total population

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	31.1 (28.2-34.3)	4.35 (3.35-5.50)	36.7 (34.2-39.4)	173 (155-189)	5321
6–11 years	30.2 (25.1-36.5)	5.70 (3.50-7.90)	33.4 (28.3-39.4)	154 (113-219)	723
12–19 years	32.5 (28.8-36.8)	5.50 (4.40-6.96)	36.8 (31.8-40.7)	165 (134-188)	1488
20–39 years	31.2 (27.1-35.8)	4.15 (2.50-5.70)	37.6 (34.4-44.2)	170 (140-197)	1139
40–59 years	31.9 (27.1-37.5)	3.80 (1.72-6.20)	37.7 (33.9-42.6)	191 (167-231)	945
60 years and older	29.1 (25.5-33.1)	4.20 (2.80-5.50)	33.1 (29.3-37.6)	163 (142-190)	1026
Males					
Total, 6 years and older	30.3 (26.8-34.2)	3.79 (2.70-5.05)	36.7 (33.2-40.4)	168 (146-187)	2581
6–11 years	30.1 (24.1-37.6)	5.70 (2.74-9.10)	34.6 (27.0-44.1)	132 (109-162)	366
12–19 years	28.6 (24.2-33.7)	4.30 (2.70-6.94)	32.7 (27.9-38.0)	140 (111-186)	729
20–39 years	30.6 (25.9-36.0)	3.60 (2.40-5.13)	37.3 (32.0-46.5)	152 (131-190)	500
40–59 years	32.7 (26.5-40.4)	3.50 (<LOD-6.66)	40.2 (33.8-48.4)	207 (163-269)	478
60 years and older	27.0 (22.4-32.7)	3.35 (2.00-4.47)	33.1 (26.5-39.1)	155 (118-197)	508
Females					
Total, 6 years and older	31.8 (28.9-35.1)	5.01 (3.50-6.40)	37.0 (34.7-39.8)	175 (160-197)	2740
6–11 years	30.3 (23.2-39.7)	5.85 (2.40-8.53)	33.4 (25.6-40.2)	174 (98.1-279)	357
12–19 years	37.3 (31.6-44.0)	6.70 (5.01-8.57)	41.7 (34.7-49.8)	171 (148-215)	759
20–39 years	31.8 (27.3-37.0)	5.30 (1.80-7.40)	38.5 (32.8-45.7)	180 (139-220)	639
40–59 years	31.1 (25.5-37.9)	3.88 (<LOD-8.50)	36.0 (30.9-41.4)	183 (148-231)	467
60 years and older	30.7 (26.1-36.2)	5.00 (2.84-7.17)	32.8 (29.3-37.7)	163 (139-209)	518

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.

Table 5.5.b. Urinary enterodiol: Mexican Americans

Geometric mean and selected percentiles of urine concentrations (in µg/L) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	25.8 (23.1-28.8)	2.76 (1.68-4.00)	30.9 (27.5-35.2)	146 (128-169)	1470
6–11 years	19.4 (16.0-23.6)	< LOD	22.3 (18.6-30.2)	120 (92.6-156)	222
12–19 years	27.2 (22.6-32.8)	3.80 (1.68-5.50)	29.5 (25.4-37.8)	159 (134-213)	533
20–39 years	28.6 (23.3-35.0)	3.60 (1.60-6.50)	34.3 (26.9-42.4)	143 (110-202)	300
40–59 years	26.5 (21.5-32.6)	2.38 (<LOD-6.60)	32.4 (26.0-38.7)	173 (141-256)	216
60 years and older	19.6 (15.3-25.2)	2.13 (<LOD-5.40)	23.8 (20.4-34.6)	92.1 (74.0-143)	199
Males					
Total, 6 years and older	23.5 (20.0-27.6)	2.04 (<LOD-3.80)	29.5 (23.7-35.0)	137 (105-169)	710
6–11 years	18.4 (15.3-22.1)	< LOD	21.3 (15.1-32.8)	99.2 (79.2-158)	115
12–19 years	20.9 (16.8-26.0)	1.68 (<LOD-4.53)	24.9 (20.4-29.0)	121 (99.9-159)	269
20–39 years	26.7 (19.8-36.0)	1.84 (<LOD-6.30)	30.9 (21.3-43.3)	144 (92.5-216)	127
40–59 years	25.0 (18.6-33.6)	2.36† (<LOD-7.70)	33.0 (19.2-43.3)	115† (75.9-244)	104
60 years and older	18.4 (12.8-26.4)	< LOD†	22.0 (15.7-31.9)	73.1† (43.8-134)	95
Females					
Total, 6 years and older	28.5 (25.3-32.2)	3.80 (2.21-5.74)	33.4 (28.3-39.0)	168 (141-192)	760
6–11 years	20.6 (14.6-29.0)	2.01† (<LOD-5.30)	24.2 (16.5-35.3)	120† (92.6-219)	107
12–19 years	36.2 (29.2-45.0)	5.20 (3.90-9.21)	38.5 (29.3-51.0)	197 (152-282)	264
20–39 years	31.0 (24.7-38.9)	5.83 (<LOD-9.20)	36.0 (26.9-48.1)	132 (97.3-187)	173
40–59 years	28.2 (20.9-38.0)	2.21 (<LOD-7.20)	31.3 (20.0-47.2)	197 (159-279)	112
60 years and older	20.7 (15.1-28.5)	2.21† (<LOD-5.48)	25.5 (16.8-37.9)	101† (63.9-199)	104

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.5.c. Urinary enterodiol: Non-Hispanic blacks

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	30.4 (26.5-34.9)	4.87 (3.30-6.21)	35.4 (31.4-38.4)	168 (140-181)	1289
6–11 years	30.7 (26.3-35.9)	6.64 (4.46-8.75)	33.7 (27.5-38.7)	132 (112-167)	249
12–19 years	34.9 (30.9-39.3)	6.11 (3.56-8.33)	41.6 (36.8-47.6)	162 (132-213)	451
20–39 years	28.8 (22.0-37.7)	5.80 (<LOD-8.67)	35.3 (26.6-41.7)	167 (115-210)	197
40–59 years	32.3 (25.6-40.9)	4.54 (2.30-10.3)	33.2 (25.7-44.9)	207 (123-278)	210
60 years and older	25.7 (19.0-34.9)	2.72 (<LOD-4.33)	32.9 (24.4-40.4)	147 (107-219)	182
Males					
Total, 6 years and older	25.2 (21.6-29.3)	4.00 (1.80-5.97)	29.9 (25.0-34.3)	124 (104-163)	628
6–11 years	29.5 (23.2-37.5)	5.80 (3.30-8.75)	35.5 (26.2-44.5)	129 (80.3-167)	127
12–19 years	30.3 (25.8-35.4)	5.70 (3.01-8.57)	34.6 (25.9-42.1)	140 (119-218)	212
20–39 years	22.8 (16.3-32.0)	< LOD†	27.9 (16.6-35.3)	107† (72.4-214)	91
40–59 years	25.2 (17.8-35.5)	3.50† (<LOD-10.5)	26.0 (20.0-34.9)	123† (75.8-227)	109
60 years and older	20.3 (14.8-28.0)	< LOD†	29.1 (19.3-38.0)	96.3† (65.0-143)	89
Females					
Total, 6 years and older	35.8 (29.9-42.9)	5.50 (3.30-8.70)	41.7 (35.4-47.0)	180 (154-237)	661
6–11 years	32.1 (25.6-40.2)	7.34 (4.00-11.4)	33.7 (27.2-38.8)	137 (92.6-230)	122
12–19 years	40.2 (33.4-48.4)	6.13 (3.20-12.0)	47.0 (38.7-59.2)	171 (125-247)	239
20–39 years	34.7 (24.7-48.8)	7.80† (<LOD-10.6)	41.7 (32.5-50.4)	176† (115-237)	106
40–59 years	40.0 (28.9-55.4)	5.50† (2.30-13.1)	37.8 (25.9-63.7)	250† (144-340)	101
60 years and older	30.1 (18.5-48.8)	2.80† (<LOD-6.25)	36.3 (22.5-49.2)	172† (123-396)	93

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.5.d. Urinary enterodiol: Non-Hispanic whites

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	32.4 (29.3-35.8)	4.68 (3.50-5.90)	38.5 (36.0-41.7)	173 (152-195)	2110
6–11 years	32.5 (24.6-42.8)	5.90 (2.40-10.5)	35.7 (28.1-44.8)	152 (106-253)	196
12–19 years	32.7 (27.6-38.7)	6.10 (3.97-7.80)	35.4 (29.7-43.8)	162 (127-185)	375
20–39 years	33.4 (28.3-39.5)	4.70 (2.70-6.10)	43.1 (37.4-47.1)	174 (138-214)	529
40–59 years	33.2 (27.3-40.4)	3.80 (<LOD-7.40)	40.5 (35.8-46.7)	207 (158-254)	433
60 years and older	29.6 (25.7-34.1)	4.35 (2.74-6.10)	33.4 (29.7-38.7)	160 (139-190)	577
Males					
Total, 6 years and older	32.7 (28.6-37.4)	4.20 (2.92-5.56)	40.0 (35.4-44.1)	174 (146-198)	1036
6–11 years	33.7 (24.0-47.3)	7.55† (<LOD-14.6)	37.8 (25.7-50.9)	135† (103-215)	101
12–19 years	28.6 (22.9-35.7)	4.30 (2.38-7.80)	32.5 (24.3-40.7)	131 (99.1-174)	190
20–39 years	33.9 (27.3-42.2)	3.79 (<LOD-5.95)	44.2 (34.9-55.1)	174 (132-226)	231
40–59 years	35.9 (28.1-46.0)	3.65 (<LOD-7.40)	46.7 (37.8-53.2)	213 (167-263)	224
60 years and older	28.1 (22.8-34.7)	3.35 (2.00-5.30)	33.2 (26.5-40.0)	163 (120-205)	290
Females					
Total, 6 years and older	32.1 (29.0-35.6)	5.35 (3.53-6.70)	37.6 (35.0-41.1)	171 (148-209)	1074
6–11 years	31.2 (20.5-47.7)	5.85† (<LOD-12.2)	34.1 (22.3-50.8)	174† (87.0-327)	95
12–19 years	38.0 (29.5-48.9)	6.87 (3.97-11.2)	43.5 (29.3-58.0)	170 (144-245)	185
20–39 years	33.0 (26.9-40.4)	5.70 (1.80-7.60)	41.1 (30.1-47.8)	166 (130-220)	298
40–59 years	30.8 (24.1-39.4)	4.09 (<LOD-10.4)	36.2 (27.8-42.5)	195 (127-259)	209
60 years and older	30.8 (25.6-37.2)	5.18 (2.74-7.50)	32.9 (29.2-39.8)	160 (127-209)	287

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.5.e. Urinary enterodiol: Total population (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	29.0 (26.5-31.7)	4.17 (3.19-5.13)	33.6 (31.1-36.8)	150 (136-163)	5321
6–11 years	32.8 (27.6-39.0)	5.61 (3.48-7.95)	36.2 (30.8-42.7)	188 (140-244)	723
12–19 years	23.5 (21.1-26.3)	4.27 (2.64-5.42)	26.6 (24.1-30.4)	102 (93.2-117)	1488
20–39 years	25.0 (21.6-28.9)	3.52 (2.52-5.12)	28.2 (25.3-32.7)	124 (108-156)	1139
40–59 years	32.0 (27.7-36.9)	3.50 (2.54-5.86)	39.1 (33.2-44.8)	162 (140-197)	945
60 years and older	34.9 (31.1-39.2)	5.13 (4.30-7.13)	41.3 (35.6-46.2)	174 (157-194)	1026
Males					
Total, 6 years and older	24.3 (21.7-27.4)	3.17 (2.52-4.34)	28.8 (25.2-31.7)	129 (111-152)	2581
6–11 years	31.8 (25.1-40.2)	4.62 (2.80-8.38)	34.8 (28.3-43.7)	172 (112-244)	366
12–19 years	20.3 (17.2-23.9)	3.27 (1.98-4.96)	23.9 (20.5-28.1)	94.1 (81.5-111)	729
20–39 years	21.3 (18.3-24.8)	2.84 (2.15-4.03)	24.6 (21.2-28.1)	111 (96.4-130)	500
40–59 years	27.2 (22.4-33.0)	3.19 (<LOD-5.80)	31.7 (28.3-41.9)	160 (121-201)	478
60 years and older	25.5 (20.5-31.7)	2.96 (2.04-4.74)	30.2 (23.8-35.4)	138 (105-179)	508
Females					
Total, 6 years and older	34.2 (31.2-37.5)	5.26 (4.20-7.08)	39.9 (36.6-43.8)	162 (148-178)	2740
6–11 years	33.9 (26.8-42.8)	6.64 (3.93-8.55)	37.3 (28.6-50.1)	193 (108-304)	357
12–19 years	27.5 (24.0-31.5)	5.26 (3.66-7.26)	30.0 (26.2-34.9)	115 (100-132)	759
20–39 years	29.2 (24.7-34.6)	4.73 (2.54-7.41)	33.5 (28.1-40.6)	141 (108-182)	639
40–59 years	37.3 (31.0-44.9)	4.11 (<LOD-9.07)	44.6 (39.0-53.0)	165 (140-217)	467
60 years and older	44.4 (38.2-51.7)	7.53 (5.23-12.3)	51.4 (44.8-58.8)	188 (164-222)	518

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.

Table 5.5.f. Urinary enterodiol: Mexican Americans (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	23.8 (21.5-26.3)	3.21 (2.34-4.32)	27.6 (25.2-30.2)	134 (116-158)	1470
6–11 years	24.8 (20.1-30.6)	< LOD	32.4 (23.9-40.2)	140 (105-182)	222
12–19 years	21.7 (18.2-25.7)	3.35 (1.53-5.17)	23.9 (19.0-30.4)	115 (99.3-134)	533
20–39 years	23.6 (19.5-28.6)	2.78 (1.62-5.36)	27.1 (22.4-30.1)	127 (91.4-181)	300
40–59 years	26.0 (21.3-31.6)	4.20 (<LOD-6.80)	30.6 (21.5-42.2)	157 (126-192)	216
60 years and older	22.7 (17.8-28.9)	2.26 (<LOD-7.79)	31.3 (25.7-38.1)	110 (80.0-149)	199
Males					
Total, 6 years and older	19.4 (16.9-22.2)	2.48 (<LOD-4.32)	21.9 (18.9-26.1)	117 (87.5-141)	710
6–11 years	21.9 (17.5-27.5)	< LOD	26.9 (19.9-39.3)	129 (83.7-188)	115
12–19 years	15.9 (12.6-20.2)	1.99 (<LOD-3.66)	18.3 (15.2-22.5)	85.9 (73.8-115)	269
20–39 years	19.6 (14.9-25.9)	2.34 (<LOD-5.83)	20.0 (15.7-27.8)	117 (82.1-179)	127
40–59 years	20.9 (15.9-27.5)	4.92† (<LOD-6.91)	23.5 (13.6-36.6)	120† (59.6-192)	104
60 years and older	17.5 (12.0-25.7)	< LOD†	22.7 (17.0-36.2)	74.3† (49.3-179)	95
Females					
Total, 6 years and older	29.8 (26.5-33.6)	4.68 (2.71-7.01)	34.4 (29.6-38.8)	154 (127-193)	760
6–11 years	28.1 (20.5-38.7)	2.82† (<LOD-6.25)	37.3 (25.1-48.1)	144† (98.7-279)	107
12–19 years	30.3 (25.3-36.3)	6.40 (3.13-9.44)	31.6 (24.0-43.4)	156 (112-195)	264
20–39 years	29.3 (23.8-36.0)	5.23 (<LOD-9.41)	31.0 (27.1-38.8)	133 (93.6-193)	173
40–59 years	32.7 (24.9-43.0)	4.56 (<LOD-10.1)	44.8 (27.0-59.4)	183 (141-235)	112
60 years and older	28.2 (20.3-39.3)	3.80† (<LOD-8.93)	34.5 (28.6-42.2)	130† (78.9-213)	104

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.5.g. Urinary enterodiol: Non-Hispanic blacks (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	20.5 (17.5-24.0)	3.30 (2.47-4.03)	23.3 (19.7-26.6)	118 (97.4-138)	1289
6–11 years	28.7 (24.0-34.4)	5.03 (4.02-7.59)	31.1 (26.1-38.8)	126 (95.2-168)	249
12–19 years	19.6 (17.2-22.3)	3.48 (2.11-4.47)	23.5 (19.7-27.2)	86.8 (72.7-116)	451
20–39 years	16.4 (12.2-22.0)	2.15 (<LOD-4.41)	19.3 (14.1-23.8)	96.0 (68.6-128)	197
40–59 years	21.8 (16.9-28.2)	3.57 (2.35-5.11)	23.3 (16.2-31.4)	145 (94.5-187)	210
60 years and older	24.2 (17.8-32.8)	2.94 (<LOD-5.25)	27.0 (22.7-38.6)	146 (88.0-241)	182
Males					
Total, 6 years and older	15.2 (12.9-18.0)	2.40 (1.44-3.12)	18.0 (14.6-21.0)	84.6 (65.9-108)	628
6–11 years	27.3 (20.5-36.4)	4.14 (2.52-9.49)	30.8 (25.6-42.5)	106 (77.7-168)	127
12–19 years	16.5 (14.0-19.5)	2.23 (1.22-4.05)	20.0 (15.1-24.3)	82.9 (61.4-103)	212
20–39 years	11.1 (7.62-16.1)	< LOD†	12.9 (10.3-18.0)	70.4† (30.6-154)	91
40–59 years	15.3 (11.1-21.3)	2.65† (<LOD-5.24)	15.9 (12.8-21.0)	72.6† (41.9-155)	109
60 years and older	15.1 (11.2-20.4)	< LOD†	24.0 (13.9-30.2)	66.1† (45.5-97.2)	89
Females					
Total, 6 years and older	26.5 (21.6-32.5)	4.41 (3.40-5.50)	30.1 (23.5-37.7)	138 (112-180)	661
6–11 years	30.3 (24.4-37.7)	6.64 (4.20-8.88)	33.8 (23.2-41.8)	134 (93.9-209)	122
12–19 years	23.2 (19.3-28.0)	3.96 (2.30-6.55)	26.2 (22.6-30.0)	106 (71.7-145)	239
20–39 years	22.4 (15.8-31.8)	4.87† (<LOD-7.83)	26.6 (18.2-41.9)	99.4† (68.6-138)	106
40–59 years	29.4 (20.0-43.3)	4.32† (2.35-8.07)	34.8 (22.6-48.1)	158† (118-321)	101
60 years and older	33.0 (20.2-53.7)	3.35† (<LOD-9.66)	33.3 (22.7-54.5)	229† (123-590)	93

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.5.h. Urinary enterodiol: Non-Hispanic whites (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	32.3 (29.5-35.3)	5.15 (3.94-6.23)	37.4 (33.7-41.4)	158 (140-174)	2110
6–11 years	35.3 (27.5-45.2)	6.62 (3.23-9.63)	40.3 (29.4-50.4)	188 (132-281)	196
12–19 years	24.8 (21.2-29.0)	5.02 (2.36-7.01)	28.1 (24.3-33.6)	99.5 (91.3-121)	375
20–39 years	29.1 (24.9-34.2)	4.84 (2.92-6.99)	31.3 (27.2-37.6)	140 (109-182)	529
40–59 years	34.9 (29.3-41.5)	3.68 (<LOD-7.14)	43.4 (37.7-52.9)	165 (135-208)	433
60 years and older	37.0 (32.4-42.2)	5.89 (4.17-7.67)	44.0 (36.7-50.3)	179 (155-209)	577
Males					
Total, 6 years and older	27.7 (24.5-31.3)	3.53 (2.80-5.38)	31.9 (28.0-36.9)	138 (114-170)	1036
6–11 years	37.0 (25.9-52.8)	6.62† (<LOD-14.2)	42.2 (21.7-60.2)	202† (105-290)	101
12–19 years	21.7 (17.2-27.5)	4.74 (1.98-6.23)	24.7 (20.8-33.1)	94.1 (71.7-119)	190
20–39 years	25.8 (21.2-31.4)	3.41 (<LOD-6.26)	28.0 (24.0-34.9)	121 (100-167)	231
40–59 years	30.2 (24.4-37.5)	3.13 (<LOD-6.83)	38.0 (30.0-51.0)	160 (114-216)	224
60 years and older	27.0 (21.1-34.5)	3.19 (2.17-5.13)	31.1 (23.8-40.0)	138 (104-189)	290
Females					
Total, 6 years and older	37.4 (34.2-40.9)	7.08 (4.81-7.92)	43.1 (38.7-48.7)	168 (151-196)	1074
6–11 years	33.4 (23.1-48.3)	6.28† (<LOD-10.0)	35.5 (27.5-60.6)	150† (87.0-325)	95
12–19 years	28.7 (23.3-35.3)	6.14 (3.02-7.64)	32.1 (26.2-38.8)	112 (90.2-146)	185
20–39 years	32.8 (27.1-39.8)	6.46 (3.12-10.7)	34.9 (27.8-47.5)	166 (107-235)	298
40–59 years	40.1 (32.3-49.8)	6.00 (<LOD-14.4)	48.7 (39.0-58.5)	165 (129-224)	209
60 years and older	47.2 (39.4-56.7)	8.54 (6.23-14.9)	53.0 (46.4-65.3)	189 (157-225)	287

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.6.a. Urinary enterolactone: Total population

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	249 (227-273)	23.6 (19.6-29.5)	330 (303-370)	1710 (1500-1960)	5342
6–11 years	297 (251-352)	55.1 (41.1-73.7)	340 (288-412)	1420 (1250-2050)	727
12–19 years	256 (223-294)	31.5 (22.1-48.0)	317 (266-377)	1560 (1250-1900)	1490
20–39 years	237 (203-276)	20.3 (13.0-28.0)	317 (255-380)	1850 (1420-2320)	1139
40–59 years	231 (190-280)	15.9 (11.0-25.3)	334 (272-399)	1810 (1510-2240)	951
60 years and older	276 (245-311)	32.9 (17.9-50.3)	362 (303-417)	1680 (1330-2170)	1035
Males					
Total, 6 years and older	258 (234-285)	21.7 (17.5-25.3)	349 (310-389)	1890 (1600-2280)	2594
6–11 years	322 (267-387)	55.3 (35.8-102)	363 (309-456)	1380 (1120-1810)	368
12–19 years	246 (212-287)	29.6 (19.4-41.7)	318 (252-391)	1560 (1250-1820)	733
20–39 years	249 (208-299)	19.2 (11.2-30.9)	337 (258-389)	2050 (1650-2540)	500
40–59 years	246 (194-312)	16.6 (12.7-25.3)	360 (278-438)	1940 (1580-2530)	480
60 years and older	274 (228-330)	19.9 (12.9-43.2)	361 (291-458)	1790 (1410-2470)	513
Females					
Total, 6 years and older	241 (215-270)	25.9 (18.1-38.7)	321 (281-359)	1500 (1300-1810)	2748
6–11 years	273 (203-368)	55.5 (24.0-83.6)	325 (236-420)	1520 (847-2280)	359
12–19 years	267 (218-326)	37.2 (20.1-59.1)	314 (259-383)	1500 (1040-2130)	757
20–39 years	225 (181-279)	21.4 (9.30-38.4)	312 (239-381)	1450 (991-2000)	639
40–59 years	217 (164-288)	15.8 (7.30-44.9)	311 (227-399)	1510 (1180-1810)	471
60 years and older	277 (231-333)	43.4 (18.9-66.5)	362 (282-419)	1490 (1190-2140)	522

Table 5.6.b. Urinary enterolactone: Mexican Americans

Geometric mean and selected percentiles of urine concentrations (in µg/L) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	236 (198-280)	32.0 (17.7-40.2)	316 (266-354)	1550 (1230-1890)	1492
6–11 years	209 (155-282)	31.4 (17.7-50.6)	265 (192-375)	913 (796-1420)	226
12–19 years	272 (238-312)	36.6 (29.5-61.7)	314 (253-370)	1650 (1350-1990)	538
20–39 years	262 (203-340)	34.5 (8.76-49.8)	346 (280-424)	1840 (1280-2620)	300
40–59 years	192 (149-249)	12.9 (8.00-35.8)	245 (200-347)	1390 (929-2060)	221
60 years and older	197 (137-285)	23.0 (6.66-50.5)	296 (180-415)	967 (825-1490)	207
Males					
Total, 6 years and older	253 (200-320)	32.7 (15.7-46.3)	346 (266-416)	1640 (1000-2380)	722
6–11 years	236 (170-328)	35.1 (24.7-55.1)	316 (171-476)	972 (815-1800)	117
12–19 years	236 (210-266)	34.3 (21.7-55.3)	293 (210-357)	1510 (950-1900)	274
20–39 years	317 (225-446)	39.6 (6.81-79.5)	455 (280-628)	2380 (1280-3560)	127
40–59 years	166 (104-265)	10.4† (4.10-38.8)	238 (148-389)	1030† (647-2120)	105
60 years and older	266 (176-402)	37.2† (6.66-99.7)	374 (248-488)	967† (679-2570)	99
Females					
Total, 6 years and older	218 (167-285)	30.2 (11.9-53.2)	279 (228-344)	1380 (980-1840)	770
6–11 years	184 (106-319)	16.8† (<LOD-80.4)	236 (170-375)	847† (745-1550)	109
12–19 years	319 (241-422)	56.1 (19.5-105)	352 (258-473)	1710 (1290-2530)	264
20–39 years	209 (134-328)	17.3 (2.91-77.7)	308 (183-414)	1100 (790-2580)	173
40–59 years	224 (159-316)	19.1 (3.44-58.0)	245 (193-392)	1480 (980-2200)	116
60 years and older	154 (96.7-246)	11.3† (<LOD-43.0)	231 (148-322)	920† (524-1490)	108

< LOD means less than the limit of detection, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.6.c. Urinary enterolactone: Non-Hispanic blacks

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	272 (230-322)	26.3 (17.6-43.6)	392 (339-441)	1500 (1270-1890)	1286
6–11 years	369 (297-457)	75.1 (41.0-99.1)	470 (391-521)	1520 (1220-2160)	249
12–19 years	351 (315-391)	53.9 (34.8-87.3)	428 (385-479)	1850 (1450-2340)	448
20–39 years	239 (167-344)	12.0 (5.40-49.4)	342 (248-504)	1680 (993-2300)	197
40–59 years	254 (202-320)	23.1 (14.5-45.9)	366 (283-479)	1350 (1050-1920)	210
60 years and older	237 (179-312)	15.2 (7.90-44.9)	399 (296-502)	1270 (1020-1960)	182
Males					
Total, 6 years and older	266 (215-329)	20.9 (12.0-36.5)	416 (339-497)	1630 (1250-2080)	627
6–11 years	362 (304-430)	65.4 (21.5-107)	487 (341-524)	1370 (1070-1720)	127
12–19 years	330 (266-409)	38.6 (26.3-77.1)	422 (363-484)	1770 (1360-2440)	211
20–39 years	261 (163-417)	17.7† (4.49-116)	416 (260-596)	1670† (1000-2500)	91
40–59 years	235 (160-345)	16.6† (4.20-34.6)	401 (184-559)	1350† (741-2580)	109
60 years and older	183 (119-281)	6.00† (3.30-19.5)	267 (155-488)	1290† (1000-1980)	89
Females					
Total, 6 years and older	278 (235-327)	39.1 (18.9-53.2)	360 (314-427)	1500 (1190-1870)	659
6–11 years	376 (259-547)	75.8 (28.7-130)	416 (299-664)	1740 (1050-2410)	122
12–19 years	374 (325-431)	87.3 (39.1-136)	441 (378-521)	1870 (1320-2260)	237
20–39 years	224 (152-330)	9.10† (3.10-49.7)	314 (219-499)	1500† (854-2140)	106
40–59 years	272 (218-340)	43.4† (15.2-71.6)	358 (246-469)	1270† (842-1540)	101
60 years and older	281 (197-401)	32.6† (9.50-102)	438 (307-565)	1270† (900-2210)	93

† Estimate is subject to greater uncertainty due to small cell size.

Table 5.6.d. Urinary enterolactone: Non-Hispanic whites

Geometric mean and selected percentiles of urine concentrations (in µg/L) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	259 (230-291)	23.9 (18.1-33.1)	344 (301-387)	1810 (1580-2100)	2112
6–11 years	308 (244-388)	57.5 (35.8-103)	331 (262-412)	1600 (1290-2310)	196
12–19 years	249 (203-306)	29.6 (17.5-58.1)	310 (242-384)	1620 (1200-2420)	375
20–39 years	235 (196-281)	19.1 (11.1-33.1)	317 (240-383)	1780 (1300-2180)	529
40–59 years	249 (195-319)	16.4 (9.30-34.1)	387 (278-424)	2030 (1610-2750)	434
60 years and older	297 (256-345)	44.8 (19.9-73.6)	372 (303-424)	1730 (1340-2260)	578
Males					
Total, 6 years and older	272 (240-308)	22.9 (17.2-33.1)	360 (310-400)	1970 (1620-2450)	1038
6–11 years	336 (257-441)	70.2† (35.8-152)	348 (283-474)	1390† (881-2600)	101
12–19 years	242 (192-306)	23.2 (10.6-64.4)	316 (222-445)	1560 (1150-2180)	190
20–39 years	236 (185-300)	19.2 (11.0-32.3)	258 (209-389)	2000 (1300-2620)	231
40–59 years	290 (218-386)	17.3 (12.7-39.6)	424 (307-555)	2400 (1710-3540)	225
60 years and older	296 (236-372)	29.6 (12.9-62.1)	377 (292-492)	1750 (1310-2730)	291
Females					
Total, 6 years and older	246 (212-286)	25.4 (15.8-43.7)	328 (280-383)	1490 (1290-2010)	1074
6–11 years	279 (185-420)	47.3† (15.7-117)	325 (224-427)	1530† (719-2900)	95
12–19 years	257 (189-349)	45.4 (17.5-62.1)	286 (222-403)	1800 (944-2950)	185
20–39 years	234 (176-310)	17.4 (7.50-43.7)	323 (238-431)	1310 (980-1970)	298
40–59 years	214 (148-310)	13.0 (5.28-46.1)	347 (206-418)	1660 (1010-2750)	209
60 years and older	298 (245-363)	53.0 (19.4-78.0)	348 (265-418)	1700 (1190-2240)	287

† Estimate is subject to greater uncertainty due to small cell size.

Table 5.6.e. Urinary enterolactone: Total population (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for the total U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	233 (213-254)	21.2 (17.4-24.5)	309 (286-335)	1500 (1380-1630)	5342
6–11 years	323 (277-375)	69.3 (41.1-91.9)	375 (305-423)	1490 (1190-1780)	727
12–19 years	185 (163-211)	23.4 (15.2-31.9)	231 (206-256)	1110 (908-1330)	1490
20–39 years	190 (163-221)	14.0 (10.4-20.9)	278 (240-304)	1290 (1110-1520)	1139
40–59 years	232 (194-277)	16.3 (11.7-24.2)	315 (267-377)	1630 (1380-1940)	951
60 years and older	331 (286-383)	37.6 (20.3-65.1)	437 (380-492)	1860 (1540-2040)	1035
Males					
Total, 6 years and older	208 (190-227)	17.4 (13.9-21.6)	279 (254-303)	1360 (1210-1540)	2594
6–11 years	339 (283-408)	76.0 (49.3-101)	397 (291-480)	1580 (1130-2120)	368
12–19 years	175 (152-201)	19.0 (12.9-29.6)	226 (200-247)	1090 (907-1310)	733
20–39 years	174 (143-210)	15.1 (10.4-22.6)	240 (206-276)	1180 (872-1530)	500
40–59 years	204 (165-253)	12.3 (8.16-24.2)	282 (243-350)	1420 (1150-1850)	480
60 years and older	257 (208-318)	18.2 (11.4-35.3)	380 (282-486)	1590 (1210-1940)	513
Females					
Total, 6 years and older	259 (232-290)	27.9 (18.6-32.9)	342 (307-379)	1590 (1440-1800)	2748
6–11 years	306 (237-394)	55.4 (30.2-126)	343 (263-401)	1400 (1110-1610)	359
12–19 years	197 (163-237)	25.9 (16.2-36.8)	243 (198-306)	1150 (850-1490)	757
20–39 years	207 (165-259)	13.9 (8.20-27.9)	302 (259-360)	1370 (1120-1800)	639
40–59 years	261 (204-335)	18.7 (9.02-39.1)	355 (267-447)	1850 (1450-2300)	471
60 years and older	401 (339-474)	60.5 (30.9-103)	472 (404-562)	2020 (1590-2250)	522

Table 5.6.f. Urinary enterolactone: Mexican Americans (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for Mexican Americans in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	219 (191-252)	24.2 (18.6-33.2)	283 (258-328)	1270 (1030-1490)	1492
6–11 years	268 (200-359)	41.3 (20.8-64.7)	348 (240-437)	1190 (871-1980)	226
12–19 years	215 (185-250)	33.0 (18.7-49.5)	257 (215-296)	1110 (955-1310)	538
20–39 years	217 (174-270)	24.2 (9.46-37.2)	281 (242-398)	1410 (995-1730)	300
40–59 years	193 (146-254)	18.1 (6.78-23.3)	277 (214-371)	1220 (1020-1430)	221
60 years and older	227 (160-323)	25.3 (10.0-60.4)	334 (231-450)	1200 (985-1800)	207
Males					
Total, 6 years and older	208 (169-257)	22.6 (14.9-36.1)	264 (227-328)	1270 (946-1730)	722
6–11 years	284 (191-421)	41.3 (12.9-83.0)	355 (217-504)	1840 (898-2790)	117
12–19 years	178 (152-208)	19.9 (14.6-43.8)	233 (184-281)	939 (716-1150)	274
20–39 years	233 (171-318)	26.9 (9.46-54.1)	280 (206-444)	1570 (868-2190)	127
40–59 years	140 (90.5-216)	8.37† (3.50-22.6)	213 (126-282)	1030† (597-1430)	105
60 years and older	251 (161-390)	26.8† (3.62-67.2)	298 (206-503)	1390† (989-2520)	99
Females					
Total, 6 years and older	231 (193-277)	24.2 (11.1-58.9)	308 (273-366)	1280 (1070-1440)	770
6–11 years	252 (166-382)	28.5† (<LOD-97.1)	319 (223-455)	1010† (786-1490)	109
12–19 years	266 (208-339)	50.2 (18.0-87.9)	282 (225-373)	1400 (1030-1630)	264
20–39 years	199 (138-286)	13.3 (2.46-70.4)	280 (179-409)	1220 (981-1650)	173
40–59 years	270 (189-387)	21.9 (7.00-73.6)	394 (233-611)	1480 (1170-2140)	116
60 years and older	209 (135-324)	21.1† (<LOD-63.0)	333 (154-422)	1070† (773-1500)	108

< LOD means less than the limit of detection for the uncorrected urine value, which may vary for some compounds by year. See Appendix D for LOD.
† Estimate is subject to greater uncertainty due to small cell size.

Table 5.6.g. Urinary enterolactone: Non-Hispanic blacks (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic blacks in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	183 (153-220)	17.9 (12.0-29.9)	269 (219-309)	1090 (911-1230)	1286
6–11 years	345 (285-417)	76.0 (48.1-108)	429 (331-495)	1170 (972-1650)	249
12–19 years	197 (176-221)	32.3 (14.1-53.4)	244 (215-273)	931 (804-1180)	448
20–39 years	136 (92.9-199)	7.64 (3.17-26.6)	197 (138-288)	888 (628-1590)	197
40–59 years	172 (134-220)	15.8 (7.07-28.9)	251 (181-318)	1010 (678-1230)	210
60 years and older	222 (167-295)	15.7 (6.74-56.4)	341 (252-439)	1390 (872-1690)	182
Males					
Total, 6 years and older	161 (128-202)	12.0 (7.64-31.9)	236 (197-278)	1010 (850-1220)	627
6–11 years	335 (272-413)	60.3 (38.6-112)	409 (329-507)	1100 (937-1570)	127
12–19 years	180 (147-221)	20.1 (11.8-45.1)	217 (186-271)	931 (728-1250)	211
20–39 years	126 (78.3-204)	7.64† (1.31-32.6)	177 (125-242)	1100† (556-1590)	91
40–59 years	143 (97.7-209)	9.30† (2.81-28.1)	252 (152-319)	820† (615-1420)	109
60 years and older	136 (86.0-215)	7.45† (1.61-15.7)	220 (128-344)	885† (705-1470)	89
Females					
Total, 6 years and older	205 (172-245)	28.9 (17.0-37.7)	298 (241-340)	1090 (911-1390)	659
6–11 years	356 (270-468)	88.1 (59.4-126)	431 (279-552)	1180 (972-1670)	122
12–19 years	216 (187-250)	50.3 (24.3-69.9)	262 (221-298)	911 (686-1300)	237
20–39 years	144 (96.1-217)	12.1† (2.05-37.2)	218 (142-326)	888† (622-1670)	106
40–59 years	200 (157-256)	28.4† (7.07-51.5)	247 (184-354)	1060† (604-1440)	101
60 years and older	308 (214-443)	41.0† (17.0-90.6)	428 (302-549)	1460† (869-2020)	93

† Estimate is subject to greater uncertainty due to small cell size.

Table 5.6.h. Urinary enterolactone: Non-Hispanic whites (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g creatinine) for non-Hispanic whites in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999–2002.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total, 6 years and older	257 (229-289)	22.6 (17.1-27.9)	338 (308-377)	1630 (1460-1880)	2112
6–11 years	334 (277-402)	76.1 (48.9-108)	378 (291-435)	1580 (1220-2020)	196
12–19 years	189 (155-229)	22.8 (15.9-29.6)	238 (192-288)	1240 (900-1720)	375
20–39 years	205 (172-243)	14.5 (9.83-22.6)	296 (268-323)	1370 (1160-1640)	529
40–59 years	261 (210-326)	16.4 (10.2-29.9)	362 (282-444)	1850 (1410-2490)	434
60 years and older	371 (310-443)	44.3 (20.3-96.7)	468 (386-570)	1920 (1570-2200)	578
Males					
Total, 6 years and older	230 (206-257)	21.2 (14.6-25.2)	308 (276-336)	1520 (1290-1690)	1038
6–11 years	370 (282-484)	82.0† (69.3-123)	435 (247-601)	1780† (1180-2940)	101
12–19 years	184 (146-233)	19.7 (7.43-31.9)	238 (189-287)	1210 (900-1880)	190
20–39 years	179 (141-227)	14.0 (9.83-24.7)	251 (201-309)	1270 (755-1630)	231
40–59 years	244 (189-316)	16.0 (8.16-29.9)	327 (254-433)	1630 (1240-2490)	225
60 years and older	283 (220-364)	19.6 (13.0-44.7)	424 (301-576)	1590 (1170-1980)	291
Females					
Total, 6 years and older	287 (247-333)	27.9 (16.9-37.7)	370 (327-418)	1850 (1520-2020)	1074
6–11 years	299 (215-416)	55.2† (25.1-142)	342 (249-401)	1400† (847-1800)	95
12–19 years	194 (147-256)	21.7 (13.8-36.8)	241 (172-344)	1250 (783-1800)	185
20–39 years	233 (174-311)	14.0 (6.11-30.6)	322 (280-424)	1410 (1180-2010)	298
40–59 years	279 (204-383)	16.9 (6.44-48.4)	378 (281-532)	1930 (1450-2560)	209
60 years and older	457 (377-553)	76.3 (30.9-151)	513 (404-681)	2040 (1620-2580)	287

† Estimate is subject to greater uncertainty due to small cell size.

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Appendices

Appendix A:

NHANES Reports Related to Nutritional Status

National Center for Health Statistics (NCHS) Series 11 Reports

http://www.cdc.gov/nchs/products/pubs/pubd/series/ser.htm#sr11

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National Center for Health Statistics (NCHS) Advance Data Reports

http://www.cdc.gov/nchs/about/major/nhanes/advancedatas.htm

Advance Data No. 349. Prevalence of leading types of dietary supplements used in the Third National Health and Nutrition Examination Survey, 1988–94.

Advance Data No. 341. Dietary intake of selected minerals for the United States population: 1999–2000.

Advance Data No. 339. Dietary intake of selected vitamins for the United States population: 1999–2000.

Advance Data No. 334. Dietary intake of ten key nutrients for public health, United States: 1999–2000.

Life Sciences Research Office (LSRO) Reports

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Appendix B:

References for Analytical Methods for Biochemical Indicators

Detailed Laboratory Procedure Manuals for Analytical Methods

- NHANES 1999–2000:
  http://www.cdc.gov/nchs/about/major/nhanes/lab_methods99_00.htm

- NHANES 2001–2002:
  http://www.cdc.gov/nchs/about/major/nhanes/lab_methods01_02.htm

Additional Useful Analytical Method References

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Appendix C:

Confidence Interval Estimation for Percentiles

A common practice to calculate confidence intervals from survey data is to use large-sample normal approximations. Ninety-five percent confidence intervals on point estimates of percentiles are often computed by adding and subtracting from the point estimate a quantity equal to twice its standard error. This normal approximation method may not be adequate, however, when estimating the proportion of subjects above or below a selected value (especially when the proportion is near 0.0 or 1.0 or when the effective sample size is small).

In addition, confidence intervals on proportions deviating from 0.5 are not theoretically expected to be symmetric around the point estimate. Further, adding and subtracting a multiple of the standard error to an estimate near 0.0 or 1.0 can lead to impossible confidence limits (i.e., proportion estimates below 0.0 or above 1.0).

We used the method of Korn and Graubard (1998) to compute Clopper-Pearson 95 percent confidence intervals about percentile estimates. We describe the method below, using SAS Proc Univariate and SUDAAN. SAS code for calculating these confidence intervals can be downloaded from http://www.cdc.gov/exposurereport.

Procedure to calculate confidence intervals about percentiles

Step 1: Use SAS (SAS Institute Inc., 1999) Proc Univariate to obtain a point estimate of the percentile of a chemical's results for the demographic group of interest (e.g., the 90th percentile of blood lead results for children aged 1–5 years). Use the Freq option to assign the correct sample weight for each chemical result.

Step 2: Use SUDAAN (SUDAAN Users Manual, 2001) Proc Descript with Taylor Linearization DESIGN = WR (i.e., sampling with replacement) and the proper sampling weight to estimate the proportion (p) of subjects with results below the percentile estimate obtained in Step 1 and to obtain the standard error (se_p) associated with this proportion estimate. Compute the degrees-of-freedom adjusted effective sample size

$$n_{df} = ((t_{num}/t_{denom})^2)p(1 - p)/(se_p^2) \quad (1)$$

where t_{num} and t_{denom} are 0.975 critical values of the Student's t distribution with degrees of freedom equal to the sample size minus 1 and the number of PSUs minus the number of strata, respectively. Note: the degrees of freedom for t_{denom} can vary with the demographic subgroup of interest (e.g., males).

Step 3: After obtaining an estimate of p (i.e., the proportion obtained in Step 2), compute the Clopper-Pearson 95 percent confidence interval ($P_L(x,n_{df})$, $P_U(x,n_{df})$) as follows:

$$P_L(x,n_{df}) = v_1F_{v1,v2}(0.025)/(v_2 + v_1F_{v1,v2}(0.025)) \quad \& \quad P_U(x,n_{df}) = v_3F_{v3,v4}(0.975)/(v_4 + v_3F_{v3,v4}(0.975)) \quad (2)$$

where x is equal to p times n_{df}, $v_1 = 2x$, $v_2 = 2(n_{df} - x + 1)$, $v_3 = 2(x + 1)$, $v_4 = 2(n_{df} - x)$, and $F_{d1,d2}(\beta)$ is the β quantile of an F distribution with d_1 and d_2 degrees of freedom. (Note: If n_{df} is greater than the actual sample size, or if p is equal to zero, then the actual sample size should be used.) This step will produce a lower and an upper limit for the estimated proportion obtained in Step 2.

Step 4: Use SAS Proc Univariate (again using the Freq option to assign weights) to determine the chemical values that correspond to the proportion obtained in Step 2 and the lower and upper limits on this proportion obtained in Step 3.

Example:

To estimate the 75th percentile, use SAS Proc Univariate with the Freq option to get a weighted point estimate of the chemical value that corresponds to the 75th percentile. Then use SUDAAN to estimate the weighted proportion of subjects with results below the 75th percentile (which should be very near 0.75). Next, obtain a confidence interval on this proportion by computing the weighted Clopper-Pearson 95 percent confidence limits using the degrees-of-freedom adjusted effective sample size. Suppose these confidence limits are 0.67 and 0.81, then use SAS Proc Univariate with the Freq option to determine the chemical values corresponding to the weighted 67th and 81st percentiles. These point estimates are the lower and upper confidence limits on the 75th percentile.

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Appendix D:
Limit of Detection Table

The table below presents the analytical limit of detection (LOD) for each of the different indicators. The LOD is the level at which the measurement has a 95 percent probability of being greater than zero (Taylor 1987). For the same indicator, LOD values may change over time as a result of changes to analytical methods. This was the case for urinary phytoestrogens. We used the higher of the two LOD values for the analysis of the combined four-year data.

Indicator	Units	1999–2000	2001–2002
Water-Soluble Vitamins & Related Biochemical Compounds			
Serum folate	ng/mL	0.1	0.1
Red blood cell (RBC) folate	ng/mL RBC	20	20
Serum vitamin B12	pg/mL	20	20
Plasma homocysteine	µmol/L	0.35	0.35
Plasma methylmalonic acid	µmol/L	0.05	0.05
Fat-Soluble Vitamins & Micronutrients			
Serum vitamin A	µg/dL	1.03	1.03
Serum vitamin E	µg/dL	40.7	40.7
Serum *gamma*-tocopherol	µg/dL	10.7	10.7
Serum *alpha*-carotene	µg/dL		0.7
Serum *trans*-beta-carotene	µg/dL		0.8
Serum *beta*-cryptoxanthin	µg/dL		0.9
Serum lutein/zeaxanthin	µg/dL		2.4
Serum *trans*-lycopene	µg/dL		0.8
Serum vitamin D, 25-hydroxy	ng/mL		1.5
Iron-Status Indicators			
Serum ferritin	ng/mL	1.1	1.1
Serum iron	µg/dL	2	
Serum total iron-binding capacity	µg/dL	6	
Serum transferrin saturation	%	n/a	
Erythrocyte protoporphyrin	µg/dL RBC	1	
Trace Elements			
Urinary iodine	ng/mL		1.0
Serum selenium	ng/mL	8	
Isoflavones & Lignans			
Urinary genistein	µg/L	0.3	0.8
Urinary daidzein	µg/L	0.5	1.6
Urinary equol	µg/L	3.0	3.3
Urinary O-desmethylangolensin	µg/L	0.2	0.4
Urinary enterodiol	µg/L	0.8	1.5
Urinary enterolactone	µg/L	0.6	1.9

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Appendix E:

Selected References of Descriptive NHANES Papers on Biochemical Indicators of Diet and Nutrition

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