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# The impact of dietary guidelines for Americans on dietary intake and obesity rates

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Thesis

**THE IMPACT OF DIETARY GUIDELINES FOR AMERICANS ON DIETARY  
INTAKE AND OBESITY RATES**

by

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B.S., Arizona State University, 2019

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**NIMISHA TANNA**

**ABSTRACT**

This study provides a comprehensive analysis of dietary trends in the United States from 2000 to 2018, examining the population's adherence to the Dietary Guidelines for Americans (DGAs) across diverse food groups. Utilizing National Health and Nutrition Examination Survey (NHANES) data and employing meta-regression analysis, the research evaluates the intake patterns of vegetables, fruits, grains, protein, dairy, fats and oils, and key nutrients. The findings reveal a consistent and widespread non-adherence to recommended DGA servings, challenging the effectiveness of dietary guidelines in influencing public behavior. Despite revisions in guidelines, the study demonstrates remarkable stability in the intake of both recommended and discouraged foods. Additionally, the study investigates trends in obesity prevalence and BMI, suggesting that the DGAs alone may not be the primary driver of the obesity epidemic. The discussion highlights the persistent disconnect between DGA recommendations and actual dietary behaviors, emphasizing the need for public health interventions. This study contributes valuable insights into the limitations of current dietary guidelines in shaping broader dietary patterns, calling for a more holistic approach to public health interventions.

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## LIST OF ABBREVIATIONS

CDC .....	Centers for Diseases Control and Prevention
DGA.....	Dietary Guidelines for Americans
FPED.....	Food Patterns Equivalents Database
MPED .....	MyPyramid Equivalents Database
NHANES .....	National Health and Nutrition Examination Survey
USDA.....	United States Department of Agriculture
WWEIA .....	What We Eat In America

## **Background**

The NHANES (National Health and Nutrition Examination Survey) is a program of studies conducted by the CDC (Centers for Disease Control and Prevention) to assesses the health and nutritional status of adults and children in the United States (About NHANES, 2023). According to data from the CDC, the prevalence of obesity (body mass index [BMI, kg/m<sup>2</sup>] $\geq$ 30) in the United States has increased significantly over the past few decades. In 1999-2000, the obesity prevalence among adults aged 20 years and above was 30.5%. By 2017-2018, the obesity prevalence had increased to 42.4% (Adult Obesity Facts , 2022). These trends are concerning as obesity is associated with numerous health problems, including diabetes, heart disease, stroke, and certain types of cancer. Obesity also places a significant economic burden on society, with an estimated obesity-related healthcare costs in the United States exceeding \$173 billion per year (Consequences of Obesity , 2022).

NHANES data can be used to monitor adherence to the Dietary Guidelines for Americans (DGA), which are released jointly by the U.S. Department of Health and Human Services (HHS) and the U.S. Department of Agriculture (USDA) every 5 years. The development of DGAs began in 1980, when the first edition was published by the USDA and the U.S. HHS (Who's Involved in Updating the Dietary Guidelines, n.d.). Since the release of the first edition, the DGAs have become an important tool for diet related promotion of health. The development of the DGAs involves a rigorous scientific review process, with input from nutrition and health experts, federal agencies, and the public. The process includes a call for public comments, a scientific advisory committee review, and review

by federal agencies before the final guidelines are released. These guidelines provide evidence-based advice for making food and beverage choices that promote good health, support healthy body weight, and prevent chronic disease based on the newest scientific analyses on nutrition and health from the previous 5 years (Purpose of the Dietary Guidelines, n.d.).

NHANES collects data on a nationally representative sample of the U.S. civilian, non-institutionalized population, which includes people of all ages, races, and ethnicities. The survey oversamples certain subgroups, such as elderly adults, children, and racial/ethnic minorities, to ensure adequate representation of these groups in the data. NHANES collects dietary intake data and data on various health and nutrition-related measures, including anthropometric measures, blood pressure, oral diseases, health behaviors, and more. The dietary intake data is collected through a 24-hour dietary recall interview during which trained NHANES interviewers ask participants about the food and beverages they consumed in the past 24 hours, starting from midnight the previous day. The interviewers use a multiple-pass method to gather detailed information about the types and amounts of foods and beverages consumed, including brand names and preparation methods. They also ask about dietary supplements and other factors that may affect nutrient intake. NHANES also collects information on dietary behaviors, food security, and food shopping and preparation practices through other surveys and interviews (Survey Methods and Analytic Guidelines, 2022).

The most recent edition of the DGAs was released in 2020, and it provides advice on healthy eating patterns for Americans of all ages including specific populations such as

elderly people, infants, women who may be pregnant or breastfeeding, and adolescents. The guidelines also provide advice on how to make healthy food and beverage choices while staying within one's budget and cultural preferences. The DGAs include recommendations for the amounts and types of foods and beverages that individuals should consume to meet their nutrient needs while staying within caloric limits. The guidelines also emphasize the importance of consuming a variety of nutrient-dense foods, such as fruits, vegetables, whole grains, lean proteins, and low-fat dairy products, while limiting intake of added sugars, saturated fats, and sodium.

Certain institutions and organizations are required to adhere to the Dietary Guidelines in their operations. For example, the National School Lunch Program and School Breakfast Program must adhere to the DGAs in planning meals and selecting foods served to students. These programs may receive funding to support the implementation of the guidelines and to provide nutrition and health education and counseling to participants. Specifically, the dietary guidelines are used to inform nutrition education and counseling provided by federally funded programs including the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP).

According to the USDA, approximately 42 million people or 13% of the U.S. population participated in SNAP in the fiscal year of 2020. The USDA states, in the 2019-2020 school year, 30 million children or 77% of all public-school students participated in the National School Lunch Program (NSLP). In fiscal year 2019, the USDA found that WIC served approximately 6.3 million participants per month, including pregnant, postpartum,

breastfeeding women, and infants and children up to age 5. The guidelines may influence funding decisions for research and other initiatives related to nutrition and health. For example, the National Institutes of Health (NIH) and other federal agencies providing funding may prioritize projects that address key topics or recommendations outlined in the Dietary Guidelines. The guidelines may also be used as a reference point for health professionals, food manufacturers, and the media when developing nutrition-related messages or products. However, these groups are not required to adhere to the guidelines in the same way that schools and federally funded programs are.

### **Statement of Problem**

DGAs are updated every 5 years to reflect the more recent available evidence to inform dietary recommendations for the general population that promote health and prevention of major chronic conditions including obesity; this has occasionally introduced shifts in recommended intakes of various food groups and nutrients. It is unclear whether changes in the recommendations for any specific food groups or nutrients have impacted average dietary intakes of US adults (defined as those aged 20 years and above).

### **Hypothesis**

Changes in the recommended intake of food groups and specific nutrients in the DGAs are intended to impact subsequent dietary intake of these food groups and nutrients on the population level. Shifts in national dietary may have contributed favorably or unfavorably to trends in the US obesity rates, particularly among individuals who rely on federally

funded programs adhering to the guidelines. We hypothesize that changes to dietary guidelines that have coincided with increased or decreased intake of the specific food groups will be reflected in the dietary intake and obesity rates of the general population of adults. For example, because of notable modifications in past years, we expect average intakes will be increased for whole grains, fruits, and vegetables. Additionally, we do not expect changes of intake of added sugars, saturated fats, sodium, and processed foods as these have become increasingly available and affordable (Patricia Serafim, 2022). By investigating the impact of changes in the DGA's recommendations and subsequent dietary intakes prevalence, we hope to better understand how changes in dietary recommendations effectively or ineffectively impact obesity and related health status of the population.

### **Objective and Specific Aims**

The objective of this analysis is to describe the temporal trends of food group and nutrient-specific changes in the DGA's recommendations with changes in dietary intake data among US adults. Second, we will examine whether changes in mean dietary intake are related to changes in trends of obesity prevalence over the same period. We intend to explore whether dietary guidelines have had a meaningful impact on diet and body weight by looking for inflections in trends over time for diet and body weight in alignment with specific changes to the dietary guidelines.

### Specific Aims

1. To characterize the recommended intake of food groups in the DGAs every 5. years and identify key changes that have occurred.
2. To assess the mean dietary intakes of food groups and nutrients and obesity prevalence in US adults using data from NHANES every 2 years and examine the relation with changes in the dietary guidelines over time.
3. To illustrate the effectiveness of evidence-based recommendations in the DGAs to improve the average dietary intake of US adults with concurrent trends in obesity prevalence.

### **Methods**

To ensure a comprehensive understanding of the influence of the DGAs on dietary intake, a multi-faceted research approach was implemented. For this study, five steps were used to gather and analyze data:

1. DGA Heat Mapping: The DGAs for each 5-year period from 1980-2020 were reviewed for food group recommendations of intake. The previous editions of DGAs were accessed and downloaded via the Dietary Guidelines for Americans website (Previous Editions , 2015). We mapped main dietary recommendations of the published dietary guidelines from their initial release in 1980 through their latest guidelines in 2020. We extracted the specific food group or nutrient recommendations, any serving size recommendations, and language reflecting advice to increase, limit, moderate, or decrease intake. General food groups were created and individual foods within those

categories were also noted. The food groups mentioned in the recommendations included fruit, vegetables, grains, dairy, protein, fats & oils, discretionary, beverages, and nutrients. Within the food groups there were subcategories for each food item; for example, total fruits included melons, berries, citrus fruit, deeply colored fruit, fruit juice, and 100% fruit juice. Using this information, we created a heatmap to illustrate the main dietary food group recommendations of the published DGAs from their initial release in 1980 through their latest guideline in 2020.

The recommendations were converted into standard units for uniformity. These standard units were uniform across the food group for example all fruits were noted in servings or converted to cup-equivalents, while all protein were tracked in servings or ounce-equivalents for comparison. Some years the units of intake shifted from “number of servings” to “cup-equivalents” or “ounce-equivalents”, and we were able to convert the servings to standardize the recommendation units across the years. The original serving ranges were used to compare against the cup-equivalent or ounce-equivalent values to convert this unit. In 1990, 1995, and 2000, the DGAs recommended a 2-4 serving range quantity for total intact fruits, which changed in 2005 to “4 servings or 2 cup-equivalents” of total intact fruit. Based off the conversion that 4 servings are equal to 2 cup-equivalents, we then converted the 1990-2000 recommendation to 1-2 cup-equivalents. Total vegetable was given to us the same as a range of 3-5 servings from 1990-2000, and then in 2005 the recommendation shifted to 5 servings or 2.5 cup-equivalents. We used the 5 servings equaling 2.5 cup-equivalents to calculate the serving to cup-equivalents amount for 1990-2000. Similarly, the total protein recommendation

was provided as 2-3 servings or 6 ounce-equivalents from 1990-2000. For total grains, a 1:1 comparison was used for servings to ounce-equivalents. Likewise, a 1:1 comparison was used for servings to cup-equivalents to convert total dairy recommendations.

Color-coding was based on advice to increase (green), moderate/limit (yellow), or reduce intake (red). Recommendations provided with thresholds were color coded as yellow to limit. For example, a recommendation of no more than 1-2 drinks per day of alcohol was coded as yellow. Of note, *Trans* fats were banned in 2015 and this change was represented by a color coding of black on the heat map as this industrially produced nutrient was ultimately banned for commercial use in the US food supply from that point on and manufactures would have to eliminate all foods containing *trans* fats by January 2020 (Dewey, 2018). Although in the early years vitamin and mineral recommendations were included in the DGAs, it was decided to omit this from the analysis as the Recommended Dietary Allowance (RDA) for nutrient requirements is now conducted separately from the DGAs (Nutrient Recommendations and Databases , n.d.). By developing a heatmap, the fluctuation in food group recommendations was captured, offering a clear visual representation for each five-year segment.

2. Extraction of Dietary Intake Data: This analysis is a cross-sectional analysis of NHANES data repeated over multiple years in different subpopulations, using a modified version of the publicly available FPED SAS code from the USDA (Databases and SAS Data Sets, 2023). The sources used for this data analysis include the publicly available NHANES dietary intake data for participants, the FPED and MPED SAS codes, and the USDA's Food Patterns Equivalents Database (FPED) (National Health and Nutrition

Examination Survey, 2023). The Healthy Eating Index Score guide provided by the National Institutes of Health (NIH) was also utilized to verify the weighting and SAS code (Healthy Eating Index SAS Code, 2023). The dietary intake data available via NHANES were collected from 2001 through 2016. NHANES does call for use of sample weighting when analyzing data in SAS, which was incorporated into the code (Weighting Module, 2022). The FPED SAS code was modified to extract mean intake, standard deviation, and standard error of the mean for each food group by cup-equivalents, ounce-equivalents, grams, milligrams, or percent calories (Overview of Food Patterns Equivalents Database, 2023). The provided SAS code calls for the NHANES demographic data, NHANES dietary interview for nutrient intake, and NHANES sample weighting distribution for each time frame analyzed. Age was adjusted to limit the data to adults aged 20+ years. After importing these files to the FPED SAS code and matching the food groups (as defined in the code for that year) for each period, the SAS output provided the mean, standard deviation, and standard error for each food group (See Supplementary Methods in the Appendix for SAS code).

3. Trends in Dietary Intakes Over Time: The trends in dietary intake were graphed using Microsoft Excel to illustrate any changes in intake over the time period of data extracted.

4. Data Analysis: We used STATA (STATA, n.d.) to perform regression models for p-values, beta coefficients, and confidence intervals of the coefficient for linear trend to estimate whether there was a significant change in intake over the full time period of 2000-2018 (Linear regression analysis using Stata , n.d.). We then used meta-regression

modeling with interaction by time to test whether each 5-year DGA timepoint was a significant inflection point in dietary intake trends ( (Meta-Regression, n.d.). We looked at the beta coefficient interaction term and confidence interval of the interaction term to determine if there was a change in the intake trend before and after the DGA timepoint (See Supplementary Methods in the Appendix for STATA code).

5. Obesity Prevalence Analysis: Using data from the National Institutes of Health, we were able to graph the obesity prevalence trend and BMI trend over the years in U.S. Adults (Overweight & Obesity Statistics, 2021). Obesity and BMI prevalence data are obtained by the N.I.H. every 2 years. Using STATA, we then looked at inflection points for obesity prevalence which was determined to be 2011. We conducted a similar regression analysis for linear trends to see if any DGA foods also had significant inflection points that same year. This was performed for 2009 and 2011 to compare the pre and post 2009 and 2011 linear trends. Comparing the trend from 2007-2009 versus 2009-2011 and the trend from 2009-2011 versus 2011-2013 allowed a comparison between the obesity inflection point and intake trend. The interaction was looked at for the following DGA year to see if any obesity/BMI trends were offset or delayed by 1 2-year NHANES cycle because of implementation of DGAs. If there was a significant inflection point in obesity prevalence, this was compared against the inflection points for DGA foods to characterize whether there were any concurrent changes in dietary intake at the population level (See Supplementary Methods in the Appendix for STATA code).

## **Results**

### DGA Heat Mapping

Figure 1 provides the DGA heat map. Visually, there are food groups and dietary items that have been consistently encourage in the recommendations (shown in green shading), such as fruits and vegetables overall, although the language used to describe the recommendations and target amounts often shift. Others, in red or yellow shading have been consistently advised to decrease intake of, such as items in the categories of fats and oils, beverages, and specific nutrients of interest. There are also notable changes and new recommendations introduced throughout the DGA tenure. For vegetables, we note that in 2010 and 2015 the DGAs specifically introduced a recommendation to decrease starchy vegetables, in particular white potatoes. The DGAs have also recommended an increase in intake of whole grains over the years and began recommending a decrease in intake of refined grains from 2000 forward.



The recommendation for dairy foods has been fairly consistent with a general recommendation to consume more low-fat and fat-free dairy foods as opposed to high-fat dairy foods such as butter, mayonnaise, and cream. In 2000, the DGAs switched from recommending an increase in intake of milk and cheese to recommending a decrease in intake of milk and cheese. The DGAs then switched back in 2005 to recommending an increase in intake of cheese and milk. The DGAs have recommended an increase in intake of overall protein foods over the years but recommended moderating intake of organ meats and egg yolks. Recommended proteins included lean meats, fish, and plant proteins such as lentils, soy, and nuts and seeds. In 2015, the DGAs recommended decreasing intake of animal proteins, and in 2020 the DGAs stated moderating intake of animal protein was best. The DGAs have consistently recommended decreasing intake of all solid fats and instead transitioning to use of oils (i.e., liquid fats). The DGAs did recommend moderating intake of oils in 1980, 2000, 2005, and 2010. The DGAs have also recommended decreasing intake of breads, fried foods, added sugars, and sugary beverages. The DGAs have recommended moderating intake of alcohol and caffeine. The DGAs consistently recommended reduction of intake of dietary cholesterol, and saturated fats, while recommended increased intake of unsaturated fats, and dietary fiber. In 1990 and 1995, the guidelines for sodium, recommended a moderate intake, but in 2000 recommended a decreasing intake of sodium again. The DGAs did recommend increasing intake of starch, but this changed in 2010 and 2015 to a decrease in intake, and then transitioned again to increase in starch in 2020. The results and tables below provide specific terminology and amounts used in each DGA cycle for adults ages 20+.

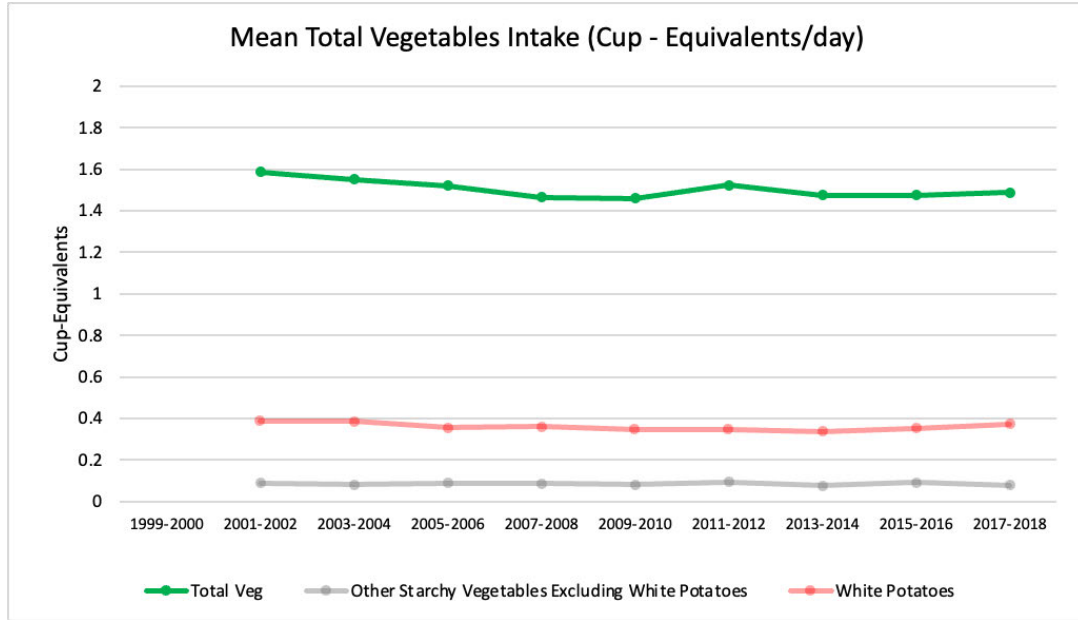
## Vegetable

The DGA recommended an overall intake of 3-5 servings (1.5-2.5 cup-equivalents (c-eq)) per day of total vegetables in the years 1990, 1995, and 2000. In 2005, they advised an intake of 5 servings or 2.5 c-eq per day. In 2010 and 2015, the recommended range broadened to 1-4 c-eq per day, and in 2020, the recommended intake was adjusted again to 2-4 c-eq per day. The guidelines emphasized a mix of red, orange, dark green, and starchy vegetables. Specifically, in 2010, they recommended an intake of 2-8 c-eq per week of total starchy vegetables and advocated for limiting or reducing intake, particularly of white potatoes.

	NHANES Mean Intake	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
	DGA Recommendations	2000			2005		2010		2015		
Total Dark Green, Red and Orange, Starchy, and Other Vegetables Excluding Legumes	DGA Recommendation	1.5-2.5			2.5		1-4		1-4		
	Mean Intake (SE)		1.59 (0.02)	1.55 (0.02)	1.52 (0.02)	1.46 (0.02)	1.46 (0.02)	1.52 (0.02)	1.48 (0.02)	1.48 (0.02)	1.49 (0.02)
White Potatoes	DGA Recommendation						"Limit"		"Limit"		
	Mean Intake (SE)	N/A	0.1 (<0.01)	0.05	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)

**Table 2.** This table shows the total vegetable intake and white potato intake from 2000-2018 alongside the DGA recommendations. According to NHANES data for the years 2001-2002 through 2017-2018, among U.S. adults the mean intake of total vegetables ranged from approximately 1.46 to 1.59 c-eq per day. White potato intake varied over time between 0.34 and 0.37 c-eq per day. Other starchy vegetables, excluding white potatoes, ranged from about 0.076 to 0.093 c-eq per day. The findings suggest that average vegetable intake remained consistently below recommendations. White potato intake consistently exceeded the recommended limit of 2-8 c-eq per week. In contrast, other starchy vegetables generally fall within the recommended range of 2-8 per week. These results indicate a potential area for targeted dietary interventions to bring vegetable intake in line with the DGAs.

**Figure 1.** This graph represents the dietary intake of Total Vegetables, White Potatoes, and Other Starchy Vegetables in cup equivalents from 2000-2018.



Visually, there is a slight decline in mean intake of total vegetable consumption over the first half of follow-up, despite the guidelines having recommended an increase. Despite a DGA recommendation to decrease consumption of white potatoes, white potato intake is relatively constant.

	2000-2018			DGA Year 2005	DGA Year 2010	DGA Year 2015
	Beta (intake slope)	P-Value linear	95% Confidence Interval of B	B-difference [95% CI]	B-difference [95% CI]	B-difference [95% CI]
Total Dark Green, Red and Orange, Starchy, and Other Vegetables Excluding Legumes	-0.011	0.044	[-0.022, -0.000]	0.034 [-0.071, 0.139]	0.023 [-0.003, 0.049]	0.016 [0.006, 0.025]
White Potatoes	-0.004	0.132	[-0.009, 0.001]	0.002 [-0.044, 0.048]	0.020 [0.007, 0.033]	0.002 [-0.004, 0.008]

**Table 3.** This table is the analysis results for total vegetable and white potato intake with the overall linear trend values from 2000-2018 and the interaction terms for DGA years.

The meta-regression demonstrates a statistically significant (p-value=0.044) overall linear trend from 2000-2018 in intake of total vegetables, indicating a decrease of 0.011 in the mean c-eq./day every 2 years, on average. There is not a significant interaction between

the linear trend of average intake at the years 2005 or 2010 when DGA guidelines were released, indicating there is no significant difference in linear trend before and after each of those timepoints. However, the slope does significantly change from before to after 2015, suggesting that the steady decline in mean total vegetable intake from 2000-2015 may have stalled out after 2015.

There is not any significant (p-value=0.132) overall change in the mean intake of white potatoes from 2000-2018 nor were there significant changes around the DGA years 2005 or 2015. However, there is a modest decline in mean intake prior to 2010 may have shifted direction to a steady increase in intake of white potatoes from 2010-2018.

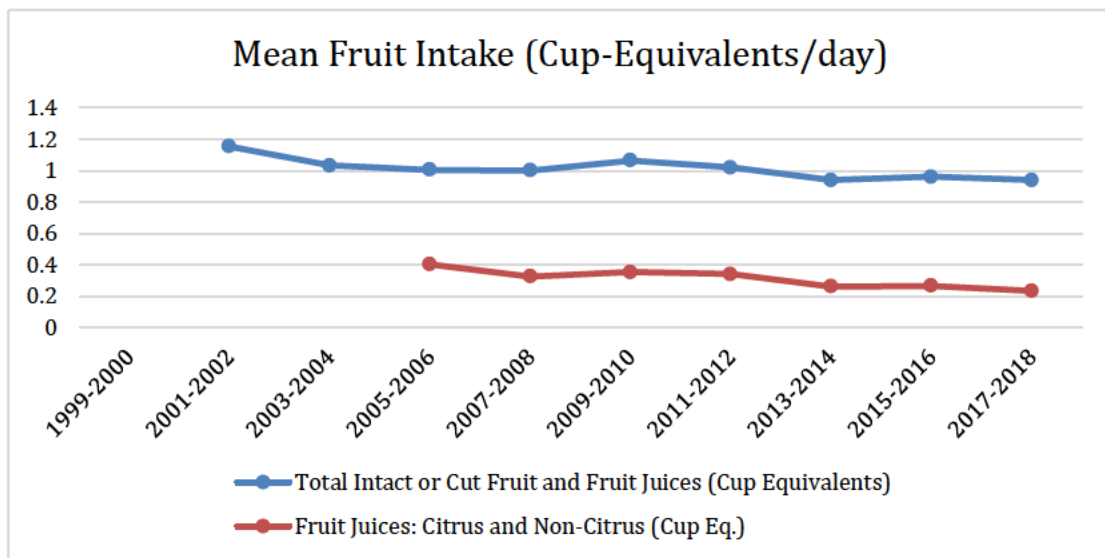
### Fruit

The DGAs have consistently encouraged an increase in fruit intake in each edition since 1980. The guidelines specifically recommend the consumption of a variety of fruits, including melons, berries, citrus fruit, deeply colored fruit, and 100% fruit juice. In 1990, 1995, and 2000, the DGAs advised an intake of 2-4 servings or 1-2 c-eq of fruit per day. In 2005, the recommendation became a fixed 2 c-eq per day, and in 2010, it evolved into a range of 1-2.5 c-eq per day. In the most recent edition in 2020, the advised range is 1.5-2.5 c-eq of fruit per day.

	NHANES Mean Intake	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
	DGA Recommendations	2000			2005		2010		2015		
Total Intact or Cut Fruit and Fruit Juices	DGA Recommendation	1-2			2		1-2.5		1-2.5		
	Mean Intake (SE)		1.15 (0.02)	1.03 (0.02)	1.00 (0.02)	1.00 (0.02)	1.06 (0.02)	1.02 (0.02)	0.94 (0.02)	0.96 (0.02)	0.94 (0.02)
Fruit Juices: Citrus and Non-Citrus	DGA Recommendation	"Increase"									
	Mean Intake (SE)				0.40 (0.01)	0.32 (0.01)	0.35 (0.01)	0.34 (0.01)	0.26 (0.01)	0.26 (0.01)	0.23 (0.01)

**Table 4.** This table shows the total fruit intake and fruit juice intake from 2000-2018 alongside the DGA recommendations.

The analysis of total fruit and fruit juices intake from 2001-2002 to 2017-2018 reveals varying patterns in adherence to the DGAs. The recommended increase in fruit consumption emphasizing a diverse range of fruits was met with a decreasing trend in overall fruit and fruit juices intake, suggesting potential shifts in dietary preferences or behaviors among the U.S. adult population. The mean intake of total intact or cut fruit and fruit juices ranged from approximately 0.94 to 1.15 c-eq per day over the specified time period. The trends over time indicate a consistent decline in fruit juice consumption, particularly for citrus and non-citrus juices.



**Figure 2.** This graph represents the dietary intake of Total Fruits and Fruit Juices in cup equivalents from 2000-2018.

In 2009-2010, there was an isolated slight increase in mean fruit intake. From 2005-2006 to 2017-2018, the mean intake of fruit juices decreased from 0.40 to 0.23 c-eq per day. This downward trajectory may reflect changing preferences or awareness regarding sugars in fruit juices. In contrast, the overall intake of total intact or cut fruit remained relatively stable, demonstrating a nuanced pattern in adherence to fruit-related dietary

recommendations. Comparing the actual intake to the DGAs recommendations, the findings suggest a potential divergence. The recommended range of 1.5-2.5 c-eq of total fruit per day is higher than the observed mean intake over the years. The decline in fruit juice consumption aligns with the guidelines' emphasis on limiting added sugars, indicating a potential positive shift in dietary habits. The trends and comparisons underscore the importance of ongoing efforts to promote adherence to dietary guidelines, with a specific focus on enhancing the consumption of a variety of whole fruits.

	2000-2018			DGA Year 2005	DGA Year 2010	DGA Year 2015
	Beta (intake slope)	P-Value linear	95% Confidence Interval of B	B-difference [95% CI]	B-difference [95% CI]	B-difference [95% CI]
Total Intact or Cut Fruit and Fruit Juices	-0.02	0.01	[-0.033, -0.006]	0.106 [-0.032, 0.245]	-0.001 [-0.073, 0.071]	0.001 [-0.027, 0.028]
Fruit Juices: Citrus and Non-Citrus	-0.025	0.003	[-0.038, -0.013]		-0.008 [-0.093, 0.078]	0.003 [-0.028, 0.033]

**Table 5.** This table is the analysis results for total fruits and fruit juices intake with the overall linear trend values from 2000-2018 and the interaction terms for DGA years.

The meta-regression demonstrates a statistically significant ( $p$ -value=0.01) overall linear trend from 2000-2018 in intake of total fruit (intact or cut fruit and 100% fruit juices). Correlating this with the graph, we can see there is a statistically significant decline in mean intake of about 0.02 c-eq per day total fruit each 2-year reporting cycle. There is also a statistically significant ( $p$ -value=0.003) overall change in intake of 100% fruit juices over the 2000-2018 time frame. Data availability for fruit juice was not provided until 2005 therefore we did not conduct an interaction for 2005. We did not see any significant trend changes at other DGA release years 2010 or 2015.

## Grains

The DGAs recommended an intake of 6-11 servings/day of total whole and refined grains in 1990, 1995, and 2000. In 2005, the DGAs shifted to recommending a total of 6 ounce-equivalents (oz-eq) per day. In 2010 they recommended an intake of 3-10 oz-eq per day of grains. In 2015, they recommended the same range, but stated individuals should limit intake of total grains. In 2020, they recommended intake of total grains per day with a range of 5-10 oz-eq. The DGAs have recommended increasing intake of whole grains since 1980 and decreasing intake of refined or non-whole grains since 2000. It was recommended in 2005, 2010, and 2015 that 50% of the total grains should be whole grains and the other 50% should be refined or non-whole grains. In 2020, it was recommended that refined grains should make up 2-5 oz-eq of the total grains consumed and the remainder should be whole grains.

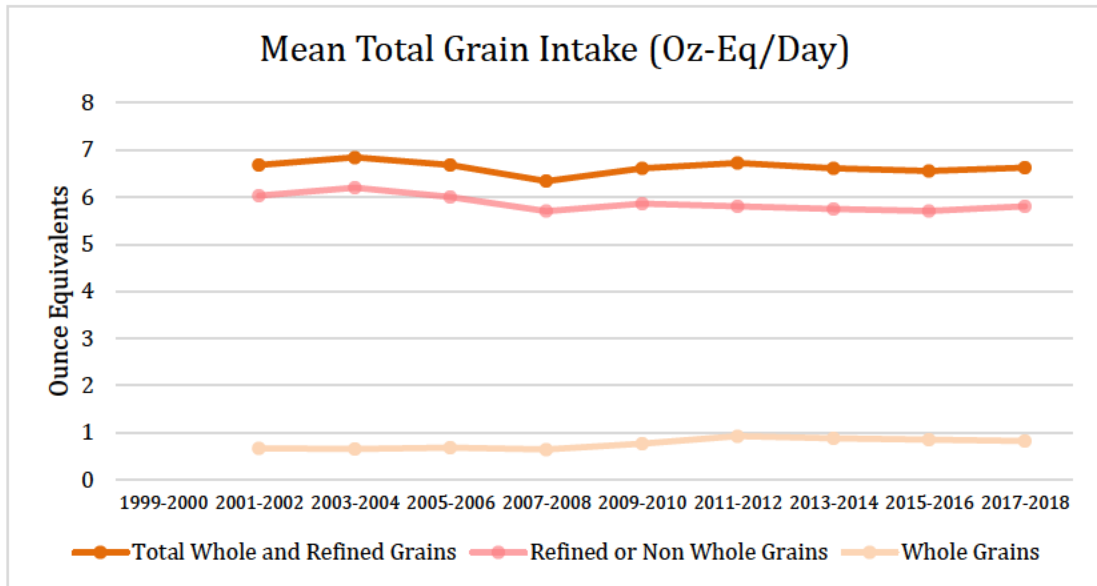
	NHANES Mean Intake	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
	DGA Recommendations	2000			2005		2010		2015		
Total Whole and Refined Grains	DGA Recommendation	6-11 servings			6		3-11		3-10		
	Mean Intake (SE)		6.68 (0.06)	6.84 (0.07)	6.67 (0.07)	6.33 (0.06)	6.61 (0.05)	6.71 (0.06)	6.61 (0.06)	6.55 (0.06)	6.62 (0.06)
Whole Grains	DGA Recommendation	"Increase"			3		1.5-5		1.5-5 oz-eq/week (.21 - .71)		
	Mean Intake (SE)		0.65 (0.02)	0.64 (0.02)	0.67 (0.02)	0.64 (0.01)	0.76 (0.02)	0.92 (0.02)	0.87 (0.02)	0.84 (0.02)	0.82 (0.02)
Refined or Non-Whole Grains	DGA Recommendation	"Limit"			<3		1.5-5		1.5-5 oz-eq/week (1.5/7 - 5/7)		
	Mean Intake (SE)		6.02 (0.06)	6.20 (0.06)	6.00 (0.06)	5.70 (0.06)	5.85 (0.05)	5.79 (0.06)	5.74 (0.06)	5.71 (0.06)	5.81 (0.06)

**Table 6.** This table shows the total grain, whole grain, and refined grain intake from 2000-2018 alongside the DGA recommendations for these foods.

The actual intake of total whole and refined grains remained relatively stable over the examined years, with a mean ranging from approximately 6.33 to 6.84 oz-eq per day.

Whole grain intake demonstrated an increasing trend until 2011-2012, reaching a peak of

0.92 oz-eq, followed by a slight decline. Refined or non-whole grain intake exhibited fluctuations but generally remained unchanged.



**Figure 3.** This graph represents the dietary intake of Total Grains, Whole Grains, and Refined Grains in ounce equivalents from 2000-2018.

The mean intake of total grains remains within the recommended range of 5-10 oz-eq per day specified in the 2020 guidelines but included mostly refined or non-whole grains.

While whole grain intake initially increased over the years, it demonstrates a slight decline in recent years, overall remaining well below the recommendations to make up 50% of total grains. Refined or non-whole grain intake has remained consistent with few changes, despite a constant recommendation to decrease intake. Intake of refined grains is nearly 5 times that of whole grains. These results highlight a notable adherence to the recommended guidelines for total grains among U.S. adults, with modest trends suggesting shifts in preferences or dietary awareness, particularly regarding whole grain

consumption. Ongoing monitoring and targeted interventions may be crucial to ensuring a shift from refined grains to whole grains.

	2000-2018			DGA Year 2005	DGA Year 2010	DGA Year 2015
	Beta (intake slope)	P-Value linear	95% Confidence Interval of B	B-difference [95% CI]	B-difference [95% CI]	B-difference [95% CI]
Total Whole and Refined Grains	-0.013	0.494	[-0.057, 0.030]	-0.154 [-0.647, 0.340]	.030 [-0.173, 0.234]	0.040 [-0.038, 0.119]
Whole Grains	0.032	0.008	[0.011, 0.053]	0.044 [-0.248, 0.336]	-0.053 [-0.104, -0.001]	0.024 [-0.002, 0.051]
Refined or Non Whole Grains	-0.046	0.023	[-0.083, -0.009]	-0.198 [-0.562, 0.166]	0.085 [-0.092, 0.261]	0.016 [-0.055, 0.088]

**Table 7.** This table shows the analysis results for total grains, whole grains, and refined grains intake with the overall linear trend values from 2000-2018 and the interaction terms for DGA years.

The meta-regression does not demonstrate any statistically significant (p-value=0.494) overall linear trend change from 2000-2018 in intake of total grains nor were there any significant changes to the trend for any DGA release year. There is a significant (p-value=0.008) overall increase per cycle of 0.032 oz-eq per day in the mean intake of whole grains from 2000-2018 as represented on the plotted trend line. There are no significant changes to the trend in intake of whole grains for DGA release years 2005 and 2015. However, in 2010, there is a trend change in intake of whole grains where a shift occurs from a steady decline in intake of whole grains from 2000-2010 to a stabilizing plateau in intake of whole grains from 2010-2018. Similarly, there is a significant (p-value=0.046) overall decrease of 0.046 oz-eq per day in the average intake of refined grains from 2000-2018 as seen visually. However, again there is not a significant trend change in intake of refined grains at any particular DGA release year.

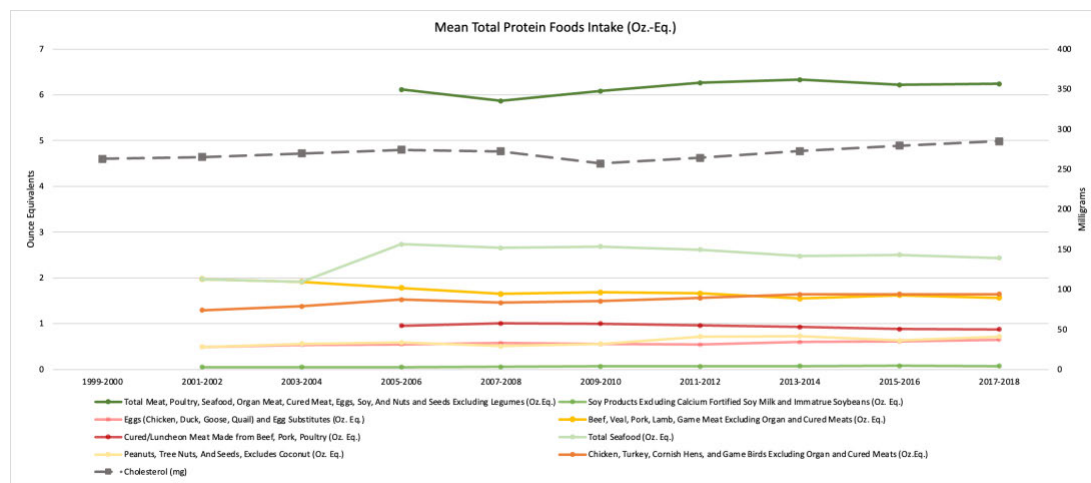
Protein

The DGAs have provided a comprehensive set of recommendations for protein intake, emphasizing diverse sources such as meat, poultry, eggs, seafood, legumes, nuts, and seeds. Over the years, the DGAs have advised a shift towards lean protein choices and an increased focus on plant-based protein sources. The recommended intake has evolved from 2-3 servings (6 oz-eq) per day from 1990-2000 to a fixed amount of 5.5 oz-eq in 2005, a range of 2-7 oz-eq per day in 2010 and 2015, and finally a range of 5-7 oz-eq in 2020. This have been specific recommendations to limit certain animal proteins such as organ meats and egg yolks from 1980-2020. In 2020, encouraged protein sources included nuts, seeds, and soy. The DGAs also included recommendations for incorporating seafood as an animal protein. The DGAs recommend a reduction in intake of dietary cholesterol from 1980-2020 with an upper limit of 300 mg specified from 1995-2010.

	NHANES Mean Intake	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
	DGA Recommendations	2000			2005		2010		2015		
Total Meat, Poultry, Seafood, Organ Meat, Cured Meat, Eggs, Soy, And Nuts and Seeds Excluding Legumes	DGA Recommendation	6-7			5.5		2-7		2-7		
	Mean Intake (SE)				6.12 (0.07)	5.89 (0.06)	6.08 (0.06)	6.26 (0.07)	6.33 (0.07)	6.22 (0.07)	6.24 (0.07)
Total Meat, Poultry, Seafood, Organ Meats, and Cured Meat	DGA Recommendation	5-7									
	Mean Intake (SE)		4.66 (0.06)	4.69 (0.06)	4.94 (0.06)	4.73 (0.05)	4.91 (0.05)	4.94 (0.06)	4.94 (0.06)	4.90 (0.06)	4.81 (0.06)
Eggs (Chicken, Duck, Goose, Quail) and Egg Substitutes	DGA Recommendation	"Moderate"					"Increase"		"Increase"		
	Mean Intake (SE)		0.49 (0.01)	0.53 (0.01)	0.54 (0.01)	0.57 (0.01)	0.55 (0.01)	0.54 (0.01)	0.60 (0.01)	0.61 (0.04)	0.65 (0.02)
Cured/Luncheon Meat Made from Beef, Pork, Poultry	DGA Recommendation										
	Mean Intake (SE)				0.95 (0.03)	1.00 (0.03)	1.00 (0.03)	0.96 (0.02)	0.93 (0.02)	0.88 (0.02)	0.87 (0.02)
Legumes Computed As Protein Foods	DGA Recommendation	"Increase"			0.857 (1.5 oz/week)		0.143- 0.857 (.25- 1.5 oz/week)		0.143- 0.857 (.25- 1.5 oz/week)		
	Mean Intake (SE)				0.53 (0.02)	0.52 (0.02)	0.55 (0.02)	0.58 (0.02)	0.54 (0.02)	0.62 (0.02)	0.55 (0.02)
Cholesterol (mg)	DGA Recommendation	<300			<300		<300		<300		
	Mean Intake (SE)	263.0 (0.01)	265.0 (0.01)	269.6 (0.01)	274.0 (0.01)	272.2 (0.01)	256.9 (0.01)	264.2 (0.01)	272.7 (0.01)	279.3 (0.01)	284.7 (0.01)

**Table 8.** This table shows the total protein, animal protein, egg, cured meat, legumes, and cholesterol intake from 2000-2018 alongside the DGA recommendations.

Examining NHANES data from 2001-2002 through 2017-2018 reveals that the average intake of total protein foods aligns with the recommended range of 5-7 oz-eq per day over the studied years. Consumption of specific protein categories, including beef, veal, pork, lamb, game meat, cured/luncheon meat, seafood, eggs, soy products, nuts, and seeds, generally falls within or close to the recommended ranges.



**Figure 4.** This graph represents the dietary intake of total proteins, eggs, nuts and seeds, cholesterol, cured meats, beef, soy products, seafood, and chicken in ounce equivalents from 2000-2018.

Cholesterol intake varied over the years, reflecting dietary diversity, however overall increases despite the recommendation to decrease intake of specific animal proteins high in cholesterol. There is a decline in intake of Beef, Veal, Pork, Lamb, Game Meat Excluding Organ and Cured Meats consistent with recommendations to decrease intake of these foods. Seafood consumption increased slightly, aligning with the emphasis on seafood as a lean protein source. Plant-based protein sources, including soy products, nuts, and seeds, demonstrate stable or slightly increasing trends, possibly reflecting a growing interest in plant-based diets. These findings indicate an overall alignment between the actual intake of protein foods and the recommended guidelines, highlighting

a diverse and balanced protein intake over time. Ongoing monitoring and education can support individuals in making informed choices that contribute to a healthy and varied diet.

	2000-2018			DGA Year 2005	DGA Year 2010	DGA Year 2015
	Beta (intake slope)	P-Value linear	95% Confidence Interval of B	B-difference [95% CI]	B-difference [95% CI]	B-difference [95% CI]
Total Meat, Poultry, Seafood, Organ Meat, Cured Meat, Eggs, Soy, And Nuts and Seeds Excluding Legumes	0.049	0.104	[-0.014, 0.111]		-0.002 [-0.324, 0.321]	0.047 [-0.058, 0.153]
Total Meat, Poultry, Seafood, Organ Meats, and Cured Meat	0.025	0.101	[-0.006, 0.056]	-0.030 [-0.365, 0.304]	-0.096 [-0.221, 0.029]	-0.003 [-0.056, 0.050]
Eggs (Chicken, Duck, Goose, Quail) and Egg Substitutes	0.015	0.001	[0.008, 0.022]	-0.026 [-0.115, 0.063]	0.017 [-0.007, 0.042]	-0.004 [-0.016, 0.007]
Cured/Luncheon Meat Made from Beef, Pork, Poultry	-0.02	0.018	[-0.036, -0.005]		-0.053 [-0.120, 0.014]	-0.013 [-0.037, 0.010]
Legumes Computed As Protein Foods	0.053	0.014	[0.015, 0.092]	0.021 [-0.062, 0.104]	-0.122 [-0.262, 0.018]	-0.035 [-0.096, 0.028]
Cholesterol (mg)	1.616	0.14	[-0.681, 3.913]	-2.394 [-34.004, 29.216]	8.201 [-0.034, 16.436]	0.800 [-2.876, 4.476]

**Table 9.** This table is the analysis results for total proteins and the subcategory protein foods with the overall linear trend values from 2000-2018 and the interaction terms for DGA years.

The meta-regression does not demonstrate a statistically significant (p-value=0.104) overall linear trend change from 2000-2018 in intake of total protein foods defined as total meat, poultry, seafood, organ meat, cured meat, eggs, soy, and nuts and seeds excluding legumes (Oz.Eq.) nor was there any significance in change of trend change for any DGA release year. The same is seen for total animal protein, defined as total meat, poultry, seafood, organ meat, and cured meat, intake with no significant (p-value=0.101) changes overall from 2000-2018 or at DGA report years. Additionally, there is no significant (p-value=0.14) trend change from 2000-2018 in cholesterol intake nor was there a significant change in trend for any DGA year. There was a significant (p-value=0.001) overall change from 2000-2018 in intake of eggs and egg substitutes, with an increase in average intake per 2-year cycle of about 0.015 oz-eq per day. However,

there is not a significant change of trend change in intake of eggs for any particular DGA release year. Similarly, there is a significant (p-value=0.018) overall decrease of 0.02 oz-eq per day in intake of Cured/Luncheon meat made from beef, pork, poultry from 2000-2018 as seen visually. However, again there is not a significant change of trend change in intake of cured/luncheon meats for any particular DGA release year. Likewise, there is a significant (p-value=0.014) overall increase in average intake per cycle of 0.053 oz-eq per day in intake of legumes. However, again there is not a significant change of trend change in intake of legumes for any particular DGA year.

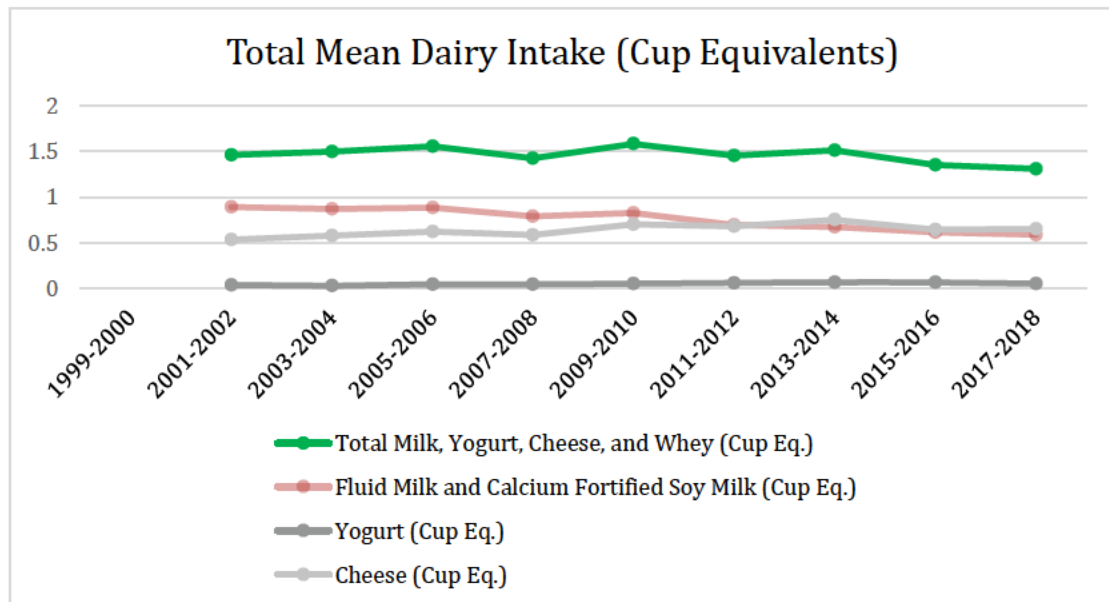
### Dairy

The DGAs have evolved in their recommendations for dairy intake, reflecting a nuanced approach over the years. In 1990, the guidelines provided a specific serving amount of 2-3 servings (1 cup-equivalent) per day without explicit language changes. In subsequent editions, the DGAs introduced terms like "moderate intake" without altering the quantity recommendation. In 2005, a shift toward increased intake emerged, with a recommendation of 3 cup-equivalents per day. The DGAs maintained the range of 2-3 cup-equivalents in 2010 and 2015 while reiterating the call for higher dairy consumption in 2015. The 2020 guidelines reinforced the recommendation for increased dairy intake, specifying a threshold of 3 cup-equivalents per day. The DGAs have recommended

reduction in intake of cream, mayonnaise, and butter, with a transition instead to fat free yogurt, low-fat milk, and soy based or lactose free yogurts and beverages.

	NHANES Mean Intake	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
	DGA Recommendations	2000			2005		2010		2015		
Total Milk, Yogurt, Cheese, and Whey	DGA Recommendation	2-3			3		2-3		2-3		
	Mean Intake (SE)		1.46 (0.02)	1.49 (0.02)	1.55 (0.02)	1.42 (0.02)	1.58 (0.02)	1.45 (0.02)	1.51 (0.02)	1.35 (0.02)	1.31 (0.02)
Fluid Milk and Calcium Fortified Soy Milk	DGA Recommendation	"Limit"			"Increase"		"Increase"		"Increase"		
	Mean Intake (SE)		0.89 (0.02)	0.87 (0.02)	0.88 (0.02)	0.79 (0.01)	0.82 (0.01)	0.69 (0.01)	0.67 (0.01)	0.61 (0.01)	0.58 (0.01)

**Table 10.** This table shows the total dairy and fluid milk intake from 2000-2018 alongside the DGA recommendations. Mean intake data from 2001-2002 to 2017-2018 of total dairy foods, comprising milk, yogurt, cheese, and whey, demonstrated a relatively steady pattern, ranging from 1.31 to 1.58 cup-equivalents over the analyzed period.



**Figure 5.** This graph represents the dietary intake of total dairy, fluid milk, yogurt, and cheese in cup equivalents from 2000-2018.

This stability suggests a consistent consumption of dairy products by the population. Breaking down the components of dairy intake, fluid milk and calcium-fortified soy milk exhibited a subtle decline over the years, hinting at potential shifts in beverage preferences. On the other hand, yogurt and cheese intake displayed minor fluctuations

with a slight overall increase in cheese intake and a stagnant intake of yogurt, contributing to the overall stability in total dairy consumption. The decline in intake of fluid milk and calcium fortified soy milk mirrors the increase in intake of cheese. These nuanced variations might be influenced by evolving dietary trends, cultural factors, or individual preferences. Comparing the observed intake values to the recommendations reveals intake of dairy is generally low. The mean intake values fall below this recommended range each year after 2005, indicating a lack of adherence to the recent guidelines and recommendation to increase intake of dairy products.

	2000-2018			DGA Year 2005	DGA Year 2010	DGA Year 2015
	Beta (intake)	P-Value linear	95% Confidence Interval of B	B-difference [95% CI]	B-difference [95% CI]	B-difference [95% CI]
Total Milk, Yogurt, Cheese, and Whey	-0.019	0.109	[-0.043, 0.005]	-0.064 [-0.352, 0.224]	-0.075 [-0.170, 0.020]	-0.012 [-0.044, 0.020]
Fluid Milk and Calcium Fortified Soy Milk	-0.042	0	[-0.053, -0.031]	-0.031 [-0.155, 0.093]	-0.017 [-0.052, 0.018]	-0.014 [-0.028, -0.001]

**Table 11.** This table is the analysis results for total dairy and fluid milk intake with the overall linear trend values from 2000-2018 and the interaction terms for DGA years.

The meta-regression does not demonstrate a statistically significant (p-value=0.109) overall linear trend change from 2000-2018 in intake of total milk, yogurt, cheese, and whey nor was there a significant change of trend for any DGA release year. There does is a significant (p-value<0.01) overall decline in intake of 0.042 c-eq per day in average intake of fluid milk and calcium fortified soy milk from 2000-2018 as represented visually. However, there is not a significant change of trend change in intake of whole grains for DGA release years 2005 and 2010. In 2015, there is a shift in the trend in the trend in intake of fluid milk from a steady decline from 2000-2015 to a seemingly steady intake after 2015.

### Solid Fats & Oils

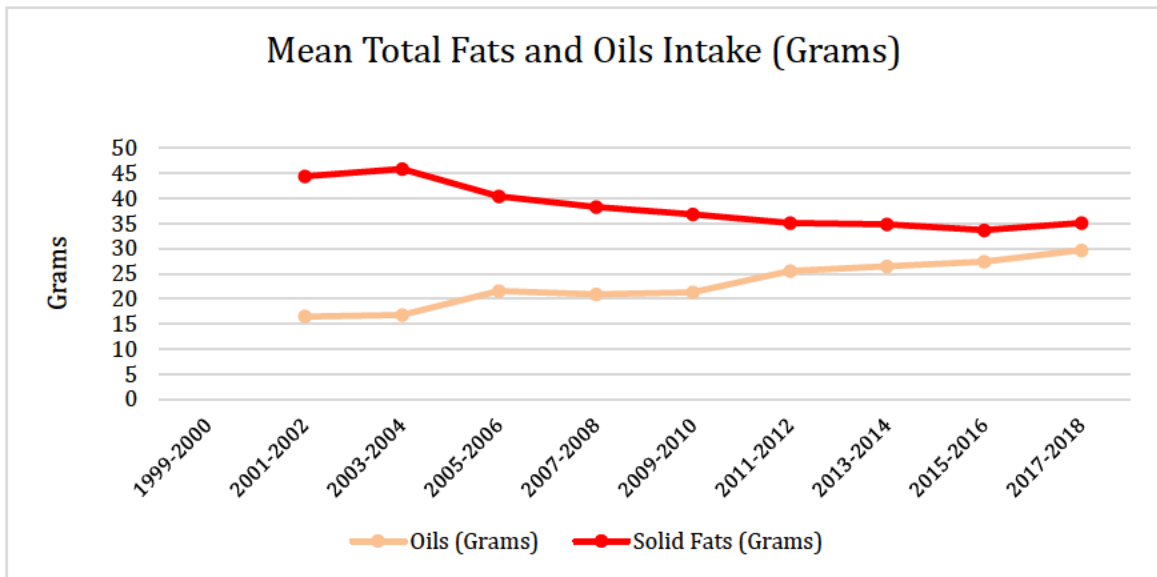
The DGAs have consistently recommended reducing the intake of solid fats, emphasizing a shift from sources like coconut oil, palm oil, shortenings, lard, and hydrogenated margarines to healthier alternatives such as vegetable oils, nut oils, and olive oils. The guidelines have urged moderation in total oil intake, with specific limits and ranges provided over the years. In 1990, 2000, and 2005, the DGAs advocated for moderation, setting an upper limit of 24 grams per day. The 2010 guidelines introduced a range of 15-51 grams per day, which continued in 2015. Notably, the language shifted in 2015 and 2020 to recommend increased oil intake, with the 2020 guidelines specifying a range of 22-44 grams per day. The DGAs have also emphasized a recommendation to decrease intake of solid fats and salad dressings.

	NHANES Mean Intake	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
	DGA Recommendations	2000			2005		2010		2015		
Oils	DGA Recommendation	"Moderate"			<24		15-51		15-51		
	Mean Intake (SE)		16.42 (0.27)	16.79 (0.27)	21.54 (0.29)	20.79 (0.26)	20.23 (0.25)	25.52 (0.31)	26.42 (0.33)	27.41 (0.31)	29.66 (0.34)
Solid Fats	DGA Recommendation	"Limit"			"Limit"		"Limit"		"Limit"		
	Mean Intake (SE)		44.38 (0.45)	45.83 (0.46)	40.42 (0.44)	38.23 (0.40)	36.82 (0.37)	35.01 (0.39)	34.79 (0.38)	33.65 (0.36)	35.07 (0.41)

**Table 12.** This table shows the total oil and solid fats intake from 2000-2018 alongside the DGA recommendations.

Analysis of data from 2001-2002 to 2017-2018 reveals trends in oil and solid fat intake.

There is a direct mirrored inverse intake of solid fat compared to oil, suggesting the interchangeability of these fat types in cooking and food processing.



**Figure 6.** This graph represents the dietary intake of total oils and solid fats in grams from 2000-2018.

The mean intake of oils increased steadily from 16.42 grams in 2001-2002 to 29.66 grams in 2017-2018. Solid fat intake exhibited a downward trend, decreasing from 44.38 grams in 2001-2002 to 35.07 grams in 2017-2018. Overall, these trends align with the DGAs' emphasis on reducing solid fat intake and promoting a moderate to increased consumption of healthier oils. The actual intake values generally fall within or close to the recommended ranges, indicating a positive adherence to the dietary guidelines. Continued monitoring and awareness can support individuals in maintaining a balanced intake of oils and solid fats in line with the evolving dietary recommendations.

	2000-2018			DGA Year 2005	DGA Year 2010	DGA Year 2015
	Beta (intake)	P-Value linear	95% Confidence Interval of B	B-difference [95% CI]	B-difference [95% CI]	B-difference [95% CI]
Oils	1.655	0	[1.300, 2.010]	1.160 [-3.347, 5.667]	-0.020 [-1.753, 1.714]	0.287 [-0.381, 0.955]
Solid Fats	-1.469	0.001	[-2.054, -0.885]	-2.424 [-6.804, 1.956]	2.171 [0.217, 4.126]	0.243 [-0.725, 1.212]

**Table 13.** This table is the analysis results for total oils and solid fats intake with the overall linear trend values from 2000-2018 and the interaction terms for DGA years.

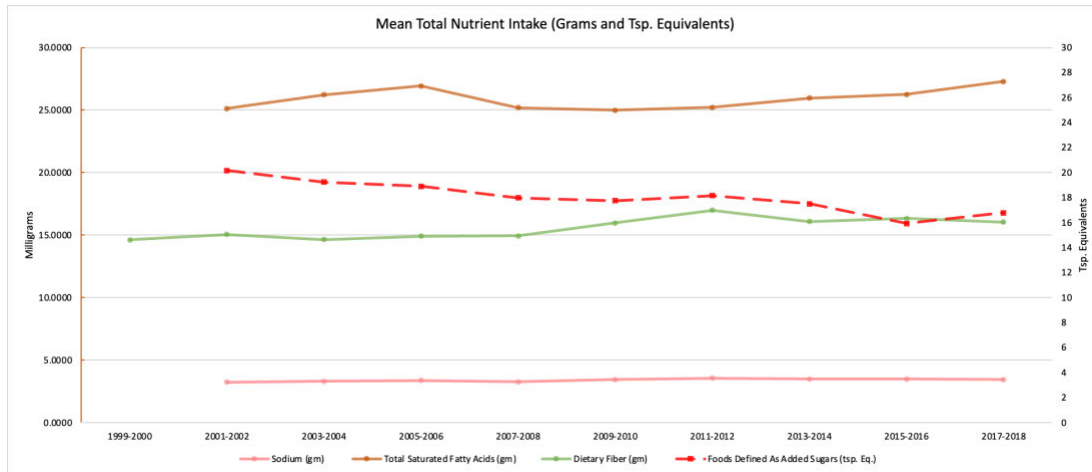
The meta-regression demonstrates a statistically significant ( $p$ -value $<0.01$ ) overall linear trend change from 2000-2018 in intake of total oils, however, does not demonstrate a significant change of trend for any DGA release year. The overall trend increased significantly with a slope of 1.655 grams per day increase from 2000-2018. This trend is reflected with a statistically significant ( $p$ -value $<0.01$ ) overall decrease in intake of 1.469 grams per day in intake of solid fats from 2000-2018 as represented visually. Of the DGA trend years, there is a significant change in intake of solid fats in 2010. In 2010, there was a shift from a steady decrease in intake of solid fats from 2000-2010 to a seemingly less steep decrease in intake of solid fats after 2010. All other DGA release years did not show any trend change in intake of oils or solid fats.

## Nutrients

The DGAs provide recommendations on nutrients of interest including total fat, saturated and unsaturated fats, *trans* fat, sodium, and added sugar. From 1985-1995, the guidelines recommend an intake of total fats less than or equal to 30% of total calories per day. They recommend saturated fats should make up no more than 10% of total calories and to shift towards unsaturated fats. A reduction in intake of *trans* fats was continually recommended until it was banned from industrial food manufacturing use in 2015. The guidelines have consistently recommended an increase in intake of dietary fibers. The DGAs recommended a decrease in added sugars and sodium with an upper limit of 2400 mg per day for the latter beginning in 1995, which later decreased to 2300 mg per day from 2005 onward for sodium and recommendation to limit added sugar to less than 10% of total dietary intake per day was specified in 2015.

	NHANES Mean Intake	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
	DGA Recommendations	2000			2005		2010		2015		
Nutrients											
Sodium (mg)	DGA Recommendation	<2400			<2300		<2300		<2300		
	Mean Intake (SE)		3242.49 (26.53)	3311.31 (26.71)	3386.62 (26.96)	3268.93 (25.13)	3446.78 (23.30)	3548.92 (25.52)	3497.48 (26.34)	3483.76 (25.58)	3451.45 (28.21)
Total Saturated Fatty Acids	DGA Recommendation	<10% kcal			<10% kcal		<10% kcal		<10% kcal		
	Mean Intake (SE)		25.13 (0.24)	26.22 (0.24)	26.92 (0.25)	25.18 (0.23)	24.98 (0.21)	25.22 (0.23)	25.95 (0.24)	26.45 (0.23)	27.92 (0.26)
Food Defined as Added	DGA Recommendation	"Limit"			"Limit"		"Limit"		<10% kcal		
	Mean Intake (SE)		20.17 (0.27)	19.23 (0.26)	18.99 (0.25)	17.99 (0.24)	17.75 (0.22)	18.17 (0.25)	17.50 (0.24)	15.93 (0.21)	16.79 (0.24)

**Table 14.** This table shows the sodium, total saturated fatty acids, and foods defined as added sugar intake from 2000-2018 alongside the DGA recommendations.



**Figure 7.** This graph represents the dietary intake of sodium, total saturated fatty acids, dietary fiber, and foods defined as added sugar in milligrams and teaspoon equivalents from 2000-2018.

The mean intake of total saturated fatty acids ranged from 24.98 gm to 27.29 gm per day, with a subtle increasing trend over time. While these values are within the DGAs recommendation of less than 10% of total daily calories, the slight upward trend emphasizes the ongoing challenge of encouraging a diet low in saturated fats. Public health initiatives may benefit from targeted interventions to address this trend and promote heart-healthy dietary choices. The mean dietary fiber intake demonstrated a consistent pattern of approximately 15,000 to 17,000 mg per day. The DGAs have consistently recommended an increase in dietary fiber intake, and the observed values fall within or near the recommended range. Encouragingly, the population appears to be incorporating dietary fiber, essential for digestive health and overall well-being, into their diets.

Over the examined period, mean sodium intake remained relatively consistent, fluctuating between approximately 3,200 mg to 3,500 mg per day. These values are significantly higher than the recommendations, which have consistently recommended a

decrease in sodium intake. The observed sodium intake values suggest a need for continued efforts to raise awareness and promote strategies to reduce sodium consumption. The mean intake of foods defined as added sugars ranged from approximately 15.93 to 20.17 teaspoon-equivalents per day. Despite a downward trend in teaspoon equivalents in foods defined as added sugars per day, these values are notably higher than the DGAs' recommendation of limiting added sugar intake to less than 10% of total daily calories. This trend underscores the ongoing challenge of reducing added sugar consumption and highlights the importance of public health strategies to address this aspect of the diet.

**Table 15.** This table is the analysis results for sodium, total saturated fatty acids, and foods defined as added sugar intake with the overall linear trend values from 2000-2018 and the interaction terms for DGA years.

	2000-2018			DGA Year 2005	DGA Year 2010	DGA Year 2015
	Beta (intake)	P-Value linear	95% Confidence Interval of B	B-difference [95% CI]	B-difference [95% CI]	B-difference [95% CI]
Sodium (mg)	31.031	0.012	[9.051, 53.012]	-44.552 [-343.735, 254.631]	-67.461 [-146.912, 11.989]	10.417 [-26.540, 47.375]
Total Saturated Fatty Acids (gm)	0.113	0.328	[-0.141, 0.368]	-0.939 [-4.323, 2.444]	0.787 [-0.263, 1.836]	0.051 [-0.413, 0.514]
Food Defined as Added Sugars (tsp. Eq.)	-0.436	0	[-0.594, -0.277]	0.560 [-1.549, 2.669]	0.035 [-0.699, 0.768]	0.172 [-0.077, 0.422]

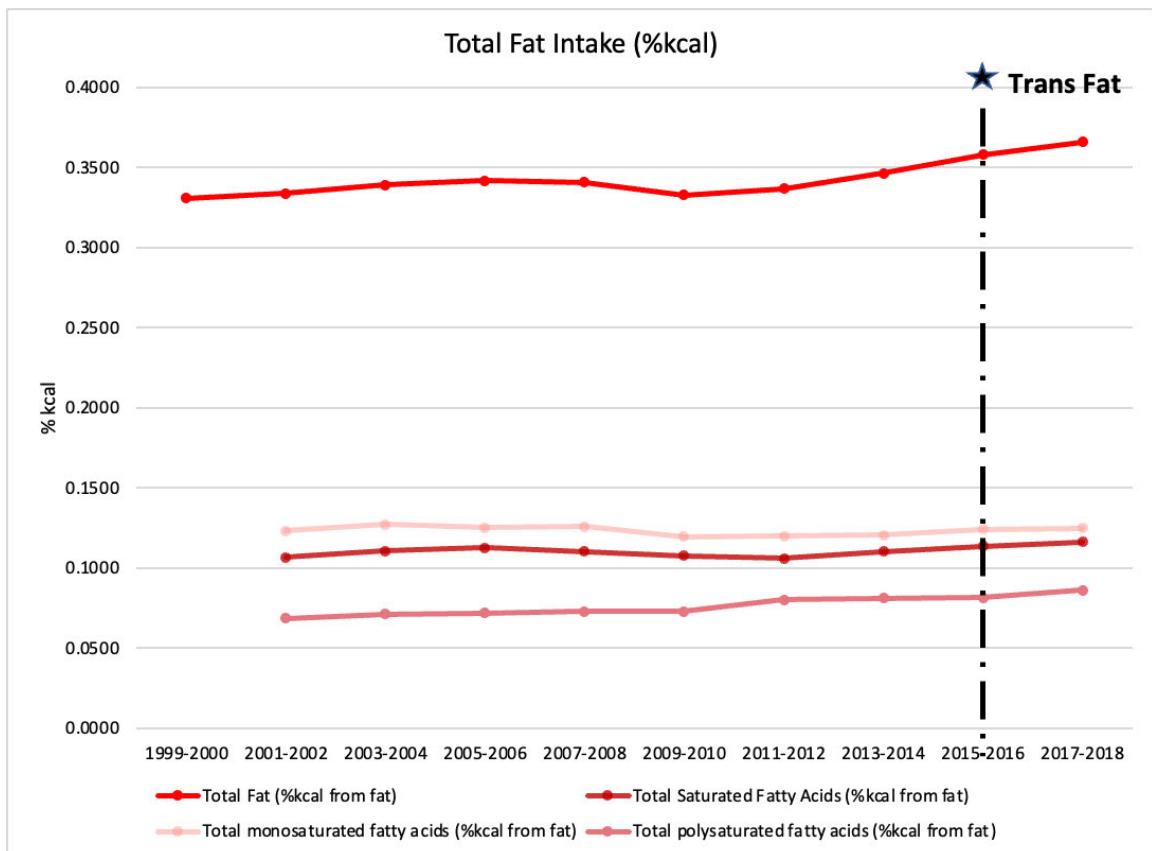
The meta-regression does not demonstrate any statistically significant (p-value=0.328) overall linear trend change from 2000-2018 in intake of total saturated fatty acids, nor was there a significant change of trend for any DGA release year. There is a significant (p-value<0.012) overall increase in intake of 31.031 mg per day in intake of sodium from 2000-2018 represented visually, however, there is not a significant change of trend change in intake of sodium for any DGA release year. Similarly, there is a significant (p-

value<0.01) overall decrease in intake of foods defined as added sugars of 0.436 teaspoon equivalents, without any significant trend change in intake of added sugar foods for any DGA release year.

### Macronutrients

Examining the trends in macronutrient composition from 1999-2000 to 2017-2018 reveals several notable patterns in the percentage of energy derived from different types of fats. The data is presented for Total Fat, Total Saturated Fatty Acids (SFA), Total Monounsaturated Fatty Acids (MUFA), and Total Polyunsaturated Fatty Acids (PUFA), along with the total energy intake in kilocalories. The percentage of energy derived from total fat remained relatively stable over the analyzed period, ranging from 33.07% in 1999-2000 to 36.57% in 2017-2018. The SD and SE values indicate a moderate level of variability, suggesting a consistent but mild upward trend in total fat intake as a percentage of total energy. The percentage of energy from saturated fatty acids displayed a modest increase from 10.68% in 2001-2002 to 11.64% in 2017-2018. The SD and SE values indicate some variability, suggesting fluctuations in saturated fat intake over time. While the increase is notable, it's important to consider whether it falls within acceptable dietary limits recommended for heart health. The percentage of energy from monounsaturated fatty acids remained relatively consistent, with slight variations within the range of 11.96% to 12.49%. The SD and SE values suggest stability in the intake of monounsaturated fats over the examined period. Similar to monounsaturated fats, the percentage of energy from polyunsaturated fatty acids remained relatively stable, ranging

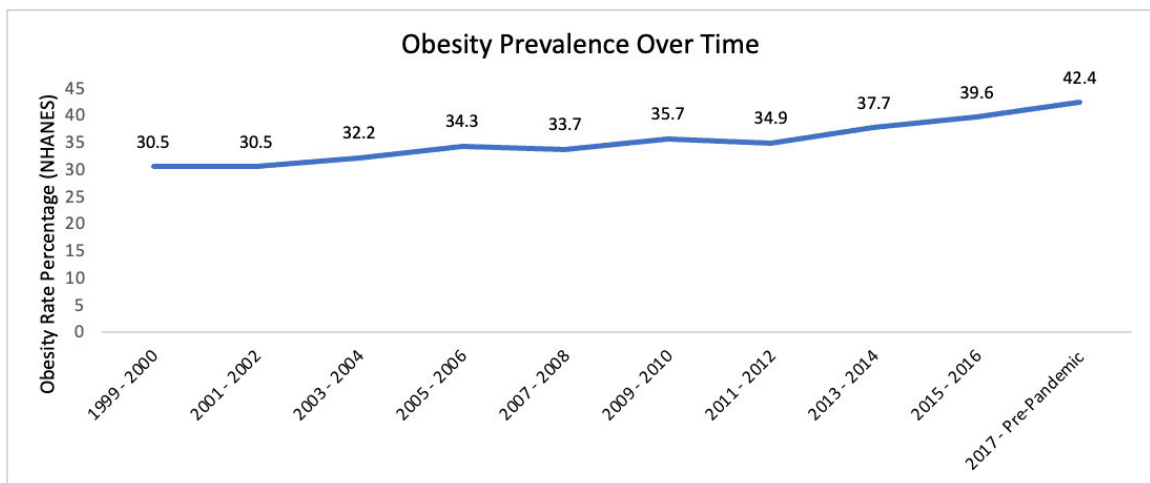
from 6.79% to 8.62%. The SD and SE values indicate consistent but moderate variability in polyunsaturated fat intake. The total energy intake in kilocalories showed a decreasing trend from 2,118.01 kcal in 2001-2002 to 2,075.88 kcal in 2015-2016, followed by a slight increase to 2,110.69 kcal in 2017-2018. The SD and SE values suggest fluctuations in energy intake, reflecting potential shifts in dietary patterns or lifestyle factors influencing calorie consumption.



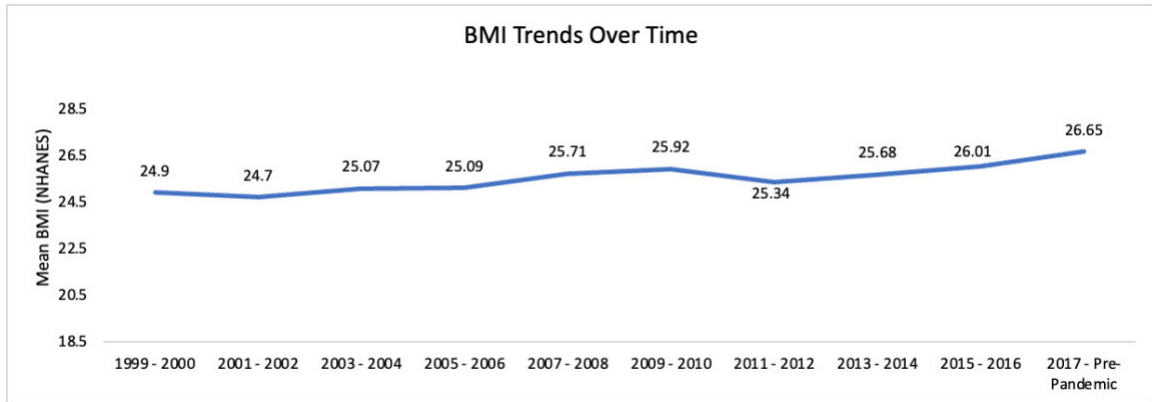
**Figure 8.** This graph represents the dietary intake of total fat, total saturated fatty acids, total monosaturated fatty acids, and total polysaturated fatty acids in percent calories from fat from 2000-2018.

### Obesity Trend

The data spanning from 1999 to 2018 reveals notable trends in BMI and obesity prevalence. Over the initial decade, BMI steadily increased from 24.9 to 25.92, indicating a consistent upward trajectory. A pivotal shift occurred in 2011-2012, marked by a decrease in BMI from 25.92 to 25.34. This inflection point suggests a departure from the preceding trend. Despite this temporary decline, post-2012 witnessed a return to the prior trend in BMI, reaching 26.65 by 2017 (Pre-Pandemic). Obesity prevalence mirrored BMI patterns, with a steady rise until 2011-2012 when a notable drop from 37.7% to 34.9% occurred. Subsequently, obesity prevalence surged, culminating in a rate of 42.4% by 2017. This intriguing inflection point in 2011-2012 signals a shift in BMI and obesity prevalence trends, highlighting a potential impact of various influencing factors such as lifestyle changes, public health initiatives, or broader societal dynamics. We conducted a post-hoc interaction test of trends with inflection year to see if any food groups had similar trends in alignment with the obesity and BMI prevalence trend change.



**Figure 9.** This graph shows the overall obesity prevalence trend from 1999-2018 for U.S. adults.



**Figure 10.** This graph shows the overall BMI trend for U.S. adults from 1999-2018.

The dietary intake for each food group was analyzed for an interaction across the inflection time point for obesity. The linear trend from 2007-2009 (upward trend prior to the obesity inflection point) was compared the linear trend from 2009-2011 (unexpected downward trend during the obesity inflection point). This was repeated for the subsequent time interval 2009-2011 (downward trend) to 2011-2013 (returning to upward trend post obesity inflection point) to see if any food groups changed trend as well during those years. The analysis examined the impact of dietary factors on obesity across three distinct time periods: 2007-2009, 2009-2011, and 2011-2013. The findings reveal notable differences in the associations between specific food groups and obesity during these time intervals. During 2007-2009 compared to 2009-2011, a significant decrease in obesity was observed in parallel with the increased consumption of vegetables (c-eq), as indicated by a beta difference of -0.013 (95% CI: -0.021, -0.006; p-value = 0.005). When the upward BMI and obesity trend resumed, the intake of whole grains (Oz. Eq.) concurrently shifted from its previous upward slope in intake to stalling from 2009-2011

to 2011-2013, with a beta difference of 0.019 (95% CI: 0.004, 0.033; p-value = 0.019).

These findings underscore the dynamic nature of dietary influences on obesity, emphasizing the need for nuanced dietary recommendations that consider temporal trends. While certain food groups exhibited significant associations with obesity, others did not reach statistical significance, highlighting the complexity of dietary patterns and their relationship to obesity across distinct time periods.

## **Discussion**

Despite the consistent dietary guideline recommendations for vegetable intake, the U.S. population has consistently fallen short of meeting the suggested daily servings. Over the years, there is a noticeable decline in mean intake, raising concerns about the population's failure to achieve even the basic minimums for vegetable consumption. It is alarming that, as a whole, the U.S. has not met the fundamental recommendations for this essential food group. Exploring the reasons behind this persistent shortfall and implementing targeted interventions may be crucial to reversing this trend. Notably, in 2010, there was a guideline emphasizing a decrease in starchy vegetable intake, particularly white potatoes. However, this did not seem to have a substantial impact on the overall vegetable intake trend. A promising aspect is the statistically significant overall linear trend from 2000-2018, showing a decrease in vegetable intake, then stalling after 2015.

Understanding the factors contributing to this trend cessation can guide future strategies to promote vegetable consumption.

Similar to vegetables, the U.S. population has consistently failed to meet the dietary guidelines for fruit intake, with mean values below the recommended range. This persistent shortfall in meeting the basic minimums is concerning and warrants targeted interventions to address potential barriers to fruit consumption. The decline in fruit juice intake, aligning with guidelines on limiting added sugars, is a promising trend indicating positive shifts in dietary habits. In 2010, the dietary guidelines changed to recommend a range of 1-2 cup-equivalents of fruit per day, replacing the fixed 2 cup-equivalent recommendation. This change coincided with a slight increase in mean fruit intake, suggesting a potential impact of the altered guideline.

The U.S. population has generally met the recommended intake range for total grains, but the slow shift towards greater proportions for whole grains has recently been more promising. Although the overall mean intake of whole grains has shown a slight decline in recent years, the increase observed from 2000-2010 suggests a positive response to guidelines emphasizing the importance of whole grains. Refined grains are consumed at a much higher percentage than whole grains, despite a constant recommendation for equal intake of whole and refined grains. In 2010, there was a notable change in guidelines, suggesting a shift from a steady decline in whole grain intake to a stabilizing plateau from 2010-2018. This change in trend may reflect the impact of the altered guideline on whole grain consumption.

The population has demonstrated positive adherence to the recommended protein intake, with mean values aligning closely with the guidelines. The diverse and balanced intake of protein sources indicates a nuanced dietary pattern. Notably, the guideline changes over

the years, emphasizing lean protein choices and increased focus on plant-based sources, do not seem to have led to drastic changes in overall protein intake trends. The steady decline in intake of cured/luncheon meat from beef, pork, poultry since 2000 is a promising trend, aligning with recommendations to decrease consumption of these foods. Despite evolving recommendations more recently to encourage increased dairy intake, the U.S. population has consistently fallen short of meeting the recommended ranges. The mean intake values have consistently remained below the suggested threshold, emphasizing the challenge in promoting higher dairy consumption. In 2010, there was a trend change in fluid milk intake, shifting from a steady decline to a seemingly stalling out after 2015. Understanding the factors contributing to this change is crucial for developing strategies to promote dairy consumption.

The inverse trends in solid fats and oils intake align well with dietary guidelines, indicating successful messaging on healthier fat choices. The overall increase in oil intake, along with a decrease in solid fat consumption, suggests a positive response to guidelines advocating for a shift from solid fats to healthier oils. In 2010, there was a significant trend change in solid fats intake, indicating a shift from a steady decrease to a less steep decline after 2010. Exploring the factors contributing to this change can inform strategies to maintain or accelerate the positive trend in fat consumption.

While the mean intake of total saturated fatty acids has shown a subtle increasing trend, it remains within acceptable limits. The positive adherence to dietary fiber recommendations is encouraging, indicating a successful integration of this dietary component into the population's eating habits. The significant overall increase in sodium

intake from 2000-2018 is concerning, emphasizing the persistent challenge in reducing sodium consumption despite dietary guidelines recommending a decrease. The observed decline in foods defined as added sugars is a promising trend, aligning with guidelines on limiting added sugar intake.

The data highlights the alarming trend of the U.S. population consistently falling short of meeting dietary guidelines across various food groups. The promising trends in some areas, such as the cessation of the decline in vegetable intake and positive shifts in fat consumption, indicate areas of success. Future interventions should address persistent challenges while building on these successes to promote a more balanced and nutritious diet among the population. Continuous monitoring, understanding the impact of guideline changes, and exploring factors contributing to trends are essential for refining dietary recommendations and improving overall public health

### **Conclusion**

The analysis of dietary recommendations and trends spanning from 2000 to 2018 reveals a concerning pattern of U.S. adults consistently falling short of meeting the DGAs.

Despite evolving guidelines and recommendations, the general populace has not adhered to the suggested dietary patterns, raising questions about the effectiveness of the guidelines in influencing the population's food choices.

One notable observation is the disconnect between the DGAs and the obesity epidemic.

The consistent failure of the population to adhere to the guidelines suggests that the recommendations put forth by the DGA are unlikely to be significant for the obesity trends observed over the years. The complex interplay of other aspects of diet not

reflected in the guidelines (e.g., food processing), lifestyle factors, social and cultural influences, and the built environment may play a more significant role in shaping dietary habits and contributing to the obesity epidemic.

Despite changes in dietary guidelines, the intake of recommended and discouraged foods has shown remarkable stability over the years. This lack of significant change in food consumption patterns, even after guideline alterations and enhanced specificity, underscores the challenge of translating recommendations into widespread behavioral change. Whether this stability results from entrenched dietary habits, marketing influences, or other factors warrants further exploration.

The strength of this analysis lies in its comprehensive examination of various food groups and nutrients over the period. The use of meta-regression provides a quantitative perspective on trends. The reliance on self-reported dietary data introduces the potential for recall bias. Additionally, external factors such as economic conditions, cultural shifts, or major secular trends and events (like the COVID-19 pandemic post-2018) could influence dietary habits but are not fully accounted for in this analysis.

While the DGAs remain a cornerstone of dietary guidance, their impact on shaping the nation's eating habits appears limited. Efforts to improve public health through dietary interventions should consider multifaceted approaches, addressing not only guideline content, but also broader environmental and societal factors influencing food choices. Continuous research and adaptation of strategies to bridge the gap between dietary recommendations and actual dietary patterns, fostering a healthier nation.

## APPENDIX

Supplementary Table 1. This table is the dietary intake data from 1999-2018 extracted from SAS.

Supplementary Table 2. This table is the data analysis results for the overall meta-regression, the DGA inflection years, and the obesity inflection years.

Supplementary Methods 1. This is the code used in SAS to extract the dietary food intake data by food group.

Supplementary Methods 2. This is the STATA code used to conduct a meta-regression for overall dietary intake trend and DGA inflection years 2005, 2010, and 2010.

Supplementary Methods 3. This is the STATA code used to conduct a regression for dietary intake trends during the obesity inflection point years.

# Supplementary Table 1.

YEAR	MEAN	SD	SE	Energy/Kcal	Total Saturated Fatty Acids (g)	Total Saturated Fatty Acids (g)	Total Monounsaturated Fatty Acids (g)	Total Polyunsaturated Fatty Acids (g)	Total Monounsaturated Fatty Acids (g)	Total Polyunsaturated Fatty Acids (g)	Sodium (mg)	Alcohol (g)	Total Intact or Cut Fruit and Juices (Cup Equivalents)	Intact (Whole/Cut) Fruit, Citrus, Melon, Berries (Cup Equivalents)	Intact (Whole/Cut) Other Fruits Excluding Citrus, Melon, Berries (Cup Equivalents)	Total Dark Green, Red and Orange, Starchy, and Other Vegetables Excluding Legumes (Cup Eq.)	Dark Green Vegetables (Cup Eq.)	Total Red and Orange Vegetables + Other Red (Cup Eq.)	Tomatoes and Tomato Products (Cup Eq.)	Other Red and Orange Vegetables Excluding Tomatoes and Tomato Products (Cup Eq.)	Other Vegetables Not in the Vegetable Components Listed Above (Cup Eq.)	White Potatoes (Cup Eq.)	Other Starchy Vegetables Excluding White Potatoes (Cup Eq.)	Total Starch Vegetables: White Potatoes + Other Starchy (Cup Eq.)	Legumes Computed as Vegetables (Cup Eq.)	Number of Cooked Dry Beans and Peas (Cup Eq.)	Total Whole and Refined Grains (Oz. Eq.)
1999-2000	MEAN	SD	SE	2118.01	25.1301111	0.10678467	28.9992023	0.12322854	16.1678118	0.06870143	3242.49	9.174747	1.151831	0.5218856	0.6301243	1.5873623	0.1106316	0.3383758	0.576919	0.3888851	0.0892784	0.4781635	0.142522	0.6760816	0.142522	0.6760816	
2001-2002	MEAN	SD	SE	14.8683973	0.239192	0.14391463	0.2694387	0.16211284	0.1642536	0.09882626	26.5349	0.4498269	0.221392	0.0139719	0.0143823	0.0194974	0.005164	0.0078936	0.0105616	0.0091254	0.0036847	0.0060675	0.0061883	0.0060675	0.0061883		
	MEAN	SD	SE	1015.67	16.2644115	0.14412332	17.8919712	0.15854337	0.11955762	0.09920562	1781.16	29.1755128	1.330544	0.8800107	0.903546	1.2854152	0.2965412	0.5324577	0.6759715	0.6641822	0.2601913	0.0039013	0.3579714	0.4380773	0.3579714	0.4380773	
2003-2004	MEAN	SD	SE	2151.12	26.920954	0.11263369	29.9361332	0.1252488	17.1771254	0.07186681	3386.62	10.3867899	1.0027013	0.1632412	0.4392035	0.4003075	1.6203576	0.07916598	0.3950088	0.3203761	0.0748881	0.5699598	0.3566062	0.0863717	0.4439912	0.1334004	0.6716327
	MEAN	SD	SE	1010.89	17.0689452	0.1519478	18.1778415	0.1618316	11.415545	0.10163285	1812.34	27.5370876	1.3553029	0.5028436	0.7963538	0.8987202	1.2444442	0.3336278	0.5004943	0.4628104	0.1957948	0.7227943	0.5847496	0.2537589	0.051085	0.37995	4.3516293
2005-2006	MEAN	SD	SE	15.0360735	0.2535555	0.15134788	0.2703791	0.16183826	0.1697955	0.10163288	28.956682	0.4059584	0.2201589	0.0074793	0.0112501	0.0133677	0.0054824	0.0158397	0.0074443	0.0088839	0.0029123	0.0107509	0.0084274	0.0037741	0.009843	0.0050508	0.0472266
	MEAN	SD	SE	2052.81	25.183617	0.11041094	28.701388	0.12583361	16.6688314	0.0730006	3268.93	8.2925113	0.9996661	0.1865354	0.4892941	0.329742	1.4632925	0.0186899	0.3994483	0.2928266	0.0766494	0.5342435	0.3601107	0.0875683	0.4476769	0.1290221	6.334819
2007-2008	MEAN	SD	SE	1021.8	16.9671873	0.14944675	18.4828598	0.16253253	11.3404253	0.09988631	1850.16	28.4070422	1.3966783	0.6822706	0.9829643	1.015174	1.2862216	0.387952	0.4287907	0.1987467	0.7733792	0.5820651	0.272294	0.069826	0.3570853	0.2153974	4.3652992
	MEAN	SD	SE	13.8791306	0.2304678	0.14944749	0.2506479	0.16253333	0.1540386	0.09988631	25.1310111	0.358587	0.0188899	0.0092674	0.0111748	0.0111045	0.0174709	0.0046019	0.0064964	0.0057972	0.0028996	0.0105049	0.008042	0.0036869	0.009511	0.003700	0.0572584
2009-2010	MEAN	SD	SE	2084.42	24.3770798	0.10784689	27.7015099	0.11946814	16.8996631	0.07292962	3446.78	10.7105992	1.0621364	0.1864843	0.5231239	0.3521295	1.4594134	0.1208487	0.3678219	0.2806178	0.0873065	0.5414873	0.3474523	0.0815654	0.4290212	0.134506	6.0599892
	MEAN	SD	SE	12.7544558	0.2119756	0.14957256	0.2244498	0.15841381	0.1458678	0.10292953	23.3016888	0.3831891	0.0195209	0.008264	0.0117755	0.0118565	0.01679	0.0049885	0.0063213	0.0055077	0.0030398	0.0093951	0.0076058	0.0035244	0.008473	0.0050517	0.0546786
2011-2012	MEAN	SD	SE	14.48471	0.2345602	0.14660726	0.2522511	0.15701936	0.1841065	0.11460123	28.5237291	0.4330889	0.2022029	0.009546	0.0118588	0.0113135	0.019023	0.0069626	0.0096966	0.0034184	0.0110344	0.0086633	0.0041308	0.009639	0.0067872	0.3870551	4.2651588
	MEAN	SD	SE	2116.1	25.9496247	0.11028232	28.4196297	0.1207576	19.1443945	0.08134628	3497.48	10.0584902	0.9380111	0.2020626	0.4754886	1.4750011	1.591421	0.3769943	0.2805132	0.0964672	0.5235942	0.3384109	0.0769744	0.4153101	0.1550987	0.6113934	
2013-2014	MEAN	SD	SE	14.576039	0.2326522	0.14588235	0.2549991	0.15744473	0.15094379	0.11738075	1871.19	28.2879214	1.3191024	0.6022145	0.8453874	0.8889895	1.2743872	0.4827879	0.4854259	0.4081817	0.2655294	0.8001419	0.5923951	0.2619018	0.6532578	0.3584118	4.3652992
	MEAN	SD	SE	2075.88	26.2466279	0.1137923	28.8775678	0.1243319	18.8380961	0.0812727	3483.76	9.3750226	0.9577868	0.2295565	0.4657744	0.2644209	1.4756809	0.1491927	0.3578134	0.2599542	0.0978752	0.5251206	0.3529041	0.0901339	0.4432424	0.1538708	6.5505162
2015-2016	MEAN	SD	SE	1032.8	18.032637	0.1571413	18.972908	0.16185002	12.8212337	0.12145469	1812	27.2687835	1.3378831	0.6318841	0.8808202	0.680489	1.2792244	0.2486086	0.4801328	0.3730595	0.298875	0.6887874	0.2856427	0.0981133	0.3912322	4.2215267	
	MEAN	SD	SE	13.4133003	0.2319314	0.15695023	0.2412103	0.16185003	0.181012	0.12145467	25.50295	0.3848846	0.0188844	0.0096729	0.0114719	0.0096072	0.0189603	0.0060435	0.0087786	0.0052951	0.0042337	0.0097089	0.0087567	0.0040328	0.0097784	0.0055233	0.0596002
2017-2018	MEAN	SD	SE	2110.69	27.2926031	0.11637589	29.296981	0.12493249	20.216987	0.08620464	3451.45	9.0075496	0.9387115	0.2411345	0.4657903	0.2318832	1.4815233	0.3524715	0.2520102	0.0992914	0.5323766	0.3730177	0.0795571	0.4526243	0.1173134	6.6248123	
	MEAN	SD	SE	1032.8	18.032637	0.1571413	18.972908	0.16185002	12.8212337	0.12145469	1812	27.2687835	1.3378831	0.6318841	0.8808202	0.680489	1.2792244	0.2486086	0.4801328	0.3730595	0.298875	0.6887874	0.2856427	0.0981133	0.3912322	4.2215267	
2017-2018	SE			14.9809599	0.2618685	0.15714105	0.2842567	0.15874515	0.2004084	0.12029151	28.2048239	0.3906143	0.0208362	0.010944	0.012054	0.0103137	0.0189877	0.0058563	0.0087116	0.0058623	0.0039566	0.0099961	0.0095312	0.0042294	0.0105446	0.005583	0.0644772

Supplementary Table 2.

	NHANES Mean Intake	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018	2000-2018			DGA Year 2005	DGA Year 2010	DGA Year 2015	Obesity Interaction: 2007-2009 vs 2009-2011		Obesity Interaction: 2009-2011 vs 2011-2013		
												Beta (slope)	P-Value linear	95% Confidence Interval of B	B-difference 95% CI	B-difference 95% CI	B-difference 95% CI	B-difference 95% CI	P-Value	B-difference 95% CI	P-Value	
<b>Vegetables (C-Eg)</b>																						
Total Dark Green, Red and Orange, Starchy, and Other Vegetables Excluding White Potatoes	DGA Recommendation	1.5-2.5			2.5			1.4		1.4			-0.011	0.044	[-0.022, -0.000]	0.034 [-0.071, 0.139]	0.023 [-0.003, 0.049]	0.016 [0.006, 0.025]	-0.013 [-0.021, -0.006]	0.005	0.002 [-0.009, 0.014]	0.666
	Mean Intake (SE)		1.59 (0.02)	1.55 (0.02)	1.52 (0.02)	1.46 (0.02)	1.46 (0.02)	1.52 (0.02)	1.48 (0.02)	1.48 (0.02)	1.49 (0.02)											
White Potatoes	DGA Recommendation							"Limit"		"Limit"			-0.004	0.132	[-0.009, 0.001]	0.002 [-0.044, 0.048]	0.020 [0.007, 0.033]	0.002 [-0.004, 0.008]	-0.003 [-0.010, 0.004]	0.383	-0.003 [-0.008, 0.002]	0.187
	Mean Intake (SE)	N/A	0.1 (<0.01)	0.05	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)	0.1 (<0.01)											
<b>Fruits (C-Eg)</b>																						
Total Intact or Cut Fruit and Fruit Juices	DGA Recommendation	1-2			2			1-2.5		1-2.5			-0.02	0.01	[-0.033, -0.006]	0.106 [-0.032, 0.245]	-0.001 [-0.073, 0.071]	0.001 [-0.027, 0.028]	0.004 [-0.016, 0.024]	0.632	-0.001 [-0.016, 0.013]	0.83
	Mean Intake (SE)		1.15 (0.02)	1.03 (0.02)	1.00 (0.02)	1.00 (0.02)	1.06 (0.02)	1.02 (0.02)	0.94 (0.02)	0.96 (0.02)	0.94 (0.02)											
Fruit Juices: Citrus and Non-Citrus	DGA Recommendation	"Increase"											-0.025	0.003	[-0.038, -0.013]		-0.008 [-0.093, 0.078]	0.003 [-0.028, 0.033]	-0.003 [-0.019, 0.013]	0.64	-0.00 [-0.010, 0.010]	0.999
	Mean Intake (SE)				0.40 (0.01)	0.32 (0.01)	0.35 (0.01)	0.34 (0.01)	0.26 (0.01)	0.26 (0.01)	0.23 (0.01)											
<b>Grains (Bread, Cereal, Pasta, Rice) (Oz.-Eq)</b>																						
Total Whole and Refined Grains	DGA Recommendation	6-11 servings			6			3-11		3-10			-0.013	0.494	[-0.057, 0.030]	-0.154 [-0.647, 0.340]	0.030 [-0.173, 0.234]	0.040 [-0.038, 0.119]	-0.041 [-0.093, 0.011]	0.101	0.012 [-0.035, 0.059]	0.546
	Mean Intake (SE)		6.68 (0.06)	6.84 (0.07)	6.67 (0.07)	6.33 (0.06)	6.61 (0.05)	6.71 (0.06)	6.61 (0.06)	6.55 (0.06)	6.62 (0.06)											
Whole Grains	DGA Recommendation	"Increase"			3			1.5-5		1.5-5 oz-eq/week (1.1-7.1)			0.032	0.008	[0.011, 0.053]	0.044 [-0.248, 0.336]	-0.053 [-0.104, -0.001]	0.024 [-0.002, 0.051]	-0.011 [-0.041, 0.019]	0.388	0.019 [0.004, 0.033]	0.019
	Mean Intake (SE)		0.65 (0.02)	0.64 (0.02)	0.67 (0.02)	0.64 (0.01)	0.76 (0.02)	0.92 (0.02)	0.87 (0.02)	0.84 (0.02)	0.82 (0.02)											
Refined or Non Whole Grains	DGA Recommendation	"Limit"			<3			1.5-5		1.5-5 oz-eq/week (1.5/7-9/7)			-0.046	0.023	[-0.083, -0.009]	-0.198 [-0.562, 0.166]	0.085 [-0.092, 0.261]	0.016 [-0.055, 0.088]	-0.030 [-0.079, 0.018]	0.178	-0.007 [-0.048, 0.034]	0.699
	Mean Intake (SE)		6.02 (0.06)	6.20 (0.06)	6.00 (0.06)	5.70 (0.06)	5.85 (0.05)	5.79 (0.06)	5.74 (0.06)	5.71 (0.06)	5.81 (0.06)											
<b>Protein Foods (Oz.-Eq)</b>																						
Total Meat, Poultry, Seafood, Organ Meat, Cured Meat, Eggs, Soy, And Nuts and Seeds Excluding Legumes	DGA Recommendation	6-7			5.5			2-7		2-7			0.049	0.104	[-0.014, 0.111]		-0.002 [-0.324, 0.321]	0.047 [-0.058, 0.153]	-0.40 [-0.100, 0.02]	0.137	0.026 [-0.014, 0.065]	0.147
	Mean Intake (SE)				6.12 (0.07)	5.89 (0.06)	6.08 (0.06)	6.26 (0.07)	6.33 (0.07)	6.22 (0.07)	6.24 (0.07)											
Total Meat, Poultry, Seafood, Organ Meats, and Cured Meat	DGA Recommendation	5-7											0.025	0.101	[-0.006, 0.056]	-0.030 [-0.365, 0.304]	-0.096 [-0.056, 0.050]	-0.003 [-0.045, 0.047]	0.001 [-0.009, 0.011]	0.06	0.015 [-0.017, 0.046]	0.29
	Mean Intake (SE)		4.66 (0.06)	4.69 (0.06)	4.94 (0.06)	4.73 (0.05)	4.91 (0.05)	4.94 (0.06)	4.94 (0.06)	4.90 (0.06)	4.81 (0.06)											
Eggs (Chicken, Duck, Goose, Quail) and Egg Substitutes	DGA Recommendation	"Moderate"						"Increase"		"Increase"			0.015	0.001	[0.008, 0.022]	-0.026 [-0.115, 0.063]	0.017 [-0.007, 0.042]	-0.004 [-0.016, 0.007]	-0.009 [-0.009, 0.011]	0.827	-0.004 [-0.010, 0.004]	0.17
	Mean Intake (SE)		0.49 (0.01)	0.53 (0.01)	0.54 (0.01)	0.57 (0.01)	0.55 (0.01)	0.54 (0.01)	0.60 (0.01)	0.61 (0.04)	0.65 (0.02)											
Cured/Luncheon Meat Made from Beef, Pork, Poultry	DGA Recommendation												-0.02	0.018	[-0.036, -0.005]		-0.053 [-0.120, 0.014]	-0.013 [-0.037, 0.010]	0.012 [-0.003, 0.026]	0.09	0.002 [-0.010, 0.014]	0.682
	Mean Intake (SE)				0.95 (0.03)	1.00 (0.03)	1.00 (0.03)	0.96 (0.02)	0.93 (0.02)	0.88 (0.02)	0.87 (0.02)											
Legumes Computed As Protein Foods	DGA Recommendation	"Increase"			0.857 (1.5 oz/week)			0.143-0.857 (2.5-1.5 oz/week)		0.143-0.857 (2.5-1.5 oz/week)			0.053	0.014	[0.015, 0.092]	0.021 [-0.062, 0.104]	-0.122 [-0.262, 0.018]	-0.035 [-0.096, 0.028]	-0.003 [-0.022, 0.016]	0.642	-0.000 [-0.012, 0.012]	0.996
	Mean Intake (SE)				0.53 (0.02)	0.52 (0.02)	0.55 (0.02)	0.58 (0.02)	0.54 (0.02)	0.62 (0.02)	0.55 (0.02)											
Cholesterol (mg)	DGA Recommendation	<300			<300			<300		<300			1.616	0.14	[-0.681, 3.913]	-2.394 [-34.004, 29.216]	8.201 [-0.034, 16.436]	0.800 [-2.876, 4.476]	-1.848 [-4.858, 1.161]	0.184	-1.032 [-3.394, 1.330]	0.326
	Mean Intake (SE)	263.0 (0.01)	265.0 (0.01)	269.6 (0.01)	274.0 (0.01)	272.2 (0.01)	256.9 (0.01)	264.2 (0.01)	272.7 (0.01)	279.3 (0.01)	284.7 (0.01)											
<b>Dairy (Cup Eq)</b>																						
Total Milk, Yogurt, Cheese and Whey	DGA Recommendation	2-3			3			2-3		2-3			-0.019	0.109	[-0.043, 0.005]	-0.064 [-0.352, 0.224]	-0.075 [-0.170, 0.020]	-0.012 [-0.044, 0.020]	0.012 [-0.023, 0.047]	0.43	-0.011 [-0.013, 0.036]	0.299
	Mean Intake (SE)		1.46 (0.02)	1.49 (0.02)	1.55 (0.02)	1.42 (0.02)	1.58 (0.02)	1.45 (0.02)	1.51 (0.02)	1.35 (0.02)	1.31 (0.02)											
Fluid Milk and Calcium Fortified Soy Milk	DGA Recommendation	"Limit"			"Increase"			"Increase"		"Increase"			-0.042	0	[-0.053, -0.031]	-0.031 [-0.155, 0.093]	-0.017 [-0.052, 0.018]	-0.014 [-0.028, -0.001]	0.009 [-0.004, 0.022]	0.135	-0.003 [-0.014, 0.009]	0.6
	Mean Intake (SE)		0.89 (0.02)	0.87 (0.02)	0.88 (0.02)	0.79 (0.01)	0.82 (0.01)	0.69 (0.01)	0.67 (0.01)	0.61 (0.01)	0.58 (0.01)											
<b>Fats and Oils (Grams)</b>																						
Oils	DGA Recommendation	"Moderate"			<24			15-51		15-51			1.655	0	[1.300, 2.010]	1.160 [-3.347, 5.667]	-0.020 [-1.753, 1.714]	0.287 [-0.381, 0.955]	-0.31 [-0.752, 0.132]	0.137	0.131 [-0.246, 0.508]	0.427
	Mean Intake (SE)		16.42 (0.27)	16.79 (0.27)	21.54 (0.29)	20.79 (0.26)	20.23 (0.25)	25.52 (0.31)	26.42 (0.33)	27.41 (0.31)	29.66 (0.34)											
Solid Fats	DGA Recommendation	"Limit"			"Limit"			"Limit"		"Limit"			-1.469	0.001	[-2.054, -0.885]	-2.424 [-6.804, 1.956]	2.171 [0.217, 4.126]	0.243 [-0.725, 1.212]	-0.410 [-1.206, 0.385]	0.254	-0.236 [-0.846, 0.373]	0.379
	Mean Intake (SE)		44.38 (0.45)	45.83 (0.46)	40.42 (0.44)	38.23 (0.40)	36.82 (0.37)	35.01 (0.39)	34.79 (0.38)	33.65 (0.36)	35.07 (0.41)											
<b>Nutrients</b>																						
Sodium (mg)	DGA Recommendation	<2400			<2300			<2300		<2300			31.031	0.012	[9.051, 53.012]	-44.552 [-343.735, 254.631]	-67.461 [-146.912, 11.989]	10.417 [-26.540, 47.375]	-6.322 [-39.175, 26.530]	0.654	15.071 [-4.464, 34.605]	0.108
	Mean Intake (SE)		3242.49 (26.53)	3311.31 (26.71)	3386.62 (26.96)	3268.93 (25.13)	3446.78 (23.30)	3548.92 (25.52)	3497.48 (26.34)	3483.76 (25.58)	3451.45 (28.21)											
Total Saturated Fatty Acid (gm)	DGA Recommendation	<10% kcal			<10% kcal			<10% kcal		<10% kcal			0.113	0.328	[-0.141, 0.368]	-0.939 [-4.323, 2.444]	0.787 [-0.263, 1.836]	0.051 [-0.413, 0.514]	-0.222 [-0.540, 0.096]	0.139	-0.101 [-0.367, 0.166]	0.391
	Mean Intake (SE)		25.13 (0.24)	26.22 (0.24)	26.92 (0.25)	25.18 (0.23)	24.98 (0.21)	25.22 (0.23)	25.95 (0.24)	26.45 (0.23)	27.92 (0.26)											
Food Defined as Added Sugars (Tsp. Eq)	DGA Recommendation	"Limit"			"Limit"			"Limit"		<10% kcal			-0.436	0	[-0.594, -0.277]	0.560 [-1.549, 2.669]	0.035 [-0.699, 0.768]	0.172 [-0.077, 0.422]	-0.107 [-0.323, 0.109]	0.269	0.095 [-0.054, 0.244]	0.169
	Mean Intake (SE)		20.17 (0.27)	19.23 (0.26)	18.99 (0.25)	17.99 (0.24)	17.75 (0.22)	18.17 (0.25)	17.50 (0.24)	15.93 (0.21)	16.79 (0.24)											

### Supplementary Methods 1.

```
data MPED;
set MPED.equiv0102;
FOODCODE=1*DRDIFDCD; if FOODCODE=11310000 then do;
M_SOY=0; D_TOTAL=round(100*(1/244),.001); end;
else if FOODCODE=11320000 then do; M_SOY=0; D_TOTAL=round (100*(1/245),.001); end;
else if FOODCODE=11321000 then do; M_SOY=0; D_TOTAL=round (100*(1/240),.001); end;
else if FOODCODE=11330000 then do; M_SOY=0; D_TOTAL=round (100*(1/245),.001); end;
if FOODCODE = 58106210 then do; G_TOTAL=1.88; G_WHL=0; G_NWHL=1.88; V_TOTAL=0.12; V_TOMATO=0.12;
D_TOTAL=0.70; D_CHEESE=0.70; DISCFAT_OIL=0.44; DISCFAT_SOL=8.00; ADD_SUG=0.19; end;
else if FOODCODE = 58106220 then do; G_TOTAL=1.75; G_WHL=0; G_NWHL=1.75; V_TOTAL=0.12;
V_TOMATO=0.12; D_TOTAL=0.66; D_CHEESE=0.66; DISCFAT_OIL=0.44; DISCFAT_SOL=10.62; ADD_SUG=0.19
end;
else if FOODCODE = 58106230 then do; G_TOTAL=1.88; G_WHL=0; G_NWHL=1.88; V_TOTAL=0.12;
V_TOMATO=0.12; D_TOTAL=0.66; D_CHEESE=0.66; DISCFAT_OIL=0.44; DISCFAT_SOL=8.82; ADD_SUG=0.19;
end; run;
```

```

data CNPPMPED_WJFRT; set MPED.cnppmyp_v1nhanes0102_wjfrt; run;

data FOOD; set NH.drxfiff_b; FOODCODE=1*DRDDRSTZ; /*convert variable name and type*/ if DRDDRSTZ=1; /*reliable
        dietary recall status*/ run;

data NUTRIENT (keep=SEQN WTDRD1 DRXTKCAL DRXTSFAT DRXTALCO DRDTSODI DRDDRSTZ DRXTMFAT
DRXTPFAT); set NH.DRxTOT_b; if DRDDRSTZ=1; /*reliable dietary recall status*/ run;

data DEMO (keep=SEQN RIDAGEYR RIAGENDR SDDSRVYR SDMVPSU SDMVSTRA); set NH.DEMO_b; if
RIDAGEYR >= 20; run;

proc sort data=MPED; by FOODCODE; run;

proc sort data=CNPPMPED_WJFRT; by FOODCODE; run;

data NEWMPED; merge MPED CNPPMPED_WJFRT; by FOODCODE; run;

proc sort data=FOOD; by FOODCODE; run;

data FDPYR; merge FOOD (in=S) NEWMPED (in=N); by FOODCODE; if S and N; run;

data FDPYR; set FDPYR; array PYRVAR G_TOTAL--A_BEV WHOLEFRT FRTJUICE; do over PYRVAR;
PYRVAR=PYRVAR*(DRXIGRMS/100); end; run;

proc sort data=FDPYR; by SEQN; run;

```

```

proc means data=FDPYR noprint; by SEQN; var G_TOTAL--A_BEV WHOLEFRT FRTJUICE; output out=PYRCALC
sum= ; run;

proc sort data=NUTRIENT; by SEQN; run;

proc sort data=DEMO; by SEQN; run;

data COHORT; merge NUTRIENT (in=N) DEMO (in=D); by SEQN; if N and D; run;

data BOTH; merge COHORT (in=C) PYRCALC(in=P); by SEQN; if C; run;

data BOTH; set BOTH; by SEQN; array PYRVAR G_TOTAL--A_BEV WHOLEFRT FRTJUICE; do over PYRVAR; if
PYRVAR < 0 then PYRVAR =0; end; run;

data BOTH (keep = DRXTKCAL DRXTSFAT DRXTMFAT DRXTPFAT DRDTSODI DRXTALCO g_total g_whl g_nwhl
v_total v_drkgr v_potato v_starcy v_tomato v_other f_total f_citmlb f_other d_total d_milk d_yogurt d_cheese m_mpf
m_meat m_organ m_frnk m_poult m_fish_hi m_fish_l m_egg m_soy m_nutsd legumes discfat_oil discfat_sol add_sug
a_bev); set BOTH; run;

proc means mean std stderr data = BOTH; run;

proc export data=BOTH outfile="/home/u63118640/thesis codes/NewResults20Yrs/RawDat.csv" dbms=csv; run;

```

## Supplementary Methods 2

```
list
generate _meta_es=mean
generate _meta_se=se

ssc install metareg

metareg mean time, wsse (se)
generate int2005=time*v5
metareg mean time v5 int2005, wsse (se)
generate int2010 = time*v6
metareg mean time v6 int2010, wsse (se)
generate int2015 = time*v6
metareg mean time v7 int2015, wsse (se)
```

## Supplementary Methods 3

```
list
generate _meta_es=mean
generate _meta_se=se
generate int0709_0911 = time*(time >= 4 & time <= 5)
metareg mean time int0709_0911, wsse(se)
generate int0911_1113 = time*(time >= 6 & time <= 7)
metareg mean time int0911_1113, wsse(se)
```

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**CURRICULUM VITAE**

