

Spring 4-4-2012

Associations of Serum Vitamin D Concentrations with Dietary Patterns in US Children

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The Master's Thesis Advisory Committee, as representatives of the faculty, certify that this thesis has met all standards of excellence and scholarship as determined by the faculty.

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ABSTRACT

ASSOCIATIONS OF SERUM VITAMIN D CONCENTRATIONS WITH DIETARY PATTERNS IN US CHILDREN

By

Bernadette Martineau

Background: Contribution of dietary sources to vitamin D status is not clearly known. Some studies have shown that dietary intake of certain vitamin D rich foods had a significant positive influence on serum 25-hydroxyvitamin D [25(OH)D] concentrations, whereas other studies have shown no effect. Although sunlight exposure is a major source of circulating serum 25(OH)D, children and adolescents have been advised on the dangers of sun exposure. Diet may therefore be an important contributor of circulating serum 25(OH)D in absence of or reduced sunlight exposure.

Objective: The aim of this study was to determine whether serum 25(OH)D concentrations were associated with any specific dietary patterns in US children and adolescents using assay-adjusted serum 25(OH)D data from National Health and Nutrition Examination Survey (NHANES) 2003-2004 and 2005-2006.

Methods: Data from 2 cycles of the NHANES 2003-2004 and 2005-2006 for individuals aged 2 to ≤ 19 y, were used to study the association between dietary patterns and serum 25(OH)D. Dietary patterns were established using factor analysis based on food-frequency questionnaire data. Eigenvalues and Scree plot were used to derive 2 major principal factors. They were labeled as High Fat Low Vegetable (HFLV) and Prudent dietary patterns.

Results: Serum 25(OH)D was significantly lower in HFLV dietary pattern group compared to Prudent dietary pattern group (25.1 vs 27.0 ng/mL; $P=0.001$). The highest serum 25(OH)D concentrations for all subjects were in the low-intake HFLV group or medium and high-intake Prudent groups ($P=0.003$ and $P=0.012$, respectively). In multivariate adjusted analysis, children with higher Prudent dietary contribution scores to overall diet showed a significant positive relation with serum 25(OH)D ($\beta=62.01$, $P=0.016$). When data were stratified by sex, a significant positive relation was observed in girls who consumed the Prudent diet ($\beta=86.34$, $P=0.014$) and a significant negative relation was observed in girls who consumed the HFLV diet ($\beta=-84.32$, $P=0.022$).

Conclusion: Overall, serum 25(OH)D concentrations were associated with Prudent dietary pattern but not with HFLV dietary pattern in US children and adolescents. When stratified by sex, the relation between dietary patterns and serum 25(OH)D was confined to only girls. Children consuming HFLV pattern diet may benefit from vitamin D supplementation and sunlight exposure (outdoor activities), and should be encouraged to consume more vitamin D fortified foods.

ASSOCIATIONS OF SERUM VITAMIN D CONCENTRATIONS WITH DIETARY
PATTERNS IN US CHILDREN

by

BERNADETTE MARTINEAU

A Thesis

Presented in Partial Fulfillment of Requirements for the

Degree of

Master of Science

in

Health Sciences

in

The Division of Nutrition

in

The Byrdine F. Lewis School of Nursing and Health Professions

Georgia State University

Atlanta, Georgia

2012

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to Dr. Vijay Ganji, chairman of my advisory committee, for his assistance, encouragement, and support during the development and writing of this thesis. I also wish to extend my appreciation and gratitude to Dr. Xu Zhang and Dr. Anita Nucci for their time and assistance with my research and writing of this thesis. Special thanks are also given to Bill Van Fleit who has spent countless hours in assisting with the statistical analysis for this thesis without which this project would not have been possible.

I dedicate this thesis to my husband, Patrick M. Martineau, for his unending support and in memory of my father, Dr. Edward A. Cole.

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ABBREVIATIONS

1,25(OH) ₂ D	1,25-dihydroxyvitamin D ₃
25(OH)D	25-hydroxyvitamin D ₃
7DHC	7-dehydrocholesterol
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
BMI	Body mass index
CI	Confidence Interval
d	day
DBP	Vitamin D binding protein
FFQ	Food frequency questionnaire
h	hour
HFLV	High Fat and Low Vegetable
IOM	Institute of Medicine
IU	International unit
kcal	kilocalorie
L	liter
MEC	Mobile examination center
mL	milliliter
mo	month
MS	Multiple sclerosis
NCHS	National Center for Health Statistics
ng	nanogram

NHANES	National Health and Nutrition Examination Survey
nmol	nanomole
OR	Odds ratio
PIR	Poverty income ratio
PTH	Parathyroid hormone
RANKL	Receptor activator nuclear factor-B ligand
SE	Standard error
T2DM	Type 2 Diabetes mellitus
US	United States
USDA	United States Department of Agriculture
UV	Ultraviolet
UVB	Ultraviolet B
VDR	Vitamin D receptor
y	year

CHAPTER I

INTRODUCTION

Vitamin D or cholecalciferol is now recognized more accurately as a prohormone. Vitamin D can be endogenously produced in the skin through ultraviolet (UV) irradiation of 7-dehydrocholesterol (7DHC) or can be obtained through limited dietary food sources or supplements (1). Its well-known function is calcium homeostasis and bone mineralization. However, current evidence suggests that vitamin D may play a role in various non-bone diseases (2) such as autoimmune disease (3,4), cardiovascular disease (5,6), type 2 diabetes mellitus (T2DM) (7,8), depression (9), and cancer (10).

Serum 25-hydroxyvitamin D [25(OH)D] is a commonly used marker of vitamin D nutritional status because it reflects both endogenous synthesis of vitamin D in the skin and dietary intake (11). It has been reported that hypovitaminosis D is a general widespread problem in the US population, specifically in children and adolescents (12–15). Prevention of suboptimal vitamin D status in childhood may reduce future adverse health conditions.

The contribution of dietary sources to vitamin D status is not clearly known. Some studies have shown that dietary intake of certain vitamin D rich foods had a significant positive influence on serum 25(OH)D concentrations (16,17), whereas other studies have shown that vitamin D intake did not affect serum 25(OH)D concentrations (18). While sunlight exposure is the major source of circulating serum 25(OH)D (19),

children and adolescents have been advised on the dangers of sun exposure (20) and are exposed to increased use of sunscreen lotions and time spent indoors which has likely contributed to the increasing prevalence of low vitamin D status (21). Therefore, diet may be an important contributor of circulating serum 25(OH)D in the absence of or in the presence of reduced sunlight exposure.

To our knowledge, no data are available on the relation between dietary patterns and serum 25(OH)D in US children and adolescents. Studies that have looked at diet and vitamin D status have addressed associations between individual food sources such as fortified milk or fatty fish. However, people consume a variety of foods in combination (22). Dietary pattern analysis, an alternative approach to traditional single nutrient epidemiology, takes into account all nutrient interactions and allows for a more comprehensive approach to study the relation between disease and dietary intake (23).

In November 2010, the National Center for Health Statistics (NCHS) released a data advisory for vitamin D and recommended use of the assay-adjusted serum 25(OH)D data by investigators rather than previously reported unadjusted data. The newly released data accounted for assay performance changes and drifts overtime (24). Therefore, the objective of this study was to determine whether serum 25(OH)D concentrations were associated with any specific dietary patterns in US children and adolescents using assay-adjusted data from the National Health and Nutrition Examination Survey (NHANES) 2003-2006.

CHAPTER II

LITERATURE REVIEW

Vitamin D was originally considered a nutrient when it was discovered that cod liver oil when fed to infants prevented rickets in children (2). In later studies, it was found that UV light also had antirachitic effects through the endogenous production of vitamin D in the skin (25). This finding along with the discovery of the vitamin D receptor (VDR) has led to the conclusion that vitamin D is considered part of a class of molecules which make up a complex endocrine system (2).

SOURCES OF VITAMIN D

Vitamin D consists of 2 main forms: cholecalciferol (vitamin D₃) and ergocalciferol (vitamin D₂). Vitamin D₃ is produced in the skin after exposure to UVB light or obtained from food sources. Vitamin D₂ is obtained through the irradiation of ergosterol found in plants (2), although in low quantities (19). The 2 forms have similar sterol structures that differ only in their side chain (11). The relative potencies of vitamin D₂ and D₃ are generally considered to be comparable (26,27). However recent reports have suggested that vitamin D₃ may be more efficient at increasing serum 25(OH)D concentrations than vitamin D₂ (28,29).

Endogenous production of vitamin D₃ in the skin is a major source of vitamin D and contributes approximately 90% to the serum 25(OH)D concentration (19).

Other main sources of vitamin D are fortified foods or supplements. A limited number of foods naturally contain vitamin D. Natural sources include oily fish such as

salmon, mackerel, bluefish (19), sardines and tuna, shiitake mushrooms (fresh or sundried), and egg yolks (30). Fortified food sources include milk, orange juice, infant formulas, yogurts, butter, margarine, cheeses, and breakfast cereals (30). Nutritional supplement sources range in a variety of different types and dosages and are available by prescription or over-the counter in the US (30).

SYNTHESIS & METABOLISM OF VITAMIN D

Endogenous production of vitamin D begins in the basal and suprabasal layers of the skin with the irradiation of 7DHC by UVB rays. This transforms 7DHC to precholecalciferol followed by thermal isomerization to cholecalciferol or vitamin D₃ (19). Vitamin D₃ moves from the skin into circulation where it binds with the vitamin D binding protein (DBP) and is transported to the liver (2). Vitamin D (D₃ or D₂) from dietary sources enters into the blood after being incorporated into chylomicrons and absorbed into the lymphatic system. It is then transported bound to DBP to the liver (31). In the liver, it undergoes the enzymatic hydroxylation by 25-hydroxylase to 25(OH)D or calcidiol, the major circulating metabolite of vitamin D (19). Regulation of 25-hydroxylase is not tightly controlled and 25(OH)D concentrations increase proportional to vitamin D intake (25). 25(OH)D bound to DBP is transported from the liver to the kidney where it is hydroxylated to 1,25-dihydroxyvitamin D₃ [1,25(OH)₂D] or calcitriol by 1- α -hydroxylase (19). This second step is tightly regulated and is dependent upon circulating calcium concentrations (25). Calcium, phosphate, parathyroid hormone (PTH), calcitonin, fibroblast growth factor 23, and 1,25(OH)₂D are all regulators of 1- α -hydroxylase (19).

PHYSIOLOGICAL FUNCTIONS OF VITAMIN D

Low serum calcium stimulates the production of PTH from the parathyroid gland. This in turn stimulates the synthesis of $1,25(\text{OH})_2\text{D}$ in the kidney (1). The binding of $1,25(\text{OH})_2\text{D}$ to intestinal tissue stimulates increased dietary calcium and phosphorus absorption (1). $1,25(\text{OH})_2\text{D}$ in conjunction with PTH stimulates osteoblasts in skeletal bone to express the surface receptor activator nuclear factor- κB ligand (RANKL). RANKL stimulates osteoclast production and activates osteoclast resorption of calcium from bone (1). In the kidney, PTH and $1,25(\text{OH})_2\text{D}$ enhances calcium reabsorption in the distal renal tubules (1). An important consideration in regards to the regulation of serum calcium concentrations is that when dietary calcium is not available, the system acts to mobilize calcium from bone and reabsorb calcium in the kidneys to raise serum calcium concentrations within normal limits (1).

Although not fully understood, vitamin D has been reported to play a role in various functions unrelated to calcium homeostasis (2). One key finding was that other tissues such as immune, adipose, pancreas, bone marrow, cardiac muscle, brain, breast, colon, lung, ovary, and prostate tissues beside intestinal, skeletal, renal, and parathyroid were also found to contain VDRs (11). Evidence data show that vitamin D may influence the expression of >200 genes and consequently may be involved in cell proliferation, differentiation, apoptosis, and angiogenesis (30). Therefore, current thought is that vitamin D may be involved in immunity, insulin secretion, heart function and blood pressure regulation, and brain and fetal development (2).

VITAMIN D STATUS AND RECOMMENDATIONS

As of now, 25(OH)D is considered to be the best indicator of vitamin D status as it represents endogenously produced vitamin D and vitamin D intake from dietary sources (11) and has a longer half-life than 1,25(OH)₂D (32). Currently, there is no standard definition of optimal vitamin D status (26). Furthermore, pediatric studies that assessed recommended vitamin D intake or serum 25(OH)D concentrations with regard to health outcomes unrelated to bone are limited (32–34). Historically, the American Academy of Pediatrics and the Institute of Medicine (IOM) defined vitamin D deficiency for infants and young children as a serum 25(OH)D concentration ≤ 11 ng/mL (≤ 27.5 nmol/L) (35). However, most define vitamin D deficiency as ≤ 20 ng/mL (≤ 50 nmol/L), vitamin D insufficiency as ≤ 30 ng/mL (≤ 75 nmol/L), and vitamin D sufficiency as > 30 ng/mL (> 75 nmol/L) (30,36–38). More recently, the IOM defined vitamin D deficiency as ≤ 12 ng/mL (≤ 30 nmol/L) and vitamin D sufficiency as > 20 ng/mL (> 50 nmol/L) (26). According to these guidelines, Estimated Average Requirement and Recommended Daily Allowance for vitamin D for children and adolescents are 400 IU/d and 600 IU/d, respectively (26). In addition, the IOM committee stated that there is no consistent evidence to associate increased benefit with serum 25(OH)D concentrations > 30 ng/mL (> 75 nmol/L) and that there may be a cause for concern with levels > 50 ng/mL (> 125 nmol/L) (26). After that the Endocrine Society released their recommendations in July 2011 and suggested that children ≥ 1 y require at least 600 IU/d and as much as 1000 IU/d of vitamin D to raise serum 25(OH)D concentrations > 30 ng/mL (32).

PREVALENCE OF VITAMIN D DEFICIENCY AND RISK FACTORS

Vitamin D deficiency and insufficiency are widespread worldwide in all ages especially in high risk groups such as young children, pregnant women, elderly, and immigrant populations (39). Fundamental factors such as seasonal variation of sunlight, age, race-ethnicity, body mass index (BMI), and vitamin D intake influence vitamin D status (40). Furthermore, barriers such as skin pigmentation, sunscreens, and clothing reduce the penetration of UVB rays into the skin, thereby significantly reducing endogenous production of vitamin D (18).

Recently Ganji et al (41) investigated changes in vitamin D status and prevalence estimates of hypovitaminosis D from 1988-1994 to 2001-2006 using various serum 25(OH)D cut points (<25, <30, <40, <50, and <75 nmol/L) as previous studies may have over- or underestimated the prevalence of vitamin D deficiency because they did not account for assay changes over time. They reported that the overall geometric mean serum 25(OH)D concentrations decreased 9% from 60.7 nmol/L in 1988-1994 to 55.2 nmol/L in 2001-2006 ($P<0.001$). In adolescents aged 12 to 19 y, this decline was even greater at 16% (from 63.9 to 53.7 nmol/L; $P<0.001$). The overall prevalence of hypovitaminosis D (serum 25(OH)D <25 nmol/L) significantly increased approximately 100% from 1988-1994 to 2001-2006 (from 2.4 to 4.7%; $P<0.001$). In children aged 12 to 15 y, the increase in prevalence of serum 25(OH)D <25 nmol/L was much greater at 196% (from 1.12 to 3.31%; $P<0.001$). In adolescents aged 12 to 19 y, the increase in prevalence was approximately 125%. The prevalence of hypovitaminosis D using the other cut point values (<30, <40, <50, and <75 nmol/L) were also generally increased in

2001-2006 compared to 1988-1994, although not as marked of a change as with serum 25(OH)D <25 nmol/L.

HEALTH EFFECTS OF VITAMIN D DEFICIENCY

Vitamin D deficiency in infants and children is the most common cause of rickets or bone deformation due to poor skeletal mineralization (35). In the US, rickets was eradicated with the fortification of milk with vitamin D in the 1930s (42). However, there have been several recent reports of rickets, especially among exclusively breastfed infants (43–45). Vitamin D deficiency also may prevent children and adolescents from attaining optimal peak bone mass and thereby increase their risk of osteoporosis later in life (46). Childhood is considered a major period for gaining one's potential peak bone mass (47), and evidence is now emerging, though controversial, that the risk of osteoporosis may be influenced by vitamin D status during intrauterine and early postnatal life (35,48,49).

Studies have shown that vitamin D improves innate immune responses to infectious agents; and helps to maintain self-tolerance by lessening over-active adaptive immune response (50). Epidemiological evidence has demonstrated significant associations between vitamin D levels, sunlight, or latitude and increased incidence of asthma (51,52), type 1 diabetes mellitus (3,53), and multiple sclerosis (MS) (4,54).

Childhood obesity is a major public health problem in the U.S. and in many other countries. Childhood obesity is linked to dyslipidemia, hypertension, and insulin resistance which are associated with an increased risk for heart disease in adulthood (55). Evidence suggests that obesity, cardiovascular disease, metabolic syndrome, and T2DM may be linked to low concentrations of vitamin D (5–8,56,57). Studies have shown an

inverse relation between serum vitamin D and adiposity in children (56,57). Currently, it is not known how vitamin D status may impact adiposity.

Recent evidence has suggested that vitamin D may have an important role in brain development (58) and that a possible causal relationship may exist between vitamin D deficiency and adverse cognitive or behavioral function (9,59,60). Vitamin D is thought to activate neuron receptors in regions that regulate behavior, stimulate neurotrophin release, and protect the brain by buffering antioxidant and anti-inflammatory defenses against vascular injury (61). It has also been proposed as an environmental risk factor and as a potential treatment in a variety of neurological diseases such as MS and psychosomatic affective disorders (62).

DIETARY PATTERNS

The traditional approach in nutritional epidemiology has been to study the effects of single nutrients or foods in relation to disease risk. However, people consume a variety of foods in combination and do not eat nutrients in isolation (22). The single-nutrient approach, therefore, may be inadequate to take into account the combined effects of various nutrients and foods that are eaten together (63). Moreover, because of the complex interaction among some nutrients, it is often difficult to examine the specific effects of each nutrient separately (64). In addition, a single nutrient's effect on disease may be too minute to detect whereas the combined effects of multiple nutrients included in a dietary pattern may result in significant measurable outcomes (65).

An alternative approach that overcomes these limitations and has become increasingly accepted is dietary pattern analysis. This approach studies how food and nutrients are consumed in combination by identifying dietary patterns characterized on

the basis of eating behavior (65). Investigation of dietary patterns takes into account all nutrient interactions and allows for a more comprehensive approach to study the relation between disease and dietary intake (23). It more closely mimics real-world conditions and therefore may be more relevant as far as public health implications. Results and conclusions related to the overall dietary patterns may be easier for the public to understand and decipher to their own diets (65).

Because dietary patterns cannot be measured directly, statistical methods are used to determine dietary patterns using collected dietary intake assessment information (65). Factor or principal component analysis is a multivariate statistical technique that uses information reported on a food frequency questionnaire (FFQ) or dietary record. It identifies common factors (or patterns) of food consumption and provides scores that allow ranking of individuals in terms of how closely they correspond to the total pattern (65). A strength of this approach in an editorial by Jacques and Tucker (64) is stated to be the “ability to summarize behavior across several variables simultaneously into a small number of orthogonal variables.” In the same editorial, they maintain a limitation is “the fact that results can be sample specific and strongly affected by subjective analytic decision.” Despite the limitations, there is evidence to support the reproducibility and validity of dietary patterns by factor analysis and that the findings may prove to be an informative and useful means to understand the role of diet and disease (22,66).

Few studies have investigated dietary patterns of children and an even smaller number have explored associations between diet and health (**Table 1**) (67–71). According to a review by Smithers et al (72), most of the studies derived at least 3 dietary patterns, although some identified as few as 2 and others as many as 6 dietary patterns.

The majority of those who investigated the diets of children ≤ 5 y found some form of “healthy” and “unhealthy” pattern. The “healthy” patterns were generally associated with foods such as rice, pasta, fish, fruit, and cheese and the “unhealthy” patterns were generally characterized by foods such as chocolates, sweets, soda, and ice cream. Although labeling of the food patterns is subjective, Smithers et al (72) found that there was some consistency across the studies in the identification of the “healthy” and “unhealthy” dietary patterns. In addition, 2 of the studies investigated a relation between dietary patterns and health outcomes (68,70). A Korean prospective cohort study by Shin et al (68) investigated 1,441 preschool aged children from the Practical Approach for Better Maternal and Child Nutrition and Health Study. They analyzed dietary information collected from a 100-item FFQ and used factor analysis to define 3 major dietary patterns. The 1st factor was labeled as the Korean healthy pattern characterized by a higher intake of vegetables, kimchi (spicy raw vegetables), seaweeds, beans, fruits, milk, and dairy products. The 2nd factor was labeled as the animal foods pattern characterized by a higher intake of beef, pork, poultry, fish, and fast foods. The 3rd factor was labeled as the sweets pattern characterized by a higher intake of ice cream, sweet drinks, chocolate, sweet baked goods, and sugary foods. They found that the children in the highest quintile of the Korean healthy pattern had a lower risk of poorer health status (OR 0.59; 95% CI 0.42-0.84; $P=0.0475$) compared to those in the lowest quintile of the Korean healthy pattern. Moreover, children in the highest quintile of the animal foods pattern had an increased risk of being overweight (OR 1.77; 95% CI 1.06-2.94; $P=0.0039$) compared to those in the lowest quintile of the animal foods pattern.

An Ukrainian prospective cohort study by Friedman et al (70) identified 6 dietary patterns of children aged 3 y from the European Longitudinal Study of Pregnancy and Childhood. Dietary assessment was collected using a 104-item FFQ and factor analysis was used to identify 6 major dietary patterns which were labeled snacks, fruit and vegetables, meats, noodles and pasta, staples, and breakfast foods. They found that none of the dietary patterns with the exception of the meat pattern was associated with an increased risk of BMI >85th percentile (OR 1.37; 95% CI 1.04-1.81; $P=0.024$).

Several studies among adults have reported using factor analysis and most found a strong relation between dietary patterns and measures of health or disease risk (**Table 2**) (23,63,73–76). Similarly in studies involving children, 2 to 6 dietary patterns were derived and identified. One of the first studies to investigate this was done by Fung et al (63) in which they did a prospective cohort study using a random subsample of 466 healthy men from the Health Professionals Follow-up Study. They analyzed dietary information collected from FFQs and used factor analysis to define 2 major dietary patterns. The 1st factor was labeled as the prudent pattern characterized by a higher intake of fruit, vegetables, poultry, fish, whole grains, and legumes. The 2nd factor was labeled as the Western pattern characterized by a higher intake of red and processed meat, French fries, eggs, high-fat dairy products, sweets, and refined grains. They found a significant positive association between the Western pattern and insulin ($r=0.32$, $P<0.01$), C-peptide ($r=0.31$, $P<0.01$), leptin ($r=0.28$, $P<0.0001$), C-reactive protein ($r=0.22$, $P<0.0001$), and homocysteine ($r=0.23$, $P<0.01$); and inverse correlation with plasma folate ($r=-0.39$, $P<0.0001$). In contrast, they observed significant inverse correlation between the prudent pattern and insulin ($r=-0.25$, $P<0.05$), and homocysteine

($r=-0.2$, $P<0.01$); and positive relation with folate ($r=0.28$, $P<0.0001$) and lipoprotein (a) ($r=0.1$, $P<0.05$). They concluded that the Western pattern was associated with less favorable biomarkers for cardiovascular risk and the prudent pattern with more favorable biomarkers; and that dietary patterns may act as predictors of cardiovascular disease risk.

More recently Lim et al (73) examined dietary patterns in patients with T2DM and investigated associations with blood lipids and abdominal obesity. They used data from the 4th Korean NHANES 2007-2008. A total of 680 participants, aged ≥ 30 y, were defined as having diabetes and were included in the analysis. They analyzed dietary information collected from 24-hour recall and used factor analysis to define 4 major dietary patterns. The Bread, Meat, and Alcohol pattern was characterized by higher intake of breads, sugars, meats, oil, beverages, and alcohol. The Noodle and Seafood pattern was characterized by higher intake of noodles, kimchi, fish, and seaweed. The Rice and Vegetable pattern, was characterized by higher intake of rice, vegetables, and egg. The last factor, the Korean Healthy pattern, was characterized by higher intake of whole grains, legumes, nuts, vegetables, mushrooms, and fruit. They found that dietary patterns were associated with blood lipid profiles. The Bread, Meat, and Alcohol pattern was found to be associated with significantly increased levels of total cholesterol (201.8 mg/dL; P for trend=0.002). Serum triglycerides (162.2 mg/dL; P for trend=0.03) and total cholesterol (188.4 mg/dL; P for trend=0.004), however, were significantly decreased in the Korean Healthy pattern. Therefore, they concluded that dietary patterns of adults with T2DM were associated with blood lipid profiles and that the Korean Healthy pattern could result in a favorable blood lipid profile among those with diabetes.

Studies on the association of dietary intake with serum 25(OH)D concentrations have shown conflicting results (16,17,77–79). Effects from individual foods on vitamin D status have been investigated in several studies where some have shown a positive influence of vitamin D rich foods on serum 25(OH)D concentrations. There is, however, limited evidence on the association of dietary patterns and serum 25(OH)D concentrations in US children.

CONCLUSION

Recently vitamin D has been shown to play a role in many functions unrelated to bone (2). While there is no consensus on the optimal concentration of serum 25(OH)D, many have reported the increased prevalence of vitamin D deficiency and insufficiency (15,18,41,80). The increasing evidence has suggested vitamin D may protect against many chronic conditions and is essential to many basic biological functions such as cell proliferation, differentiation, apoptosis, and angiogenesis (30). Although sunlight exposure is a major source of circulating serum 25(OH)D, current recommendations for children and adolescents are to avoid the dangers of the sun and take protective measures to limit sun exposure (20). Therefore, diet may be an important contributor in the absence of or reduced sun exposure. The use of dietary patterns has been shown to be a more comprehensive approach to study the relation between disease and dietary intake. Thus, the objective of this study was to investigate a relation between serum 25(OH)D concentrations and dietary patterns in US children and adolescents using NHANES 2003-2006.

Table 1**Studies assessing dietary patterns among children using factor analysis and cluster analysis¹**

Study	Sample size, age assessed	Study Design and Methods	Dietary Patterns	Associations with health or disease risk
Ystrom et al (67)	<i>n</i> =27763;	Prospective Cohort	<i>Unhealthy</i>	-
2009	1 1/2 y	36-item FFQ	<i>Wholesome</i>	
MoBa		Factor Analysis		
Shin et al (68)	<i>n</i> =1441;	Prospective Cohort	<i>Korean healthy</i>	<i>Animal foods</i> pattern
2007	5.2 y	100-item FFQ	<i>Animal foods</i>	associated with risk
PABMCNHS		Factor Analysis	<i>Sweets</i>	of being overweight
Northstone and Emmett (69)	<i>n</i> =9550	Prospective Cohort	<i>Junk</i>	-
2005	54 mo	90-item FFQ	<i>Traditional</i>	
ALSPAC		Factor Analysis	<i>Health conscious</i>	

Friedman et al (70)	n=883	Prospective Cohort	<i>Meat</i>	<i>Meat</i> pattern associated
2009	3 y	104-item FFQ	<i>Staples</i>	with increased risk of
ELSPAC		Factor Analysis	<i>Noodle & pasta</i>	BMI >85th percentile
			<i>Fruit & vegetables</i>	
			<i>Breakfast foods</i>	
Pryer and Rogers (71)	n=1675	Cross-sectional	<i>Traditional</i>	-
2009	1 1/2 - 4 1/2 y	19 food/beverage	<i>Healthy</i>	
NDNS		Cluster analysis	<i>Convenience</i>	

¹Abbreviations: MoBa, Norwegian Mother and Child Cohort Study; n, number of subjects; FFQ, Food Frequency

Questionnaire; PABMCNHS, Practical Approach for Better Maternal and Child Nutrition and Health Study; ALSPAC,

Avon Longitudinal Study of Parents and Children; ELSPAC, European Longitudinal Study of Pregnancy and

Childhood; NDNS, National Diet and Nutrition Survey of Great Britain

Table 2**Studies assessing associations between dietary patterns and health or disease risk among adults¹**

Study	Sample size	Study Design and Methods	Dietary Patterns	Associations with health or disease risk
Fung et al (63) 2001 HPFS	<i>n</i> =466	Prospective Cohort 130-item FFQ Factor Analysis	<i>Prudent</i> <i>Western</i>	Major dietary patterns are predictors of plasma biomarkers of CVD and obesity risk
Cho et al (74) 2011 NCCNCS	<i>n</i> =1131	Cross-sectional 103-item FFQ Factor Analysis	<i>Vegetable-Seafood</i> <i>Meat-Fat</i> <i>Snack</i>	<i>Meat-Fat</i> pattern associated with obesity
Kerver et al (23) 2003 NHANES III	<i>n</i> =13130	Cross-sectional 80-item FFQ Factor Analysis	<i>Western</i> <i>American-healthy</i> <i>4 minor patterns</i>	<i>Western</i> pattern associated with biomarkers of cardiovascular disease risk

Kim and Jo (75)	<i>n</i> =9850	Cross-sectional	<i>White rice & kimchi</i>	<i>Meat & alcohol</i> pattern associated with
2011		24-h recall	<i>Meat & alcohol</i>	hypertriglyceridemia and elevated
KNHANES III		Factor Analysis	<i>High fat, sweets, & coffee</i>	blood pressure
			<i>Grains, vegetables, & fish</i>	<i>Grains, vegetables, & fish</i> pattern
				associated with lower risk of
				hypertriglyceridemia and metabolic
				syndrome
Lim et al (73)	<i>n</i> =680	Cross-sectional	<i>Bread, Meat, & Alcohol</i>	Dietary patterns of adults with diabetes
2011		24-h recall	<i>Noodles & Seafood</i>	were found to be associated with
4th KNHANES		Factor Analysis	<i>Rice & Vegetables</i>	Blood lipid profiles
			<i>Korean Healthy</i>	
Ganji et al (76)	<i>n</i> =4009	Cross-sectional	<i>Vegetable, Fruit, & Lean Meat</i>	No associations between serum leptin and
2009		80-item FFQ	<i>Western</i>	dietary patterns
NHANES III		Factor Analysis	<i>Mixed</i>	

¹Abbreviations: HPFS, Health Professionals Follow-Up Study; n, number of subjects; FFQ, Food Frequency Questionnaire; CVD, Cardiovascular Disease; KNHANES, Korean National Health and Nutrition Examination Survey; NCCNCS, National Cancer Center National Cancer Study; NHANES, National Health and Nutrition Examination Survey

CHAPTER III

METHODOLOGY

BRIEF NHANES SURVEY METHODS

The NCHS conducts large, nationally representative, sample surveys known as NHANES on the noninstitutionalized US civilian population. A sample representative of individuals aged >2 months was selected by using a stratified, multistage, probability sample survey design. Beginning in 1999, NHANESs were conducted as annual surveys and data are released in 2-y cycles for public use. Certain subgroups including low-income persons, adolescents, persons aged ≥ 60 y, non-Hispanic blacks, and Hispanics/Mexicans are oversampled to yield more reliable estimates for these specific groups. The detailed descriptions of the survey design and methodologies are described elsewhere (81).

NHANES 2003-2004 was conducted between January 2003 and December 2004 in 12,761 individuals (9,643 were examined in the MECs) and NHANES 2005-2006 was conducted between January 2005 and December 2006 in 12,862 individuals (9,950 were examined in the MECs). Participants were interviewed in their homes to gather information on demographic characteristics, diet, and health. Additional health data were collected during a medical examination conducted in mobile examination centers (MECs). At the MECs, a physical exam, blood and urine sample collection, and other diagnostic measurements were performed. All NHANES protocols were approved by the NCHS Ethics Review Board prior to data collection.

Households were randomly selected and all members within the household were screened for demographic characteristics. One or more individuals within the household were then selected for sample population based on age, sex, and race-ethnicity. NHANES 2003-2006 included individuals ≥ 2 mo old. Race-ethnicity was categorized as non-Hispanic white, non-Hispanic black, Hispanic/Mexican American, and Other. Participants self-reported their race-ethnicity status. Poverty income ratio (PIR) was calculated as the ratio of income to the family's appropriate poverty threshold. To avoid damage to the MECs, examination data in the North were collected in spring/summer (May 1 – October 31) and in South were collected in fall/winter (November 1 – April 30). Data for BMI was obtained from the medical examination component of NHANES. Supplement users were defined based on participants who answered 'yes' to the question "Did you take supplements in the past 30 d?" Participants were asked about hours spent watching television, playing video games, and using the computer. Daily total energy intake was calculated based on USDA's Food and Nutrient Database.

Blood samples were collected by venipuncture from participants in MECs according to standard protocols. Detailed specimen collection and processing methods have been previously reported (82,83). Serum 25(OH)D concentrations were analyzed and determined at the National Center for Environmental Health, Centers for Disease Control and Prevention using the Diasorin Radioimmunoassay (Stillwater, MN).

Periodically, NHANES data files are updated by the NCHS, replacing previous data files. In November 2010, an update occurred for serum 25(OH)D data because of changes and drifts in serum 25(OH)D assay over time. This was likely due to method variation that resulted from reagent and calibration lot-to-lot variation. The NCHS

released a data advisory for vitamin D and recommended use of the assay-adjusted data by investigators rather than previously available unadjusted data. A detailed description of this data advisory for serum 25(OH)D is described elsewhere (24).

A 216-item FFQ component was newly added to NHANES 2003-2004 and was used to gather information on the frequency of food consumption of participants over the past 12 months. The questionnaire was developed, tested, and validated by the National Institutes of Health, National Cancer Institute. Participants were asked the average number of times foods were consumed over the past 12 months and for certain types of foods, their seasonal intake were also gathered. Participants reported the number of times/d, wk, mo, or never that a food was consumed. All foods' frequency of consumption was standardized to a monthly intake by using a conversion factor of 30.4 d/mo as this is the number of days in an average month. Frequency of consumption was collected for dairy products, meat, fish and seafood, poultry, eggs, fruits and juices, vegetables, grains and legumes, snacks and sweets, beverages, and added fats. Those participants who did not answer the FFQ were excluded from this study. The detailed FFQ from NHANES 2003-2006 is attached as **Appendix A**.

CURRENT STUDY METHODOLOGY

STUDY SAMPLE

The 2 most recent cycles of NHANES 2003-2004 and 2005-2006 were used in this study. Although serum 25(OH)D concentrations are available publically in NHANES 2001-2002, this survey was not included in this current study because FFQ data were not collected. Data on children between ages 2 to ≤ 19 y from NHANES 2003-

2004 and 2005-2006 were concatenated into one master analytic database, NHANES 2003-2006 ($n=8747$). Children <2 y old had been excluded from the data analysis due to lack of completed FFQ. Subjects with serum 25(OH)D concentration data were then selected ($n=7172$). Of the remaining 7172 participants, 71 were excluded because they reported that they were lactating or currently pregnant. A further 2697 respondents were excluded due to missing data for any study variable. After applying the above exclusion criteria, the final sample consisted of 4404 children and adolescents (weighted sample: 60,274,697). This sample was used for the data analysis of measurement of association between dietary patterns and serum 25(OH)D concentrations. The detailed sample derivation for this current study is provided in **Figure 1**.

STUDY VARIABLES

In this study, the foods from the FFQ were categorized into 30 food groups. These 30 food groups were low-fat and high-fat dairy products, dairy alternatives, fish and other seafood, eggs, meat, processed meat, poultry, creamed soups, other soups, pizza, mixed foods, cereals, refined grains, whole grains, nuts, legumes, tomatoes, cruciferous, starchy, and other vegetables, fruit, fruit juices, snacks and sweets, butter and margarine, other fats, added sugars, coffee/tea, energy drinks (high or low), and alcohol (**Table 3**). Foods were categorized based on nutrient profiles or culinary use and were grouped similar to those used in other studies (22). Frequency of dietary intake of these 30 food groups for each individual was used to identify major dietary patterns. Age, sex, race-ethnicity, BMI, PIR, time of examination, energy intake, use of supplements, and screen use hours were considered as potential confounding variables as these are known to affect serum 25(OH)D concentrations (21,41). Participants were categorized into 2-3

y, 4-8 y, 9-13 y, and 14-19 y old age groups. BMI was categorized as normal weight (<85th percentile) and overweight and obese (\geq 85th percentile) for age and sex. PIR was categorized as below poverty (<1.0), middle income (1.0-2.5), higher income (>2.5), and not reported. Daily total energy intake was categorized into <1000 kcal/d, 1000-1500 kcal/d, 1501-2000 kcal/d, and >2000 kcal/d. Combined television, computer, and video game use hours were categorized as \leq 2 h, 3-4 h, or >4 h/d. Smoking status and alcohol intake variables were also considered as potential confounding variables. However, smoking-related questions were only asked to children aged \geq 12 y and alcohol-related questions were asked to adults aged \geq 20 y; therefore, both were dropped from the analysis.

STATISTICAL ANALYSIS

Statistical analysis was performed using SAS statistical software (version 9.2, SAS Institute) as it is capable of handling the complex survey design of NHANES. The survey analysis procedures accounted for primary sampling unit, stratum, cluster, and observation weight in the calculation of variances used for interval estimation and hypothesis testing. The NOMCAR option was used in all analyses so that design variables with missing values are used in the domain analysis to estimate variances using Taylor series linearization method. Detailed guidelines on the sample weighting and the proper variance estimation procedures are outlined in the NHANES Analytic and Reporting Guidelines (81).

Factor analysis (principal component) was used to identify dietary patterns based on the frequency of dietary intake of the 30 predefined food groups. The PROC FACTOR procedure in SAS was used to conduct this analysis. The factors were rotated

by orthogonal transformation to achieve a structure of independent factors with greater interpretability. The number of factors that were retained was determined based on an Eigenvalue (≥ 1.5), explained variance ($\geq 5\%$), and Cattell scree plot. The remaining factors were considered the main dietary patterns and were labeled based on interpretation of the data. Factor loadings were derived for each of the 30 food groups across the extracted factors. For each dietary pattern, a factor score was calculated for each participant by combining the frequency of dietary intake of the food groups weighted by their factor loadings. Dietary pattern scores were then stratified into tertiles (low, medium, and high) based on the factor scores for each dietary pattern.

Chi-square tests were used to identify associations between demographic, lifestyle, and health characteristics among the dietary pattern tertiles. Multivariate-adjusted regression analysis was used to determine the associations between serum 25(OH)D concentrations and dietary patterns. Associations were analyzed according to the participants' dominant dietary pattern, to the factor scores divided into tertiles labeled as low, medium, and high, and to the factor scores as a continuous variable. This analysis included sex, age, race-ethnicity, use of supplements, time of examination, BMI, PIR, screen use hours, and energy intake as potential confounding variables. Variables found to be non-significant such as PIR, use of supplements, and energy intake were dropped from the model. Because previous studies found differences of serum 25(OH)D concentrations by sex (14,41), the present analysis for the relation between serum 25(OH)D and dietary patterns was then stratified by sex. Univariate ANOVA was used to establish if serum 25(OH)D concentrations varied across dietary patterns for all subjects, boys, and girls in an unadjusted analysis. Analysis of covariance (ANCOVA)

was utilized to establish if serum 25(OH)D concentrations varied across dietary patterns after adjusting for various confounding variables. Multiple comparisons among dietary patterns for serum 25(OH)D concentrations were made using independent unpaired t-tests with a Bonferroni correction. Serum 25(OH)D concentrations were presented as mean \pm standard error (SE). Statistical significance was set at $\alpha=0.05$.

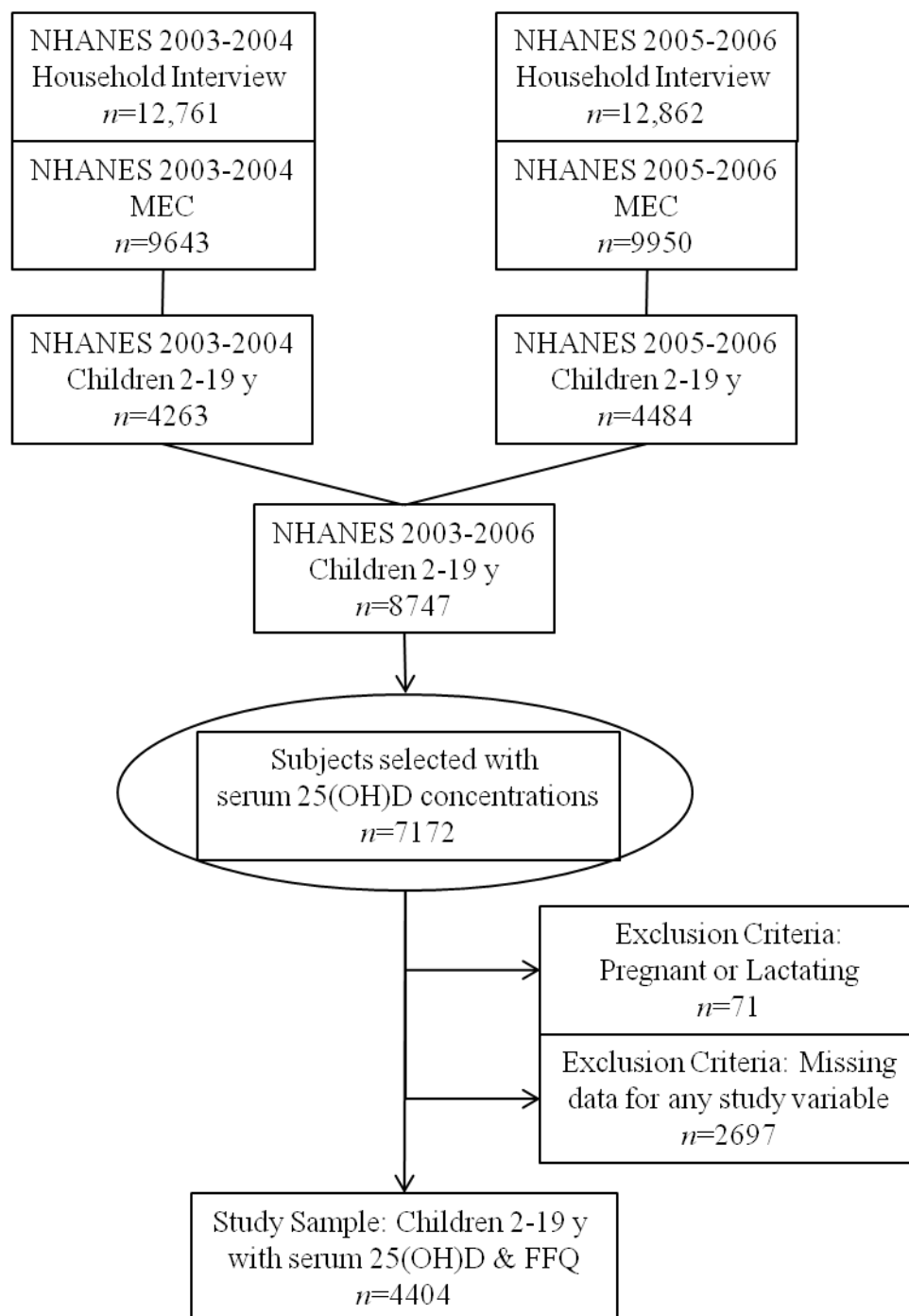


Figure 1. Derivation of study sample: Serum 25(OH)D concentrations in US children 2 to ≤ 19 y. The final sample was driven by sampled serum 25(OH)D concentrations after exclusion criteria.

Table 3**Food groups used in the dietary pattern analysis: NHANES 2003-2006¹**

Food Groups ²	Foods from the Food-Frequency Questionnaire ³
Low-fat dairy	1%, 2%, skim, nonfat, and evaporated milk; yogurt/frozen, low-fat cheese, and low-fat sour cream
High-fat dairy	Whole milk, cream, ice cream, pudding, cottage cheese, cheese, and sour cream
Dairy alternative	Soy, rice, and other milk; non-dairy creamer, and meal replacement beverage
Fish and other seafood	Oysters, clams, and shellfish; fish: fillets, sticks, tuna, salmon, and raw fish sushi
Eggs	Egg whites, whole egg, egg substitute, and egg salad
Meat	Beef, steak, roasts, hamburger, pork, ribs, and ham
Processed Meat	Bacon, Canadian bacon, sausage, hot dogs, luncheon meats, liver, and liverwurst

Poultry	Chicken, all types; and turkey
Creamed soup	Creamed soups, all types; and chowders
Other soup	Broth-based soups and bean soups
Pizza	Pizza, all types
Mixed dishes	Casseroles, lasagna, macaroni and cheese, and chili
Cereal	Oatmeal, grits, and other cooked cereals; and cold cereal, all types
Refined grains	English muffin, bagel, roll, cracker, stuffing, cornbread, biscuit, pancake, waffle, pasta, and rice
Whole grains	Dark breads and rolls; brown rice, bulgur, cracked wheat and millet; and granola bars
Nuts	Peanuts, walnuts, and other nuts; seeds; and nut butters
Legumes	Pintos, kidney, blackeyed peas, lima, lentils, refried beans, baked beans, soybeans, and tofu
Starchy vegetables	White potatoes, french fries, and potato salad; squash, sweet potatoes, carrots,

	and yams
Tomatoes	Tomatoes, including fresh, tomato juice, and salsa
Cruciferous and green vegetables	Spinach, turnip, collard, chard, kale, broccoli, cabbage, cauliflower, Brussel sprouts, and lettuce
Other vegetables	Pickles, green beans, peas, peppers, onion, cucumber, corn, and mixed vegetables
Fruit	Apples, pears, peaches, bananas, melons, strawberries, grapes, pineapple, and dried fruit
Fruit juices	Orange juice, grapefruit juice, apple juice, grape juice, and prune juice
Sweets and Snacks	Donuts, danish, cookie, brownie, cake, pie, cobbler, popcorn, pretzels, tortilla chips, and candy
Butter and Margarine	Butter and margarine, all types
Other fats	Olive oil, corn oil, canola oil, salad dressings, mayonnaise, and gravies

Condiments	Maple syrup, honey, jam, and jelly
Coffee/Tea	Coffee and tea, regular and decaffeinated
Energy drinks	Sodas and fruit drinks, including Hi-C, Kool-Aid, lemonade, and cranberry cocktail
Alcohol	Beer, wine, wine coolers, hard liquor, and mixed drinks

¹ $n=4404$; weighted $n=60,274,698$. NHANES 2003-2004 and 2005-2006 were combined into one master database, NHANES 2003-2006.

²Foods consumed by survey participants were categorized into 30 food groups based on nutrient profiles or culinary use.

³Food consumption data were collected using a 216-item qualitative Food Frequency Questionnaire.

CHAPTER IV

RESULTS

DEMOGRAPHIC CHARACTERISTICS

The sample sizes by demographic and health characteristics of the study population are given in **Table 4**. The sample consisted of 51.5% ($n=2154$) boys and 48.5% ($n=2250$) girls. Of the 4404 participants, 62.5% ($n=1293$) were non-Hispanic white, 15.3% ($n=1428$) were non-Hispanic black, and 13.3% ($n=1323$) were Hispanic/Mexican American. The participants were distributed across the age categories: 8.4% ($n=399$) 2-3 y, 26.4% ($n=924$) 4-8 y, 29.9% ($n=1282$) 9-13 y, and 35.3% ($n=1799$) 14-19 y. Of the study population, 34.1% ($n=1133$) reported having taken a supplement 30 days prior to the completing the survey. The majority (61.1%, $n=2215$) of the participants were examined in the summer. 84.8% ($n=3626$) were classified as healthy weight and 15.2% ($n=778$) as overweight and obese. The majority (49.9%, $n=1984$) reported ≤ 2 h/d of television, computer, and video game usage, though 28.5% ($n=1296$) reported between 3-4 h/d and 21.6% ($n=1124$) reported >4 h/d.

DIETARY PATTERNS

Two major dietary patterns were identified based on factor analysis from the 30 predefined food groups described previously in **Table 3**. Higher positive factor loading scores are interpreted to contribute most to the factor score, and conversely, higher negative factor loading scores contribute least to the factor score. The 1st factor had heavy factor loading scores for meats, snacks and sweets, condiments, mixed dishes,

pizza, processed meats, refined grains, high fat dairy, coffee/tea, poultry, starchy vegetables, and fish and other seafood. The 2nd factor had heavy factor loading scores for all vegetable groups, fruit, other fats, mixed dishes, fish and other seafood, tomatoes, and meats. Factor 1 was the most dominant dietary food pattern in the population and explained 17.0% of the variance in food intake, whereas factor 2 explained 16.3% of the variance. The 2 dietary patterns accounted for combined ~33% of the variance in intake. The 1st factor was labeled as the High Fat and Low Vegetable (HFLV) dietary pattern and the 2nd factor was labeled as the Prudent dietary pattern, according to the foods found to have the highest factor loading scores within each factor pattern. Individuals in the HFLV dietary pattern had higher intakes of meats such as beef and pork, snacks and sweets such as cookies, cake, chips, and popcorn, condiments such as honey, jam, and jelly, mixed dishes such as lasagna, processed meats such hot dogs, refined grains such as bagels, pancakes, and crackers, high fat dairy products such as whole milk, ice cream, and cheese, coffee, tea, poultry such as chicken and turkey, starchy vegetables such as French fries, and fish. Foods that were least likely to be consumed in the HFLV dietary pattern were low-fat dairy products such as low fat milks and yogurt, whole grains such as dark breads and brown rice, cruciferous and other vegetables, tomatoes, legumes, fruit, alcohol, and cereals. The Prudent dietary pattern had high consumption of foods such as cruciferous, starch, and other vegetables, fruits, tomatoes, oil and vinegar salad dressings, mixed dishes such as casseroles, fish and meats. Least likely to be consumed in the prudent dietary pattern were foods such as coffee/tea, alcohol, energy drinks, condiments such as jams and jellies, pizza, and high fat dairy such as whole milk, ice

cream, and high-fat cheeses. The detailed factor loading matrixes for the 2 factors are listed in **Table 5**.

CHARACTERISTICS BY DIETARY PATTERN

The sample distribution by characteristics of the study population across tertiles of each dietary pattern is presented in **Table 6**. Subjects in the high-intake group of the HFLV dietary pattern were more likely to be non-Hispanic white (55.2%) and older, between 14-19 y (40.6%). They were also more likely have a PIR ≥ 2.5 (37.2%), ≤ 2 h of combined television, computer, and video games (41.6%), and consumed >2000 kcal/d (56.2%), though, were less likely to have consumed a supplement 30 d prior to survey (71.5%). Subjects in the high-intake group of the Prudent dietary pattern were more likely to be non-Hispanic white (60.0%) and slightly older, between 9-13 y (31.8%). They were also more likely to have a PIR ≥ 2.5 (39.3%), ≤ 2 h of combined television, computer, and video games (55.4%), and BMI $<85^{\text{th}}$ percentile (86.4%), though, were less likely to have consumed a supplement 30 d prior to survey (61.1%).

Both dietary patterns appeared to have differences with regards to several demographic and lifestyle factors. Non-Hispanic whites and Hispanic/Mexican Americans who consumed the HFLV dietary pattern were more likely to be in the low-intake group, whereas non-Hispanic blacks and other race-ethnicities were more likely to be in the high and medium-intake groups, respectively (P for trend <0.0001). Non-Hispanic blacks and other race-ethnicities who consumed the Prudent dietary pattern were more likely to be in the low-intake group, whereas non-Hispanic whites and Hispanic/Mexican Americans were more likely to be in the medium and high-intake groups, respectively (P for trend =0.003). Subjects in the high and medium-intake

groups of the HFLV dietary pattern tended to be in the older (4-19 y), whereas younger subjects (2-3 y) tended to be in the low-intake group (P for trend =0.003). Conversely, subjects in the high-intake group of the Prudent dietary pattern were more likely to be younger (2-13 y) compared to those in the low-intake group (P for trend <0.0001). Subjects of higher income were more likely to be in the low-intake group of the HFLV dietary pattern (P for trend <0.0001) or medium-intake group of the Prudent dietary pattern (P for trend =0.001). Subjects of lower income tended to be in the high-intake groups of the both the HFLV and Prudent dietary patterns. Subjects in the low-intake group of the HFLV dietary pattern (P for trend =0.003) and the high-intake group of the Prudent dietary pattern (P for trend <0.001) were more likely to have used supplements pattern. Those in the high-intake group of the HFLV dietary pattern and low-intake group of the Prudent dietary pattern tended to not use supplements. Subjects in the low-intake group of the Prudent dietary pattern were more likely to have a higher BMI (P for trend <0.001), and those in the medium-intake group of the HFLV pattern tended to have a higher BMI, though not statistically significant. Subjects in the high-intake group of the HFLV dietary pattern were more likely to have higher combined usage of television, computer, and video games/d, whereas those in the low-intake group tended to have ≤ 2 h/d (P for trend <0.0001). Subjects in the high-intake group of the Prudent dietary pattern were more likely to have lower combined usage of television, computer, and video games/d, whereas those in the low and medium-intake groups tended to have ≥ 3 h/d (P for trend <0.0001).

RELATION BETWEEN SERUM 25(OH)D CONCENTRATIONS AND DIETARY PATTERNS

The relation examining mean serum 25(OH)D concentrations according to the dominant dietary pattern using multivariate regression analysis is presented in **Table 7**. The unadjusted mean serum 25(OH)D concentrations of the total study population for HFLV and Prudent dietary patterns were 25.1 ± 0.6 ng/mL and 27.0 ± 0.5 ng/mL, respectively. Subjects who consumed the HFLV dietary pattern showed a significant negative relation to serum 25(OH) concentrations compared to those who consumed the Prudent dietary pattern ($\beta=-1.90$; $P=0.001$). The unadjusted mean serum 25(OH)D concentrations of the boys for the HFLV and Prudent dietary patterns were 26.1 ± 0.7 ng/mL and 27.2 ± 0.5 ng/mL, respectively and were not found significantly different. The unadjusted mean serum 25(OH)D concentrations of the girls for the HFLV and Prudent dietary patterns were 24.0 ± 0.8 ng/mL and 26.8 ± 0.6 ng/mL, respectively. Girls who consumed the Prudent dietary pattern showed a significant positive relation to serum 25(OH)D concentration compared to those who consumed the HFLV dietary pattern ($\beta=2.84$; $P=0.003$).

The adjusted mean serum 25(OH)D concentration for HFLV dietary pattern was 22.3 ± 0.4 ng/mL and for Prudent dietary pattern was 22.8 ± 0.3 ng/mL. After adjustment, a relation between HFLV dietary pattern and serum 25(OH) concentrations was no longer present ($P=0.209$). Similarly after stratifying by sex, the relation of serum 25(OH)D concentrations with girls who consume the Prudent dietary pattern was no longer present ($P=0.088$). Serum 25(OH)D concentrations continued not to be significantly different for boys ($P=0.533$).

The relation of mean serum 25(OH)D concentrations and dietary pattern according to the tertiles of factor scores are presented in **Table 8**. The unadjusted mean serum 25(OH)D concentrations of the total study population for low, medium, and high-intake groups of the HFLV dietary pattern were 27.3 ± 0.5 ng/mL, 26.1 ± 0.6 ng/mL, and 24.8 ± 0.7 ng/mL, respectively. Serum 25(OH)D concentrations differed significantly across the tertiles of the HFLV dietary pattern ($P=0.003$). Subjects who were in the low-intake group of the HFLV dietary pattern had greater serum 25(OH)D concentrations compared to those in the medium and high-intake groups ($+1.2 \pm 0.1$ ng/mL and $+2.5 \pm 0.01$ ng/mL, respectively). The unadjusted mean serum 25(OH)D concentrations of the total study population for low, medium, and high-intake groups of the Prudent dietary pattern were 24.7 ± 0.7 ng/mL, 26.8 ± 0.5 ng/mL, and 26.7 ± 0.6 ng/mL, respectively. Similarly, serum 25(OH)D concentrations differed significantly across the tertiles of the Prudent dietary pattern ($P=0.012$). However, subjects who were in the medium-intake group of the Prudent dietary pattern had greater serum 25(OH)D concentrations compared to those in the high and low-intake groups ($+0.9 \pm 0.1$ ng/mL and $+2.1 \pm 0.2$ ng/mL, respectively).

The unadjusted mean serum 25(OH)D concentrations of the boys for low, medium, and high-intake groups of the HFLV dietary pattern were 27.4 ± 0.6 ng/mL, 26.8 ± 0.7 ng/mL, and 25.8 ± 0.8 ng/mL, respectively. These concentrations were not significantly different. The unadjusted mean serum 25(OH)D concentrations of the girls for low, medium, and high-intake groups of the HFLV dietary pattern were 27.2 ± 0.7 ng/mL, 25.2 ± 0.8 ng/mL, and 23.6 ± 0.8 ng/mL, respectively. These concentrations, however, did differ significantly ($P=0.003$). Girls who were in the low-intake group of

the HFLV dietary pattern had greater serum 25(OH)D concentrations compared to those in the medium and high-intake groups ($+2.0 \pm 0.1$ ng/mL and $+3.6 \pm 0.1$ ng/mL, respectively).

The unadjusted mean serum 25(OH)D concentrations of the boys for low, medium, and high-intake groups of the Prudent dietary pattern were 25.8 ± 0.7 ng/mL, 26.9 ± 0.7 ng/mL, and 27.3 ± 0.7 ng/mL, respectively. These concentrations did not differ significantly ($P=0.151$). The unadjusted mean serum 25(OH)D concentrations of the girls for low, medium, and high-intake groups of the Prudent dietary pattern were 23.6 ± 0.9 ng/mL, 26.6 ± 0.6 ng/mL, and 26.1 ± 0.7 ng/mL, respectively. These concentrations, however, differed significantly across the tertiles of the Prudent dietary pattern ($P=0.005$). Girls who were in the medium-intake group of the Prudent dietary pattern had greater serum 25(OH)D concentrations compared to those in the high and low-intake groups ($+0.5 \pm 0.1$ ng/mL and $+3.0 \pm 0.3$ ng/mL, respectively).

The multivariate adjusted mean serum 25(OH)D concentrations of the total study population for low, medium, and high-intake groups of the HFLV or Prudent dietary pattern did not differ significantly. Similarly, the multivariate adjusted mean serum 25(OH)D concentrations of the boys and girls for low, medium, and high-intake groups of the HFLV or Prudent dietary patterns did not differ significantly. Though girls who were in the medium and high-intake groups of Prudent dietary pattern had slightly higher mean serum 25(OH)D concentrations compared to those in the low-intake group (21.5 ± 0.5 vs. 19.9 ± 0.6 ng/mL; $P=0.064$).

The relation between mean serum 25(OH)D concentrations and dietary patterns according to factor scores using multivariate regression analysis is presented in **Table 9**.

In the unadjusted multivariate regression analysis, all subjects with higher HFLV dietary contributions scores to overall diet showed a significant negative relation to serum 25(OH) concentrations ($\beta=-135.56$; $P<0.001$). Though, all subjects with higher Prudent dietary contribution scores to overall diet did not show a significant association to serum concentrations. However when subjects were stratified into boys and girls, only girls continued to show significant relation with serum 25(OH)D concentrations for both dietary patterns. Girls with higher HFLV dietary contribution scores showed a significant negative relation ($\beta=-192.99$; $P<0.001$) and girls with higher Prudent dietary contribution scores showed a significant positive association ($\beta=79.75$; $P=0.035$) to serum 25(OH)D concentrations. In the adjusted multivariate regression analysis, all subjects with higher HFLV dietary contributions scores to overall diet no longer showed a significant association to serum 25(OH) concentrations ($P=0.224$). However, all subjects with higher Prudent dietary contribution scores to overall diet showed a significant positive relation with serum 25(OH)D ($\beta=62.01$; $P=0.016$). Similarly, when subjects were stratified into boys and girls in the adjusted analysis, only girls continued to show significant relation with serum 25(OH)D concentrations for both dietary patterns. Girls with higher HFLV dietary contribution scores showed a significant negative relation ($\beta=-84.32$; $P=0.022$) and girls with higher Prudent dietary contribution scores showed a significant positive association ($\beta=86.34$; $P=0.014$) to serum 25(OH)D concentrations.

Table 4**Sample sizes by demographic and health characteristics of the study****population: NHANES 2003-2006¹**

Characteristic	<i>n</i> ²	% ³
Sex		
Boys	2154	51.5
Girls	2250	48.5
Race-ethnicity		
Non-Hispanic white	1293	62.5
Non-Hispanic black	1428	15.3
Hispanic/Mexican American	1323	13.3
Other	360	8.9
Age		
2-3 y	399	8.4
4-8 y	924	26.4
9-13 y	1282	29.9
14-19 y	1799	35.3
Poverty income ratio ⁴		
<1.0	1332	21.6
1.0-2.5	1526	32.3

≥2.5	1395	43.3
not reported	151	2.8
Time of Examination ⁵		
Fall/Winter	2189	38.9
Spring/Summer	2215	61.1
Use of Supplements ⁶		
Yes	1133	34.1
No	3271	65.9
BMI		
<85 th percentile	3626	84.8
≥85 th percentile	778	15.2
Daily Screen Use ⁷		
≤2 h	1984	49.9
3-4 h	1296	28.5
>4 h	1124	21.6
Daily Caloric Intake		
<1000 kcal/d	304	6.6
1000-1500 kcal/d	842	18.5
1501-2000 kcal/d	1201	26.9
>2000 kcal/d	2057	48.0

¹*n*=4404; weighted *n*=60,274,698. NHANES 2003-2004 and 2005-2006

were combined into one master database, NHANES 2003-2006.

²Unweighted.

³Weighted. All weighted percentages were estimated with NHANES complex survey design taken into account.

⁴Ratio of income to the family's appropriate poverty threshold, provided by the US Census Bureau. A ratio of <1.0 is characterized as below poverty.

⁵Data collected during May 1 - October 31 (spring/summer) and November 1 - April 30 (fall/winter).

⁶Participants who took supplements 30 days before survey was conducted.

⁷Data collected on the combined h/d usage of television, computer, and video games.

Table 5**Rotated factor loading matrix for dietary patterns^{1,2}**

Category ³	Factor 1: HFLV ⁴	Factor 2: Prudent
Cruciferous & green vegetables	0.11772	0.70550
Other vegetables	0.14405	0.73387
Tomatoes	0.17242	0.46396
Starchy vegetables	0.51390	0.51826
Fruit	0.19937	0.67637
Fruit juice	0.36418	0.24275
Nuts	0.22837	0.40923
Legumes	0.08487	0.40597
Fish & other seafood	0.50504	0.47944
Meat	0.64530	0.45666
Poultry	0.51951	0.39210
Processed Meat	0.57973	0.34615
Whole grains	-0.04954	0.44837
Refined grains	0.56961	0.44761
Cereals	0.08430	0.34700
Eggs	0.27862	0.29808
Low fat dairy	-0.13618	0.41351

High fat dairy	0.54352	0.13302
Dairy Alternative/Meal Replacement	0.20299	0.08244
Creamed soups	0.16354	0.19632
Other soups	0.29895	0.41552
Mixed dishes	0.60462	0.52268
Pizza	0.60447	0.08907
Snacks & sweets	0.63461	0.33823
Butter & Margarine	0.42341	0.28823
Other fats	0.35340	0.52495
Condiments	0.63240	0.17312
Energy drinks	0.51320	-0.07380
Alcohol	0.12023	-0.01767
Coffee/Tea	0.52315	-0.07769

¹ $n=4404$; weighted $n=60,274,698$.

²Factor procedure, principal component analysis. The 2 factors with Eigenvalues ≥ 1.5 were rotated and extracted. The factors were labeled according to the foods found to have the highest factor loading scores within each factor pattern.

³Food categories were based on consumption data collected from a 216-item Food Frequency Questionnaire from NHANES 2003-2004 and 2005-2006. Individual foods were categorized into 30 food groups.

⁴High Fat and Low Vegetable dietary pattern.

Table 6

Sample distribution by demographic and health characteristics according to the tertiles of factor scores for dietary patterns: NHANES 2003-2006^{1,2}

Characteristic	HFLV ³			<i>P</i> for trend ⁴	Prudent			<i>P</i> for trend ⁴
	Low	Medium	High		Low	Medium	High	
<i>n</i>	1338	1465	1601		1523	1376	1505	
Sex								
Boys (% , <i>n</i> =2154)	48.6	51.8	54.2	0.165	48.7	55.8	50.1	0.098
Girls (% , <i>n</i> =2250)	51.4	48.2	45.8		51.3	44.2	49.9	
Race-ethnicity								
Non-Hispanic white (% , <i>n</i> =1293)	70.0	62.2	55.2	<0.001	61.0	66.4	60.0	0.003
Non-Hispanic black (% , <i>n</i> =1428)	7.3	13.9	24.7		18.0	13.2	14.7	
Hispanic/Mexican American (% , <i>n</i> =1323)	14.3	14.1	11.5		10.9	13.1	15.9	
Other (% , <i>n</i> =360)	8.3	9.8	8.6		10.9	7.3	9.4	

Age

2-3 y (% , n=399)	9.6	8.9	6.7	0.003	5.3	8.9	11.0	<0.001
4-8 y (% , n=924)	25.8	26.6	26.8		18.6	30.0	30.4	
9-13 y (% , n=1282)	34.6	29.4	25.8		27.3	30.7	31.8	
14-19 y (% , n=1799)	30.1	35.1	40.6		48.8	30.4	26.8	

Poverty income ratio⁵

<1.0 (% , n=1332)	16.7	19.6	28.4	<0.001	20.4	20.0	24.3	0.001
1.0-2.5 (% , n=1526)	33.0	31.9	32.0		32.5	29.8	34.7	
≥2.5 (% , n=1395)	48.1	44.7	37.2		42.3	48.2	39.3	
not reported (% , n=151)	2.1	3.8	2.4		4.8	2.0	1.6	

Time of Examination⁶

Fall/Winter (% , n=2189)	40.2	39.6	36.8	0.693	39.0	36.3	41.4	0.395
Spring/Summer (% , n=2215)	59.8	60.4	63.2		61.0	63.7	58.6	

Use of Supplements⁷

Yes (% , <i>n</i> =1133)	38.4	35.3	28.5	0.003	27.0	36.4	38.9	<0.001
No (% , <i>n</i> =3271)	61.6	64.7	71.5		73.0	63.6	61.1	

BMI

<85 th percentile (% , <i>n</i> =3626)	86.0	84.0	84.5	0.610	81.8	86.2	86.4	0.028
≥85 th percentile (% , <i>n</i> =778)	14.0	16.0	15.5		18.2	13.8	13.6	

Daily Screen Use⁸

≤2 h (% , <i>n</i> =1984)	59.8	48.4	41.6	<0.001	42.7	51.6	55.4	<0.001
3-4 h (% , <i>n</i> =1296)	25.1	28.8	31.5		30.2	27.8	27.4	
>4 h (% , <i>n</i> =1124)	15.2	22.8	26.9		27.0	20.6	17.3	

Daily Caloric Intake

<1000 kcal/d (% , <i>n</i> =304)	8.6	6.0	5.2	<0.001	7.5	5.8	6.4	0.500
1000-1500 kcal/d (% , <i>n</i> =842)	20.3	20.8	14.1		18.1	18.0	19.3	
1501-2000 kcal/d (% , <i>n</i> =1201)	28.0	28.2	24.5		27.9	24.5	28.4	

>2000 kcal/d (% , n=2057)	43.1	44.9	56.2	46.5	51.7	45.9
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¹n=4404; weighted n=60,274,698. NHANES 2003-2004 and 2005-2006 were combined into one master database, NHANES 2003-2006.

²Dietary pattern scores were stratified into tertiles (low, medium, and high) based on factor scores for each dietary pattern.

³High Fat and Low Vegetable dietary pattern.

⁴Significance determined by Rao-Scott chi-square test.

⁵Ratio of income to the family's appropriate poverty threshold, provided by the US Census Bureau. A ratio of <1.0 is characterized as below poverty.

⁶Data collected during May 1 - October 31 (spring/summer) and November 1 - April 30 (fall/winter).

⁷Participants who took supplements 30 days before survey was conducted.

⁸Data collected on the combined hours of television, computer, and video games usage per day.

Table 7**Relation between mean serum 25(OH)D concentrations and dietary patterns:****NHANES 2003-2006¹**

	ng/mL ²	β^3	SE ⁴	<i>P</i> value ⁵
Unadjusted analysis				
HFLV ⁶				
All subjects	25.1 ± 0.6	-1.90	0.52	0.001
Boys	26.1 ± 0.7	1.10	0.66	0.109
Girls	24.0 ± 0.8	2.84	0.86	0.003
Prudent				
All subjects ⁷	27.0 ± 0.5	-	-	
Boys ⁷	27.2 ± 0.5	-	-	
Girls ⁷	26.8 ± 0.6	-	-	
Adjusted analysis				
HFLV ⁶				
All subjects ⁸	22.3 ± 0.4	-0.50	0.41	0.209
Boys ⁸	23.2 ± 0.5	0.32	0.58	0.533
Girls ⁸	20.3 ± 0.6	-1.45	0.70	0.088
Prudent				
All subjects ^{7,8}	22.8 ± 0.3	-	-	

Boys ^{7,8}	22.9 ± 0.5	-	-	
Girls ^{7,8}	21.6 ± 0.4	-	-	-

¹ $n=4404$; weighted $n=60,274,698$. NHANES 2003-2004 and 2005-2006 were combined into one master database, NHANES 2003-2006. Regression analysis of dietary patterns and recently released assay-adjusted serum 25(OH)D concentrations.

²Mean ± standard error.

³Multivariate regression coefficient.

⁴Standard error for multivariate regression coefficient.

⁵Significance determined by t-test in analysis of variance for unadjusted analysis and in analysis of covariance for adjusted analysis.

⁶High Fat and Low Vegetable dietary pattern.

⁷Referent category.

⁸Analysis was adjusted for sex, race-ethnicity, age, time of examination, BMI, and daily screen use. Poverty income ratio, supplement use, and energy intake were not found significant in this model and therefore dropped as confounding variables.

Table 8**Relation of mean serum 25(OH)D concentrations and dietary patterns according to the tertiles of factor scores:****NHANES 2003-2006^{1,2}**

	HFLV ^{3,4}				Prudent ³			
	Low	Medium	High	<i>P</i> value ⁵	Low	Medium	High	<i>P</i> value ⁵
	ng/mL	ng/mL	ng/mL		ng/mL	ng/mL	ng/mL	
Unadjusted analysis								
All subjects	27.3 ± 0.5	26.1 ± 0.6	24.8 ± 0.7	0.003	24.7 ± 0.7	26.8 ± 0.5	26.7 ± 0.6	0.012
Boys (<i>n</i> =2154)	27.4 ± 0.6	26.8 ± 0.7	25.8 ± 0.8	0.123	25.8 ± 0.7	26.9 ± 0.7	27.3 ± 0.7	0.151
Girls (<i>n</i> =2250)	27.2 ± 0.7	25.2 ± 0.8	23.6 ± 0.8	0.003	23.6 ± 0.9	26.6 ± 0.6	26.1 ± 0.7	0.005
Adjusted analysis								
All subjects ⁶	22.1 ± 0.4	22.1 ± 0.3	21.7 ± 0.5	0.594	21.4 ± 0.5	22.1 ± 0.3	22.5 ± 0.4	0.195
Boys (<i>n</i> =2154) ⁷	22.9 ± 0.5	23.3 ± 0.4	23.1 ± 0.6	0.810	23.0 ± 0.5	22.9 ± 0.4	23.5 ± 0.5	0.370
Girls (<i>n</i> =2250) ⁷	21.4 ± 0.5	20.9 ± 0.5	20.4 ± 0.7	0.529	19.9 ± 0.6	21.5 ± 0.5	21.5 ± 0.5	0.064

¹ $n=4404$; weighted $n=60,274,698$. NHANES 2003-2004 and 2005-2006 were combined into one master database, NHANES 2003-2006. Regression analysis of dietary patterns and recently released assay-adjusted serum 25(OH)D concentrations.

²Dietary pattern scores were stratified into tertiles (low, medium, and high) based on factor scores for each dietary pattern.

³Mean \pm standard error.

⁴High Fat and Low Vegetable dietary pattern.

⁵Significance determined by F test in analysis of variance for unadjusted analysis and in analysis of covariance for adjusted analysis.

⁶Analysis was adjusted for sex, race-ethnicity, age, time of examination, BMI, and daily screen use. Poverty income ratio, supplement use, and energy intake were not found significant in this model and therefore dropped as confounding variables.

⁷Analysis was adjusted for race-ethnicity, age, time of examination, BMI, and daily screen use. Poverty income ratio, supplement use, and energy intake were not found significant in this model and therefore dropped as confounding variables.

Table 9**Relation of mean serum 25(OH)D concentrations with dietary patterns****according to factor scores: NHANES 2003-2006^{1,2}**

	β^3	SE ⁴	<i>P</i> value ⁵
Unadjusted analysis			
HFLV ⁶			
All subjects	-135.56	32.26	<0.001
Boys	-81.36	47.77	0.099
Girls	-192.99	36.74	<0.001
Prudent			
All subjects	57.12	30.78	0.073
Boys	36.13	31.80	0.265
Girls	79.75	36.12	0.035
Adjusted analysis			
HFLV ⁶			
All subjects ⁷	-32.50	26.18	0.224
Boys ⁸	30.76	38.35	0.429
Girls ⁸	-84.32	34.94	0.022
Prudent			
All subjects ⁷	62.01	24.17	0.016
Boys ⁸	42.45	23.76	0.084

Girls ⁸	86.34	32.93	0.014
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¹*n*=4404; weighted *n*=60,274,698. NHANES 2003-2004 and 2005-2006 were combined into one master database, NHANES 2003-2006. Analysis was based on recently released assay-adjusted serum 25(OH)D concentrations.

²Regression analysis using factor scores as continuous variable and dependent variable, serum 25(OH)D concentrations.

³Multivariate regression coefficient.

⁴Standard error for multivariate regression coefficient.

⁵Significance between dietary patterns and serum 25(OH)D in the regression model.

⁶High Fat and Low Vegetable dietary pattern.

⁷Analysis was adjusted for sex, race-ethnicity, age, time of examination, BMI, and daily screen use. Poverty income ratio, supplement use, and energy intake were not found significant in this model and therefore dropped as confounding variables.

⁸Analysis was adjusted for race-ethnicity, age, time of examination, BMI, and daily screen use. Poverty income ratio, supplement use, and energy intake were not found significant in this model and therefore dropped as confounding variables.

CHAPTER V

DISCUSSION

To our knowledge, this is the most comprehensive study that investigated the relation between serum 25(OH)D concentrations and dietary patterns in children and adolescents in a nationally representative sample survey. We derived 2 major dietary patterns, HFLV and Prudent, using factor analysis based on an Eigenvalue ≥ 1.5 , explained variance $\geq 5\%$, and Catell scree plot. This method has been used in various dietary studies (72). Results from factor analysis are reproducible and valid (22,66). The 2 dietary patterns derived in this study accounted for a combined 33% of the variance in dietary intakes which is similar to the explained variance found in several studies (74–76). Serum 25(OH)D was significantly lower in HFLV compared to Prudent dietary pattern group, and the highest serum 25(OH)D concentrations for all subjects were in the low-intake HFLV or medium and high-intake Prudent groups. In the multivariate adjusted analysis, a significant positive relation was found between Prudent dietary pattern factor scores and serum 25(OH)D concentrations among US children and adolescents. When data were stratified by sex, a significant positive relation was observed in girls who consumed the Prudent diet and a significant negative relation was observed in girls who consumed the HFLV diet.

The 2 dietary patterns identified in the present study were similar to those found in previous studies using factor analysis (23,63,67–69,76). In studies assessing dietary

patterns among children, Ystrom et al (67) also derived 2 major dietary patterns, which they labeled as Unhealthy and Wholesome. The Unhealthy dietary pattern was characterized by high consumption of foods high in sugar and fat such as sweets, chocolate, soda, cakes, cookies, and bread with jam or honey; and the Wholesome dietary pattern was characterized by foods rich in fiber and vitamins and minerals such as vegetables, fish, fruit, yogurt, beans, pasta, and meats. Ystrom et al's (67) Unhealthy dietary pattern differs slightly from our HFLV dietary pattern, in that, our pattern was also characterized by high consumption of pizza, meats, processed meats, and mixed dishes. The differences are possibly due to the fact that Ystrom et al's (67) study population was younger. In a study by Northstone and Emmett (69) among children at 4 and 7 y old identified 3 dietary patterns, i.e., Junk (associated with high-fat processed foods and snack foods), Traditional (associated with poultry and meat dishes, vegetables, peas, corn, and potatoes), and Health-conscious (associated with vegetarian style foods). Similarly Fung et al (63) derived 2 major dietary patterns, Prudent (characterized by higher intake of fruit, vegetables, poultry, fish, whole grains, and legumes) and Western (characterized by higher intake of red and processed meat, French fries, eggs, high-fat dairy products, sweets, and refined grains) using the Health Professionals Follow-up Study. Ganji et al (76), using NHANES III data, identified 3 dietary patterns, Vegetable, Fruit and Lean Meat (higher intakes of vegetables, fruits/fruit juices, soups, fish, poultry, whole grains, low-fat dairy, and legumes), Western (higher intakes of red and processed meats, high-energy drinks, refined grains, eggs, snacks/sweets, pizza/lasagna, and alcohol), and Mixed (higher intakes of high-fat dairy, fats, nuts and cereals). Although labeling of the food patterns is subjective and the number of dietary patterns derived in

each study varied slightly due to differences in characteristics of subjects, food groupings, and Eigenvalue cutoffs used, there seems to be consistency across studies in the identification of a healthy and an unhealthy dietary pattern.

Several studies have demonstrated that dietary patterns may be influenced by demographic and other lifestyle factors (72). In studies assessing dietary patterns among children, Northstone and Emmett (69) reported ethnicity-related differences. They found a significant negative association with the Junk dietary pattern and non-white ethnicity and a positive association with the Health conscious dietary pattern and non-white ethnicity. In the present study, we found somewhat similar trends in factor scores across race-ethnicities. Hispanic/Mexican Americans were more likely to be in the low-intake HFLV or high-intake Prudent diet pattern, though Non-Hispanic blacks were more likely to be in the high-intake HFLV or low-intake Prudent groups. Several adult studies have also reported trends with age and dietary patterns (23,74,76). This study found that those in the high-intake Prudent were younger and those in the high-intake HFLV were older. This is in contrast to age trends found in the adult studies. This may be likely due to the fact that our study population consisted of children who do not control the foods that are brought into and prepared in the home. Parents may attempt to be more conscious of food they give to their younger children and may likely be a reason for the higher intakes of the healthier pattern at younger ages. Older children may be more likely to be in the higher intakes of the unhealthier pattern as the child ages and exerts more independence over the foods he or she consumes. Differences have also been demonstrated with regards to income and dietary patterns (67,68). Ystrom et al (67) found that their Unhealthy dietary pattern was associated with relatively poorer income, and Shin et al

(68) found that households with higher income was associated with higher dietary pattern scores for the Korean-healthy pattern. Similarly, we found subjects of below poverty income were more likely to be in the high-intake groups of the HLFV pattern. However, we also found that those in the low income group were more likely to have high factor scores for the high-intake Prudent pattern. Furthermore, in contrast to Shin et al (68), we found that the subjects in households with higher income had high factor scores for medium-intake Prudent or low-intake HFLV patterns. Difference between findings may be due to the fact that Shin et al (68) used a convenience sample that recruited from urban areas and therefore may not be generalizable. We did not however see any differences between sex and dietary patterns. This is in contrast to several studies that have reported an association (23,68,76). Previous studies reported those who consume the healthier eating pattern were more likely to be female (23,76) and those who consume the unhealthier eating pattern were male (23,68). While several studies among adults have reported differences related to sex, very few studies among children have reported. Differences in dietary patterns related to sex may be more evident in adults because adults have more direct control over the foods they consume.

Our study is the first to report a relation between dietary patterns and serum 25(OH)D concentrations. Previous studies relating vitamin D intake with the vitamin D status have shown conflicting results (16–18). In the unadjusted analysis in which we categorized subjects into one of the 2 dietary patterns, we found a significant negative relation between HFLV and serum 25(OH)D concentrations. We found that those in the Prudent dietary pattern had significantly higher mean serum 25(OH) concentrations compared to those in the HFLV dietary pattern. In contrast, a study in Polish vegetarian

children by Ambroszkiewicz et al (77), it was found that serum 25(OH)D concentrations were 2-fold lower than in their omnivorous counterparts. While in this study those who consumed the Prudent dietary pattern were not necessarily vegetarians, they did have higher factor scores for many similar type foods found in a vegetarian diet and lesser factor scores for foods typical in an omnivorous diet. However in a study by Chan et al (78) that compared vegetarians, partial vegetarians, and non-vegetarians, they found no association between serum 25(OH)D concentrations and vegetarian status. In the multivariate adjusted analysis, serum 25(OH)D concentrations in the HFLV dietary group were lower than those in the Prudent group though not significant. Differences between studies may be due to differences in subject characteristics and confounding variables used in the statistical analysis.

When the mean serum 25(OH) concentrations across tertiles of factor scores for each dietary pattern were examined in the unadjusted analysis, the highest serum concentrations for all subjects were found in the low-intake HFLV group or medium- and high-intake Prudent groups. In this analysis individuals were scored on each pattern, therefore a person's diet would be represented by a combination of both factors. A high factor score from one dietary pattern does not necessarily mean a low factor score from the other dietary pattern for an individual. However, these results seem to suggest that the greatest unadjusted serum 25(OH)D concentrations occurred in individuals who consumed a healthier type diet that had a higher emphasis on vegetables, fruits and some emphasis on mixed dishes, fish, and meats. The differences seen in the serum 25(OH)D concentrations may be due to other factors other than diet. Because when the analysis was adjusted for confounding variables, the association between serum 25(OH)D

concentrations and dietary patterns was no longer present. This was seen in other studies such that other factors such as race, season, and sun exposure were more significant predictors of serum 25(OH)D concentrations than dietary intake (40,84).

In the unadjusted regression analysis using dietary factor scores, serum 25(OH)D concentrations had a significantly negative relation in individuals who adhere to a HFLV pattern diet. However when analysis was adjusted for confounding variables, we found serum 25(OH)D concentrations had significantly positive relation in individuals who adhere to a Prudent dietary pattern while HFLV dietary pattern had no relation. Cole et al (18) found an inverse relationship between dietary fat intake and serum 25(OH)D concentrations. This may be a possible factor for why we found no relation between our HFLV diet pattern and serum 25(OH)D concentrations. The higher fat content in the HFLV diet may have played a part. In early work by Hollander et al (85), absorption of vitamin D in rats was significantly decreased with the addition of certain saturated and unsaturated fatty acids. They proposed that long chain fatty acids decreased vitamin D absorption by causing the expansion of micelles, reducing their diffusion rate and making it difficult to cross the unstirred water layer of the intestinal mucosa (85). Another potential explanation is that the fatty acids may have increased the solubility of vitamin D in the micelles so that it remained within the micelle (86). A recent randomized, double-blind, placebo controlled trial of 152 subjects by Niramitmahapanya et al (87) reported that the type of dietary fat influenced the bioavailability of vitamin D. It was found that polyunsaturated fatty acids and saturated fatty acids were inversely associated with circulating 25(OH)D concentrations. This suggests that a diet high in fat may affect vitamin D absorption, thereby impacting serum 25(OH)D concentrations. However, in a

small clinical trial by Raimundo et al (88), they investigated the effect of a high or low fat meal on serum 25(OH)D concentrations after a single oral dose of 50,000 IU vitamin D supplement. They found that vitamin D supplementation was more effective at increasing mean serum 25(OH)D concentrations with a high fat meal compared to a low-fat meal. The sample size, however, was very small and measured the effects of the supplement with only two meals (one high fat and the second low fat). Raimundo et al (88) did not take into effect other possible confounding variables such as outdoor activity, vitamin D foods consumed, and race-ethnicity which may under- or overstated their results. In this study, we investigated the relation of serum 25(OH)D with the entire dietary pattern, rather than just one meal.

The higher serum 25(OH)D concentrations in those who adhere more closely to a Prudent diet pattern may be related to certain lifestyle and health-related factors. In this study, we found that there was a greater proportion of children who used supplements in the high-intake Prudent pattern compared to those in the high-intake HFLV pattern. Burgaz et al (89) in a cross-sectional study of Swedish women during the winter found that regular use of dietary supplements was associated with an increase of serum 25(OH)D concentration by 11.8 nmol/L. Kumar et al (12) using NHANES 2001-2004 data for children aged 1 to ≤ 21 y found that those who used vitamin D supplementation were less likely to be vitamin D deficient. Similarly, van der Meer et al (17) found that vitamin D supplements showed a significant positive association with serum 25(OH)D concentrations. While we did not look at vitamin D supplementation specifically, our results suggest that supplementation could have been a factor for the increased serum 25(OH)D concentrations in those who adhere to a Prudent diet. Additionally, it has been

suggested that the bioavailability of vitamin D may be lowered in those who are overweight or obese because of excessive sequestering of vitamin D in adipose tissue due to its hydrophobic nature (57). Gordon et al (15) found that a higher BMI and being African American was associated with decreased serum 25(OH)D concentrations in healthy adolescents. Similarly, we found in the high-intake HFLV group that there were a greater proportion of children who were overweight or obese and a significantly greater proportion of Non-Hispanic blacks. This could be another possible explanation of the lower serum 25(OH)D concentrations found in this study for those who adhered more closely to the HFLV pattern. Furthermore, greater indoor activity measured by hours spent watching television, using computers, or playing video games has also been found to be a factor associated with lower 25(OH)D concentrations (12). In the present study, there was a greater proportion of children who had ≤ 2 h/d of combined television, computer, and video game usage in the high-intake Prudent group compared to the high-intake HFLV group. This suggests could be another potential factor for the increased serum 25(OH)D concentrations in those who adhere to a Prudent diet.

Furthermore, the relation of serum 25(OH)D concentrations with both dietary patterns remained for girls only in the adjusted analysis. Differences based on sex were observed in other studies (90). Nanri et al (90) found higher serum 25(OH)D concentrations in women who had higher fish/shellfish consumption and lower BMI. They proposed the difference may be related to body composition of females compared to males. Because females generally have higher fat mass than males and vitamin D is fat-soluble, this could result in higher amounts being stored in the fat tissue of females and lower serum vitamin D concentrations. This could be a possible explanation for why

in the present study we are seeing girls who adhere most closely to the HFLV diet pattern have significantly lower serum concentrations. The higher fat content in the HFLV diet pattern could result in more fat tissue in this group and thus, more vitamin D being stored and lowering serum concentrations. Differences seen in those who adhere most closely to the Prudent diet pattern based on sex may be somewhat the opposite. Girls who follow the Prudent diet closely may feel the societal pressures to remain thin which may be a reason they choose this type of dietary pattern. Therefore, dietary intake of vitamin D rich foods may be able to have more of an effect on serum 25(OH)D concentrations because fat mass in these girls is lower. Additionally, Richter et al (91) in dietary study of German adolescents found that micronutrient density of vitamin D decreased with increasing western pattern dietary intake among boys. This may explain why in the present study no relation was found between serum 25(OH)D concentrations and our HFLV dietary pattern among boys.

STRENGTHS AND LIMITATIONS

The present study has several strengths that included a nationally representative survey with a large sample size of children and adolescents. Because of a wide range of data are available on demographic characteristics, dietary information, and other health-related factors we were able to adjust serum 25(OH)D concentrations for several known confounding variables. The statistical method used in this study was capable of handling the complex survey design of NHANES and account for sample weights, stratification, and clustering of the design. Results in this study can be interpreted towards the general US children and adolescents population because NHANES is based on a probability sample survey design and is representative of the US population.

As with any cross-sectional study, cause and effect measurement is not possible. The use of factor analysis to derive the dietary patterns is limited by the subjective decisions that investigators must make in grouping of individual foods into food groups, extracting the number of factors (or patterns), and labeling of the dietary patterns. In addition, dietary intakes of children estimated by a FFQ may be underreported due to subjects' inability to recall intakes accurately (92). The errors in reporting food intakes may be minimal because the FFQ used in NHANES had been previously tested and validated by the National Cancer Institute. Additionally, other potential confounding variables such as information on the latitude of subject's home, use of sunscreen lotions, and clothing habits were not reported in NHANES and therefore could not be taken into account in the analysis.

CONCLUSION

In conclusion, 2 dietary patterns, HFLV and Prudent, were derived using factor analysis. Overall, serum 25(OH)D concentrations were associated with the Prudent dietary pattern but not with the HFLV dietary pattern in US children and adolescents. When stratified by sex, the relation between dietary patterns and serum 25(OH)D was confined to only girls. Given the high prevalence of hypovitaminosis D in US children and adolescents and that vitamin D deficiency is a risk factor in the development of a wide range of chronic conditions, it is prudent to improve the vitamin D status of this at risk population. Girls consuming HFLV pattern diet would benefit from vitamin D supplementation and sunlight exposure (outdoor activities), and should be encouraged to consume more vitamin D fortified foods.

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APPENDICES

APPENDIX A

NHANES Food Questionnaire



More than one member of your household may have received a questionnaire. Please make sure this is your booklet before answering any questions.



LABEL HERE

GENERAL INSTRUCTIONS

- Answer each question as best you can. Estimate if you are not sure. A guess is better than leaving a blank.
- Use only a No. 2 pencil.
- Be certain to completely blacken in each of the answers.
- Erase completely if you make any changes.
- Do not make any stray marks on this form.
- If you blacken NEVER or NO for a question, please follow any arrows or instructions that direct you to the next question.

PLEASE DO NOT WRITE IN THIS AREA



SERIAL #



Public reporting burden of this collection of information is estimated to be 45 minutes per response for total participation, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. An agency may not conduct or sponsor, and a person is not required to respond to collection of information unless it displays a currently valid OMB control number. Send comments regarding this burden estimate or any other aspects of this collection of information, including suggestions for reducing burden to: CDC/ATSDR Reports Clearance Officer, 1800 Clifton Road, MS D-24, Atlanta, GA 30333, Attention: PRA (0920-0237).

1. Over the past 12 months, how often did you drink tomato juice or vegetable juice?

- NEVER
- | | |
|--|---|
| <input type="radio"/> 1 time per month or less | <input type="radio"/> 1 time per day |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 1-2 times per week | <input type="radio"/> 4-5 times per day |
| <input type="radio"/> 3-4 times per week | <input type="radio"/> 6 or more times per day |
| <input type="radio"/> 5-6 times per week | |

2. How often did you drink orange juice or grapefruit juice?

- NEVER
- | | |
|--|---|
| <input type="radio"/> 1 time per month or less | <input type="radio"/> 1 time per day |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 1-2 times per week | <input type="radio"/> 4-5 times per day |
| <input type="radio"/> 3-4 times per week | <input type="radio"/> 6 or more times per day |
| <input type="radio"/> 5-6 times per week | |

3. How often did you drink apple juice?

- NEVER
- | | |
|--|---|
| <input type="radio"/> 1 time per month or less | <input type="radio"/> 1 time per day |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 1-2 times per week | <input type="radio"/> 4-5 times per day |
| <input type="radio"/> 3-4 times per week | <input type="radio"/> 6 or more times per day |
| <input type="radio"/> 5-6 times per week | |

4. How often did you drink grape juice?

- NEVER
- | | |
|--|---|
| <input type="radio"/> 1 time per month or less | <input type="radio"/> 1 time per day |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 1-2 times per week | <input type="radio"/> 4-5 times per day |
| <input type="radio"/> 3-4 times per week | <input type="radio"/> 6 or more times per day |
| <input type="radio"/> 5-6 times per week | |

5. How often did you drink other 100% fruit juice or 100% fruit juice mixtures (such as pineapple, prune, or others)?

- NEVER
- | | |
|--|---|
| <input type="radio"/> 1 time per month or less | <input type="radio"/> 1 time per day |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 1-2 times per week | <input type="radio"/> 4-5 times per day |
| <input type="radio"/> 3-4 times per week | <input type="radio"/> 6 or more times per day |
| <input type="radio"/> 5-6 times per week | |

6. How often did you drink other fruit drinks (such as cranberry cocktail, Hi-C, lemonade, or Kool-Aid, diet or regular)?

- NEVER (GO TO QUESTION 7)
- | | |
|--|---|
| <input type="radio"/> 1 time per month or less | <input type="radio"/> 1 time per day |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 1-2 times per week | <input type="radio"/> 4-5 times per day |
| <input type="radio"/> 3-4 times per week | <input type="radio"/> 6 or more times per day |
| <input type="radio"/> 5-6 times per week | |

6a. How often were your fruit drinks diet or sugar-free drinks?

- Almost never or never
- About $\frac{1}{4}$ of the time
- About $\frac{1}{2}$ of the time
- About $\frac{3}{4}$ of the time
- Almost always or always

7. How often did you drink milk as a beverage (NOT in coffee, NOT in cereal)? (Please include chocolate milk and hot chocolate.)

- NEVER (GO TO QUESTION 8)
- | | |
|--|---|
| <input type="radio"/> 1 time per month or less | <input type="radio"/> 1 time per day |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 1-2 times per week | <input type="radio"/> 4-5 times per day |
| <input type="radio"/> 3-4 times per week | <input type="radio"/> 6 or more times per day |
| <input type="radio"/> 5-6 times per week | |

7a. What kind of milk did you usually drink?

- Whole milk
- 2% fat milk
- 1% fat milk
- Skim, nonfat, or $\frac{1}{2}$ % fat milk
- Soy milk
- Rice milk
- Raw, unpasteurized milk
- Other

BAR

CODE

LABEL

HERE



Question 8 appears on the next page.

Over the past 12 months...

8. How often did you drink meal replacement, energy, or high-protein beverages such as Instant Breakfast, Ensure, Slimfast, Sustacal or others?

NEVER

<input type="radio"/> 1 time per month or less	<input type="radio"/> 1 time per day
<input type="radio"/> 2-3 times per month	<input type="radio"/> 2-3 times per day
<input type="radio"/> 1-2 times per week	<input type="radio"/> 4-5 times per day
<input type="radio"/> 3-4 times per week	<input type="radio"/> 6 or more times per day
<input type="radio"/> 5-6 times per week	

9. Over the past 12 months, did you drink soft drinks, soda, or pop?

NO (GO TO QUESTION 10)

YES

9a. How often did you drink soft drinks, soda, or pop IN THE SUMMER?

NEVER

<input type="radio"/> 1 time per month or less	<input type="radio"/> 1 time per day
<input type="radio"/> 2-3 times per month	<input type="radio"/> 2-3 times per day
<input type="radio"/> 1-2 times per week	<input type="radio"/> 4-5 times per day
<input type="radio"/> 3-4 times per week	<input type="radio"/> 6 or more times per day
<input type="radio"/> 5-6 times per week	

9b. How often did you drink soft drinks, soda, or pop DURING THE REST OF THE YEAR?

NEVER

<input type="radio"/> 1 time per month or less	<input type="radio"/> 1 time per day
<input type="radio"/> 2-3 times per month	<input type="radio"/> 2-3 times per day
<input type="radio"/> 1-2 times per week	<input type="radio"/> 4-5 times per day
<input type="radio"/> 3-4 times per week	<input type="radio"/> 6 or more times per day
<input type="radio"/> 5-6 times per week	

9c. How often were these soft drinks, soda, or pop diet or sugar-free?

Almost never or never

About 1/4 of the time

About 1/2 of the time

About 3/4 of the time

Almost always or always

9d. How often were these soft drinks, soda, or pop caffeine-free?

Almost never or never

About 1/4 of the time

About 1/2 of the time

About 3/4 of the time

Almost always or always

10. Over the past 12 months, did you drink beer?

NO (GO TO QUESTION 11)

YES

10a. How often did you drink beer IN THE SUMMER?

NEVER

<input type="radio"/> 1 time per month or less	<input type="radio"/> 1 time per day
<input type="radio"/> 2-3 times per month	<input type="radio"/> 2-3 times per day
<input type="radio"/> 1-2 times per week	<input type="radio"/> 4-5 times per day
<input type="radio"/> 3-4 times per week	<input type="radio"/> 6 or more times per day
<input type="radio"/> 5-6 times per week	

10b. How often did you drink beer DURING THE REST OF THE YEAR?

NEVER

<input type="radio"/> 1 time per month or less	<input type="radio"/> 1 time per day
<input type="radio"/> 2-3 times per month	<input type="radio"/> 2-3 times per day
<input type="radio"/> 1-2 times per week	<input type="radio"/> 4-5 times per day
<input type="radio"/> 3-4 times per week	<input type="radio"/> 6 or more times per day
<input type="radio"/> 5-6 times per week	

11. How often did you drink wine or wine coolers?


NEVER

<input type="radio"/> 1 time per month or less	<input type="radio"/> 1 time per day
<input type="radio"/> 2-3 times per month	<input type="radio"/> 2-3 times per day
<input type="radio"/> 1-2 times per week	<input type="radio"/> 4-5 times per day
<input type="radio"/> 3-4 times per week	<input type="radio"/> 6 or more times per day
<input type="radio"/> 5-6 times per week	

12. How often did you drink liquor or mixed drinks?

NEVER

<input type="radio"/> 1 time per month or less	<input type="radio"/> 1 time per day
<input type="radio"/> 2-3 times per month	<input type="radio"/> 2-3 times per day
<input type="radio"/> 1-2 times per week	<input type="radio"/> 4-5 times per day
<input type="radio"/> 3-4 times per week	<input type="radio"/> 6 or more times per day
<input type="radio"/> 5-6 times per week	



Over the past 12 months...

13. Did you eat oatmeal, grits, or other cooked cereal?

NO (GO TO QUESTION 14)

YES

- 13a. How often did you eat oatmeal, grits, or other cooked cereal IN THE WINTER?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per winter | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per winter | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

- 13b. How often did you eat oatmeal, grits, or other cooked cereal DURING THE REST OF THE YEAR?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

- 13c. How often was the cooked cereal you ate oatmeal?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

14. How often did you eat cold cereal?

NEVER (GO TO QUESTION 15)

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |



Question 15 appears in the next column.

- 14a. How often was the cold cereal you ate a whole grain type (such as shredded wheat, Wheaties, Cheerios, Raisin Bran or other bran, oat, or whole wheat cereal)?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

- 14b. Was milk added to your cold cereal?

NO (GO TO QUESTION 15)

YES

- 14c. What kind of milk was usually added?

- Whole milk
 2% fat milk
 1% fat milk
 Skim, nonfat, or 1/2% fat milk
 Soy milk
 Rice milk
 Raw, unpasteurized milk
 Other

15. How often did you eat applesauce?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

16. How often did you eat apples?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

17. How often did you eat pears (fresh, canned, or frozen)?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

Over the past 12 months...

18. How often did you eat bananas ?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

19. How often did you eat pineapple?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

20. How often did you eat dried fruit, such as prunes or raisins?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

21. Over the past 12 months, did you eat peaches, nectarines, or plums?

NO (GO TO QUESTION 22)

YES

21a. How often did you eat fresh peaches, nectarines, or plums WHEN IN SEASON?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per season | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per season | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |



Question 22 appears in the next column.

21b. How often did you eat peaches, nectarines, or plums (fresh, canned, or frozen) DURING THE REST OF THE YEAR?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

22. How often did you eat grapes?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

23. Over the past 12 months, did you eat melons (such as cantaloupe, watermelon, or honeydew)?

NO (GO TO QUESTION 24)

YES

23a. How often did you eat fresh melons (such as cantaloupe, watermelon, or honeydew) WHEN IN SEASON?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per season | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per season | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

23b. How often did you eat fresh or frozen melons (such as cantaloupe, watermelon, or honeydew) DURING THE REST OF THE YEAR?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

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Question 24 appears on the next page.

Over the past 12 months...

24. Did you eat strawberries?

NO (GO TO QUESTION 26)

YES

24a. How often did you eat fresh strawberries WHEN IN SEASON?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per season | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per season | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

24b. How often did you eat fresh or frozen strawberries DURING THE REST OF THE YEAR?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

25. Over the past 12 months, did you eat oranges, tangerines, clementines, or tangelos?

NO (GO TO QUESTION 28)

YES

25a. How often did you eat fresh oranges, tangerines, clementines, or tangelos WHEN IN SEASON?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per season | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per season | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

Question 28 appears in the next column.

25b. How often did you eat oranges, tangerines, clementines, or tangelos (fresh or canned) DURING THE REST OF THE YEAR?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

26. Over the past 12 months, did you eat grapefruit?

NO (GO TO QUESTION 27)

YES

26a. How often did you eat fresh grapefruit WHEN IN SEASON?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per season | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per season | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

26b. How often did you eat grapefruit (fresh or canned) DURING THE REST OF THE YEAR?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

27. How often did you eat other kinds of fruit?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |



Over the past 12 months...

28. How often did you eat **COOKED** greens (such as spinach, turnip, collard, mustard, chard, or kale)?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

29. How often did you eat **RAW** greens (such as spinach, turnip, collard, mustard, chard, or kale)?
(We will ask about lettuce later.)

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

30. How often did you eat **coleslaw**?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

31. How often did you eat **sauerkraut** or **cabbage** (other than coleslaw)?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

32. How often did you eat **carrots** (fresh, canned, or frozen)?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

33. How often did you eat **string beans** or **green beans** (fresh, canned, or frozen)?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

34. How often did you eat **peas** (fresh, canned, or frozen)?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

35. Over the past 12 months, did you eat **corn**?

NO (GO TO QUESTION 38)

YES

35a. How often did you eat **corn** (fresh, canned, or frozen) **WHEN IN SEASON**?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per season | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per season | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

35b. How often did you eat **corn** (fresh, canned, or frozen) **DURING THE REST OF THE YEAR**?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |



Question 36 appears on the next page.

Over the past 12 months...

36. How often did you eat broccoli (fresh or frozen)?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

37. How often did you eat cauliflower or Brussels sprouts (fresh or frozen)?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

38. How often did you eat mixed vegetables?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

39. How often did you eat onions (including in mixtures)?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

40. Over the past 12 months, how often did you eat sweet or hot peppers (green, red, or yellow)?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

41. How often did you eat raw cucumbers (not including pickles)?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

42. Over the past 12 months, did you eat fresh tomatoes (including those in salads)?

NO (GO TO QUESTION 43)

YES

42a. How often did you eat fresh tomatoes (including those in salads) **WHEN IN SEASON?**

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per season | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per season | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

42b. How often did you eat fresh tomatoes (including those in salads) **DURING THE REST OF THE YEAR?**

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |



Question 43 appears on the next page.

Over the past 12 months...

43. Did you eat summer squash (Include yellow and green squash)?

NO (GO TO QUESTION 44)

YES

- 43a. How often did you eat summer squash WHEN IN SEASON (Include yellow and green squash)?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per season | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per season | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

- 43b. How often did you eat summer squash DURING THE REST OF THE YEAR (Include yellow and green squash)?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

44. How often did you eat lettuce salads (with or without other vegetables)?

NEVER (GO TO QUESTION 46)

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

- 44a. How often were the lettuce salads you ate made with dark green leaves?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always



Question 45 appears in the next column.

45. How often did you eat salad dressing (Including low-fat) on salads or other vegetables?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

46. How often did you eat sweet potatoes or yams?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

47. How often did you eat French fries, home fries, hash browned potatoes, or tater tots?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

48. How often did you eat potato salad?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

49. How often did you eat baked, boiled, or mashed potatoes?

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

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Over the past 12 months...

50. How often did you eat salsa?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

51. How often did you eat catsup?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

52. How often did you eat pickles or pickled vegetables?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

53. How often did you eat stuffing, dressing, or dumplings?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

54. How often did you eat chili?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

55. How often did you eat tortillas or tacos?

- NEVER (GO TO QUESTION 68)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

55a. How often were your tortillas or tacos corn tortillas or tacos?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

56. How often did you eat cooked dried beans (such as baked beans, pintos, kidney, blackeyed peas, lima, lentils, soybeans, or refried beans)? (Please don't include bean soups or chili.)

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

57. How often did you eat other kinds of vegetables?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

58. How often did you eat rice or other cooked grains (such as bulgur, cracked wheat, or millet)?

- NEVER (GO TO QUESTION 68)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

Question 59 appears on the next page.

Over the past 12 months...

58a. How often was the rice or other cooked grains you ate brown rice, cracked wheat, or millet?

- Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

59. How often did you eat pancakes, waffles, or French toast?

- NEVER (GO TO QUESTION 80)
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

59a. How often was syrup added to your pancakes, waffles, or French toast?

- Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

60. How often did you eat lasagna, stuffed shells, stuffed manicotti, ravioli, or tortellini? (Please do not include spaghetti or other pasta.)

- NEVER
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

61. How often did you eat macaroni and cheese?

- NEVER
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

62. How often did you eat pasta salad or macaroni salad?

- NEVER
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

63. Other than the pastas listed in Questions 60, 61, and 62, how often did you eat pasta, spaghetti, or other noodles?

- NEVER (GO TO QUESTION 84)
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

63a. How often did you eat your pasta, spaghetti, or other noodles with tomato sauce or spaghetti sauce made WITH meat?

- Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

63b. How often did you eat your pasta, spaghetti, or other noodles with tomato sauce or spaghetti sauce made WITHOUT meat?

- Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

63c. How often did you eat your pasta, spaghetti, or other noodles with margarine, butter, oil, or cream sauce?

- Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always



Question 64 appears on the next page.

Over the past 12 months...

64. How often did you eat bagels or English muffins?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

The next questions ask about your intake of breads other than bagels or English muffins. First, we will ask about bread you ate as part of sandwiches only. Then we will ask about all other bread you ate.

65. How often did you eat breads or rolls AS PART OF SANDWICHES (including burger and hot dog rolls)?

- NEVER (GO TO QUESTION 88)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

65a. How often were the breads or rolls that you used for your sandwiches **white bread** (including burger and hot dog rolls)?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

66. How often did you eat breads or dinner rolls, NOT AS PART OF SANDWICHES?

- NEVER (GO TO QUESTION 87)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

66a. How often were the breads or rolls you ate **white bread**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

Question 67 appears in the next column.

67. How often did you eat jam, jelly, or honey on bagels, muffins, bread, rolls, or crackers?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

68. How often did you eat peanut butter or other nut butter?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

69. How often did you eat roast beef or steak IN SANDWICHES?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

70. How often did you eat turkey or chicken COLD CUTS (such as loaf, luncheon meat, turkey ham, turkey salami, or turkey pastrami)? (We will ask about other turkey or chicken later.)

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

71. How often did you eat luncheon or deli-style ham? (We will ask about other ham later.)

- NEVER (GO TO QUESTION 72)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

Question 72 appears on the next page.

Over the past 12 months...

71a. How often was the luncheon or deli-style ham you ate **light, low-fat, or fat-free**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

72. How often did you eat **other cold cuts or luncheon meats** (such as bologna, salami, corned beef, pastrami, or others, including low-fat)? (Please do not include ham, turkey, or chicken cold cuts.)

NEVER (GO TO QUESTION 73)

- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

72a. How often were the other cold cuts or luncheon meats you ate **light, low-fat, or fat-free**? (Please do not include ham, turkey, or chicken cold cuts.)

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

73. How often did you eat **canned tuna** (including in salads, sandwiches, or casseroles)?

NEVER

- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

74. How often did you eat **GROUND chicken or turkey**? (We will ask about other chicken and turkey later.)

NEVER

- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

75. How often did you eat **beef hamburgers or cheeseburgers**?

NEVER (GO TO QUESTION 78)

- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

75a. How often were the beef hamburgers or cheeseburgers you ate made with **lean ground beef**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

76. How often did you eat **ground beef in mixtures** (such as meatballs, casseroles, chili, or meatloaf)?

NEVER

- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

77. How often did you eat **hot dogs or frankfurters**? (Please do not include sausages or vegetarian hot dogs.)

NEVER (GO TO QUESTION 78)

- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

77a. How often were the hot dogs or frankfurters you ate **light or low-fat hot dogs**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always



Question 78 appears on the next page.

Over the past 12 months...

78. How often did you eat beef mixtures such as beef stew, beef pot pie, beef and noodles, or beef and vegetables?

NEVER

<input type="radio"/> 1-6 times per year	<input type="radio"/> 2 times per week
<input type="radio"/> 7-11 times per year	<input type="radio"/> 3-4 times per week
<input type="radio"/> 1 time per month	<input type="radio"/> 5-6 times per week
<input type="radio"/> 2-3 times per month	<input type="radio"/> 1 time per day
<input type="radio"/> 1 time per week	<input type="radio"/> 2 or more times per day

79. How often did you eat roast beef or pot roast? (Please do not include roast beef or pot roast in sandwiches.)

NEVER

<input type="radio"/> 1-6 times per year	<input type="radio"/> 2 times per week
<input type="radio"/> 7-11 times per year	<input type="radio"/> 3-4 times per week
<input type="radio"/> 1 time per month	<input type="radio"/> 5-6 times per week
<input type="radio"/> 2-3 times per month	<input type="radio"/> 1 time per day
<input type="radio"/> 1 time per week	<input type="radio"/> 2 or more times per day

80. How often did you eat steak (beef)? (Do not include steak in sandwiches)

NEVER (GO TO QUESTION 81)

<input type="radio"/> 1-6 times per year	<input type="radio"/> 2 times per week
<input type="radio"/> 7-11 times per year	<input type="radio"/> 3-4 times per week
<input type="radio"/> 1 time per month	<input type="radio"/> 5-6 times per week
<input type="radio"/> 2-3 times per month	<input type="radio"/> 1 time per day
<input type="radio"/> 1 time per week	<input type="radio"/> 2 or more times per day

- 80a. How often was the steak you ate lean steak?

Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

81. How often did you eat pork or beef spare ribs?

NEVER

<input type="radio"/> 1-6 times per year	<input type="radio"/> 2 times per week
<input type="radio"/> 7-11 times per year	<input type="radio"/> 3-4 times per week
<input type="radio"/> 1 time per month	<input type="radio"/> 5-6 times per week
<input type="radio"/> 2-3 times per month	<input type="radio"/> 1 time per day
<input type="radio"/> 1 time per week	<input type="radio"/> 2 or more times per day



82. How often did you eat roast turkey, turkey cutlets, or turkey nuggets (including in sandwiches)?

NEVER

<input type="radio"/> 1-6 times per year	<input type="radio"/> 2 times per week
<input type="radio"/> 7-11 times per year	<input type="radio"/> 3-4 times per week
<input type="radio"/> 1 time per month	<input type="radio"/> 5-6 times per week
<input type="radio"/> 2-3 times per month	<input type="radio"/> 1 time per day
<input type="radio"/> 1 time per week	<input type="radio"/> 2 or more times per day

83. How often did you eat chicken as part of salads, sandwiches, casseroles, stews, or other mixtures?

NEVER

<input type="radio"/> 1-6 times per year	<input type="radio"/> 2 times per week
<input type="radio"/> 7-11 times per year	<input type="radio"/> 3-4 times per week
<input type="radio"/> 1 time per month	<input type="radio"/> 5-6 times per week
<input type="radio"/> 2-3 times per month	<input type="radio"/> 1 time per day
<input type="radio"/> 1 time per week	<input type="radio"/> 2 or more times per day

84. How often did you eat baked, broiled, roasted, stewed, or fried chicken (including nuggets)? (Please do not include chicken in mixtures.)

NEVER (GO TO QUESTION 86)

<input type="radio"/> 1-6 times per year	<input type="radio"/> 2 times per week
<input type="radio"/> 7-11 times per year	<input type="radio"/> 3-4 times per week
<input type="radio"/> 1 time per month	<input type="radio"/> 5-6 times per week
<input type="radio"/> 2-3 times per month	<input type="radio"/> 1 time per day
<input type="radio"/> 1 time per week	<input type="radio"/> 2 or more times per day

- 84a. How often was the chicken you ate fried chicken (including deep fried) or chicken nuggets?

Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

- 84b. How often was the chicken you ate WHITE meat?

Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

Question 85 appears on the next page.

Over the past 12 months...

84c. How often did you eat chicken WITH skin?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

85. How often did you eat baked ham or ham steak?

- NEVER
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

86. How often did you eat pork (including chops, roasts, and in mixed dishes)? (Please do not include ham, ham steak, or sausage.)

- NEVER
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

87. How often did you eat gravy on meat, chicken, potatoes, rice, etc.?

- NEVER
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

88. How often did you eat liver (all kinds) or liverwurst?

- NEVER
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

89. How often did you eat bacon (including low-fat)?

- NEVER (GO TO QUESTION 80)
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

89a. How often was the bacon you ate light, low-fat, or lean bacon?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

90. How often did you eat sausage (including low-fat)?

- NEVER (GO TO QUESTION 81)
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

90a. How often was the sausage you ate light, low-fat, or lean sausage?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

91. How often did you eat smoked fish or seafood (such as smoked salmon, lox, or others)?

- NEVER
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

92. How often did you eat sushi?

- NEVER (GO TO QUESTION 83)
 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

Question 83 appears on the next page.

Over the past 12 months...

92a. How often did the **sushi** you ate contain raw fish or seafood (including shellfish)?

- Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

93. How often did you eat raw oysters, raw clams, or other raw fish (not including raw fish in sushi)?

- NEVER
 1–6 times per year 2 times per week
 7–11 times per year 3–4 times per week
 1 time per month 5–6 times per week
 2–3 times per month 1 time per day
 1 time per week 2 or more times per day

94. How often did you eat fish sticks or fried fish (including fried seafood or shellfish)?

- NEVER
 1–6 times per year 2 times per week
 7–11 times per year 3–4 times per week
 1 time per month 5–6 times per week
 2–3 times per month 1 time per day
 1 time per week 2 or more times per day

95. How often did you eat all other fish or seafood (including shellfish) that was NOT FRIED, SMOKED, or RAW?

- NEVER
 1–6 times per year 2 times per week
 7–11 times per year 3–4 times per week
 1 time per month 5–6 times per week
 2–3 times per month 1 time per day
 1 time per week 2 or more times per day

96. How often did you eat tofu, soy burgers, or soy meat-substitutes?

- NEVER
 1–6 times per year 2 times per week
 7–11 times per year 3–4 times per week
 1 time per month 5–6 times per week
 2–3 times per month 1 time per day
 1 time per week 2 or more times per day

97. Over the past 12 months, did you eat soups?

NO (GO TO QUESTION 88)

YES

97a. How often did you eat soup DURING THE WINTER?

- NEVER
 1–6 times per winter 2 times per week
 7–11 times per winter 3–4 times per week
 1 time per month 5–6 times per week
 2–3 times per month 1 time per day
 1 time per week 2 or more times per day

97b. How often did you eat soup DURING THE REST OF THE YEAR?

- NEVER
 1–6 times per year 2 times per week
 7–11 times per year 3–4 times per week
 1 time per month 5–6 times per week
 2–3 times per month 1 time per day
 1 time per week 2 or more times per day

97c. How often were the soups you ate bean soups?

- Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

97d. How often were the soups you ate cream soups (including chowders)?

- Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always

97e. How often were the soups you ate tomato or vegetable soups?

- Almost never or never
 About $\frac{1}{4}$ of the time
 About $\frac{1}{2}$ of the time
 About $\frac{3}{4}$ of the time
 Almost always or always



Question 88 appears on the next page.

Over the past 12 months...

97f. How often were the soups you ate broth soups (including chicken) with or without noodles or rice?

Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

98. How often did you eat pizza?

NEVER (GO TO QUESTION 88)

1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

98a. How often did you eat pizza with pepperoni, sausage, or other meat?

Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

99. How often did you eat crackers?

NEVER

1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

100. How often did you eat corn bread or corn muffins?

NEVER

1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

101. How often did you eat biscuits?

NEVER

1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

102. How often did you eat potato chips (including low-fat, fat-free, or low-salt)?

NEVER (GO TO QUESTION 103)

1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

102a. How often were the potato chips you ate low-fat or fat-free chips?

Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

103. How often did you eat tortilla chips or corn chips (including low-fat, fat-free, or low-salt)?

NEVER (GO TO QUESTION 104)

1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

103a. How often were the tortilla or corn chips you ate low-fat or fat-free chips?

Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

104. How often did you eat popcorn (including low-fat)?

NEVER

1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

105. How often did you eat pretzels?

NEVER

1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

Over the past 12 months...

106. How often did you eat peanuts, walnuts, seeds, or other nuts?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

107. How often did you eat granola bars?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

108. How often did you eat yogurt (NOT including frozen yogurt)?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

109. How often did you eat cottage cheese (including low-fat)?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

110. How often did you eat cheese (including low-fat; including on cheeseburgers or in sandwiches or subs)?

- NEVER (GO TO QUESTION 111)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

Question 111 appears in the next column.

110a. How often was the cheese you ate light or low-fat cheese?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

111. How often did you eat frozen yogurt, sorbet, or ice cream (including low-fat or fat-free)?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

112. How often did you eat ice cream, ice cream bars, or sherbet (including low-fat or fat-free)?

- NEVER (GO TO QUESTION 113)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

112a. How often was the ice cream you ate light, low-fat, or fat-free ice cream or sherbet?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

113. How often did you eat pudding or custard?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

114. How often did you eat cake (including low-fat or fat-free)?

- NEVER
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

Over the past 12 months...

115. How often did you eat cookies or brownies (including low-fat or fat-free)?
- NEVER
- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day
116. How often did you eat doughnuts, sweet rolls, Danish, or pop-tarts?
- NEVER
- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day
117. How often did you eat sweet muffins or dessert breads (including low-fat or fat-free)?
- NEVER
- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day
118. How often did you eat fruit crisp, cobbler, or strudel?
- NEVER
- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day
119. How often did you eat pie?
- NEVER (GO TO QUESTION 120)
- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

Question 120 appears in the next column.

119a. How often was the pie you ate fruit pie (such as apple, cherry, peach, blueberry, or others)?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

120. How often did you eat chocolate candy?

- NEVER
- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

121. How often did you eat other candy?

- NEVER
- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

122. How often did you eat eggs, egg whites, or egg substitutes (NOT counting eggs in baked goods and desserts)? (Please include eggs in salads, quiche, and souffles.)

- NEVER (GO TO QUESTION 123)
- 1-6 times per year 2 times per week
 7-11 times per year 3-4 times per week
 1 time per month 5-6 times per week
 2-3 times per month 1 time per day
 1 time per week 2 or more times per day

122a. How often were the eggs you ate egg substitutes?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always



Question 123 appears on the next page.

Over the past 12 months...

122b. How often were the eggs you ate **egg whites only**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

122c. How often were the eggs you ate **regular whole eggs**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

122d. How often were the eggs you ate **part of egg salad**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

123. How many cups of **coffee**, caffeinated or decaffeinated, did you drink?

- NONE (GO TO QUESTION 124)
- | | |
|---|--|
| <input type="radio"/> Less than 1 cup per month | <input type="radio"/> 5-6 cups per week |
| <input type="radio"/> 1-3 cups per month | <input type="radio"/> 1 cup per day |
| <input type="radio"/> 1 cup per week | <input type="radio"/> 2-3 cups per day |
| <input type="radio"/> 2-4 cups per week | <input type="radio"/> 4-5 cups per day |
| | <input type="radio"/> 6 or more cups per day |

123a. How often was the coffee you drank **decaffeinated**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

124. How many glasses of **ICED tea**, caffeinated or decaffeinated, did you drink?

- NONE (GO TO QUESTION 126)
- | | |
|---|--|
| <input type="radio"/> Less than 1 cup per month | <input type="radio"/> 5-6 cups per week |
| <input type="radio"/> 1-3 cups per month | <input type="radio"/> 1 cup per day |
| <input type="radio"/> 1 cup per week | <input type="radio"/> 2-3 cups per day |
| <input type="radio"/> 2-4 cups per week | <input type="radio"/> 4-5 cups per day |
| | <input type="radio"/> 6 or more cups per day |

Question 125 appears in the next column.

124a. How often was the iced tea you drank **decaffeinated or herbal tea**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

125. How many cups of **HOT tea**, caffeinated or decaffeinated, did you drink?

- NONE (GO TO QUESTION 128)
- | | |
|---|--|
| <input type="radio"/> Less than 1 cup per month | <input type="radio"/> 5-6 cups per week |
| <input type="radio"/> 1-3 cups per month | <input type="radio"/> 1 cup per day |
| <input type="radio"/> 1 cup per week | <input type="radio"/> 2-3 cups per day |
| <input type="radio"/> 2-4 cups per week | <input type="radio"/> 4-5 cups per day |
| | <input type="radio"/> 6 or more cups per day |

125a. How often was the hot tea you drank **decaffeinated or herbal tea**?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

126. How often did you add **sugar or honey** to your coffee or tea?

- NEVER
- | | |
|--|---|
| <input type="radio"/> Less than 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 1-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 2-4 times per week | <input type="radio"/> 4-5 times per day |
| | <input type="radio"/> 6 or more times per day |

127. How often did you add **artificial sweetener** to your coffee or tea?

- NEVER
- | | |
|--|---|
| <input type="radio"/> Less than 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 1-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 2-4 times per week | <input type="radio"/> 4-5 times per day |
| | <input type="radio"/> 6 or more times per day |



Over the past 12 months...

128. How often was non-dairy creamer added to your coffee or tea?

NEVER (GO TO QUESTION 129)

- | | |
|--|---|
| <input type="radio"/> Less than 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 1-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 2-4 times per week | <input type="radio"/> 4-5 times per day |
| | <input type="radio"/> 6 or more times per day |

128a. What kind of non-dairy creamer did you usually use?

- Regular powdered
 Low-fat or fat-free powdered
 Regular liquid
 Low-fat or fat-free liquid

129. How often was cream or half and half added to your coffee or tea?

NEVER

- | | |
|--|---|
| <input type="radio"/> Less than 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 1-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 2-4 times per week | <input type="radio"/> 4-5 times per day |
| | <input type="radio"/> 6 or more times per day |

130. How often was milk added to your coffee or tea?

NEVER (GO TO QUESTION 131)

- | | |
|--|---|
| <input type="radio"/> Less than 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 1-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2-3 times per day |
| <input type="radio"/> 2-4 times per week | <input type="radio"/> 4-5 times per day |
| | <input type="radio"/> 6 or more times per day |

130a. What kind of milk was usually added to your coffee or tea?

- Whole milk
 2% milk
 1% milk
 Skim, nonfat, or 1/2% milk
 Evaporated or condensed (canned) milk
 Soy milk
 Rice milk
 Raw, unpasteurized milk
 Other

Question 131 appears in the next column.

131. How often was sugar or honey added to foods you ate? (Please do not include sugar in coffee, tea, other beverages, or baked goods.)

NEVER

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

132. How often did you eat margarine on breads, bagels, English muffins, other muffins, pancakes, or waffles?

NEVER (GO TO QUESTION 133)

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

132a. How often was the margarine you ate on these breads low-fat or fat-free?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

133. How often did you eat butter on breads, bagels, English muffins, other muffins, pancakes, or waffles?

NEVER (GO TO QUESTION 134)

- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

133a. How often was the butter you ate on these breads low-fat or fat-free?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

Question 134 appears on the next page.

Over the past 12 months...

134. How often did you eat margarine on potatoes, cooked vegetables, rice, grains, or beans?

- NEVER (GO TO QUESTION 136)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

134a. How often was the margarine you ate on these cooked potatoes, cooked vegetables, rice, grains, or beans low-fat or fat-free?

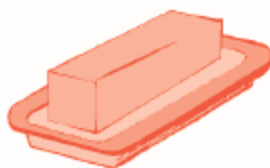
- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

135. How often did you eat butter on potatoes, cooked vegetables, rice, grains, or beans?

- NEVER (GO TO QUESTION 138)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

135a. How often was the butter you ate on these cooked potatoes, cooked vegetables, rice, grains, or beans low-fat or fat-free?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always



Question 136 appears in the next column.

136. How often did you eat mayonnaise as a spread or as part of food mixtures?

- NEVER (GO TO QUESTION 137)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

136a. How often was the mayonnaise you ate low-fat or fat-free?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always

137. How often did you eat cream cheese?

- NEVER (GO TO QUESTION 138)
- | | |
|---|---|
| <input type="radio"/> 1-6 times per year | <input type="radio"/> 2 times per week |
| <input type="radio"/> 7-11 times per year | <input type="radio"/> 3-4 times per week |
| <input type="radio"/> 1 time per month | <input type="radio"/> 5-6 times per week |
| <input type="radio"/> 2-3 times per month | <input type="radio"/> 1 time per day |
| <input type="radio"/> 1 time per week | <input type="radio"/> 2 or more times per day |

137a. How often was the cream cheese you ate low-fat or fat-free?

- Almost never or never
 About 1/4 of the time
 About 1/2 of the time
 About 3/4 of the time
 Almost always or always



Question 138 appears on the next page.

Over the past 12 months...

138. How often did you eat sour cream?

- NEVER (GO TO QUESTION 139)
- 1-6 times per year 2 times per week
- 7-11 times per year 3-4 times per week
- 1 time per month 5-6 times per week
- 2-3 times per month 1 time per day
- 1 time per week 2 or more times per day

138a. How often was the sour cream you ate low-fat or fat-free?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

Question 139 appears in the next column.

139. How often did you eat foods with oils added or with oils used in cooking (do not include baked goods or salads)?

- NEVER
- 1-6 times per year 2 times per week
- 7-11 times per year 3-4 times per week
- 1 time per month 5-6 times per week
- 2-3 times per month 1 time per day
- 1 time per week 2 or more times per day

139a. What kind of oils do you usually eat? (Mark all that apply.)

- Olive
- Corn
- Canola/rapeseed
- Other

Thank you very much for completing this questionnaire! Because we want to be able to use all the information you have provided, we would greatly appreciate it if you would please take a moment to review each page making sure that you:

- Did not skip any pages,
- Completely blackened-in each answer, and
- Completely erased any changes you may have made.

If found, please return to:

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