Salad Consumption in Relation to Daily Dietary Intake and Diet Quality among U.S. Adults, 2003-2012

Ruopeng An [1], Naiman Khan [1]

(1) Department of Kinesiology and Community Health, College of Applied Health Sciences, University of Illinois at Urbana-Champaign

CORRESPONDING AUTHOR: *Ruopeng An, 1206 South 4th Street, Champaign IL 61820, USA, Phone: 1-217-244-0966, Fax: 1-217-333-2766, E-mail: ran5@illinois.edu*

DOI: ***10.2427/11791***
Accepted on May 23, 2016

ABSTRACT

Background: This study examined salad consumption in relation to daily dietary intake and diet quality among U.S. adults.
Methods: Nationally representative sample came from the National Health and Nutrition Examination Survey 2003-2012 waves. Salad consumption was identified through both Food and Nutrient Database for Dietary Studies codes for salad items and combination code for components of and/or additions to salads. First-difference estimator addressed confounding bias from time-invariant unobservable (e.g., eating habits, taste preferences) by using within individual variations in salad consumption between 2 non-consecutive 24-hour dietary recalls.
Results: Approximately 28.7% of U.S. adults consumed salad on any given day. Among salad consumers, salad consumption occupied 12.5% of daily total energy, 62.8% vegetable, 11.9% fruit, 18.4% fibre, 9.1% sugar, 20.3% total fat, 14.7% saturated fat, 14.9% cholesterol and 17.7% sodium intake. Compared to no salad consumption on a dietary recall day, salad consumption was associated with increased daily intake of total energy by 461.5 kJ (110.3 kcal), vegetable 85.0 g, fibre 1.0 g, sugar 5.7 g, total fat 10.0 g, saturated fat 1.3 g, cholesterol 18.7 mg and sodium 216.3 mg. Salad consumption was associated with an increase in the Healthy Eating Index-2010 score by 4.2.
Conclusion: Salad consumption is related to better overall diet quality but also higher total energy, sugar, fat, cholesterol and sodium intake. Interventions that promote salad consumption should provide low-energy-dense, nutrient-rich salad products. Salad consumers should prudently evaluate the caloric and nutrient content of salad in order to make informed and more healthful diet choices.

Key words: salad; vegetable and fruit; diet quality; 24-hour dietary recall

INTRODUCTION

Improving diet quality is a key health promotion strategy [1]. The 2015-2020 Dietary Guidelines for Americans calls for substantial increase in fruit and vegetable consumption and decrease in added sugar, saturated fat and sodium consumption as a way to improve overall diet quality while reducing daily total calorie intake [2]. Nevertheless, in 2013 less than 14% of adults across U.S. states consumed the guidelines-recommended amount of vegetables and less than 15% consumed the recommended amount of fruits [3]. In the meantime,

excessive calorie intake from energy-dense, nutrient-poor foods has increasingly become a central public health concern [4-6].

Salad is an essential component to the American diet and may provide an important means of meeting dietary recommendations for daily produce intake [7,8]. Small-scale experimental studies have previously related low-energy-dense salad consumption to decreased daily total caloric intake and healthier body weight status [9-12]. Recent public nutrition interventions promote salad consumption in schools and workplaces through increasing availability (e.g., building new or expanding existing salad bars, providing more diverse and healthful choices) and improving affordability (e.g., providing discounts, coupons and subsidies) [13-16]. On the other hand, salad as an image for healthy diet, has seen to be gradually eroded partially owing to the prevailing use of dressings high in saturated fat, added sugar and sodium, as well as other less healthful additives (e.g., fried chicken strips) [17]. Despite the increasing attention paid to salad consumption [18], little has been documented regarding the impact of salad consumption on Americans' daily diet at the population level in a naturalistic setting. Moreover, population heterogeneity has not been studied—demographic and socioeconomic subgroups may differ in the relationship between salad consumption and daily dietary intake due to various dissimilarities in genetic and socio-behavioural factors like metabolism, dietary habit, health attitude, nutrition knowledge and affordability [19]. Documenting these population heterogeneities can be essential in designing targeted policy interventions.

This study fills in the gap by examining salad consumption in relation to daily dietary intake and diet quality among U.S. adults, using a decade of 24-hour dietary recall data from a nationally representative repeated cross-sectional health survey. To our knowledge, this study would serve as the first attempt to assess the role of salad consumption in daily diet using a first-difference approach. This approach aimed to employ within individual variations in salad consumption status between the 2 non-consecutive 24-hour dietary recalls, thus overcoming the confounding bias due to unobservable individual characteristics like eating habits and food/taste preferences. We hypothesised that salad consumption would be inversely associated with daily total caloric intake and nutrient markers of poorer diet quality including total fat, saturated fat, cholesterol and sodium [2]; but positively associated with overall diet quality and intake of foods and nutrients emphasised including vegetables, fruits and dietary fibre [2]. We identified certain individual characteristics that predicted salad consumption. We examined salad consumption in relation to daily dietary intake and diet quality in the overall U.S. adult population and by sex, race/ethnicity, age group, education attainment, income level and body weight status.

METHODS

Survey setting and participants

The National Health and Nutrition Examination Survey (NHANES) is a program of studies conducted by the National Center for Health Statistics (NCHS) to assess the health and nutritional status of children and adults. The program began in the early 1960s and periodically conducted separate surveys focusing on different population groups or health topics. Since 1999, the NHANES has been conducted continuously in 2-year cycles and has a changing focus on a variety of health and nutrition measurements. A multistage probability sampling design is used to select participants representative of the civilian, non-institutionalised U.S. population. Certain population subgroups are oversampled to increase the reliability and precision of health status indicator estimates for these groups. Detailed information regarding the NHANES sampling design, questionnaires, clinical measures and individual-level data, can be found on its web portal (http://www.cdc.gov/nchs/nhanes.htm).

Dietary interview

Except for the NHANES 1999-2000 wave where all participants were asked to complete a single 24-hour dietary recall, all subsequent waves incorporated 2 dietary recalls, with the first collected in-person and the second by telephone 3 to 10 days later. In both interviews, each food or beverage item and corresponding quantity consumed by a participant from midnight to midnight on the day before the interview was recorded. The in-person dietary recall (day 1) was conducted by trained dietary interviewers in the Mobile Examination Center (MEC) with a standard set of measuring guides. These tools aimed to help the participant accurately report the volume and dimensions of the food/beverage items consumed. Upon completion of the in-person interview, participants were provided measuring cups, spoons, a ruler and a food model booklet, which contained 2-dimensional drawings of the various measuring guides available in the MEC, to use for reporting dietary intake during the telephone interview (day 2). Following the dietary interview, the caloric and nutrient contents of each reported food and/or beverage item were systematically coded with the U.S. Department of Agriculture (USDA) Food and Nutrient Database for Dietary Studies (FNDDS). Access restrictions apply to the day 2 dietary recall data collected in the NHANES 2001-2002 wave, whereas dietary data for both recall days are released to the public for all subsequent waves.

Salad consumption

Salad is a highly diverse and complex food category. To capture the variety of salad types and

multiple components mixed together in salad that the Americans consumed, we identified salad consumption in the NHANES dietary recall data through: (1) specific FNDDS codes for salad items as well as (2) combination code for components of and/or additions to salads. In the NHANES 2003-2004, 2005-2006, 2007-2008, 2009-2010 and 2011-2012 waves, 137, 138, 148, 149 and 200 food items were classified as salads based on specific FNDDS codes, respectively. In addition, combination code 4 (corresponding to the food type "salad" in the NHANES) was used to identify components of salads that did not have a single code in FNDDS or additional food items consumed together with single-code salad items (e.g., Italian dressing added to garden salad). A salad consumer refers to an NHANES participant who consumed any positive quantity of salad during a dietary recall day.

In the dietary recall data, energy derived from each consumed food/beverage item was recorded based on the quantity of food/beverage reported and the corresponding energy contents. We calculated salad consumers' daily total caloric intake (kJ) and intake of vegetable (g), fruit (g), fibre (g), sugar (g), total fat (g), saturated fat (g), cholesterol (mg) and sodium (mg) from both salad alone and all food/beverage items. We then averaged their caloric and nutrient intake between the 2 dietary recall days.

This study used individual-level data from the NHANES 2003-2004, 2005-2006, 2007-2008, 2009-2010 and 2011-2012 waves due to data availability for both dietary recall days and consistency in combination code across these waves. Among a total of 26,863 U.S. adults 18 years of age and above who participated in the 24-hour dietary recalls in the NHANES 2003-2012 waves, 1,478 who were pregnant, lactating, and/or on a special diet to lose weight at the time of interview were excluded. Of the remaining 25,385 NHANES adult participants, 9,360 consumed salad on either or both dietary recall days.

Diet quality

The Healthy Eating Index (HEI)-2010 was developed by the USDA as a measure of dietary quality in accordance with the Dietary Guidelines for Americans, 2010 [2,20]. It consists of 12 components: total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium and empty calories (calories from solid fats, alcohol and added sugars). With a maximum score of 100, a higher HEI-2010 score reflects closer adherence to the Federal dietary guidelines. We calculated each NHANES participant's HEI-2010 score on either 24-hour dietary recall day using the MyPyramid Equivalents Database and following the procedures established by the USDA and the National Cancer Institute [21,22].

Individual characteristics

The following individual characteristics were reported for U.S. adults 18 years of age and above: sex, age (stratified into 2 age groups: 18-64 years of age and 65 years of age and above), race/ethnicity (non-Hispanic white, non-Hispanic African American, non-Hispanic other race or multi-race and Hispanic), education (high school and below, and college and above), household income (income to poverty ratio IPR < 130%, 130% ≤ IPR < 300%, and IPR ≥ 300%) and body weight status. Participants' body height and weight were measured by stadiometer and digital scale in the MEC. Body mass index (BMI) is defined by weight in kilograms divided by height in meters squared (kg/m2). Body weight status was classified into underweight (BMI < 18.5 kg/m^2), normal weight (18.5 kg/m^2 ≤ BMI < 25 kg/m^2), overweight (25 kg/m^2 ≤ BMI < 30 kg/m^2) and obesity (BMI ≥ 30 kg/m^2) based on the international classification of adult BMI values.(23)

Statistical analysis

In descriptive statistics, we summarised individual characteristics of adult salad consumers and their daily total caloric intake, and intake of vegetable, fruit, fibre, sugar, total fat, saturated fat, cholesterol and sodium from both salad alone and all food/beverage items. We calculated the percentage of dietary intake from salad in daily total dietary intake among adult salad consumers.

Logistic regression was performed to estimate the adjusted odds ratios of salad consumption with respect to individual characteristics among the NHANES adult participants. The dependent variable was an indicator variable for any salad consumption on either of the 2 dietary recall days.

First-difference estimator was performed on the NHANES adult salad consumers using data from their day 1 and day 2 dietary interviews that provided 2 observations per person. The outcome (i.e., daily total caloric intake and intake of vegetable, fruit, fibre, sugar, total fat, saturated fat, cholesterol and sodium from all food/beverage items) of participant i on day t (t=1,2) is denoted by y_{it}. We let vector X_i represent the set of variables that vary by participant (e.g., sex and race/ethnicity), but remain constant within participant between the 2 dietary interviews. Given the short recall time interval of 3-10 days, X_i includes individual characteristics that vary only in the longer term, such as age, education attainment, income level, body weight, etc. Dichotomous variable $salad_{it}$ denotes any salad consumption by participant i on day t. Indicator variable we_{it} denotes whether day t was a

weekend (Friday, Saturday or Sunday).

A pooled cross-sectional setup (a conventional regression that treats repeated measures within each study subject as independent observations) specifies the outcome y_{it} as a function of an unobservable term that varies by participant α_i, observable variables that vary by participant X_i, observable variables that vary within participant between the 2 dietary interviews $salad_{it}$ and we_{it}, and an independently-distributed unobservable disturbance term εit.

$$y_{it}=\mu X_i+\beta_1 salad_{it}+\beta_2 we_{it}+\alpha_i+\varepsilon_{it} \quad (1)$$

Due to the presence of the unobservable term α_i (e.g., eating habits, taste preferences), estimating equation (1) by controlling for the observables X_i only is prone to omitted variable bias. The first-difference estimator eliminates the bias by taking the difference between the 2 days of data within each participant, so that α_i and μX_i that are common within participant are removed.

$$y_{i1} - y_{i2} = \beta_1 (salad_{i1} - salad_{i2}) + \beta_2 (we_{i1}-we_{i2}) + (\varepsilon_{i1} - \varepsilon_{i2}) \quad (2)$$

Equation (2) was estimated for the overall adult sample and subsamples stratified by sex, race/ethnicity (non-Hispanic other race/multi-race excluded due to insufficient sample size), age group, education attainment, income level and body weight status (underweight excluded due to insufficient sample size).

The NHANES 2003-2012 multi-wave complex survey design was accounted for in both descriptive statistics and regression analyses. All statistical procedures were performed in Stata 14.1 SE version (StataCorp, College Station, TX).

Human subjects protection

The NHANES was approved by the NCHS Research Ethics Review Board. This study used the NHANES de-identified public data and was deemed exempt from human subjects review by the University of Illinois at Urbana-Champaign Institutional Review Board.

RESULTS

Approximately 28.7% of adult participants in the NHANES 2003-2012 waves consumed salad on a dietary recall day. Figure 1 reports the percentage of dietary intake from salad in daily total dietary intake among the NHANES adult salad consumers. Dietary intake from salad accounted for 12.5% (95% confidence interval CI = 12.2%, 12.9%) of daily total energy consumption, 62.8% (95% CI = 61.7%, 63.9%) of vegetable consumption, 11.9% (95% CI = 10.9%, 12.8%) of fruit consumption, 18.4% (95% CI = 18.0%, 18.9%) of dietary fibre consumption, 9.1% (95% CI = 8.8%, 9.4%) of sugar consumption, 20.3% (95% CI = 19.8%, 20.9%) of total fat consumption, 14.7% (95% CI = 14.2%, 15.2%) of saturated fat consumption, 14.9% (95% CI = 14.2%, 15.6%) of cholesterol consumption and 17.7% (95% CI = 17.3%, 18.2%) of sodium consumption.

Table 1 reports individual characteristics of adult salad consumers. They on average consumed 1050.2 kJ (251.0 kcal) of total energy, 114.4 g of vegetable, 11.6 g of fruit, 3.0 g of fibre, 7.9 g of sugar, 16.7 g of total fat, 3.4 g of saturated fat, 37.2 mg of cholesterol and 597.1 mg of sodium from salad. Daily overall diet quality measured by the HEI-2010 scored 52.7 among adult salad consumers. Over 2/3 (67.6%) of them were either overweight or obese (BMI ≥ 25 kg/m^2), with less than a third (30.8%) in the normal weight range (18.5 kg/m^2 ≤ BMI < 25 kg/m^2).

Table 2 reports the adjusted odds ratios of salad consumption using logistic regressions. Women, non-Hispanic whites, older adults 65 years of age and above, those with college education and above, people at middle (130% ≤ IPR < 300%) or high income level (IPR ≥ 300%), and overweight (25 kg/m^2 ≤ BMI < 30 kg/m^2) or obese adults (BMI ≥ 30 kg/m^2) were significantly more likely to consume salad compared to men, racial/ethnic minorities, young and middle-aged adults 18-64 years of age, those with high school or lower education, people at low income level (IPR < 130%) and normal weight adults (18.5 kg/m^2 ≤ BMI < 25 kg/m^2), respectively. No secular trend in salad consumption was identified as none of the estimated odds ratios associated with the indicator variables for survey waves were statistically significant (P > 0.05).

Table 3 reports the estimated associations between salad consumption and daily dietary intake and diet quality among U.S. adults by sex, race/ethnicity, age group, education level, income level and body weight status using the first-difference estimator. Compared with no salad consumption on a dietary recall day, salad consumption on a recall day was associated with an increase in daily intake of total energy by 461.5 (95% CI = 342.3, 580.7) kJ (110.3 kcal), vegetable by 85.0 (95% CI = 78.4, 91.6) g, fibre by 1.0 (95% CI = 0.6, 1.4) g, sugar by 5.7 (95% CI = 3.3, 8.1) g, total fat by 10.0 (95% CI = 8.4, 11.7) g, saturated fat by 1.3 (95% CI = 0.7, 1.9) g, cholesterol by 18.7 (95% CI = 10.9, 26.6) mg and sodium by 216.3 (95% CI = 146.8, 285.9) mg. Compared with no salad consumption on a dietary recall day, salad consumption on a recall day was associated with an increase in the HEI-2010 score by 4.2 (95% CI = 3.8, 4.6). Salad consumption status was not found to be associated with change in daily fruit intake in both the overall sample and subsamples by sex, race/ethnicity, age group, education level, income level and body weight status (P > 0.05). The estimated relationships

TABLE 1. Individual characteristics of adult salad consumers, 2003-2012 NHANES

INDIVIDUAL CHARACTERISTICS	MEAN/PROPORTION
Daily total nutrient intake (mean)	
Total energy (kJ)	8842.8 (8748.1, 8937.4)
Vegetable (g)	163.07 (156.23, 169.92)
Fruit (g)	108.79 (104.09, 113.49)
Fibre (g)	17.71 (17.34, 18.08)
Sugar (g)	114.16 (112.02, 116.30)
Total fat (g)	81.75 (80.71, 82.79)
Saturated fat (g)	25.95 (25.55, 26.35)
Cholesterol (mg)	281.99 (277.23, 286.75)
Sodium (mg)	3511.71 (3471.26, 3552.16)
Healthy Eating Index-2010 (score = 0-100)	52.73 (52.15, 53.32)
Daily nutrient intake from salad (mean)	
Total energy (kJ)	1050.1 (1020.2, 1080.1)
Vegetable (g)	114.37 (110.25, 118.50)
Fruit (g)	11.61 (10.03, 13.19)
Fibre (g)	2.98 (2.87, 3.08)
Sugar (g)	7.88 (7.62, 8.14)
Total fat (g)	16.68 (16.14, 17.22)
Saturated fat (g)	3.40 (3.27, 3.53)
Cholesterol (mg)	37.21 (35.24, 39.18)
Sodium (mg)	597.14 (578.28, 616.00)
Sex (%)	
Male	43.30 (42.20, 44.41)
Female	56.70 (55.59, 57.80)
Race/ethnicity (%)	
White, non-Hispanic	76.56 (73.79, 79.33)
African American, non-Hispanic	8.94 (7.44, 10.43)
Other race/multi-race, non-Hispanic	9.96 (8.23, 11.69)
Hispanic	4.54 (3.92, 5.17)
Age group (%)	
18-64 years of age	78.42 (77.23, 79.61)
65 years of age and above	21.58 (20.39, 22.77)
Education (%)	
High school education and below	35.44 (33.53, 37.35)
College education and above	62.50 (60.61, 64.39)
Income to poverty ratio (IPR) (%)	
IPR < 130%	14.87 (13.69, 16.05)
130% ≤ IPR < 300%	25.36 (23.79, 26.94)
IPR ≥ 300%	53.74 (51.63, 55.84)
Body weight status (%)	
Underweight (BMI < 18.5 kg/m^2)	1.63 (1.32, 1.94)
Normal weight (18.5 kg/m^2 ≤ BMI < 25 kg/m^2)	30.80 (29.53, 32.07)
Overweight (25 kg/m^2 ≤ BMI < 30 kg/m^2)	34.30 (32.93, 35.67)
Obese (BMI ≥ 30 kg/m^2)	32.32 (30.74, 33.89)

Notes: Individual-level data (N = 9,360) came from the NHANES 2003-2012 waves. Descriptive statistics count for the NHANES multiyear complex survey design. Proportions may not add up to 100% due to missing values in some individual characteristics. 95% confidence intervals are in parentheses.

TABLE 2. Adjusted odds ratios of salad consumption, 2003-2012 NHANES

INDIVIDUAL CHARACTERISTICS	ODDS RATIO
Sample size	25,385
Sex	
Male	Reference
Female	1.57*** (1.48, 1.67)
Race/ethnicity	
White, non-Hispanic	Reference
African American, non-Hispanic	0.66*** (0.60, 0.72)
Other race/multi-race, non-Hispanic	0.54*** (0.46, 0.63)
Hispanic	0.76*** (0.69, 0.84)
Age group	
18-64 years of age	Reference
65 years of age and above	1.71*** (1.59, 1.84)
Education	
High school education and below	Reference
College education and above	1.50*** (1.40, 1.60)
Income to poverty ratio (IPR)	
IPR < 130%	Reference
130% ≤ IPR < 300%	1.19*** (1.09, 1.29)
IPR ≥ 300%	1.72*** (1.58, 1.87)
Body weight status	
Underweight (BMI < 18.5 kg/m^2)	0.83 (0.65, 1.07)
Normal weight (18.5 kg/m^2 ≤ BMI < 25 kg/m^2)	Reference
Overweight (25 kg/m^2 ≤ BMI < 30 kg/m^2)	1.18*** (1.10, 1.27)
Obese (BMI ≥ 30 kg/m^2)	1.13** (1.04, 1.23)
Survey wave	
2003-2004	Reference
2005-2006	0.96 (0.81, 1.14)
2007-2008	0.90 (0.79, 1.03)
2009-2010	0.91 (0.83, 1.01)
2011-2012	0.90 (0.80, 1.02)

*Notes: Logistic regressions were performed to estimate the adjusted odds ratios of salad consumption, accounting for the NHANES multi-wave complex sampling design. 95% confidence intervals are in parentheses. *, 0.01 ≤ P < 0.05; **, 0.001 ≤ P < 0.01; and ***, P < 0.001.*

between salad consumption and daily dietary intake and diet quality held in almost all subgroup analyses, with only a few exceptions—salad consumption status was not found to be associated with daily saturated fat intake among Hispanics and overweight adults, nor daily cholesterol intake among Hispanics and older adults 65 years of age and above (P > 0.05). The effects of salad consumption on daily dietary intake and diet quality to some extent differed by sex, education and income level. The estimated increase in daily vegetable intake associated with salad consumption was larger among men (92.3 g) than among women (55.9 g) (P < 0.001); and the estimated increase in daily sodium intake associated with salad consumption was larger among adults with high school or lower education and people at low income level (IPR < 130%) than among adults with college education and above (P < 0.05) and people at high income level (IPR ≥ 300%) (P < 0.01), respectively.

DISCUSSION

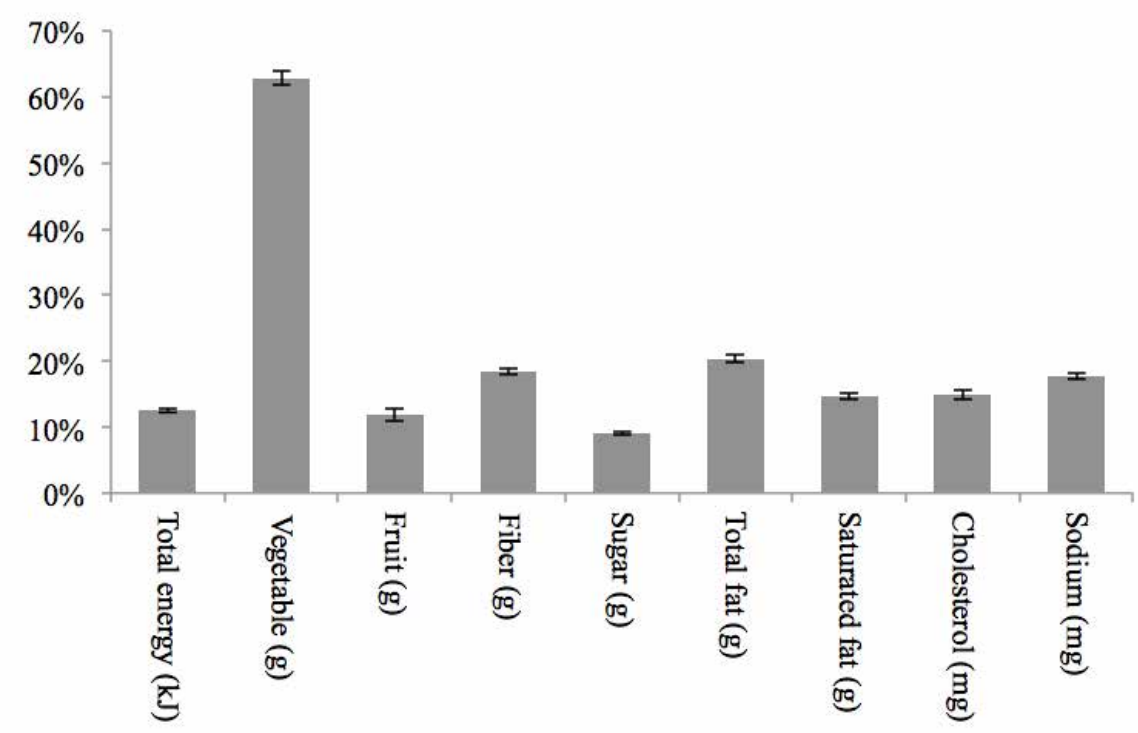
Salad serves as a major source of people's daily fresh produce consumption in the U.S [7,8]. Using data

TABLE 3. Estimated effects of salad consumption on daily dietary intake and diet quality among U.S. adults, 2003-2012 NHANES

SAMPLE	TOTAL ENERGY (KJ)	VEGETABLE (G)	FRUIT (G)	FIBRE (G)	SUGAR (G)	TOTAL FAT (G)	SATURATED FAT (G)	CHOLESTEROL (MG)	SODIUM (MG)	HEI-2010 (SCORE)
All (N = 9,360)	461.45*** (342.08, 580.86)	85.00*** (78.41, 91.60)	4.35 (-1.75, 10.45)	0.96*** (0.56, 1.36)	5.73*** (3.33, 8.14)	10.04*** (8.37, 11.71)	1.29*** (0.72, 1.86)	18.72*** (10.87, 26.58)	216.34*** (146.81, 285.87)	4.19*** (3.75, 4.64)
Male (N = 4,071)	492.83*** (309.36, 676.30)	96.03*** (86.04, 106.01)	1.77 (-6.80, 10.33)	1.12*** (0.55, 1.69)	4.97* (1.16, 8.78)	11.18*** (8.79, 13.57)	1.35*** (0.56, 2.14)	17.90** (4.81, 31.00)	195.11*** (90.23, 299.99)	4.24*** (3.54, 4.93)
Female (N = 5,289)	428.99*** (280.20, 577.77)	76.35*** (67.31, 85.38)	6.31 (-0.44, 13.06)	0.83*** (0.38, 1.29)	6.29*** (3.49, 9.10)	9.08*** (7.10, 11.05)	1.23*** (0.49, 1.97)	18.66*** (10.20, 27.12)	232.96*** (159.09, 306.82)	4.15*** (3.52, 4.77)
Non-Hispanic white (N = 5,114)	477.98*** (326.64, 629.27)	88.52*** (80.31, 96.73)	4.57 (-3.29, 12.42)	0.91*** (0.43, 1.38)	5.62*** (2.81, 8.43)	10.51*** (8.39, 12.63)	1.43*** (0.71, 2.15)	21.40*** (11.28, 31.52)	222.96*** (132.82, 313.11)	4.08*** (3.55, 4.62)
Non-Hispanic black (N = 1,770)	396.81** (144.89, 648.73)	64.21*** (54.75, 73.67)	-1.94 (-13.40, 9.51)	0.82** (0.23, 1.40)	8.01* (1.85, 14.18)	9.07*** (6.23, 11.92)	1.16* (0.14, 2.17)	20.51* (2.49, 38.53)	263.02*** (135.91, 390.12)	4.40*** (3.44, 5.36)
Hispanic (N = 2,011)	544.84*** (244.64, 845.00)	82.31*** (70.75, 93.87)	2.60 (-8.78, 13.97)	1.48*** (0.65, 2.31)	7.49*** (3.14, 11.84)	9.26*** (5.70, 12.81)	1.11 (-0.09, 2.31)	3.19 (-16.35, 22.73)	214.38** (66.20, 362.55)	4.03*** (2.83, 5.23)
18-64 years of age (N = 6,589)	470.24*** (320.75, 619.69)	92.31*** (84.60, 100.03)	5.78 (-1.30, 12.85)	0.99*** (0.53, 1.45)	5.88*** (3.09, 8.66)	10.45*** (8.38, 12.51)	1.35*** (0.65, 2.05)	20.84*** (11.47, 30.21)	224.06*** (139.73, 308.39)	4.41*** (3.89, 4.94)
65+ years of age (N = 2,771)	411.16*** (254.39, 567.89)	55.59*** (42.98, 68.20)	-1.33 (-9.86, 7.20)	0.84** (0.28, 1.40)	4.93** (1.71, 8.14)	8.34*** (6.20, 10.48)	1.03** (0.29, 1.76)	10.01 (-3.44, 23.45)	180.75*** (101.00, 260.49)	3.30*** (2.34, 4.27)
Education ≤ high school (N = 3,981)	608.77*** (441.33, 776.22)	70.02*** (59.87, 80.18)	-0.23 (-7.59, 7.12)	1.01*** (0.55, 1.48)	5.95** (1.99, 9.92)	12.24*** (9.94, 14.54)	2.02*** (1.19, 2.85)	28.01*** (16.52, 39.5)	327.87*** (241.23, 414.52)	4.16*** (3.58, 4.74)
Education ≥ college (N = 4,981)	373.21*** (222.51, 523.88)	94.08*** (86.16, 102.01)	7.24 (-2.44, 16.92)	0.96*** (0.43, 1.49)	5.57*** (2.63, 8.51)	8.54*** (6.61, 10.47)	0.87* (0.17, 1.57)	11.45* (0.05, 22.85)	146.65** (56.04, 237.26)	4.17*** (3.58, 4.76)
IPR < 130% (N = 2,168)	675.38*** (418.86, 931.94)	73.52*** (60.69, 86.34)	-0.21 (-11.31, 10.90)	1.73*** (1.03, 2.44)	7.56* (1.43, 13.69)	12.64*** (9.69, 15.60)	1.87** (0.73, 3.01)	22.19** (7.07, 37.30)	379.77*** (267.11, 492.42)	4.55*** (3.56, 5.53)
130% ≤ IPR < 300% (N = 2,622)	542.92*** (305.47, 780.40)	72.94*** (59.97, 85.91)	0.78 (-8.88, 10.44)	1.14*** (0.47, 1.82)	5.50* (0.84, 10.16)	10.70*** (8.01, 13.38)	1.79*** (0.73, 2.85)	28.42*** (15.41, 41.43)	256.89*** (135.87, 377.91)	4.02*** (3.13, 4.90)
IPR ≥ 300% (N = 3,919)	346.69*** (178.32, 515.05)	93.31*** (83.70, 102.92)	8.90 (-0.40, 18.20)	0.57* (0.00, 1.14)	5.36*** (2.45, 8.27)	8.83*** (6.31, 11.35)	0.85* (0.01, 1.70)	13.20* (0.61, 25.80)	138.70** (39.48, 237.92)	4.23*** (3.52, 4.94)
Normal weight (N = 2,665)	514.97*** (296.77, 733.16)	85.80*** (72.75, 98.85)	5.42 (-6.22, 17.06)	0.78* (0.11, 1.46)	7.40*** (3.38, 11.41)	9.85*** (7.13, 12.57)	1.26** (0.33, 2.19)	15.83* (0.16, 31.51)	194.16** (71.81, 316.51)	3.42*** (2.60, 4.24)
Overweight (N = 3,168)	421.29*** (220.37, 622.16)	86.41*** (75.17, 97.64)	8.80 (-2.56, 20.16)	1.27*** (0.69, 1.86)	5.76*** (2.59, 8.92)	9.30*** (6.70, 11.90)	0.85 (-0.13, 1.82)	17.74** (5.52, 29.95)	209.67*** (110.14, 309.20)	4.95*** (4.20, 5.70)
Obese (N = 3,262)	469.78*** (286.02, 653.54)	85.33*** (73.76, 96.91)	-1.45 (-10.44, 7.55)	0.85** (0.23, 1.46)	5.18* (1.24, 9.12)	11.30*** (8.83, 13.76)	1.90*** (1.02, 2.78)	20.86** (5.94, 35.79)	238.33*** (137.68, 338.98)	4.12*** (3.44, 4.80)

*Notes: Individual-level data came from the NHANES 2003-2012 waves. First-difference estimators were used to estimate the effects of salad consumption on daily dietary intake and diet quality among U.S. adults, adjusting for whether the consumption was on a weekday or weekend and accounting for the NHANES multiyear complex survey design. IPR denotes income poverty ratio. HEI-2010 denotes Healthy Eating Index-2010 with possible score ranging from 0 (lowest daily diet quality) to 100 (highest daily diet quality). 95% confidence intervals are in parentheses. *, 0.01 ≤ P < 0.05; **, 0.001 ≤ P < 0.01; and ***, P < 0.001.*

FIGURE 1. Percentage of dietary intake from salad in daily total dietary intake among U.S. salad consumers, 2003-2012 NHANES



Notes: Individual-level data (N = 9,360) came from the NHANES 2003-2012 waves. Estimated percentages count for the NHANES multiyear complex survey design. The percentage of dietary intake from salad in daily total dietary intake was undefined for those who had zero daily total dietary intake (e.g., no fruit consumption on a dietary recall day). As a result, the percentages reported in Figure 1 might not equal to the ratios of mean daily dietary intake from salad over mean daily total dietary intake as reported in Table 1. Error bars denote 95% confidence intervals.

from a nationally representative survey, this study examined salad consumption in relation to daily dietary intake and diet quality among the U.S. adult population. About 28.7% of U.S. adults consumed salad on any given day. Among salad consumers, 1/8 of their daily total caloric intake and nearly 2/3 of vegetable intake came from salad consumption. Women, non-Hispanic whites, older adults, adults at higher income and education level and overweight/obese individuals were more likely to consume salad. Salad consumption was associated with noticeable increase in daily intake of total energy, vegetable, fibre, sugar, total fat, saturated fat, cholesterol and sodium, and it was linked with better overall diet quality measured by the HEI-2010. In addition, marginal differences in the relationship between salad consumption and daily dietary intake and diet quality across population subgroups by sex, education and income level were observed.

Findings from this study to some extent confirmed results from previous experimental work regarding the effects of salad consumption on increased vegetable intake and improved overall diet quality [9-12]. However, contrary to our hypothesis, salad consumption among U.S. adults was not found to be associated with increased fruit intake. Moreover, compared to no salad consumption on a dietary recall day, salad consumption on a recall day was found to be linked with significant increase in daily total caloric intake and intake of nutrients that were recommended significant reduction, including total fat, saturated fat, cholesterol and sodium. The discrepancies between these findings and results from previous experimental studies on salad consumption could result from differences in study sample (nationally representative vs. small convenient sample), and potentially more importantly, study setting (naturalistic setting vs. randomized controlled trial). Portion size and energy density of salad, to a large extent, determine consumers' caloric and nutrient intake [24-26]. In a controlled experiment, individuals who were randomised to consume low-energy-dense salads with varying portion sizes reduced daily total caloric intake by 7% (for big portion size consumers) to 12% (for small portion size consumers), whereas those randomised to consume high-energy-dense salads increased daily total caloric intake by 8% (for small portion size consumers) to 17% (for big portion size consumers) [9]. In a review of over 30,000 U.S. chain restaurant menu items in terms of their energy and nutrient content, salads combined with dressings had caloric values approaching those of main entrées [17]. Despite salad as a primary source of daily vegetable consumption and its positive impact on fibre intake and overall diet quality, excess portion

size and high energy density of salad could substantially compromise its nutrition and health benefits for consumers. Salad consumers are thus advised to carefully assess the caloric and nutrient content of salad in order to make informed and better diet choices.

A crucial distinction should be made between the sample and estimates based on the first-difference estimator and those based on the conventional pooled cross-sectional model. The conventional model used the entire study sample that consisted of both salad consumers and non-consumers. As salad consumers could be more likely to have adopted healthful eating habits and been cautious about their daily caloric and nutrient intake in comparison to salad non-consumers, failure to control for unobservable individual characteristics such as eating habits and food preferences in the conventional model could result in overestimation on the beneficial effect of salad consumption. In contrast, the first-difference estimator only used within individual variations between the 2 non-consecutive dietary recall days among salad consumers to identify the effects of salad consumption, which eliminated the potential bias owing to individual unobservable. However, estimates based on the first-difference estimator only pertain to its sample base, namely salad consumers, rather than to the general adult population comprising both salad consumers and non-consumers.

Salad consumption was found to be less prevalent among men, racial/ethnic minorities, young and middle-aged adults, adults at lower income and education level and normal weight adults. Dietary habit, nutrition knowledge, affordability, health awareness and disease prevention/management could all contribute to this observed disparity [19]. Interventions that promote availability and affordability of salad consumption should target these population subgroups and be tailored to meet their specific needs. On the other hand, despite a few differences, the effects of salad consumption on daily dietary intake and diet quality among salad consumers were largely replicated in all population subgroups under study. This finding indicates that programs that promote salad consumption could have similar influences on habitual salad consumers with diverse demographic and socioeconomic backgrounds.

A few limitations of this study should be noted. Salad is a highly diverse and complex food category and can be classified by a variety of ways based on main contents (chicken salad versus potato salad), preparation methods (e.g., home-made versus pre-packaged), types of dressings, etc. There may not be one "typical" or "generalizable" model for salad and the same argument could be made for salad consumers, who had diverse consumption preferences and eating habits. The aim of this study was to document the overall salad consumption patterns and their aggregated impact on energy and nutrient intake among American adults. Future studies are warranted to classify salads into finer categories based on predetermined criteria in an effort to examine their differential nutritional implications. The NHANES is a probability sample of the U.S. no institutionalised population and patients in penal/mental facilities, institutionalised older adults, and/or military personnel on active duty are not represented. Dietary intakes in the NHANES were self-reported and subject to measurement error and social desirability bias [27]. First-difference estimator eliminated confounding bias from unobservable factors that remained constant within participant between the 2 dietary interviews, but could not control more transient factors like daily variations in physical activity, appetite, or emotions. Estimates based on the first-difference approach only pertain to salad consumers but may not be generalizable to the general adult population. Salad consumption is merely one of many potential diet choices that may fulfil dietary reference intakes for fibre and other micronutrients. Moreover, high salad intake is likely a marker of a healthier lifestyle, which may include complex aspects of quantity and quality of diet and be difficult to measure. However, a comprehensive estimation of overall dietary patterns is beyond this scope of this study.

CONCLUSION

In conclusion, salad is an essential component of the American diet and serves as a primary source of daily fresh produce consumption for a significant proportion of U.S. adults. Salad consumption was associated with higher daily intake of vegetable and fibre and overall diet quality; whereas on the other hand, it was also linked with elevated daily intake of total energy, sugar, total fat, saturated fat, cholesterol and sodium, likely owing to excess portion size and high energy density. Interventions that promote salad consumption should provide low-energy-dense, nutrient-rich salad products. Salad consumers need to prudently evaluate the caloric and nutrient content of salad in order to make informed and more healthful diet choices. Despite the use of a first-difference approach, this study is observational in nature and future work adopting an experimental study design is warranted to confirm relevant findings.

References

1. U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion. Nutrition and Weight Status. Healthy People 2020. Available from: http://www.healthypeople.gov/2020/topics-objectives/topic/nutrition-and-weight-status [Accessed December 2015].
2. Sebastian RS, Enns CW, Goldman JD, et al. Sandwich consumption by adults in the US. U.S. Department of Agriculture Food Surveys Research Group, Dietary Data Brief No.4, 2015. Available from: http://www.

ars.usda.gov/SP2UserFiles/Place/80400530/pdf/DBrief/14_sandwich_consumption_0912.pdf [Accessed January 2016].
3. Moore LV, Thompson FE. Adults Meeting Fruit and Vegetable Intake Recommendations—United States, 2013. MMWR Morb Mortal Wkly Rep 2015;64:709–13.
4. Krebs-Smith SM, Guenther PM, Subar AF, et al. Americans do not meet federal dietary recommendations. J Nutr 2010;140:1832–8.
5. Drewnowski A, Specter SE. Poverty and obesity: the role of energy density and energy costs. Am J Clin Nutr 2004;79:6–16.
6. An R. Beverage Consumption in Relation to Discretionary Food Intake and Diet Quality among US Adults, 2003 to 2012. J Acad Nutr Diet 2015;116:28-37
7. Su LJ, Arab L. Salad and raw vegetable consumption and nutritional status in the adult US population: results from the Third National Health and Nutrition Examination Survey. J Am Diet Assoc 2006;106:1394–404.
8. Cordain L, Eaton SB, Sebastian A, et al. Origins and evolution of the Western diet: health implications for the 21st century. Am J Clin Nutr 2005;81:341–54.
9. Rolls BJ, Roe LS, Meengs JS. Salad and satiety: energy density and portion size of a first-course salad affect energy intake at lunch. J Am Diet Assoc 2004;104:1570–6.
10. Roe LS, Meengs JS, Rolls BJ. Salad and satiety. The effect of timing of salad consumption on meal energy intake. Appetite 2012;58:242–8.
11. Pérez-Guisado J, Muñoz-Serrano A, Alonso-Moraga A. Spanish Ketogenic Mediterranean Diet: a healthy cardiovascular diet for weight loss. Nutr J 2008;7:30.
12. Engels HJ, Gretebeck RJ, Gretebeck KA, et al. Promoting healthful diets and exercise: efficacy of a 12-week after-school program in urban African Americans. J Am Diet Assoc 2005;105:455–9.
13. Jeffery RW, French SA, Raether C, et al. An environmental intervention to increase fruit and salad purchases in a cafeteria. Prev Med 1994;23:788–92.
14. Paine-Andrews A, Francisco VT, Fawcett SB, et al. Health marketing in the supermarket: using prompting, product sampling, and price reduction to increase customer purchases of lower-fat items. Health Mark Q 1996;14:85–99.
15. French SA, Story M, Jeffery RW, et al. Pricing strategy to promote fruit and vegetable purchase in high school cafeterias. J Am Diet Assoc 1997;97:1008–10.
16. An R. Effectiveness of subsidies in promoting healthy food purchases and consumption: a review of field experiments. Public Health Nutr 2013;16:1215–28.
17. Wu HW, Sturm R. What's on the menu? A review of the energy and nutritional content of US chain restaurant menus. Public Health Nutr 2013;16:87–96.
18. Harris DM, Seymour J, Grummer-Strawn L, et al. Let's move salad bars to schools: a public-private partnership to increase student fruit and vegetable consumption. Child Obes 2012;8:294–7.
19. Faith MS, Kral TVE. Social environmental and genetic influences on obesity and obesity-promoting behaviors: fostering research integration. In Genes, Behavior, and the Social Environment: Moving Beyond the Nature/Nurture Debate. Washington (DC): National Academies Press, 2006.
20. Guenther PM, Casavale KO, Reedy J, et al. Update of the Healthy Eating Index: HEI-2010. J Acad Nutr Diet 2013;113:569–80.
21. National Cancer Institute. Sources of beverage intakes among the US population, 2005-06. Applied Research Program Web site. Available from: http://riskfactor.cancer.gov/diet/foodsources/beverages/ [Accessed December 2015].
22. Ogden CL, Kit BK, Carroll MD, et al. Consumption of sugar drinks in the United States, 2005-2008. NCHS Data Brief 2011;1–8.
23. World Health Organization. The international classification of adult underweight, overweight and obesity according to BMI. Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.htm [Accessed 2015 December].
24. Kral TVE, Roe LS, Rolls BJ. Combined effects of energy density and portion size on energy intake in women. Am J Clin Nutr 2004;79;962–8.
25. Ello-Martin JA, Ledikwe JH, Rolls BJ. The influence of food portion size and energy density on energy intake: implications for weight management. Am J Clin Nutr 2005;82;236S–241S.
26. Rolls BJ, Roe LS, Meengs JS. Reductions in portion size and energy density of foods are additive and lead to sustained decreases in energy intake. Am J Clin Nutr 2006;83:11–7.
27. Hebert JR, Hurley TG, Peterson KE, et al. Social desirability trait influences on self-reported dietary measures among diverse participants in a multicenter multiple risk factor trial. J Nutr 2008;138;226S–234S.

*