Original Investigation

Dietary Intake Among US Adults, 1999-2012

Colin D. Rehm, PhD, MPH; José L. Peñalvo, PhD; Ashkan Afshin, MD, ScD; Dariush Mozaffarian, MD, DrPH

IMPORTANCE Most studies of US dietary trends have evaluated major macronutrients or only a few dietary factors. Understanding trends in summary measures of diet quality for multiple individual foods and nutrients, and the corresponding disparities among population subgroups, is crucial to identify challenges and opportunities to improve dietary intake for all US adults.

OBJECTIVE To characterize trends in overall diet quality and multiple dietary components related to major diseases among US adults, including by age, sex, race/ethnicity, education, and income.

DESIGN, SETTING, AND PARTICIPANTS Repeated cross-sectional investigation using 24-hour dietary recalls in nationally representative samples including 33 932 noninstitutionalized US adults aged 20 years or older from 7 National Health and Nutrition Examination Survey (NHANES) cycles (1999-2012). The sample size per cycle ranged from 4237 to 5762.

EXPOSURES Calendar year and population sociodemographic subgroups.

MAIN OUTCOMES AND MEASURES Survey-weighted, energy-adjusted mean consumption and proportion meeting targets of the American Heart Association (AHA) 2020 continuous diet scores, AHA score components (primary: total fruits and vegetables, whole grains, fish and shellfish, sugar-sweetened beverages, and sodium; secondary: nuts, seeds, and legumes, processed meat, and saturated fat), and other individual food groups and nutrients.

RESULTS Several overall dietary improvements were identified ($P < .01$ for trend for each). The AHA primary diet score (maximum of 50 points) improved from 19.0 to 21.2 (an improvement of 11.6%). The AHA secondary diet score (maximum of 80 points) improved from 35.1 to 38.5 (an improvement of 9.7%). Changes were attributable to increased consumption between 1999-2000 and 2011-2012 of whole grains (0.43 servings/d; 95% CI, 0.34-0.53 servings/d) and nuts or seeds (0.25 servings/d; 95% CI, 0.18-0.34 servings/d) (fish and shellfish intake also increased slightly) and to decreased consumption of sugar-sweetened beverages (0.49 servings/d; 95% CI, 0.28-0.70 servings/d). No significant trend was observed for other score components, including total fruits and vegetables, processed meat, saturated fat, or sodium. The estimated percentage of US adults with poor diets (defined as <40% adherence to the primary AHA diet score components) declined from 55.9% to 45.6%, whereas the percentage with intermediate diets (defined as 40% to 79.9% adherence to the primary AHA diet score components) increased from 43.5% to 52.9%. Other dietary trends included increased consumption of whole fruit (0.15 servings/d; 95% CI, 0.05-0.26 servings/d) and decreased consumption of 100% fruit juice (0.11 servings/d; 95% CI, 0.04-0.18 servings/d). Disparities in diet quality were observed by race/ethnicity, education, and income level; for example, the estimated percentage of non-Hispanic white adults with a poor diet significantly declined (53.9% to 42.8%), whereas similar improvements were not observed for non-Hispanic black or Mexican American adults. There was little evidence of reductions in these disparities and some evidence of worsening by income level.

CONCLUSIONS AND RELEVANCE In nationally representative US surveys conducted between 1999 and 2012, several improvements in self-reported dietary habits were identified, with additional findings suggesting persistent or worsening disparities based on race/ethnicity, education level, and income level. These findings may inform discussions on emerging successes, areas for greater attention, and corresponding opportunities to improve the diets of individuals living in the United States.

JAMA. 2016;315(23):2542-2553. doi:10.1001/jama.2016.7491

Editorial page 2527

Supplemental content at jama.com

CME Quiz at jamanetworkcme.com

Author Affiliations: Office of Community and Population Health, Montefiore Medical Center, Bronx, New York (Rehm); Tufts Friedman School of Nutrition Science and Policy, Boston, Massachusetts (Rehm, Peñalvo, Afshin, Mozaffarian); Institute for Health Metrics and Evaluation, Department of Global Health, University of Washington, Seattle (Afshin).

Corresponding Author: Dariush Mozaffarian, MD, DrPH, Tufts Friedman School of Nutrition Science and Policy, 150 Harrison Ave, Boston, MA 02111 (dariush.mozaffarian@tufts.edu).

Suboptimal diet is among the leading causes of poor health, particularly obesity, diabetes, cardiovascular diseases, and diet-related cancers.[1,2] In the United States, dietary factors are estimated to account for more than 650 000 deaths per year and 14% of all disability-adjusted life-years lost.[1] Understanding trends in dietary habits is crucial to inform priorities and policies to improve diets and reduce diet-related illness. In addition, identifying how such trends vary according to specific subgroups is essential to evaluate prevalent, worsening, or potentially improving disparities and inform corresponding interventions.

Most prior investigations on US dietary trends have focused on a limited number of components, such as total energy, broad macronutrients, summary diet measures, or a few selected items (eg, consumption of sugary beverages, added sugars, or meat).[3-7] Therefore, the trends and corresponding disparities across a full range of dietary factors linked to major health outcomes, including both dietary patterns and multiple individual foods and nutrients, are not well established. In addition, investigations have generally not evaluated relevant food subclasses, such as subtypes of whole grains, fruits, and vegetables, which may uncover important underlying trends in consumption.

To address these major knowledge gaps, data from 7 consecutive 2-year cycles of the National Health and Nutrition Examination Survey (NHANES) between 1999-2012 were used to examine temporal trends in both overall dietary patterns and individual foods and nutrients consumed by US adults overall and by age, sex, race/ethnicity, education level, and income level. To assess overall dietary patterns, we used the American Heart Association (AHA) 2020 Strategic Impact Goals, which focus on actionable, evidence-based priorities to improve cardiometabolic health.[8]

Methods

Data Source, Study Population, and Dietary Assessment

This investigation used data from US adults aged 20 years or older completing at least 1 valid 24-hour diet recall, as determined by National Center for Health Statistics (NCHS) criteria, during 7 cycles of NHANES from 1999-2000 through 2011-2012. The average response rate during these cycles was 73.6% (range: 78.3% in 2001-2002 to 67.4% in 2011-2012). All examined participants were eligible for dietary assessment, consisting of 1 or 2 dietary recalls in which respondents reported all foods and beverages consumed during the previous 24 hours (midnight to midnight).

The protocol and data collection methods are fully documented.[9] The NHANES interviewers and diet recall participants were monitored with established criteria to evaluate data acceptability. Dietary data from the first recall was used for individuals with a single recall and 2-day means for those with 2 recalls. Group means of either a single recall or multiple recalls provide unbiased estimates of population and stratum means.[10] Race/ethnicity was reported by participants using categories provided by the NCHS. NHANES was approved by the NCHS ethics review board, and all participants provided written informed consent.

AHA Diet Score

As a summary indicator, a diet score was constructed based on the AHA 2020 Strategic Impact Goals for diet, which have been associated with cardiovascular and metabolic outcomes in multiple populations.[11] The 5 primary dietary components were total consumption of fruits and vegetables, fish and shellfish, sodium, sugar-sweetened beverages, and whole grains (eTable 1 in the Supplement). The 3 secondary dietary components were nuts, seeds, and legumes; processed meat; and saturated fat. To best assess changes, a new continuous score was constructed by summing across all components (the eText provides more details). Based on the AHA 2020 Goals, the proportions of US adults with a poor diet (defined as a score of <20 [of 50 possible points] for the primary score or <40% adherence), an intermediate diet (score of 20-39.9 or 40%-79.9% adherence), or an ideal diet (score of ≥40 or ≥80% adherence) were estimated.

Food Groups and Nutrients

In addition to the AHA 2020 Goals, we evaluated individual foods and nutrients linked to major health outcomes as well as those of current policy or general public interest (eTable 2 in the Supplement provides examples and serving sizes).[12-21] The USDA Food Patterns Equivalents Database and the MyPyramid Equivalents Database,[22,23] which disaggregate mixed foods into their component parts, were used to measure changes in consumption of particular food groups. Food groups (eg, vegetables) were further disaggregated to elucidate within-category trends (eg, dark green vegetables vs potatoes). Nutrients were derived from cycle-specific versions of the USDA Food and Nutrient Database for Dietary Studies.[24] Intake of all dietary components was energy-adjusted using the residual method[10] to evaluate trends independent of the small declines in energy intake during this period,[25] which could relate to nondietary changes, such as physical activity, and to minimize measurement error in dietary estimates.[10]

Population Subgroups

To evaluate key population subgroups, findings were stratified by age group (20-34 years, 35-49 years, 50-64 years, ≥65 years), sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American), education level (<high school graduate, high school graduate or general equivalency diploma, some college, ≥college), and ratio of family income to the federal poverty level (<1.30, 1.30-1.84, 1.85-2.99, and ≥3.00). Trends in diet for the other Hispanic and the other race or mixed race group are not presented in the race/ethnicity-stratified results due to their small sample sizes. Race/ethnicity-specific results are presented for Mexican American individuals as opposed to all Hispanic individuals due to changes in participant sampling over time.

Statistical Analysis

The nationally representative population mean intake for dietary components in the AHA diet score and other individual foods and nutrients was estimated for each NHANES cycle. To calculate the AHA diet score and also place the results within the context of dietary recommendations, the proportion of US adults meeting specific cut points for the components of the AHA diet score was estimated. The proportion meeting the guideline recommendations for other foods and nutrients was estimated using the 2015 Dietary Guidelines for Americans and Dietary Reference Intakes.[11,21,26,27] These analyses of proportions used the established National Cancer Institute method to estimate the percentage of the population at a specified cut point (details appear in the Supplement).[28-30]

Because such methods are based not on stratum means but on distributions of dietary intake above or below a certain threshold, which are not comparable from single vs multiple diet recalls, the analyses of proportions and corresponding AHA diet scores were restricted to participants with 2 nonconsecutive 24-hour recalls (2003 onward). To account for the NHANES complex sampling design, first-day survey weights were used for the analyses of individual foods and nutrients, and 2-day survey weights were used for AHA diet scores.

The statistical significance of trends was assessed by treating survey year as a continuous variable in a survey-weighted linear regression model. To assess statistical heterogeneity of trends by subgroups, a survey-weighted Wald test was used to test for an interaction term between year and categorical variables (age, sex, race/ethnicity) or ordinal variables (income level, education level).

To assess whether observed trends were driven by demographic shifts, sensitivity analyses were adjusted for age and race/ethnicity within each cycle and statistically significant trend coefficients were evaluated before and after adjustment to quantify the percentage change in the coefficient. Stata version 13.1 (StataCorp) and SAS version 9.3 (SAS Institute Inc) were used for all statistical analyses. A 2-sided α level of .05 was used to assess significance. All trends described as increasing, decreasing, or with similar terminology were statistically significant ($P < .05$ for trend). No adjustments were made for multiple comparisons.

Results

Among 33 932 US adults, the average response rate was 73.6% (range: 78.3% in 2001-2002 to 67.4% in 2011-2012). This included 11 721 with a single dietary recall and 22 211 with 2 recalls. Over time, the proportion of older adults increased and the proportion of younger adults decreased (**Table 1**). The proportion of non-Hispanic white individuals slightly declined (70.6% in 1999-2000 to 66.6% in 2011-2012), whereas the percentage of some other races/ethnicities increased. Educational attainment also increased, with the proportion of adults having a college degree increasing from 21.7% in 1999-2000 to 31.0% in 2011-2012.

Trends in Diet

Trends for the AHA diet scores and other key foods and nutrients appear in **Table 2**, **Figure 1**, and **Table 3**. Diets improved overall based on the evaluation of both the primary and secondary AHA score. The mean primary AHA score increased from 19.0 in 2003-2004 to 21.2 in 2011-2012 (an improvement of 11.6%) and the mean secondary AHA score increased from 35.1 in 2003-2004 to 38.5 in 2011-2012 (an improvement of 9.7%). Based on the primary score, the estimated proportion of US adults with poor dietary quality (<40% adherence or <20 points) changed from 55.9% (95% CI, 51.5%-60.2%) in 2003-2004 to 45.6% (95% CI, 41.6%-49.7% in 2011-2012; $P < .001$ for trend); intermediate (40%-79.9% adherence or 20-39.9 points) from 43.5% (95% CI, 39.3%-47.8%) to 52.9% (95% CI, 48.9%-56.8%; $P < .001$ for trend); and ideal (≥80% adherence or ≥40 points) from 0.7% (95% CI, 0.5%-1.0%) to 1.5% (95% CI, 0.9%-2.4%; $P = .003$ for trend) (Table 3 and eFigure 1 in the Supplement).

Among the individual components of the diet score, the largest changes were found in consumption of sugar-sweetened beverages (between 1999-2000 and 2011-2012, −0.49 servings/d; 95% CI, −0.70 to −0.28 servings/d); whole grains (0.43 servings/d; 95% CI, 0.34 to 0.53 servings/d); and nuts, seeds, and legumes (0.26 servings/d; 95% CI, 0.18 to 0.34 servings/d). Intake of total fruits and vegetables did not significantly change. Intake of processed meat, saturated fat, and sodium also did not significantly change; however, consumption of fish and shellfish slightly increased.

Among subcomponents of these food groups (Table 2 and eFigures 2-4 in the Supplement), consumption of whole fruit increased by 0.15 servings/d (95% CI, 0.05 to 0.26 servings/d), whereas it decreased by 0.11 servings/d (95% CI, 0.04 to 0.18 servings/d) for 100% fruit juice. Consumption of white potatoes decreased by 0.07 servings/d (95% CI, 0.02 to 0.11 servings/d). After excluding starchy vegetables (eg, potatoes, corn, and peas), there was no significant change in vegetable consumption (0.10 servings/d; 95% CI, −0.02 to 0.23 servings/d). Declines in sugar-sweetened beverages were largely due to decreased intake of soda and, to a lesser extent, fruit drinks (eFigure 4). Intake of presweetened iced tea did not significantly change, whereas intake of sports and energy drinks increased.

In addition, legume consumption did not significantly change, whereas increases in nuts or seeds were attributable to increased consumption of tree nuts or seeds (0.16 servings/d; 95% CI, 0.12-0.20 servings/d) and peanut butter (0.06 servings/d; 95% CI, 0.04-0.09 servings/d). Increases in consumption of whole grains were largely driven by increases in whole-grain bread (0.24 servings/d; 95% CI, 0.19-0.29 servings/d) and other whole-grain foods such as pasta and crackers (0.11 servings/d; 95% CI, 0.09-0.13 servings/d).

Among foods and nutrients not included in the AHA diet score (eTable 3 in the Supplement), unprocessed red meat consumption was stable, whereas poultry slightly increased. Total dairy was stable, but with heterogeneity by subclass: milk decreased by 0.19 servings/d (95% CI, 0.11-0.28 servings/d), whereas cheese increased by 0.15 (95% CI, 0.09-0.20 servings/d) as well as yogurt by 0.03 servings/d (95% CI, 0.01-0.04 servings/d). Intake of added sugars decreased by 4.4 tsp/d (95% CI, 2.9-6.0 tsp/d).

Table 1. Participant Sociodemographics by NHANES Cycle, 1999-2012

	No. (%) [95% CI][a]						
	1999-2000 (n = 4237)	2001-2002 (n = 4744)	2003-2004 (n = 4448)	2005-2006 (n = 4520)	2007-2008 (n = 5420)	2009-2010 (n = 5762)	2011-2012 (n = 4801)
Age group, y							
20-34	1136 (32.0) [29.3-34.8]	1320 (29.6) [26.4-33.0]	1207 (29.5) [26.6-32.5]	1378 (27.8) [25.0-30.8]	1260 (27.7) [25.2-30.3]	1442 (27.9) [25.7-30.2]	1317 (27.7) [23.2-32.7]
35-49	1035 (31.3) [28.3-34.5]	1258 (33.1) [30.9-35.3]	1044 (28.8) [25.8-32.0]	1141 (30.1) [27.2-33.1]	1369 (30.1) [27.3-33.1]	1522 (28.9) [26.8-31.0]	1178 (26.6) [23.8-29.7]
50-64	929 (20.4) [18.3-22.6]	1011 (21.5) [18.9-24.3]	901 (24.0) [21.3-27.0]	953 (24.1) [21.9-26.5]	1395 (25.6) [23.3-28.1]	1419 (25.8) [23.9-27.9]	1274 (28.1) [25.6-30.8]
≥65	1137 (16.3) [14.9-17.8]	1155 (15.8) [13.9-17.9]	1296 (17.7) [16.4-18.9]	1048 (18.0) [15.0-21.3]	1396 (16.6) [15.1-18.1]	1379 (17.4) [15.7-19.2]	1032 (17.6) [15.4-20.0]
Sex							
Male	2259 (52.2) [49.7-54.6]	2494 (51.8) [50.6-53.0]	2313 (51.9) [50.1-53.7]	2357 (52.0) [50.3-53.6]	2758 (52.9) [51.5-54.3]	2973 (51.8) [50.5-53.2]	2407 (51.3) [49.1-53.5]
Female	1978 (47.8) [45.4-50.3]	2250 (48.2) [47.0-49.4]	2135 (48.1) [46.3-49.9]	2163 (48.0) [46.4-49.7]	2662 (47.1) [45.7-48.5]	2789 (48.2) [46.8-49.5]	2394 (48.7) [46.5-50.9]
Race/ethnicity							
Non-Hispanic white	1891 (70.6) [65.1-75.5]	2494 (72.1) [66.7-77.0]	2391 (73.0) [64.7-79.9]	2276 (72.7) [66.1-78.4]	2548 (70.2) [62.2-77.1]	2786 (68.7) [61.0-75.4]	1842 (66.6) [57.7-74.4]
Non-Hispanic black	792 (10.8) [7.7-14.9]	890 (10.9) [7.9-15.0]	867 (11.2) [7.8-15.9]	1012 (11.5) [7.8-16.5]	1136 (11.3) [7.8-16.0]	1025 (11.4) [9.6-13.5]	1274 (11.5) [7.4-17.3]
Mexican American	1146 (6.4) [4.0-10.0]	997 (7.2) [5.3-9.7]	882 (7.8) [4.4-13.5]	907 (8.0) [6.2-10.2]	930 (8.3) [5.7-12.1]	1062 (8.5) [5.0-14.1]	467 (8.0) [4.7-13.2]
Other Hispanic	275 (7.6) [3.6-15.5]	203 (5.6) [2.7-11.1]	134 (3.1) [2.0-4.8]	142 (2.7) [1.6-4.4]	595 (4.9) [3.0-8.0]	585 (5.1) [3.0-8.6]	465 (6.3) [3.9-9.9]
Other or mixed race	133 (4.7) [3.1-7.0]	160 (4.2) [3.0-5.8]	174 (5.0) [3.6-6.9]	183 (5.2) [4.1-6.5]	211 (5.3) [3.5-7.8]	304 (6.3) [4.6-8.6]	753 (7.7) [5.8-10.0]
Education level[b]							
<High school graduate	1633 (24.0) [21.3-26.9]	1421 (19.2) [17.1-21.5]	1288 (17.1) [14.4-20.2]	1234 (17.1) [14.4-20.2]	1665 (20.1) [17.0-23.7]	1634 (18.8) [16.7-21.1]	1102 (16.3) [12.9-20.4]
High school graduate or GED	957 (26.3) [22.7-30.2]	1110 (24.7) [23.0-26.5]	1111 (25.4) [22.9-28.0]	1093 (25.4) [22.9-28.0]	1341 (25.8) [23.1-28.8]	1316 (22.5) [20.2-24.9]	1008 (19.9) [16.6-23.7]
Some college	954 (28.1) [25.6-30.7]	1240 (29.3) [27.1-31.6]	1216 (31.2) [29.0-33.5]	1290 (31.2) [29.0-33.5]	1398 (29.4) [27.6-31.3]	1624 (31.2) [29.3-33.1]	1463 (32.7) [29.1-36.6]
≥College	679 (21.7) [16.8-27.5]	967 (26.8) [23.6-30.2]	827 (26.3) [21.9-31.4]	901 (26.3) [21.9-31.4]	1012 (24.7) [20.4-29.5]	1175 (27.6) [25.1-30.2]	1225 (31.0) [25.8-36.8]
Ratio of family income to poverty level[b,c]							
<1.30[d]	1106 (23.4) [18.3-29.4]	1190 (21.3) [18.8-24.1]	1209 (21.4) [17.2-26.3]	1115 (17.4) [15.1-19.9]	1498 (21.4) [17.6-25.7]	1746 (22.2) [19.8-24.8]	1564 (25.1) [21.0-29.8]
1.30-1.849	516 (11.6) [9.5-14.0]	572 (10.5) [8.9-12.3]	570 (10.0) [9.1-11.0]	540 (9.4) [7.9-11.2]	699 (11.4) [10.0-13.1]	702 (10.7) [9.4-12.2]	594 (10.6) [8.9-12.5]
1.85-2.99	664 (17.4) [14.6-20.5]	840 (17.6) [15.5-19.9]	830 (19.6) [18.0-21.3]	838 (19.7) [17.2-22.6]	986 (18.2) [15.3-21.6]	923 (16.9) [15.2-18.7]	702 (17.5) [15.0-20.5]
≥3.00[e]	1354 (47.6) [40.7-54.6]	1827 (50.6) [46.5-54.6]	1602 (49.0) [44.2-53.8]	1832 (53.5) [49.2-57.7]	1752 (49.0) [42.7-55.3]	1857 (50.2) [47.6-52.8]	1574 (46.8) [40.4-53.2]

Abbreviation: GED, general equivalency diploma; NHANES, National Health and Nutrition Examination Survey.

[a] The percentages were weighted.

[b] The numbers may not sum to the total number of participants due to missing data.

[c] Represents the ratio of family income to the federal poverty threshold, adjusting for household size. For reference, the federal threshold in 2012 for a family of 4 was $23 492/y. A family of 4 earning $42 460/y would have a ratio of 1.85.

[d] Indicates a lower level of income.

[e] Indicates a higher level of income.

Table 2. Mean Consumption of Key Dietary Components Among US Adults Aged 20 Years or Older by NHANES Survey Cycle, 1999-2012

	Survey-Weighted Mean (95% CI)[a]								
	1999-2000 (n = 4237)	2001-2002 (n = 4744)	2003-2004 (n = 4448)	2005-2006 (n = 4520)	2007-2008 (n = 5420)	2009-2010 (n = 5762)	2011-2012 (n = 4801)	*P* Value for Trend	Mean Change From 1999-2000 to 2011-2012 (95% CI)[b]
AHA Primary Component Goals[c]									
Primary total diet score			19.0 (18.1 to 20.0)	19.9 (19.2 to 20.6)	19.5 (18.7 to 20.3)	20.9 (20.5 to 21.4)	21.2 (20.4 to 21.9)	<.001	2.1 (0.9 to 3.4)
Fruits and vegetables, servings/d	2.3 (2.1 to 2.5)	2.4 (2.2 to 2.5)	2.3 (2.2 to 2.5)	2.3 (2.2 to 2.5)	2.3 (2.2 to 2.5)	2.4 (2.4 to 2.5)	2.4 (2.3 to 2.6)	.27	0.13 (−0.12 to 0.38)
Whole grains, servings/d	0.56 (0.51 to 0.62)	0.71 (0.66 to 0.77)	0.66 (0.60 to 0.72)	0.76 (0.71 to 0.82)	0.75 (0.68 to 0.82)	0.90 (0.85 to 0.94)	1.00 (0.93 to 1.07)	<.001	0.43 (0.34 to 0.53)
Fish and shellfish, servings/d	0.16 (0.14 to 0.18)	0.15 (0.13 to 0.17)	0.16 (0.14 to 0.18)	0.18 (0.16 to 0.21)	0.16 (0.15 to 0.18)	0.19 (0.17 to 0.21)	0.19 (0.16 to 0.22)	.02	0.03 (−0.01 to 0.06)
Sugar-sweetened beverages, servings/d	1.73 (1.55 to 1.91)	1.64 (1.50 to 1.79)	1.59 (1.41 to 1.76)	1.40 (1.27 to 1.53)	1.42 (1.24 to 1.60)	1.26 (1.19 to 1.34)	1.24 (1.13 to 1.35)	<.001	−0.49 (−0.70 to −0.28)
Sodium, mg/d	3424 (3359 to 3489)	3355 (3305 to 3406)	3454 (3401 to 3506)	3557 (3491 to 3624)	3531 (3485 to 3576)	3483 (3440 to 3526)	3445 (3417 to 3474)	.005	21.2 (−49.9 to 92.4)
AHA Secondary Component Goals[c]									
Secondary total diet score			35.1 (33.9 to 36.4)	35.8 (34.7 to 36.8)	35.8 (34.6 to 37.1)	37.6 (36.9 to 38.4)	38.5 (37.4 to 39.5)	<.001	3.3 (1.7 to 5.0)
Nuts, seeds, and legumes, servings/d	0.49 (0.43 to 0.54)	0.53 (0.46 to 0.60)	0.58 (0.52 to 0.64)	0.63 (0.58 to 0.68)	0.60 (0.53 to 0.67)	0.66 (0.62 to 0.71)	0.75 (0.68 to 0.81)	<.001	0.25 (0.18 to 0.34)
Processed meat, servings/d	0.26 (0.23 to 0.29)	0.27 (0.25 to 0.28)	0.28 (0.25 to 0.30)	0.28 (0.26 to 0.31)	0.28 (0.26 to 0.30)	0.28 (0.26 to 0.30)	0.28 (0.26 to 0.29)	.22	0.02 (−0.02 to 0.05)
Saturated fat, % of energy	10.9 (10.6 to 11.2)	10.6 (10.4 to 10.7)	11.2 (10.9 to 11.4)	11.2 (11.1 to 11.4)	11.0 (10.9 to 11.2)	10.7 (10.6 to 10.9)	10.7 (10.5 to 10.9)	.39	−0.20 (−0.6 to 0.1)
Subcategories of AHA Diet Score Components									
Total fruit, servings/d	0.99 (0.86 to 1.12)	1.07 (0.97 to 1.16)	0.99 (0.89 to 1.10)	0.99 (0.93 to 1.05)	1.00 (0.91 to 1.09)	1.08 (1.05 to 1.12)	1.05 (0.97 to 1.12)	.39	0.06 (−0.09 to 0.20)
Whole fruit	0.59 (0.51 to 0.67)	0.63 (0.58 to 0.68)	0.62 (0.55 to 0.69)	0.64 (0.59 to 0.70)	0.70 (0.64 to 0.76)	0.76 (0.74 to 0.79)	0.74 (0.68 to 0.81)	<.001	0.15 (0.05 to 0.26)
100% fruit juice	0.43 (0.37 to 0.48)	0.42 (0.38 to 0.47)	0.39 (0.34 to 0.44)	0.38 (0.34 to 0.43)	0.33 (0.30 to 0.37)	0.34 (0.31 to 0.37)	0.32 (0.27 to 0.36)	<.001	−0.11 (−0.18 to −0.04)
Total vegetables, servings/d	1.61 (1.54 to 1.68)	1.59 (1.52 to 1.66)	1.62 (1.58 to 1.66)	1.63 (1.55 to 1.71)	1.61 (1.57 to 1.66)	1.62 (1.57 to 1.67)	1.63 (1.55 to 1.71)	.53	0.02 (−0.08 to 0.13)
Dark green	0.12 (0.09 to 0.15)	0.12 (0.10 to 0.14)	0.11 (0.10 to 0.12)	0.14 (0.12 to 0.16)	0.13 (0.11 to 0.15)	0.14 (0.13 to 0.16)	0.16 (0.13 to 0.18)	.005	0.04 (0.01 to 0.08)
Tomatoes	0.30 (0.27 to 0.33)	0.34 (0.31 to 0.37)	0.36 (0.32 to 0.39)	0.32 (0.30 to 0.34)	0.31 (0.30 to 0.33)	0.30 (0.27 to 0.32)	0.30 (0.29 to 0.32)	.10	0.01 (−0.03 to 0.04)
Other red or orange	0.09 (0.07 to 0.10)	0.08 (0.07 to 0.10)	0.07 (0.07 to 0.08)	0.08 (0.08 to 0.09)	0.09 (0.07 to 0.10)	0.10 (0.09 to 0.11)	0.11 (0.10 to 0.12)	<.001	0.02 (0.01 to 0.04)
White potatoes	0.39 (0.35 to 0.43)	0.37 (0.35 to 0.39)	0.39 (0.36 to 0.42)	0.35 (0.32 to 0.39)	0.36 (0.33 to 0.40)	0.35 (0.34 to 0.37)	0.32 (0.30 to 0.34)	.002	−0.07 (−0.11 to −0.02)
Other starchy (eg, peas, corn)	0.10 (0.08 to 0.11)	0.10 (0.09 to 0.10)	0.08 (0.07 to 0.09)	0.09 (0.08 to 0.11)	0.09 (0.08 to 0.10)	0.09 (0.08 to 0.10)	0.09 (0.07 to 0.10)	.32	−0.01 (−0.03 to 0.01)
Other	0.60 (0.55 to 0.66)	0.58 (0.53 to 0.62)	0.60 (0.58 to 0.62)	0.61 (0.57 to 0.65)	0.58 (0.55 to 0.62)	0.60 (0.57 to 0.63)	0.62 (0.57 to 0.68)	.44	0.02 (−0.06 to 0.10)
Excluding potatoes and other starchy	1.12 (1.03 to 1.22)	1.13 (1.06 to 1.19)	1.16 (1.10 to 1.21)	1.18 (1.11 to 1.26)	1.16 (1.10 to 1.22)	1.18 (1.13 to 1.22)	1.22 (1.14 to 1.31)	.06	0.10 (−0.02 to 0.23)
Nuts and seeds, servings /d	0.43 (0.38 to 0.49)	0.48 (0.41 to 0.55)	0.53 (0.47 to 0.59)	0.58 (0.53 to 0.63)	0.55 (0.48 to 0.62)	0.61 (0.56 to 0.66)	0.69 (0.62 to 0.76)	<.001	0.25 (0.17 to 0.34)
Legumes, servings/d	0.11 (0.09 to 0.13)	0.11 (0.09 to 0.12)	0.09 (0.08 to 0.11)	0.10 (0.08 to 0.11)	0.11 (0.09 to 0.12)	0.11 (0.09 to 0.12)	0.12 (0.10 to 0.14)	.28	0.01 (−0.02 to 0.03)

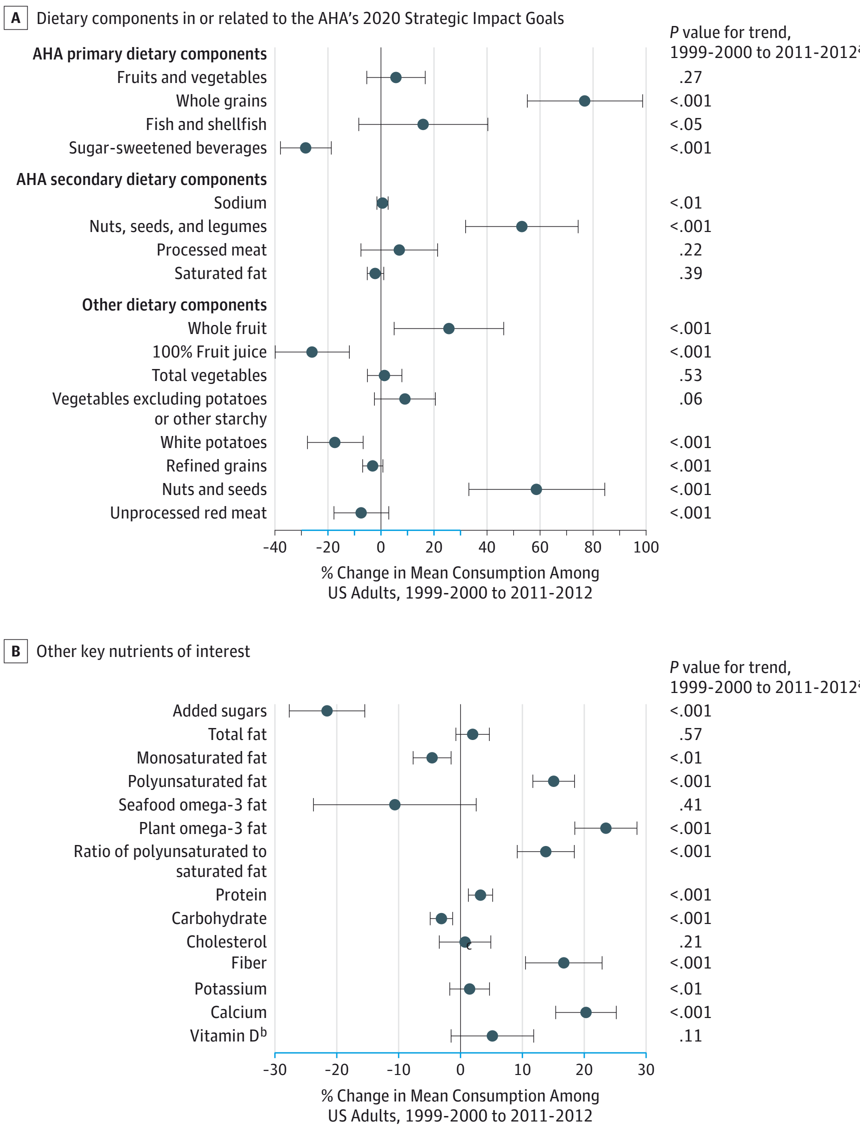
Abbreviations: AHA, American Heart Association; NHANES, National Health and Nutrition Examination Survey.

[a] The majority of means were adjusted for energy to 2000 kcal/d using the residual method. The means for saturated fat were adjusted as a percentage of total energy. eTable 2 in the Supplement provides serving sizes and eTable 3 provides additional data.

[b] For the primary and secondary total diet scores only, the mean change is from 2003-2004 to 2011-2012.

[c] Based on the AHA 2020 Strategic Impact Goals. Intake of each dietary component was scored from 0 to 10 (beneficial components) and from 10 to 0 (harmful components). eTable 1 and eTable 2 in the Supplement provide details. Components were summed to calculate the primary AHA total diet score (range, 0-50). Components were further summed to calculate the secondary AHA total diet score (range, 0-80).

Figure 1. Changes in Mean Consumption Among US Adults of Dietary Components Based on NHANES Data From 1999-2000 to 2011-2012



Data markers indicate the percentage change in average population dietary intake from 1999-2000 to 2011-2012 and the error bars represent the corresponding 95% CIs. In some cases, the 95% CIs may overlap with zero even though the *P* value for trend is statistically significant because the 95% CIs are based on only 1999-2000 vs 2011-2012 data, whereas the *P* values for trend are based on all observed data across 7 National Health and Nutrition Examination Survey (NHANES) cycles. The x-axis scale shown in blue indicates the range of the percent change from −30% to 30%. The analyses are based on energy-adjusted values to 2000 kcal/d using the residual method. AHA indicates the American Heart Association.

[a] The *P* values are across the 7 NHANES cycles.

[b] The percentage change is from 2005-2006 to 2011-2012 because vitamin D data were not available previously.

Intake of polyunsaturated fat increased by 1.1% of energy (95% CI, 0.9%-1.3% of energy), whereas monounsaturated fat intake declined by 1.5% of energy (95% CI, 0.4%-2.7% of energy). Protein intake increased by 0.5% of energy (95% CI, 0.2%-0.8% of energy), whereas carbohydrate intake decreased by 1.6% of energy (95% CI, 0.7%-2.5% of energy). There was no significant trend for intake of seafood omega-3 fat; however, intake of plant omega-3 fat increased by 23.4 mg/d (95% CI, 18.4-28.3 mg/d). Increased intake was also observed for dietary fiber (2.5 g/d; 95% CI, 1.7-3.3 g/d) and calcium (158 mg/d; 95% CI, 123-193 mg/d). Similar to sodium, intake of potassium varied modestly during these years but was relatively unchanged overall comparing 1999-2000 with 2011-2012.

Estimated Proportions of US Adults Meeting Recommendations

Trends in the estimated proportion of US adults meeting recommended cut points for foods and nutrients also were evaluated (**Figure 2**). No significant change was observed for the estimated percentage of US adults consuming the recommended amounts of total fruits and vegetables, processed meat, or sodium. Significant increases were observed for US adults meeting the recommended cut points for whole grains; fish and shellfish; sugar-sweetened beverages; nuts, seeds, and legumes; and saturated fat. The proportion of adults meeting the recommended intake for added sugars and fiber also increased.

Sensitivity Analyses Adjusting for Demographic Changes

The findings for most dietary components were not materially altered by adjustment for changes in age and racial/ethnic composition over time (eTable 4 in the Supplement). One exception was fish and shellfish, in which the observed increased intake was partly attenuated (by 24%) after accounting for demographic changes. For a few foods, the observed

Table 3. Dietary Components and Trends in Dietary Components of the American Heart Association (AHA) 2020 Strategic Impact Goals Among US Adults Aged 20 Years or Older, 2003-2012

	Dietary Consumption		Weighted Mean Score (95% CI)[a]					
	AHA Intake Target (Range)	Maximum Points	2003-2004 (n = 4118)	2005-2006 (n = 4064)	2007-2008 (n = 4682)	2009-2010 (n = 5037)	2011-2012 (n = 4309)	*P* Value for Trend
AHA Primary Diet Score								
Primary total diet score		50[b]	19.0 (18.1-20.0)	19.9 (19.2-20.6)	19.5 (18.7-20.3)	20.9 (20.5-21.4)	21.2 (20.4-21.9)	<.001
Fruits and vegetables[c]	≥4.5 c/d (0-≥4.5 c/d)	10	4.9 (4.7-5.2)	5.0 (4.8-5.2)	4.9 (4.7-5.1)	5.1 (5.0-5.2)	5.1 (4.9-5.3)	.31
Whole grains	≥3-oz equivalents/d (0- to ≥3-oz equivalents/d)	10	2.1 (1.9-2.3)	2.4 (2.3-2.6)	2.4 (2.2-2.6)	2.8 (2.7-2.9)	3.1 (2.9-3.3)	<.001
Fish and shellfish	≥2 oz/d (0-≥2 oz/d)	10	2.5 (2.2-2.8)	2.6 (2.4-2.8)	2.5 (2.2-2.7)	2.8 (2.4-3.1)	2.5 (2.2-2.8)	.84
Sugar-sweetened beverages	≤36 fl oz/wk (≤36->16 fl oz/wk)	10	5.6 (5.2-6.1)	6.3 (6.0-6.6)	6.2 (5.9-6.5)	6.6 (6.4-6.8)	6.7 (6.4-7.0)	<.001
Sodium	≤1500 mg/d (≤1500->4500 mg/d)	10	3.8 (3.6-3.9)	3.5 (3.4-3.6)	3.5 (3.4-3.6)	3.6 (3.5-3.8)	3.8 (3.7-3.9)	.35
AHA Secondary Diet Score								
Secondary total diet score		80[b]	35.1 (33.9-36.4)	35.8 (34.7-36.8)	35.8 (34.6-37.1)	37.6 (36.9-38.4)	38.5 (37.4-39.5)	<.001
Nuts, seeds, and legumes	≥4 servings/wk (0-≥4 servings/wk)	10	4.4 (4.2-4.6)	4.5 (4.2-4.8)	4.6 (4.2-5.0)	4.6 (4.4-4.9)	5.1 (4.9-5.3)	<.001
Processed meat	≤0.5 oz/d (≤0.5->1.76 oz/d)	10	6.8 (6.6-6.9)	6.5 (6.1-6.8)	6.7 (6.5-6.9)	6.6 (6.4-6.9)	6.7 (6.4-6.9)	.99
Saturated fat	≤7% (≤7%->15%)	10	5.0 (4.7-5.2)	4.9 (4.7-5.0)	5.1 (4.9-5.3)	5.4 (5.2-5.6)	5.5 (5.3-5.7)	<.001
Diet Quality by Primary and Secondary Scores			**Weighted % (95% CI)**					
Primary score[d]		50						
Poor		<20	55.9 (51.5-60.2)	52.3 (48.2-56.4)	53.9 (49.9-57.9)	47.9 (45.4-50.4)	45.6 (41.6-49.7)	<.001
Intermediate		39.9	43.5 (39.3-47.8)	47.0 (43.2-50.8)	45.3 (41.5-49.1)	50.6 (47.9-53.4)	52.9 (48.9-56.8)	<.001
Ideal		≥40	0.7 (0.5-1.0)	0.7 (0.4-1.3)	0.8 (0.4-1.6)	1.4 (1.0-2.1)	1.5 (0.9-2.4)	.003
Secondary score[d]		80						
Poor		<32	41.5 (37.5-45.7)	40.7 (36.9-44.7)	39.4 (34.8-44.2)	35.2 (32.6-37.9)	31.8 (29.4-34.4)	<.001
Intermediate		63.9	57.3 (53.2-61.2)	57.8 (53.9-61.6)	59.3 (54.6-63.8)	62.7 (60.1-65.3)	66.1 (63.8-68.4)	<.001
Ideal		≥64	1.2 (0.8-1.9)	1.5 (0.9-2.3)	1.3 (0.9-2.0)	2.1 (1.5-2.9)	2.0 (1.4-3.0)	.04

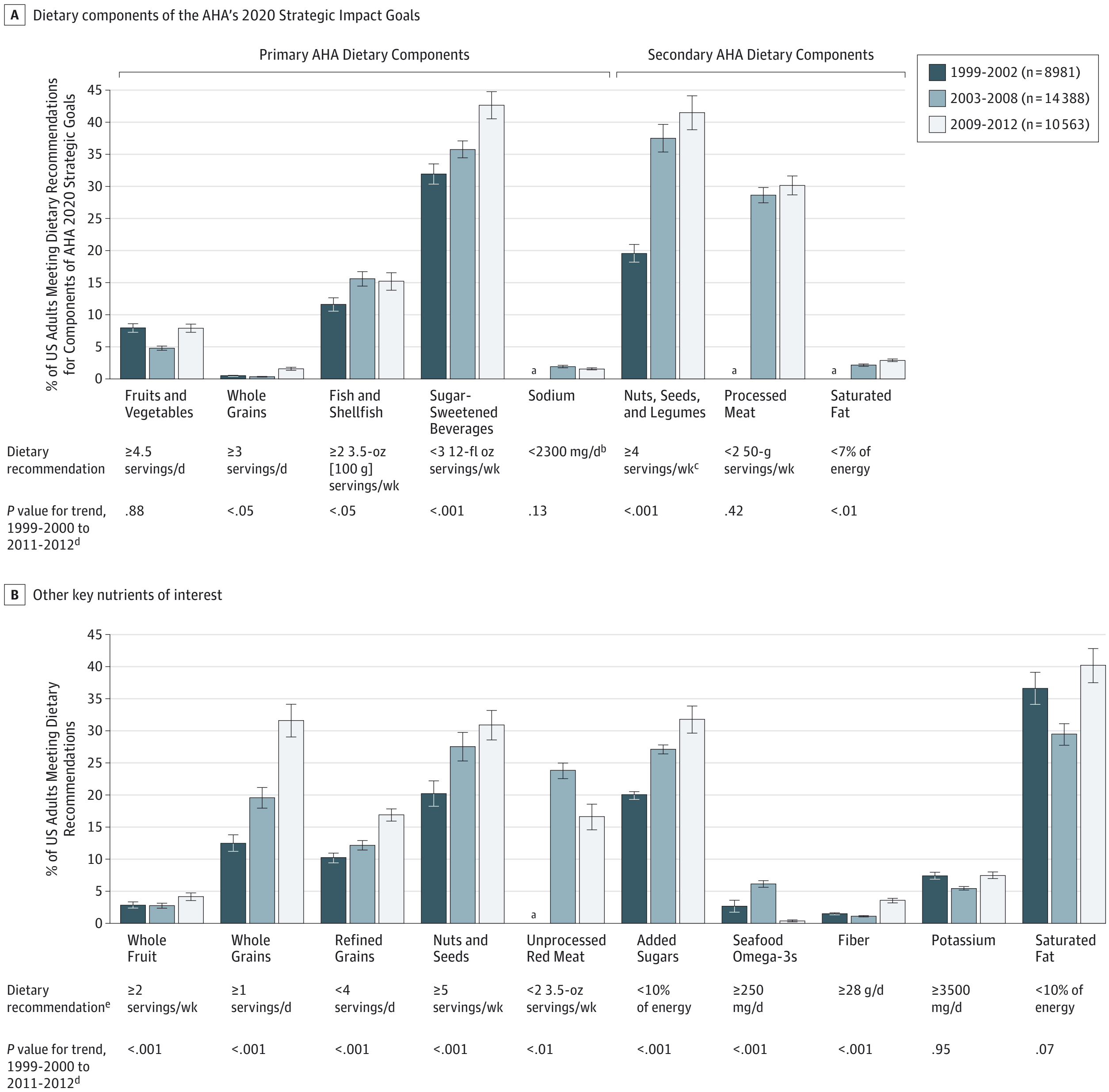
[a] All dietary variables were adjusted for energy to 2000 kcal/d using the residual method prior to analysis. Each AHA consumption target was evaluated based on a continuous scoring system. Intake of each dietary component was scored from 0 to 10 (beneficial components) and from 10 to 0 (harmful components). For beneficial dietary components, individuals with zero intake received the lowest score (0). For harmful dietary components, the lowest score (0) was assigned to a higher level approximately equivalent to the 80th to 90th percentile of intake among US adults and rounded to a practical value (eg, 4500 mg/d of sodium, one 50-g serving/d of processed meat, two 8-oz servings/d of sugar-sweetened beverages, and 15% energy of saturated fat). Intermediate dietary intake was scored linearly between 0 and 10. For example, an adult consuming 3000 mg/d of sodium would receive 5 sodium points (ie, his or her sodium consumption was halfway between 1500 mg/d and the maximum value of 4500 mg/d).

[b] The primary total diet score is the sum of the scores for the 5 dietary components included in the primary score. The secondary total diet score is the sum of the scores for all 8 components included in the primary and secondary scores.

[c] According to the AHA 2020 Goals, up to 3 c/wk (0.42 c/d) of starchy vegetables (eg, potatoes, peas, corn) could be included; this maximum was incorporated into the analysis, with higher intake not contributing toward the score. Consumption of 100% fruit juice could also be included; however, its contribution was not capped in the original AHA 2020 Goals and not in our score. Some organizations recommend no more than 1 serving/d of 100% fruit juice.

[d] For each continuous score, cut points were defined to correspond to the AHA binary dietary component scoring system. Poor was defined as being less than 40% adherent (<20 points for primary and <32 points for secondary). Intermediate was defined as adherence of 40% to 79.9% (20-39.9 points for primary and 32-63.9 points for secondary). Ideal was defined as 80% adherence or greater (≥40 points for primary and ≥64 points for secondary).[8]

Figure 2. Trends in the Proportion of US Adults Meeting Dietary Recommendations Based on NHANES Data From 1999 to 2012



The analyses are based on energy-adjusted values to 2000 kcal/d using the residual method. The error bars represent the corresponding 95% CIs. AHA indicates the American Heart Association; NHANES, National Health and Nutrition Examination Survey.

[a] The 1999-2002 estimates could not be reliably imputed using the National Cancer Institute method (details appear in the Supplement).

[b] The recommendation is based on the 2015 Dietary Guidelines for Americans due to too few individuals meeting the AHA target of 1500 mg/d.

[c] Serving sizes are 1-oz equivalent for nuts and seeds and ½ c for legumes.

[d] The *P* values are across the 3 pooled NHANES cycles (1999-2002, 2003-2008, and 2009-2012).

[e] Based on the Dietary Guidelines for Americans Dietary Reference Values, the Global Burden of Diseases Study, and other alternative cutoffs.

trends were strengthened after adjustment for demographic changes; examples include total dairy (increase of 38.1%) and cheese (increase of 17.5%).

Disparities in Trends According to Population Subgroups

Trends for the AHA diet scores by age, sex, race/ethnicity, education level, and income level appear in eTable 5 in the Supplement. Significant increases were observed among all ages and both sexes, but with persistent comparative differences by age, with older ages having healthier diets. By race/ethnicity, dietary improvements were most notable among non-Hispanic white adults (*P* < .001 for trend), with more modest improvements among non-Hispanic black adults (*P* = .05 for trend) and no significant change among Mexican American adults (*P* = .30

for trend). Even though diet scores tended to improve across all income and education levels, disparities present in earlier years widened over time (ie, smaller overall improvements were seen in those with lower levels of family income [*P* = .03 for interaction] and lower education levels [*P* = .03 for interaction]).

In the evaluation of the estimated proportions of US adults with poor, intermediate, or ideal diet scores, improvements were seen in each population subgroup, but with differences in disparities over time (**Table 4** and eTable 6 in the Supplement). For example, among 20- to 34-year-olds, the proportion with intermediate diets (40%-79.9% adherence or 20-39.9 points) increased from 29.2% in 2003-2004 to 42.9% in 2011-2012. Among adults aged 65 years or older, the corresponding change was 63.6% to 68.4%, reflecting smaller relative improvements but still higher diet scores in 2011-2012. Similar findings were seen by sex, race/ethnicity, and education level. In contrast, disparities by income worsened over time (*P* = .046 for interaction), with larger relative and absolute improvements among US adults with higher vs lower levels of income.

Trends in individual food groups and nutrients by age, sex, race/ethnicity, education level, and income level appear in eTables 7-11 and eFigures 5-6 in the Supplement. Among the individual components of the diet scores, certain disparities in trends over time were identified. For instance, increases in nuts and seeds were highly dependent on education (*P* < .001 for interaction); among those with less than a high school education, there was no significant change, whereas among those with a higher level of education, there were progressively larger increases. These disparities were also present by income level (eTable 11). Trends in consumption of whole fruit and 100% fruit juice varied by income level (*P* < .05 for interaction for each). The largest increases in intake of whole fruit and declines in 100% fruit juice were found among those with higher incomes.

For many other foods and nutrients, trends over time were generally similar by age, race/ethnicity, education level, and income level, including for total vegetables, whole grains, unprocessed red meat, and milk (eTables 7-11 in the Supplement). For total vegetables, whole grains, unprocessed red meat, and milk, consumption remained higher over time among adults with higher vs lower socioeconomic status and among non-Hispanic white adults vs non-Hispanic black or Mexican American adults.

For other components, heterogeneity in trends was observed. Refined grain consumption decreased by 0.33 servings/d among non-Hispanic white adults and by 0.28 servings/d among non-Hispanic black adults, but increased by 0.76 servings/d among Mexican American adults (*P* < .001 for interaction; eFigures 5-6 and eTable 9 in the Supplement). Sodium intake did not significantly change among non-Hispanic white adults, but increased among non-Hispanic black adults and especially Mexican American adults (*P* = .01 for interaction). Seafood omega-3 fat consumption did not significantly change among non-Hispanic white and Mexican American adults, but decreased among non-Hispanic black adults (*P* < .001 for interaction). Intake of white potatoes decreased among non-Hispanic white and Mexican American adults, but increased among non-Hispanic black adults (*P* = .002 for interaction).

Discussion

Based on nationally representative self-reported dietary data collected between 1999-2000 and 2011-2012, many aspects of the US diet improved. Evaluating a summary AHA continuous diet score, the mean score improved by 11.6%, the estimated proportion of US adults with poor quality diets decreased from 55.9% to 45.6%, and the proportion with intermediate quality diets increased from 43.5% to 52.9%. The percentage with ideal diets increased but remained low (0.7% to 1.5%). For the primary AHA diet score, these changes were largely attributable to increased consumption of whole grains and declining consumption of sugar-sweetened beverages. For the secondary AHA diet score, further improvements were attributable to increased intake of nuts, seeds, and legumes (due to increases in nuts and seeds but not legumes). No significant change was observed for consumption of total fruits and vegetables, processed meat, or sodium.

Other noteworthy changes included increased consumption of whole fruit and yogurt and decreased consumption of white potatoes, refined grains, and 100% fruit juice. Consistent with these trends, US adults increased intake of dietary fiber, calcium, protein, total polyunsaturated fat, and plant omega-3 fat, while reducing intake of added sugars and total carbohydrate. In comparison, changes in consumption of unprocessed red meat and legumes were not evident. To the best of our knowledge, these findings represent the most comprehensive evaluation of contemporary trends in multiple relevant dietary habits among US adults.

Despite observed improvements, small percentages of the sample of US adults reported attaining recommended levels of most dietary components according to AHA 2020 or the US Dietary Guidelines. For example, by 2011-2012, only 7.9% reported consuming recommended amounts of total fruits and vegetables; 11.6% for fish and shellfish; 11.6% for total nuts, seeds, and legumes; and 1.6% for whole grains. Only 1.6% consumed less than 2300 mg/d of sodium and the proportion consuming less than 1500 mg/d could not be reliably estimated. In comparison, with recent national declines in sugar-sweetened beverages, 43% of adults were at or below recommended levels of consumption.

Estimation of the effect of these dietary changes on health, in particular chronic diseases, was beyond the scope of this investigation. With some key exceptions (eg, polyunsaturated fats, *trans* fats, sodium, potassium), the evidence linking isolated nutrients to chronic disease outcomes is relatively weak. In comparison, the evidence linking certain foods and food-based diet patterns to chronic disease outcomes is more robust, with supportive and consistent evidence from not only prospective cohort studies, but also trials of physiological risk factors, trials of body weight, and trials of clinical disease outcomes.[31] Ecologically, the dietary improvements documented herein coincide with continued nationwide reductions, unrelated to drug treatment, in levels of high blood pressure, dyslipidemia, and cardiovascular mortality[11,32] as well as the potential plateauing of obesity. Our findings suggest that modest dietary changes, across the entire population, may be

Table 4. Trends in Percentage of Population With Poor or Intermediate Diet Based on Primary American Heart Association (AHA) Continuous Diet Score by Age Group, Sex, Race/Ethnicity, Education Level, and Family Income, 2003-2012

	AHA Primary Diet Score, Weighted % (95% CI)[a]						
	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	*P* Value for Trend	*P* Value for Interaction
Poor Diet[b]							
Age group, y							
20-34	70.8 (62.4-78.0)	66.1 (58.8-72.7)	69.2 (65.0-73.1)	62.0 (56.2-67.5)	56.4 (49.6-62.9)	.006	.55
35-49	59.2 (54.1-64.1)	56.1 (49.7-62.4)	59.3 (52.8-65.6)	51.9 (48.8-55.0)	52.1 (45.4-58.7)	.046	
50-64	48.7 (43.8-53.7)	44.9 (39.1-51.0)	43.1 (36.8-49.6)	39.6 (36.0-43.2)	39.1 (34.2-44.2)	.003	
≥65	34.7 (30.4-39.3)	34.8 (31.4-38.4)	35.7 (32.1-39.5)	31.0 (27.4-34.7)	29.3 (23.9-35.4)	.06	
Sex							
Male	57.5 (53.1-61.8)	57.2 (52.8-61.5)	58.6 (53.5-63.5)	51.7 (48.0-55.4)	49.3 (44.7-54.0)	.002	.38
Female	54.4 (49.4-59.2)	47.9 (43.1-52.7)	49.9 (45.8-54.0)	44.4 (42.2-46.7)	42.2 (37.3-47.1)	<.001	
Race/ethnicity							
Non-Hispanic white	53.9 (47.8-59.8)	49.1 (44.5-53.7)	51.3 (45.2-57.3)	45.3 (42.0-48.7)	42.8 (38.0-47.9)	.003	.90
Non-Hispanic black	64.7 (58.9-70.1)	64.2 (56.2-71.5)	67.7 (62.5-72.5)	60.5 (55.3-65.5)	57.7 (48.8-66.1)	.12	
Mexican American	66.0 (56.3-74.4)	61.9 (56.5-66.9)	60.9 (56.0-65.6)	55.4 (50.5-60.3)	58.9 (50.0-67.2)	.13	
Education level							
<High school graduate	63.1 (59.8-66.2)	62.9 (57.7-67.9)	67.1 (64.1-70.0)	57.5 (53.4-61.5)	57.6 (54.3-60.9)	.005	.65
High school graduate or GED	63.4 (58.0-68.5)	60.0 (55.3-64.6)	61.6 (58.3-64.8)	59.2 (53.6-64.6)	52.8 (46.5-59.1)	.02	
Some college	56.6 (51.7-61.4)	52.6 (45.5-59.6)	53.0 (48.4-57.6)	49.2 (45.6-52.7)	47.4 (40.6-54.4)	.03	
≥College	41.6 (36.1-47.4)	38.0 (32.8-43.5)	37.4 (30.7-44.7)	31.8 (26.4-37.8)	33.3 (25.6-42)	.06	
Ratio of family income to poverty level[c]							
<1.30	67.8 (62.7-72.5)	62.6 (56.7-68.2)	68.0 (62.8-72.8)	60.5 (56.1-64.6)	60.6 (56.2-64.9)	.03	.04
1.30-1.849	55.1 (44.0-65.6)	57.4 (52.1-62.6)	54.6 (48.8-60.3)	57.1 (51.0-63.1)	49.7 (40.3-59.1)	.46	
1.85-2.99	56.0 (49.6-62.3)	55.1 (49.1-61.0)	55.6 (49.9-61.2)	51.2 (45.5-56.8)	48.6 (42.2-54.9)	.06	
≥3.00	50.5 (46.0-55.1)	47.1 (42.2-52.1)	47.9 (42.4-53.5)	39.8 (36.2-43.6)	35.7 (29.8-41.9)	<.001	
Intermediate Diet[d]							
Age group, y							
20-34	29.2 (22.0-37.6)	33.9 (27.3-41.1)	30.5 (26.5-34.8)	37.2 (31.9-42.8)	42.9 (36.5-49.6)	.008	.51
35-49	40.3 (35.4-45.5)	43.2 (37.3-49.3)	39.3 (33.3-45.8)	47.0 (44.0-50.0)	46.0 (39.8-52.3)	.09	
50-64	50.3 (45.7-55.0)	54.5 (48.6-60.2)	56.3 (50.0-62.5)	58.2 (53.7-62.5)	59.5 (54.3-64.5)	.008	
≥65	63.6 (59.3-67.8)	63.1 (60.1-66.0)	63.1 (59.6-66.4)	67.3 (63.5-70.8)	68.4 (62.5-73.8)	.07	
Sex							
Male	42.0 (37.7-46.4)	42.3 (38.3-46.5)	41.1 (36.2-46.2)	46.3 (42.2-50.5)	49.0 (44.4-53.6)	.01	.22
Female	44.8 (40.2-49.5)	51.1 (46.6-55.6)	48.8 (45.2-52.5)	54.6 (52.3-56.9)	56.5 (51.5-61.3)	.001	
Race/ethnicity							
Non-Hispanic white	45.4 (39.6-51.4)	50.1 (45.7-54.5)	47.7 (42.0-53.4)	53.0 (49.4-56.6)	55.7 (50.8-60.5)	.006	.91
Non-Hispanic black	34.8 (29.6-40.4)	35.4 (28.5-42.9)	31.7 (27.2-36.5)	38.5 (33.5-43.8)	41.0 (33.3-49.2)	.14	
Mexican American	33.6 (25.3-43.1)	37.9 (32.9-43.2)	39.1 (34.4-44.0)	43.8 (38.6-49.2)	40.5 (32.2-49.4)	.14	
Education level							
<High school graduate	36.7 (33.6-39.9)	36.9 (31.9-42.1)	32.6 (29.7-35.6)	42.1 (38.0-46.4)	41.5 (38.4-44.7)	.009	.83
High school graduate or GED	36.2 (31.0-41.6)	39.3 (35.0-43.7)	38.2 (34.8-41.6)	39.6 (34.5-44.9)	46.4 (39.7-53.2)	.03	
Some college	42.7 (38.1-47.4)	47.1 (40.1-54.2)	45.5 (41.0-50.1)	50.1 (46.6-53.6)	51.1 (44.3-58.0)	.04	
≥College	57.2 (51.3-62.8)	60.4 (55.3-65.3)	61.4 (54.1-68.3)	65.1 (58.6-71.2)	64.3 (56.3-71.6)	.10	
Ratio of family income to poverty level[c]							
<1.30	31.9 (27.3-36.9)	37.4 (31.8-43.3)	31.0 (26.5-35.9)	39.3 (35.2-43.5)	38.4 (34.3-42.7)	.04	.046
1.30-1.849	44.6 (34.1-55.7)	42.0 (37.1-47.1)	45.3 (39.6-51.0)	42.3 (36.4-48.3)	48.8 (39.3-58.4)	.57	
1.85-2.99	43.6 (37.4-50.0)	44.4 (38.3-50.7)	43.6 (37.8-49.7)	47.8 (42.5-53.3)	50.0 (43.2-56.8)	.12	
≥3.00	48.5 (44.0-52.9)	51.8 (47.2-56.4)	51.1 (45.3-56.9)	57.9 (53.6-62.0)	62.5 (56.4-68.1)	<.001	

[a] Data on the percentage meeting an ideal diet (≥40 points or ≥80% adherence) are not presented due to small numbers and large statistical uncertainty in these subgroup analyses.

[b] Defined as less than 40% adherence or less than 20 points.

[c] Less than 1.30 indicates a lower income; 3.00 or greater, higher income.

[d] Defined as 40% to 79.9% adherence or 20 to 39.9 points.

contributing to these improvements. These results provide relevant data for future analyses to estimate the health effects of the identified trends.

Several of the observed mean changes in dietary intake appeared relatively small when considered as daily servings, such as trends in yogurt, dark green and red orange vegetables, poultry, fish and shellfish, and refined grains. Yet many of these foods are commonly consumed episodically, rather than daily, and small changes in average daily intake sum to more meaningful changes in weekly or monthly consumption. Also, small mean changes across an entire population can substantially influence the overall exposure distribution and corresponding risk in that population.[33] Consistent with this premise, the modest changes in mean intake led to meaningful changes in the estimated proportions of US adults meeting recommended overall diet patterns (ie, moving from poor to intermediate diets); this was especially pronounced among younger adults.

Important trends among demographic subgroups were identified. Even though diets among younger adults remained worse than among older adults, these gaps appeared to narrow, whether evaluating the proportion with poor or intermediate diets or particular dietary components (eg, sugar-sweetened beverages). In contrast, there was little evidence that other dietary disparities (such as by race, income, or education) improved during this 14-year period, whereas some worsened.

For certain items, such as sugar-sweetened beverages and whole grains, comparable improvements (and thus stable disparities) were observed by socioeconomic and race/ethnicity strata. Conversely, increases in whole fruit and nut or seed consumption were notably larger among adults with higher levels of income and education. Intake of refined grains and sodium increased among Mexican American adults. Intake of seafood omega-3 fat decreased among non-Hispanic black adults. These findings highlight the need to understand and address reasons for these divergent trends. Careful evaluation of population-specific facilitators and barriers to altering intake of particular foods is essential to crafting tailored approaches to improving diet quality.

Prior analyses of US dietary trends have focused on a limited number of dietary components or overall summary measures (eg, Alternative Healthy Eating Index).[3,34,35] In items for which overlap exists (eg, added sugars, sugar-sweetened beverages), these findings are consistent with prior reports.[3,7,36]

This investigation has several strengths. The most recent nationally representative data available were incorporated, providing an up-to-date portrait of the US diet. Both an overall diet score as well as multiple relevant food groups and nutrients were evaluated, including subtypes, providing detailed and comprehensive findings. Consistent analytic methods across diverse factors and population subgroups facilitate direct comparisons. Potential differences in dietary intake and trends by key population subgroups were assessed, allowing characterization of persistent and increasing disparities. Sensitivity analyses incorporated changes in US demographics.

Potential limitations should be considered. As with any population measure, self-reported dietary information is subject to random and systematic error. Yet interviewer-administered, 24-hour recalls were used and results were further adjusted for total energy, each of which reduce measurement error. Total energy intake was not included as a primary exposure because of its inaccurate estimation from dietary questionnaires. However, even when well estimated, total energy intake does not provide information on energy balance, which depends on age, sex, metabolic rate, and physical activity. The optimal evidence to assess trends in energy balance across a population is body weight, and several prior reports on such trends have been published.[37] Whereas both the individual AHA dietary components and the binary AHA score have been linked to disease end points in multiple studies,[11] the novel continuous summary measure of diet used in this study, which allows greater discrimination of dietary differences, needs to be validated against clinical end points.

Even though systematic bias in reporting over time, such as from varying social desirability (eg, differential time trends in the underreporting of less healthful foods), cannot be excluded, it seems unlikely that such biases would be observed across the entire population for all of the dietary components evaluated. A large number of statistical tests were performed without adjustment for multiple comparisons, so some statistically significant trends may represent false-positive results (ie, type I error). NHANES data by geographic region are not available, so region-specific findings were not examined. In addition, these findings do not provide explanations for the observed dietary trends; newly launched US surveys, such as the National Household Food Acquisition and Purchase Survey, can help facilitate future evaluations.[38]

Conclusions

In nationally representative US surveys conducted between 1999 and 2012, several improvements in self-reported dietary habits were identified, with additional findings suggesting persistent or worsening disparities based on race/ethnicity, education level, and income level. These findings may inform discussions on emerging successes, areas for greater attention, and corresponding opportunities to improve the diets of individuals living in the United States.

ARTICLE INFORMATION

Author Contributions: Dr Rehm had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: All authors.
Acquisition, analysis, or interpretation of data: Rehm, Peñalvo, Afshin.
Drafting of the manuscript: Rehm, Mozaffarian.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Rehm, Peñalvo.
Obtained funding: Mozaffarian.
Administrative, technical, or material support: Rehm.
Study supervision: Penalvo, Mozaffarian.

Conflict of Interest Disclosures: The authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Mozaffarian reported receiving honoraria from

Nutrition Impact, Haas Avocado Board, Amarin, and AstraZeneca; personal fees from Bunge, Life Sciences Research Organization, and Boston Heart Diagnostics; serving on advisory boards for Unilever North America (ended 2014); and chapter royalties from UpToDate. No other disclosures were reported.

Funding/Support: This work was supported by grant 5R01HL115189 from the National Heart, Lung, and Blood Institute.

Role of the Funder/Sponsor: The National Heart, Lung, and Blood Institute had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

REFERENCES

1. Murray CJ, Atkinson C, Bhalla K, et al. The state of US health, 1990-2010. *JAMA*. 2013;310(6):591-608.

2. Danaei G, Ding EL, Mozaffarian D, et al. The preventable causes of death in the United States. *PLoS Med*. 2009;6(4):e1000058.

3. Wang DD, Leung CW, Li Y, et al. Trends in dietary quality among adults in the United States, 1999 through 2010. *JAMA Intern Med*. 2014;174(10):1587-1595.

4. Slining MM, Mathias KC, Popkin BM. Trends in food and beverage sources among US children and adolescents. *J Acad Nutr Diet*. 2013;113(12):1683-1694.

5. Kit BK, Fakhouri TH, Park S, et al. Trends in sugar-sweetened beverage consumption among youth and adults in the United States. *Am J Clin Nutr*. 2013;98(1):180-188.

6. Daniel CR, Cross AJ, Koebnick C, Sinha R. Trends in meat consumption in the USA. *Public Health Nutr*. 2011;14(4):575-583.

7. Welsh JA, Sharma AJ, Grellinger L, Vos MB. Consumption of added sugars is decreasing in the United States. *Am J Clin Nutr*. 2011;94(3):726-734.

8. Lloyd-Jones DM, Hong Y, Labarthe D, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction. *Circulation*. 2010;121(4):586-613.

9. US Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey: MEC in-person dietary interviewers procedures manual. http://www.cdc.gov/nchs/data/nhanes/nhanes_09_10/DietaryInterviewers_Inperson.pdf. Accessed September 28, 2014.

10. Willett W. *Nutritional Epidemiology*. 3rd ed. Oxford, England, and New York, NY: Oxford University Press; 2013.

11. Mozaffarian D, Benjamin EJ, Go AS, et al. Heart disease and stroke statistics—2015 update. *Circulation*. 2015;131(4):e29-e322.

12. Chowdhury R, Warnakula S, Kunutsor S, et al. Association of dietary, circulating, and supplement fatty acids with coronary risk. *Ann Intern Med*. 2014;160(6):398-406.

13. Mozaffarian D, Hao T, Rimm EB, et al. Changes in diet and lifestyle and long-term weight gain in women and men. *N Engl J Med*. 2011;364(25):2392-2404.

14. Micha R, Wallace SK, Mozaffarian D. Red and processed meat consumption and risk of incident coronary heart disease, stroke, and diabetes mellitus. *Circulation*. 2010;121(21):2271-2283.

15. Dauchet L, Amouyel P, Hercberg S, Dallongeville J. Fruit and vegetable consumption and risk of coronary heart disease. *J Nutr*. 2006;136(10):2588-2593.

16. Afshin A, Micha R, Khatibzadeh S, Mozaffarian D. Consumption of nuts and legumes and risk of incident ischemic heart disease, stroke, and diabetes. *Am J Clin Nutr*. 2014;100(1):278-288.

17. Mozaffarian D, Lemaitre RN, Kuller LH, et al. Cardiac benefits of fish consumption may depend on the type of fish meal consumed. *Circulation*. 2003;107(10):1372-1377.

18. Cho SS, Qi L, Fahey GC Jr, Klurfeld DM. Consumption of cereal fiber, mixtures of whole grains and bran, and whole grains and risk reduction in type 2 diabetes, obesity, and cardiovascular disease. *Am J Clin Nutr*. 2013;98(2):594-619.

19. Aune D, Norat T, Romundstad P, Vatten LJ. Whole grain and refined grain consumption and the risk of type 2 diabetes. *Eur J Epidemiol*. 2013;28(11):845-858.

20. He FJ, Li J, Macgregor GA. Effect of longer-term modest salt reduction on blood pressure. *Cochrane Database Syst Rev*. 2013;4:CD004937.

21. Forouzanfar MH, Alexander L, Anderson HR, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013. *Lancet*. 2015;386(10010):2287-2323.

22. Bowman SA, Friday JE, Moshfegh A. MyPyramid Equivalents Database 2.0 for USDA survey foods, 2003-2004. http://www.ars.usda.gov/SP2UserFiles/Place/80400530/pdf/mped/mped2_doc.pdf. Accessed May 31, 2016.

23. Bowman SA, Clemens JC, Friday JE, et al. USDA Food Patterns Equivalents Database 2007-08: methodology and user guide. http://www.ars.usda.gov/SP2UserFiles/Place/12355000/pdf/fped/FPED_0708.pdf. Accessed May 31, 2016.

24. US Department of Agriculture; Agricultural Research Service. The USDA Food and Nutrient Database for Dietary Studies: 2011-2012: documentation and user guide. http://www.ars.usda.gov/SP2UserFiles/Place/12355000/pdf/fndds/fndds_2011_2012_doc.pdf. Accessed Accessed May 31, 2016.

25. Ford ES, Dietz WH. Trends in energy intake among adults in the United States. *Am J Clin Nutr*. 2013;97(4):848-853.

26. US Department of Agriculture; US Department of Health and Human Services. Dietary Guidelines for Americans, 2015-2020: 8th ed. http://health.gov/dietaryguidelines/2015/guidelines/. Accessed May 20, 2016.

27. US Food and Drug Administration. Guidance for industry: a food labeling guide. http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm064928.htm. Accessed January 14, 2016.

28. Tooze JA, Kipnis V, Buckman DW, et al. A mixed-effects model approach for estimating the distribution of usual intake of nutrients: the NCI method. *Stat Med*. 2010;29(27):2857-2868.

29. Kipnis V, Midthune D, Buckman DW, et al. Modeling data with excess zeros and measurement error. *Biometrics*. 2009;65(4):1003-1010.

30. Dodd KW, Guenther PM, Freedman LS, et al. Statistical methods for estimating usual intake of nutrients and foods. *J Am Diet Assoc*. 2006;106(10):1640-1650.

31. Mozaffarian D. Dietary and policy priorities for cardiovascular disease, diabetes, and obesity. *Circulation*. 2016;133(2):187-225.

32. Kuklina EV, Carroll MD, Shaw KM, Hirsch R. Trends in high LDL cholesterol, cholesterol-lowering medication use, and dietary saturated-fat intake. *NCHS Data Brief*. 2013;(117):1-8.

33. Rose G. Sick individuals and sick populations. *Int J Epidemiol*. 2001;30(3):427-432.

34. Chiuve SE, Fung TT, Rimm EB, et al. Alternative dietary indices both strongly predict risk of chronic disease. *J Nutr*. 2012;142(6):1009-1018.

35. Guenther PM, Casavale KO, Reedy J, et al. Update of the Healthy Eating Index: HEI-2010. *J Acad Nutr Diet*. 2013;113(4):569-580.

36. Han E, Powell LM. Consumption patterns of sugar-sweetened beverages in the United States. *J Acad Nutr Diet*. 2013;113(1):43-53.

37. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA*. 2012;307(5):491-497.

38. US Department of Agriculture Economic Research Service. FoodAPS national household food acquisition and purchase survey. http://www.ers.usda.gov/data-products/foodaps-national-household-food-acquisition-and-purchase-survey.aspx. Accessed October 10, 2015.