# The Association between Types of Soda Consumption and Overall Diet Quality: Evidence from National Health and Nutrition Examination Survey (NHANES)

Pimbucha Rusmevichientong[1], Sinjini Mitra[2], Archana J. McEligot[1], and Emma Navajas[1]

*[1]Department of Health Science, California State University Fullerton*
*[2]Department of Information Systems & Decision Sciences*

## Abstract

**Background and Purpose:** Daily soda consumption may lead to high energy intake and poor diet quality. Although diet sodas contain no calories, they lack healthful nutrients. The study examined different types of soda consumption [regular (sugar-sweetened) sodas, diet sodas, and non-sodas] associated with overall diet quality. **Methods:** Cross sectional, 24-hour dietary recall data from the National Health and Nutrition Examination Survey (NHANES) from 2005-2012 were utilized for the study. Majority of the participants (n = 4,427) were female (57%), adults aged 19-55 years (51%), and non-Hispanic whites (67%). Nutritional Quality Index (NQI) was calculated as an indicator of diet quality. Multiple linear regression models were used to estimate the significant association between types of soda consumption and NQI stratified by body mass index. **Results:** Regular soda drinkers had lower NQI than diet soda drinkers, but only for overweight ($\beta$ =-9.72; p=0.031) and obese ($\beta$ =-7.06; p<0.002) individuals. Non-soda drinkers had higher NQI compared to diet soda drinkers in normal weight ($\beta$ =12.38; p=0.006) and obese ($\beta$ =6.19; p<0.000) individuals. **Conclusion:** Nutrition intervention programs, therefore, should target overweight and obese soda drinkers, emphasizing reduction in soda consumption, which may improve nutrient density in their diets and subsequently impact long-term health outcomes.

*Keywords: sugar-sweetened (regular) sodas, diet sodas, Nutritional Quality Index (NQI), Body Mass Index (BMI)*

## Introduction

Sugar-sweetened sodas also referred to as regular or non-diet sodas mostly contain carbonated water, flavoring, and natural sweetener. In the United States (U.S.), approximately 50% of adults consume sugar-sweetened beverages (SSB), including regular sodas, on any given day (Fakhouri, Kit, & Ogden, 2012; Ogden, Kit, Carroll, & Park, 2011). According to the Gallup Poll conducted in 2012, 48% of Americans reported drinking an average of 2.6 glasses of regular sodas per day (Saad, 2012). Regular sodas are commonly regarded as beverages with poor nutrient-to-energy ratio, as they tend to be high in energy (kcal) and added sugars, but low in nutrient density (Malik, Schulze, & Hu, 2006). Though there is no general accepted definition, nutrient density is typically defined as foods or beverages that provide substantial amounts of nutrients for relatively few calories (American Dietetic Association, 2007). An increasing intake of added sugars has been found to be associated with decreasing intake of micronutrients, such as calcium, zinc, vitamin C and vitamin B12 (Joyce & Gibney, 2008; Alexy, Sichert-Hellert, & Kersting, 2002; Forshee & Storey, 2001; Bowman, 1999; Farris, Nicklas, Myers, & Berenson, 1998).

In 2012, about 20% of U.S. adults consumed energy-free, artificially sweetened beverages including diet sodas (Fakhouri et al., 2012), which has increased dramatically from about 3% in 1965 (Duffey & Popkin, 2006). Unlike regular sodas, diet sodas tend to lack energy (kcal) and added sugars. Both regular and diet sodas, however, lack many healthful nutrients. For example, they are high in phosphate and devoid of calcium, which can lead to a change in the calcium-phosphorus ratio in the diet, and ultimately to a deleterious effect on bone health/density (Malik et al., 2006; Wyshak,

2000). A systematic review and meta-analysis based on studies conducted in the U.S. (Vartanian, Schwartz, & Brownell, 2011, 2007) found that daily soda consumption can dilute calcium, riboflavin, vitamin A and B12 intakes. As a consequence, it may lead to poor diet quality and subsequent deleterious health outcomes.

## The Present Study

To our knowledge, limited research studies have investigated the overall diet quality of soda drinkers in the U.S. population. Much of the research to date has been focused on SSB in general and conducted in countries outside of the U.S., such as Germany (Libuda et al. 2009) and Spain (Schröder et al., 2014). Utilizing the National Health and Nutrition Examination Survey (NHANES), a continuous nationally representative cross-sectional database of adults and children in the U.S., we examined the association between types of soda consumption [regular (sugar-sweetened) sodas, diet sodas, and non-sodas] and overall diet quality stratified by Body Mass Index (BMI). Due to the difference in beverage and food patterns, demographic/heritage factors, and a multitude of other differences, the results from one country cannot be generalized to another. The findings from the present study could contribute to the literature on understanding and deciphering the differences in overall diet quality patterns of different types of soda drinkers by BMI categories in the U.S. population, and subsequently contribute to targeted nutrition interventions for BMI sub-groups.

## Methods

### Study Design and Sample
What We Eat in American (WWEIA) is a continuous, nationally representative cross-sectional sample of approximately 9,000 participants per two-year release cycle for NHANES (ARS, 2016). Dietary assessment is conducted via WWEIA, which contributes to the NHANES dietary data, including food/beverage and dietary supplement intakes. Two non-consecutive 24-hour dietary recalls were collected per participant. The Day 1 interview

was conducted in-person in the Mobile Examination Center (MEC). The Day 2 interview was conducted on the telephone by appointment within 3 to 10 days following the MEC interview on a different day of the week. During the interviews, survey respondents were instructed to report the description of food and beverages they consumed, quantity, time of consumption occasion, and source of the consumed food and beverages. Given the continuous design of NHANES, it is possible to combine data from several cycles in order to increase sample size. Our study combined data from four cycles of NHANES from 2005 to 2012, which resulted in a nationally representative sample of 37,529 participants. However, consistency in the data collection methods and other methodological issues between cycles needed to be considered.

The reliability of two non-consecutive 24-hour dietary recalls were justified using dietary recall status variables provided by NHANES i.e., DR1DRSTZ variable for the Day 1 interview and DR2DRSTZ variable for the Day 2 interview. For example, if either variable was not taking the value of one, the corresponding data were non-reliable and hence excluded. A total of 9,379 participants (25%) who had non-reliable two non-consecutive 24-hour dietary recalls were excluded from the study. The participants who had complete reliable data for two non-consecutive 24-hour dietary recalls of food and beverage intakes with no missing selected sociodemographic data were included in our analyses. As a result, the study sample resulted in 4,427 participants, which was relatively small compared to the original NHANES data. The Centers for Disease Control and Prevention's (CDC) Institutional Review Board approved NHANES, and all participants were provided written informed consent. Study protocol review was conducted and approved by the Internal Review Board (IRB) of the California State University, Fullerton (HSR# 16-0221).

### Measures
**Soda Drinker Classification.** NHANES does not categorize the types of beverage drinkers, i.e., diet soda drinkers, regular soda drinkers,

non-soda drinkers, or other. In addition, a majority of participants consumed and reported various types of beverages within a day, such as regular sodas, diet sodas, juices, milk, water, energy drinks, alcoholic beverages, etc. We utilized the participants' two non-consecutive 24-hour dietary recalls data to classify drinkers into three mutually exclusive categories as follows: (1) diet soda drinkers (DSD), (2) regular soda drinkers (RSD), and (3) non-soda drinkers (NSD). DSD are classified as those participants who reported drinking only diet sodas and no other types of alcoholic or non-alcoholic beverages in Day 1 and Day 2. RSD are classified as those participants who reported drinking only regular sodas and no other types of alcoholic or non-alcoholic beverages in Day 1 and Day 2. Last, NSD are classified as those participants who reported drinking other types of non-alcoholic beverages and no other types of sodas or alcoholic beverages in Day 1 and Day 2. All reported beverage items were systematically coded using the U.S. Department of Agriculture Food and Nutrient Database for Dietary Studies (FNDDS, 2016). Specifically, there are 8 digits in a FNDDS food code number. For example, a code with "92" as the first two digits indicates non-alcoholic beverages. A code in which the first three digits are "924" indicates soda beverages, and their last five digits specify the types and brands of soda beverages.

**Nutritional Quality Index.** We utilized the Nutritional Quality Index (NQI) as an indicator to assess individual overall diet quality. The NQI of each participant was computed from the harmonic mean of the Intake Quality Score (IQS) values (Libuda et al., 2009; Gedrich & Karg, 2001) as follows:

$$NQI = \frac{n}{\sum_{i=1}^{n} \frac{1}{IQS_i}}$$

where $n$ = numbers of nutrients; $IQS_i$ = intake quality score of nutrient $i$ which is computed as the percentage of the age- and sex-specific dietary reference value for mean intake of nutrient $i$. The reference values were obtained from the U.S. Dietary Reference Intakes (DRI) (NIH, 2011). Thirteen nutrients were included in the NQI computation i.e., protein, vitamin A,

vitamin C, calcium, iron, zinc, folate, thiamine, riboflavin, vitamin B-12, vitamin E and potassium. These nutrients belonged to the group of nutrients used to calculate the Naturally Nutrient Rich Score (NNR) (Hansen, Wyse, & Sorenson, 1979; Lachance & Fisher, 1986; Bandini, Vu, Must, Cyr, Goldberg, & Dietz, 1999; IOM, 2003). However, we excluded monounsaturated fat (MUFA) because there was no reference value in the DRI, and also excluded vitamin D because the sources of vitamin D are not primarily from foods, but rather from sunlight exposure.

IQS values were truncated at 100 if the intake of a nutrient exceeded the reference value. As such, the deficient intake of one nutrient will not be compensated by the exceeding intake of another nutrient (Libuda et al., 2009; Gedrich & Karg, 2001). In addition, the harmonic mean is more sensitive to imbalances in nutrient intake than the arithmetic mean.

**Other Variables.** Sociodemographic variables including gender, age, BMI, race/ethnicity, education, and family income, and average energy intake (kcal) were obtained from the respective NHANES dataset e.g., demographic data, dietary data, and examination data. The age groups were defined as follows: (i) children: age < 12 years; (ii) teenagers: 12 years ≤ age ≤ 18 years; (iii) young adults: 19 years ≤ age ≤ 35 years; (iv) middle-aged adults: 36 years ≤ age ≤ 55 years, and (v) elderly: age ≥ 56 years. It is worth noting that the study included children and teenagers in the analyses, because empty calories from added sugars contribute to 40% of daily calories for children and adolescents age 2-18 years affecting their overall diet quality. Approximately, half of these empty calories come from soda, fruit drinks, dairy desserts, grain desserts, pizza and whole milk. Two-thirds of kids drink at least one soda on any given day (CDC, 2017).

BMI ($kg/m^2$) was obtained via weight and height measurements during the in-person interview in the MEC using standardized methods. Standard BMI categories were applied for participants older than 20 years as follows: (i) underweight - BMI < 18.5; (ii) normal weight - 18.5 ≤ BMI <

25; (iii) overweight - $25 \leq BMI <30$; and (iv) obese - $BMI \geq 30$. The BMI categories for participants 20 years of age or less used the 2000 CDC growth chart based on age and gender (CDC, 2002) as follows: (1) underweight - BMI $<5^{th}$ percentile; (ii) normal weight - $5^{th}$ percentile $\leq BMI< 85^{th}$ percentile; overweight - $85^{th}$ percentile $\leq BMI< 95^{th}$ percentile; obese - BMI $\geq 95^{th}$ percentile.

Four ethnic groups included Hispanic (Mexican Americans and other Hispanics), non-Hispanic white, non-Hispanic black, and other race. Education was categorized as follows: (i) less than high school; (ii) high school; and (iii) higher than high school. Family income was reported: (i) family income < $20K; (ii) $20K $\leq$ family income < $35K; (iii) $35K $\leq$ family income < $55K; (iv) $55K $\leq$ family income < $75K; (v) $75K $\leq$ family income < $100K; and (vi) family income $\geq$ $100K.

**Statistical Methods.** NHANES data and selection of participants are based on a complex, multistage, probability sampling design (CDC[a], 2013). Thus, a sample weight is assigned to each sample person, and therefore each individual can represent multiple individuals. The analyses were based on a weighted survey sample and performed using SURVEY: MEAN, SURVEY: REG, and LINCOM commands from the statistical software package *STATA*, version 14 (Stata-Corp LP, College Station, TX), and IBM-SPSS version 24, to account for the complex structure of the survey design in NHANES. The sample weight variable used for point estimate correction was 0.25*WTDR2D, which is the sample weight of two dietary recalls for four cycles from 2005-2006 to 2011-2012. The design weight variables used for standard error adjustment were *SDMVSTRA* and *SDMVPSU* (CDC[b,c], 2013).

In addition to the descriptive statistics, we used inferential statistical methods: two-sample t-tests and multiple linear regression models to test our hypothesis. Two-sample t-tests were used to test for NQI differences between DSD and RSD by body mass index (BMI) categories. Due to the very small sample size of DSD group compared to RSD and NSD groups, the significance

comparison demonstrated by the p-values in these cases may not be meaningful (Sullivan and Feinn, 2012). We assessed and utilized effect sizes to quantify the differences between the two groups, which emphasize the size of the difference rather than relying on sample size, as well as p-values. *Hedges' g* is recommended if the sample sizes of the two groups are widely different (as in our case), which was used to calculate the effect sizes to measure the strength of the significance in each of the above cases (Hedges & Olkin, 1985).

Furthermore, we conducted five multiple linear regression models stratified by BMI categories, including overall, underweight, normal weight, overweight, and obese. The models estimated the association between NQI (dependent variable) and types of beverage drinkers (independent variable), while adjusting for confounding factors, such as sociodemographic variables. Specifically, the independent variable was a categorical variable with three categories (1) DSD, (2) RSD, and (3) NSD. The sociodemographic variables included gender with male as the reference category, race/ethnicity with Hispanic as the reference, age groups with children as reference, education with less than high school as the reference, family income with the category $\leq$$20K as the reference, and average energy intake (kcal). The level of statistical significance was set at 5%, or 0.05 based on p-values.

## Results

Based on data from 4,427 survey respondents, there were 3,351 NSD (76%), 879 RSD (20%), and 197 DSD (4%). The sociodemographic variables presented in Table 1 included respective % or mean (SE). Interestingly, compared to the RSD group, the DSD group had a higher proportion of obese individuals [55.4% (0.012) vs 33.3% (0.024)], elderly [23.8% (0.036) vs 7.8% (0.012)], non-Hispanic whites [83.7% (0.046) vs 65.2% (0.034)], individuals whose education level was higher than high school (58.6% (0.041) vs 33.6% (0.026)), and individuals who had family income $\geq$ $55K. Furthermore, the DSD group had a lower average energy intake (kcal) [1,767.43 (75.05)]

and a higher average NQI [63.20 (1.98)] compared to the RSD group [2,136 (46.922) and 61.60 (1.33), respectively]. Chi-Square and One-Way ANOVA (F-ratio) tests were conducted across three different types of beverage drinkers

to test the group differences. The results showed sociodemographic characteristics of DSD, RSD, and NSD groups were significantly different except the other race, high school education and family income levels.

## Table 1

Descriptive Statistics of Overall and Different Types of Soda Drinkers: National Health Examination Survey (NHANES), from 2005-2006 to 2011-2012

| Types of Beverage Drinkers | Overall (N=4,427) | | DSD[a] (N=197) | | RSD[b] (N=879) | | NSD[c] (N=3,351) | | $X^2$ (P)[e] |
|---|---|---|---|---|---|---|---|---|---|
| | % | | % | | % | | % | | |
| **Gender** | | | | | | | | | |
| Male | 43 | | 34.2 | | 50 | | 37.7 | | 48.67 (0.00) |
| **Body weight status (BMI)** | | | | | | | | | |
| Underweight (BMI≤18.5) | 1.9 | | 1.7 | | 3.6 | | 1.5 | | 15.78 (0.05) |
| Normal weight (18.5≤BMI<25) | 34.7 | | 17.3 | | 39.2 | | 34.9 | | 46.11 (0.00) |
| Overweight (25≤BMI<30) | 29.6 | | 25.6 | | 23.9 | | 31.6 | | 21.67 (0.03) |
| Obese (BMI≥30) | 33.8 | | 55.4 | | 33.3 | | 32.0 | | 64.46 (0.00) |
| **Age groups (year)** | | | | | | | | | |
| Children (y<12) | 7.3 | | 2.0 | | 11.0 | | 6.7 | | 31.92 (0.00) |
| Teens (y12-18) | 9.3 | | 2.2 | | 19.3 | | 7.3 | | 138.33 (0.00) |
| Young adults (y19-35) | 20.7 | | 24.5 | | 35.7 | | 16.0 | | 172.12 (0.00) |
| Middle-aged adults (y36-55) | 30.8 | | 47.5 | | 26.2 | | 30.6 | | 46.46 (0.00) |
| Elderly (y56 or up) | 31.9 | | 23.8 | | 7.8 | | 39.4 | | 333.57 (0.00) |
| **Ethnicity** | | | | | | | | | |
| Hispanic[d] | 13.5 | | 5.3 | | 17.3 | | 13.2 | | 27.54 (0.00) |
| Non-Hispanic White | 66.9 | | 83.7 | | 65.2 | | 65.9 | | 39.24 (0.00) |
| Non-Hispanic Black | 12.1 | | 4.7 | | 11.7 | | 12.9 | | 16.89 (0.00) |
| Other race | 7.5 | | 6.3 | | 5.8 | | 8.0 | | 5.75 (0.42) |
| **Education levels** | | | | | | | | | |
| Less than high school | 32.2 | | 23.0 | | 45.4 | | 29.4 | | 95.21 (0.00) |
| High school | 20.0 | | 18.4 | | 21.0 | | 19.8 | | 1.11 (0.72) |
| Higher than high school | 47.8 | | 58.6 | | 33.6 | | 50.8 | | 98.40 (0.00) |
| **Family income levels** | | | | | | | | | |
| <$20K | 20.5 | | 16.8 | | 25.6 | | 19.4 | | 19.12 (0.02) |
| <$35K and >=$20K | 19.8 | | 17.2 | | 21.7 | | 19.5 | | 3.42 (0.33) |
| <$55K and >=$35K | 17.9 | | 12.5 | | 19.7 | | 17.9 | | 7.59 (0.28) |
| <$75K and >=$55K | 13.3 | | 15.7 | | 8.8 | | 14.2 | | 20.14 (0.10) |
| <$100K and >=$75K | 10.8 | | 18.3 | | 10.4 | | 10.3 | | 17.14 (0.07) |
| $100K or up | 17.7 | | 19.5 | | 13.8 | | 18.7 | | 12.39 (0.24) |
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE | F-ratio (P)[e] |
| Energy intake | 1,908.8 | 17.13 | 1,767.43 | 75.05 | 2,136.64 | 46.92 | 1,857.88 | 19.44 | 16.95 (0.00) |
| Nutritional Quality Index (NQI) (%) | 69.85 | 0.61 | 63.20 | 1.98 | 61.60 | 1.33 | 72.74 | 0.54 | 45.26 (0.00) |

Note : The descriptive statistics were based on a weighted sample and computed using the STATA procedure SURVEY command ; N= Total observation; SE = Linearized Standard Error; P = p-value
[a] DSD = Diet Soda Drinkers
[b] RSD = Regular (Sugar-Sweetened) Soda Drinkers
[c] NSD = Non- Soda Drinkers
[d] Hispanic includes Mexican American and other Hispanic.
[e] Chi-Square test and One-Way ANOVA (F-ratio) test were conducted across three different types of drinkers to test the group differences.

**Comparisons among Beverage Drinker Types.** A pairwise comparison of NQI between DSD and the other two types of beverage drinkers, RSD and NSD, stratified by BMI categories, are presented in Table 2. We found that DSD and RSD were not significantly different in NQI for overall and all of the

different BMI categories. However, DSD had a significantly lower NQI than NSD for overall [($M$=63.20, $SD$=16.62) vs ($M$=72.74, $SD$=18.89); $t$ (49) = -4.34, $p$<0.000] and obese groups [($M$=61.26, $SD$=16.11) vs ($M$=70.82, $SD$=19.44); $t$ (49) = -3.99, $p$<0.000]. Using *Hedges' g* to calculate the effect size, the results

showed that all of the significance results stated above have medium effect size (Hedges'g> 0.5).

**Table 2**

The Average Nutritional Quality Index (NQI) Among Different Types of Soda Drinkers Stratified by BMI Categories: National Health Examination Survey (NHANES), from 2005-2006 to 2011-2012

| | Overall M (N, SD) | Underweight BMI≤18.5 M (N, SD) | Normal weight 18.5≤BMI<25 M (N, SD) | Overweight 25≤BMI<30 M (N, SD) | Obese BMI≥30 M (N, SD) |
|---|---|---|---|---|---|
| DSD[a] (Reference level) | 63.20 (197, 16.62) | 71.18 (4, 7.77) | 64.64 (30, 16.67) | 65.14 (53, 17.62) | 61.26 (110, 16.11) |
| RSD[b] | 61.60 (879, 21.56) | 62.79 (27, 22.13) | 65.50 (358, 21.13) | 59.84 (190, 19.80) | 58.17 (304, 22.46) |
| NSD[c] | 72.74[*d] (3351,18.89) | 73.69 (52, 16.16) | 74.76 (1140, 18.33) | 72.39 (988, 18.77) | 70.82[*d] (1171, 19.44) |

Note: The average NQIs were calculated based on weighted sample. The sampling weight was used to adjust for the point estimates. The design weights which include clustering and stratification were used to adjust for standard errors; N = Total observation; SD = Standard Deviation.
[a] DSD = Diet Soda Drinkers
[b] RSD = Regular (Sugar-Sweetened) Soda Drinkers
[c] NSD = Non- Soda Drinkers
[d] Effect sizes is greater than 0.5 (medium effect)
[*] Statistically different from the overall mean NQI at 5% significance level

**Multiple Linear Regression Results.** The five multiple linear regression models assessing the association between NQI and different types of beverage drinkers for overall and by BMI categories, are presented in Table 3. RSD group was negatively associated with NQI but only for the overall ($\beta$ =-7.03; p<0.000), overweight ($\beta$ =-10.04; p=0.011) and obese ($\beta$ =-6.85; p=0.002) groups. In other words, RSD who are overweight or obese had relatively lower NQI compared to their DSD counterparts. The association between NQI and RSD group was not significant for individuals who were underweight or normal weight. In addition, there was a positive significant association between NQI and NSD for overall ($\beta$ =7.28; p<0.000), normal weight ($\beta$ =11.42; p=0.008) and obese ($\beta$ =6.22; p<0.000) groups. Generally,

NSD had relatively higher NQI compared to DSD in these respective groups. Additionally, some sociodemographic variables were found to be significantly associated with NQI. Males, especially underweight and obese males, had lower NQI than females. Non-Hispanic blacks had lower NQI than Hispanics for overall, normal weight, and obese groups. Age was negatively associated with NQI. Lastly, education level was positively associated with NQI. Individuals whose education level was higher than high school had higher NQI than those having a less than high school education in most of the BMI categories, except in the overweight group. Family income was positively associated with NQI.

## Table 3

Multiple Linear Regression Models of the Association between Nutritional Quality Index (NQI) and Different Types of Soda Drinkers Stratified by BMI Categories: National Health Examination Survey (NHANES), from 2005-2006 to 2011-2012

| | Overall | | Underweight BMI≤18.5 | | Normal weight 18.5≤BMI<25 | | Over weight 25≤BMI<30 | | Obese BMI≥30 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | B (SE) | P | B (SE) | P | B (SE) | P | B (SE) | P | B (SE) | P |
| **Types of Beverage Drinkers** (Reference =DSD[a]) | | | | | | | | | | |
| RSD[b] | -7.03* (1.79) | 0.000 | 0.009 (8.39) | 0.999 | -2.16 (4.64) | 0.633 | -10.04* (3.79) | 0.011 | -6.85* (2.06) | 0.002 |
| NSD[c] | 7.28* (1.62) | 0.000 | 4.20 (8.97) | 0.642 | 11.42* (4.09) | 0.008 | 5.73 (3.26) | 0.084 | 6.22* (1.54) | 0.000 |
| **Gender** (Reference=Female) | | | | | | | | | | |
| Male | -2.85* (0.79) | 0.001 | -12.79* (5.15) | 0.017 | -2.29 (1.18) | 0.006 | -3.16 (1.63) | 0.059 | -2.65* (1.297) | 0.042 |
| **Ethnicity** (Reference = Hispanic) | | | | | | | | | | |
| Non-Hispanic White | -1.72 (0.94) | 0.074 | -3.62 (5.06) | 0.479 | -1.67 (1.31) | 0.209 | -0.92 (1.67) | 0.586 | -2.40 (1.80) | 0.189 |
| Non-Hispanic Black | -5.43* (1.07) | 0.000 | -2.34 (4.39) | 0.598 | -5.31* (1.70) | 0.003 | -1.65 (1.92) | 0.394 | -6.97* (1.75) | 0.000 |
| Other race | -1.69 (1.08) | 0.126 | -1.88 (5.68) | 0.742 | -2.88 (1.60) | 0.079 | 0.12 (1.92) | 0.950 | -2.43 (2.50) | 0.336 |
| **Age groups** (Reference = Children (y <11)) | | | | | | | | | | |
| Teens (y12-18) | -14.78* (1.13) | 0.000 | -8.47 (6.28) | 0.184 | -14.56* (1.43) | 0.000 | -14.44* (3.64) | 0.000 | -15.07* (2.46) | 0.000 |
| Young adults (y19-35) | -19.92* (1.64) | 0.000 | -29.00* (7.37) | 0.000 | -20.83* (1.98) | 0.000 | -16.46* (3.03) | 0.000 | -21.01* (2.34) | 0.000 |
| Middle-aged adults (y36-55) | -18.51* (1.44) | 0.000 | -15.69* (6.62) | 0.022 | -18.04* (2.24) | 0.000 | -15.65* (2.14) | 0.000 | -19.70* (1.93) | 0.000 |
| Elderly (y56 or up) | -15.26* (1.16) | 0.000 | -16.54* (7.48) | 0.032 | -17.25* (2.03) | 0.000 | -11.44* (2.50) | 0.000 | -15.33* (1.53) | 0.000 |
| **Education levels** (Reference = Less than high school) | | | | | | | | | | |
| High school | 2.31* (0.95) | 0.018 | 8.57 (5.64) | 0.136 | 1.87 (1.94) | 0.338 | 0.49 (1.72) | 0.775 | 3.83* (1.35) | 0.007 |
| Higher than high school | 4.98* (1.19) | 0.000 | 10.33* (4.71) | 0.034 | 7.53* (2.04) | 0.001 | 1.25 (2.15) | 0.565 | 5.43* (1.61) | 0.001 |
| **Family income levels** (Reference = <$20 K) | | | | | | | | | | |
| ≥$20K and <$35K | 0.47 (1.13) | 0.679 | 0.16 (4.73) | 0.973 | 1.29 (1.66) | 0.442 | 0.84 (2.34) | 0.722 | -0.51 (1.58) | 0.750 |
| ≥$35K and <$55K | 2.99* (1.04) | 0.006 | 5.27 (6.44) | 0.471 | 5.00* (1.80) | 0.008 | 1.80 (1.87) | 0.341 | 1.84 (1.51) | 0.227 |
| ≥$55K and <$75K | 2.757* (1.24) | 0.031 | -7.41 (7.13) | 0.304 | 3.72 (1.99) | 0.069 | 2.33 (2.29) | 0.313 | 2.92 (1.86) | 0.124 |
| ≥$75K and <$100K | 5.161* (1.15) | 0.000 | 12.26 (6.34) | 0.060 | 4.22* (1.97) | 0.038 | 7.55 (3.90) | 0.059 | 4.83* (1.28) | 0.000 |
| $100K or up | 3.83* (1.33) | 0.007 | 12.09* (5.61) | 0.037 | 3.90* (1.94) | 0.050 | 5.74* (2.79) | 0.045 | 1.63 (1.63) | 0.416 |
| **Energy intake** | 0.016* (0.00) | 0.000 | 0.013* (0.003) | 0.000 | 0.016* (0.001) | 0.000 | 0.02* (0.001) | 0.000 | 0.02* (0.001) | 0.000 |
| **Constant** | 48.65* (2.16) | 0.000 | 55.41* (12.22) | 0.000 | 44.61* (4.89) | 0.000 | 48.36* (4.25) | 0.000 | 48.51* (3.08) | 0.000 |
| Total observation | 4,427 | | 83 | | 1,528 | | 1,231 | | 1,585 | |
| R-squared | 0.480 | | 0.60 | | 0.49 | | 0.450 | | 0.51 | |

Note: The multiple linear regression model were based on weighted sample ; B = Unstandardized Coefficient; SE = Linearized Standard Error; P = p-value

[a] DSD = Diet Soda Drinkers

[b] RSD = Regular (Sugar-Sweetened) Soda Drinkers

[c] NSD = Non- Soda Drinkers

* <=5% significant level

**Discussion**

The rising rates of regular soda consumption have been found to be significantly associated with increasing obesity rates around the world (Basu, McKee, Galea, & Stuckler, 2013), decreasing intakes of key nutrients (Vartanian et al., 2011), and thus a deterioration of the overall diet quality of individuals (Libuda et al., 2009). Although diet sodas are considered as reasonable alternatives for soda drinkers who try to cut back on energy/calories and added sugar intake, they provide no nutritional value, and little is known about the health consequences of consuming artificial sweeteners during a lifetime (Mattes & Popkin, 2009). Some individuals may switch to diet sodas as a weight-loss strategy and/or because of obesity and health issue concerns, including diabetes (Popkin, Armstrong, Bray, Caballero, Frei & Willet, 2006); however, whether their overall diet quality improved is unknown.

Our study examined the association between overall diet quality and types of soda consumption including regular (sugar-sweetened) sodas, diet sodas, and non-sodas stratified by different BMI categories in the U.S. population by utilizing the National Health and Nutrition Examination Survey (NHANES) from 2005-2006 to 2011-2012. The proportion of diet soda drinkers were higher in females (65.8%), non-Hispanic whites (83.7%), middle-aged adults (47.5%), people with family income ≥ $55K (53.5%), and people with higher than high school education (58.6%). Our characteristics of diet soda consumption corresponded to Gallup's Annual Consumption Habits Survey in 2012, where the percentage of soda drinkers increases with age as income rises (Mendes, 2013).

Similar to other studies (Dennis, Flack, & Davy, 2009; Appleton & Conner, 2001; Strachan & Brawley, 2009), the proportion of overweight and obese individuals was higher among diet soda drinkers. Although studies have reported that overweight and obese individuals who drink diet beverages consume significantly more calories than heavier individuals who drink sugary beverages (Bleich, 2014; Dennis et al., 2009), our findings assessing their diet quality

found that overweight or obese DSD have higher nutritional quality index (NQI) than RSD counterparts. Furthermore, NSD had the highest NQI, which was significantly higher than DSD. This may be because both regular and diet soda consumption is related to higher intake of carbohydrates, lower intakes of fruit and dietary fiber, and lower intakes of a variety of macronutrients (Vartanian et al., 2007). It may also be likely that NSD are generally more healthful and potentially aware of dietary choices, choosing more nutrient-dense foods rather than empty calories.

Our findings regarding age groups and race/ethnicity associated with NQI corresponded with the results from Hiza, Casavale, Guenther, & Davis, 2013; specifically, that children had better-quality diets than younger and middle-aged adults, and blacks had lower diet quality than Hispanics. Hispanics are more likely to prepare meals at home (Heise, 2002) and foods eaten at home have been shown to be more nutritious than foods eaten away from home (Biign-Hwan, Guthrie, & Frazão, 1999). Education level, more than any other socioeconomic factor, has been shown to predict diet quality (Popkin, Zizza, & Siega, 2003; Rafferty, Anderson, McGee, & Miller, 2002). Our results showed that individuals whose education level was higher than high school had relatively higher NQI compared to those who had less than a high school education for overall, and especially in underweight, normal weight, and obese groups. Similarly, Popkin et al., 2003 showed greater improvement of diet quality index among adults who attended at least some college, compared with those who attained a high school degree or less. This suggests that higher education promotes more nutritious diets.

**Limitations**
There are certain limitations in this study that need to be addressed. Although the data combined two non-consecutive 24-hour dietary recalls to ensure the consistency of self-reporting data of dietary intake recalls, several

studies found that adults underreport their dietary consumption by 25% (Bingham et a., 1994; Briefel, Sempos, McDowell, Chien, & Alaimo, 1997). Therefore, the actual NQI of participants may be potentially lower. Second, the NHANES data are cross-sectional which limits us in establishing a long-term drinking pattern and only allows us to investigate association rather than causality (Bleich et al., 2014).

### Conclusion

Based on our findings, regular soda drinkers had relatively lower NQI and non-soda drinkers had relatively higher NQI compared to diet soda drinkers particularly for obese individuals. This evidence suggests that specialized nutrition education programs should target overweight and obese soda drinkers specifically and recommend them in reducing soda consumption and increasing nutrient dense unflavored beverages or water which may improve nutrient density in their diets and subsequently impact long-term health outcomes.

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Author Information
Pimbucha Rusmevichientong, Ph.D.
Department of Health Science, California State University, Fullerton
800 North State College Blvd., Fullerton, California 92831 Room KHS 135