Beverage Consumption in the Diets of Children is Not Consistently Associated with Weight: National Health and Nutrition Examination Survey 2007-2014

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Abstract: *Objectives*: The objective of this study was to examine whether there was significant risk associated with types of beverages consumed on the weight status in children.

Design: Nationally representative cross-sectional sample.

Setting: Demographic information was obtained from the NHANES interviews. Dietary intake data were obtained from Day 1, in-person 24-hour dietary recall interviews administered using an automated multiple-pass method. Height and weight were obtained according to NHANES Anthropometry Procedures Manual.

Subjects: Children 2-18 years of age.

Results: The likelihood of being overweight or obese was not significant for any of the beverages studied between consumers and non-consumers. For the total sample, for every 29.6 mL of water consumed the risk of being obese was 1%. For ages 6-11 years water consumption increased the risk of being obese and in ages 2-5 years, consumption of sugar sweetened beverages (SSB) increased the risk of being obese. The risk of being obese was significant $p < 0.05$ for Hispanic males for every 29.6 mL of water consumed and for 100% fruit juice and SSB for other males; increased risk was ≤3%. The risk of being obese increased for White females for every 29.6 mL of flavored milk consumed and water consumption for both Black females and Hispanic females; the significant $p<0.05$ increased risk of obesity was ≤7%.

Conclusions: Beverage consumption was not consistently associated with weight status in the diets of a nationally representative sample of children. In some cases the increased risk was very small.

Keywords: Beverage, consumption, NHANES, weight status, children.

INTRODUCTION

Beverages are an integral part of the American diet. Fluids (drinking water and other beverages) provide over 80% of the daily intake of total water, which is necessary for life [1]. Plain drinking water provides approximately one-third of total water intake, more than food [2, 3] or any other individual beverage group [4]. Between 2001 and 2010, total beverage consumption (excluding water) in the diets of children decreased from 24.4% to 21.1% energy [5]. Significant decreases occurred in sugar-sweetened sodas, whole milk, juice drinks with added sugar, and fruit-flavored drinks [5].

Although beverages are a major contributor of energy in the diet [6, 7], some beverages make large contributions to daily intakes of some nutrients [8, 9]. In many cases, this high nutrient contribution comes primarily from milk and 100% fruit juice (FJ), which are among the top beverage sources of vitamins A, D, and C; B vitamins; calcium; magnesium; phosphorus; and potassium for children [9]. Vitamins A, C, D, and E; folate; calcium; fiber; potassium and magnesium are among the shortfall nutrients [6]. Several studies have documented that beverage choices, specifically milk [10, 11] and 100% FJ [12] affect nutrient intake and adequacy and overall diet quality [6, 13]. However, sugar-sweetened beverages (SSB) are major contributors of energy and added sugars with virtually no contribution to vitamin and mineral intake [8].

Consumption of beverages, specifically SSB, has been adversely associated with weight [14-19]. Contrarily, meta-analysis of studies that attempted to reduce consumption of SSB showed no effect on body mass index [20]. Earlier studies focusing on weight and consumption of milk [21] and 100% FJ [12], have shown consistently no association with weight. Given that the relationship of beverage choice on weight status is relevant to several ongoing nutrition policy debates, more recent studies are needed. The goal of this study was to examine whether there was significant risk associated with types of beverages consumed on the weight status in children 2-18 years of age using the most recent national data available.

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METHODS

Study Population and Analytic Sample

The National Health and Nutrition Examination Survey (NHANES) is an ongoing cross-sectional study conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) to collect information on the health and nutritional status of a nationally represented cross-sectional sample of the total civilian, noninstitutionalized US population. The NHANES design is a stratified, multistage probability sample. For the present analyses, data from children 2-18 years (n=7,913) participating in the NHANES 2007-2014 [22, 23] were combined to increase sample size. Analyses excluded individuals without reliable dietary records or breastfeeding (n=17), those with missing weight status (n=115), and those with missing covariates in regression analyses (n=972). NHANES employs stringent protocols and procedures that ensure confidentiality and protects individual participants from identification [24]. As this was a secondary data analysis which lacked personal identifiers, this did not require further institutional review beyond the approval from the NCHS Research Ethics Review Board [25].

Demographics and Dietary Information

The methods and study design for NHANES have been previously described [22, 23, 26]. An update on NHANES dietary data collection, release, and analytical considerations was recently published [27]. Briefly, demographic information was obtained from the NHANES interviews [28]. Caretakers of children 2 to 5 years provided the 24-hour dietary recalls for their children; children 6-11 years were assisted by an adult, older children provided their own recall. Intake data were obtained from Day 1, in-person 24-hour dietary recall interviews administered using an automated multiple-pass method [29, 30]. Detailed descriptions of the dietary interview methods are provided in the NHANES Dietary Interviewers Procedure Manual [28].

Determination of Intake of Types of Beverages

In this study, types of beverages were defined according to USDA food codes and food categories [31, 32]. Specifically the five categories were: 100% FJ, were the food codes in categories 7002-7008 and 9202, water had the food codes in categories 7702, 7704, and 9204, milk, with food codes in categories 1002-1008, flavored milk, (food codes in categories 1202-1208, and SSB, food codes in categories 7202-7220. Intakes were converted to mL assuming 29.6 mL per fluid ounce for all beverages.

Anthropometric Measures

Height and weight were obtained according to NHANES Anthropometry Procedures Manual [33]. The manual provides information about equipment, calibration, methods, quality control, and survey procedures. Body mass index (BMI) was calculated as body weight (in kilograms) divided by height (in meters) squared [34]. The CDC's growth chart programs were used to determine BMI z-score; children with a BMI z-score greater than or equal to the 85th and less than 95th, and greater than or equal to the 95th percentile were considered overweight or obese, respectively [35].

Statistical Analyses

Demographics of consumers and non-consumers were determined and compared using independent t-tests. The primary focus of the statistics was a risk analysis of beverage consumption and weight status in children. Logistic regression was used to assess the odds ratios of being overweight, obese, or overweight/ obese for each beverage category. Covariates for the regression analyses were age, gender, race/ethnicity, poverty income ratio grouped into three categories (< 1.35, 1.35-1,85, and >1,85) [36], physical activity (sedentary, moderate and vigorous) [37], and current smoking status. For all analyses study-specific sample weights [38] were used and adjustment for the complex sample design of NHANES was used for all analyses using the statistical package SUDAAN (version 11, Research Triangle Institute, Research Triangle Park, NC). Analyses were conducted comparing consumers (of any amount) and non-consumers of each beverage; additionally we evaluated whether there was a linear effect of increased consumption of each beverage. The former was a categorical analyses that did not consider amount of beverage consumed while the latter directly assessed the impact of amount of beverage consumed with non-consumers designated as having zero consumption. Significance was set at $p<0.01$ due to the large sample size. However, results with a less conservative significance level ($p<0.05$) were also reported.

Results

Demographics of the Sample by Beverage Category (Table 1)

The sample of 2-18 years old (n=7,913) consisted of 49% females, 23% Hispanics, 55% Non-Hispanic

Table 1: Demographics of Children 2 to 18 Years (n=7,913) Participating in NHANES 2007-2014 by Beverage Category

Demographics (%)	Beverage Category									
	LSM and SE									
	100% Fruit Juice	SE	Water	SE	Milk	SE	Flavored Milk	SE	Sweetened Beverages	SE
Gender= Female	47.9	1.7	50.2	1.0	46.6	1.1	46.1	2.1	46.8	1.2
Gender=Male	52.1	1.7	49.8	1.0	53.4	1.1	53.9	2.1	43.2	1.2
Ethnicity										
Non-Hispanic White	48.5	3.0	56.3	2.6	57.8	2.6	53.8	3.9	53.3	3.0
Non-Hispanic Black	16.3	1.7	12.4	1.2	11.0	1.2	13.6	2.0	15.4	1.6
Hispanic	26.3	2.4	21.8	2.0	22.6	2.0	23.9	2.9	24.8	2.4
Other	9.0	0.8	9.5	0.8	8.6	0.9	8.6	1.2	6.5	0.6
% Consumers 2-18 years*	32.6	1.0	78.8	0.8	60.5	0.9	20.5	0.9	60.0	1.2
% Age Groups (years)										
2-5*	37.5	1.6	23.6	0.8	29.4	1.0	22.3	1.8	18.5	1.0
6-11*	37.4	1.9	37.4	0.9	39.1	1.0	52.9	2.5	39.5	1.0
12-18*	25.1	1.4	39.0	1.0	31.5	1.0	24.8	1.9	42.0	1.2
Poverty Index Ratio (PIR)										
Percentage <1.35 PIR	38.8	2.2	34.8	1.9	37.4	2.1	44.0	2.6	39.7	2.1
Physical Activity										
Sedentary	8.8	1.0	9.9	0.6	9.5	0.7	10.5	1.3	10.3	0.7
Moderate	16.5	1.0	20.6	0.8	17.2	0.9	18.6	1.7	20.4	1.0
Vigorous	74.8	1.5	69.5	1.0	73.2	1.1	70.9	1.9	69.4	1.1
Smoking Current	0.8	0.4	2.2	0.3	1.4	0.2	1.6	0.5	2.7	0.4
Day 1 Intake (mL)*	286.9	5.9	748.2	20.7	363.8	5.9	307.6	8.9	529.4	11.8

Abbreviations: LSM= Least square mean; SE= Standard error; Day 1 intakes.
*Significant differences exist across beverages.

Whites, 14% Non-Hispanic Blacks, and 9% other. There were no significant differences across the five beverage categories for gender, race/ethnicity, poverty income ratio, levels of physical activity, and smoking status. On average, 286.9 mL of 100% FJ, 748.2 mL of water, 363.8 mL of milk, 307.6 mL of flavored milk, and 529.4 mL of SSB were consumed. The percentage of children 2-18 year consuming individual beverage groups was 78.8% for water, 60.5% for milk, 60.0% for SSB, 32.6% for 100% FJ, and 20.5% for flavored milk. Age differences were found across the five beverage categories. A higher percentage of children 2-11 years consumed 100% FJ, 6-11 years consumed flavored milk, and 6-18 years consumed SSB when compared to the other beverage categories.

Likelihood of Overweight and Obesity in Children by Consumers and Non-Consumers (Categorical) and by Linear Assessment (Continuous) of Various Beverages

Total Sample (Table 2)

The likelihood of being overweight or obese in children by consumers and non-consumers was not significant for any of the five beverage categories studied. With regard to the linear assessment of beverage consumption, for every 29.6 mL of water consumed the risk for being obese increased 1% [beta=1.01; p=0.0029].

By Age Group (Table 3)

The likelihood of being overweight or obese in children among three age groups was not significant for the five beverage categories studied. With regard to the linear assessment of beverage consumption, water consumption increased the risk of being obese in children 6-11 years [beta=1.02; p<0.0001] and consumption of SSB increased the risk of being obese in children 2-5 years [beta=1.03; p=0.0015]. Albeit, the significant increase in risk of obesity was very small (i.e. ≤3%).

By Gender, Race and Ethnicity (Tables 4 and 5)

The likelihood of being overweight or obese in male children by race/ethnicity was not significant for the five beverage categories studied. With regard to the linear

Table 2: Likelihood of Overweight and Obesity in Children by Consumers and Non-consumers of Various Beverages†

Beverage Category‡	Weight Status		
	Overweight		
	Consumer vs Non-consumer	Linear Assessment of Consumption	
	OR (LCL,UCL)	Beta (LCL,UCL)	P value
100% Fruit Juice	1.03 (0.77, 1.37)	1.00 (0.98, 1.01)	0.4512
Water	1.08 (0.88, 1.44)	1.00 (1.00, 1.01)	0.1239
Milk	0.90 (0.67, 1.21)	1.00 (0.98, 1.01)	0.4799
Flavored Milk	1.08 (0.81, 1.44)	1.00 (0.98, 1.03)	0.5499
Sweetened Beverages	1.10 (0.88, 1.39)	1.00 (0.99, 1.00)	0.3498
	Obese		
	OR (LCL,UCL)	Beta (LCL,UCL)	P value
100% Fruit Juice	0.91 (0.65, 1.25)	0.99 (0.98, 1.00)	0.1862
Water	1.03 (0.71, 1.50)	1.01 (1.00, 1.01)	0.0029
Milk	0.90 (0.67, 1.20)	0.99 (0.98, 1.01)	0.5588
Flavored Milk	1.23 (0.84, 1.81)	1.01 (0.98, 1.04)	0.2829
Sweetened Beverages	1.21 (0.91, 1.61)	1.01 (1.00, 1.01)	0.1102
	Overweight or Obese		
	OR (LCL,UCL)	Beta (LCL,UCL)	P value
100% Fruit Juice	0.97 (0.76, 1.22)	0.99 (0.98, 1.01)	0.1746
Water	1.05 (0.79, 1.40)	1.00 (1.00, 1.01)	0.0067
Milk	0.90 (0.72, 1.14)	1.00 (0.98, 1.01)	0.4760
Flavored Milk	1.16 (0.88, 1.53)	1.01 (0.99, 1.03)	0.2638
Sweetened Beverages	1.17 (0.96 1.41)	1.00 (0.99, 1.01)	0.5160

Abbreviations: OR= Odds Ratio; LCL= Lower 99th Percentile Confidence Limit; UCL= Upper 99th Percentile Confidence Limit; Beta: regression coefficient and 99th LCL/UCL per mL of beverage per Day 1 intakes (n=7,913).
†Covariates: Age, gender, ethnicity, poverty index ratio (PIR), physical activity level, smoker status.
‡Sample size by beverage: 100% fruit juice: 2785; water: 6,127; milk: 4,663; flavored milk: 1,503; and sweetened beverage: 5,015.

Table 3: Likelihood of Overweight and Obesity in Children by Consumers and Non-consumers of Various Beverages by Age Group†

Age Group (years)	Weight Status		
	Overweight		
	Consumer vs Non-consumer	Linear Assessment of Consumption	
	OR (LCL, UCL)	Beta (LCL, CL)	P value
2-18 years (n=7,913)			
100% Fruit Juice (n=2,785)	1.03 (0.77, 1.37)	1.00 (0.98, 1.01)	0.4512
Water (n=6,127)	1.08 (0.81, 1.44)	1.00 (1.00, 1.01)	0.1239
Milk (n=4,663)	0.90 (0.67, 1.21)	1.00 (0.98, 1.01)	0.4799
Flavored Milk (n=1,503)	1.08 (0.81, 1.44)	1.00 (0.98, 1.03)	0.5499
Sugar Sweetened Beverages (n=5,015)	1.10 (0.88, 1.39)	1.00 (0.99, 1.00)	0.3498
2-5 years (n= 2,127)			
100% Fruit Juice (n=1,095)	1.04 (0.62, 1.74)	1.01 (0.98, 1.04)	0.6005
Water (n=1,670)	0.95 (0.52, 1.73)	1.00 (0.98, 1.01)	0.5770

(Table 3). Continued.

Milk (n=1,604)	1.20 (0.65, 2.21)	1.00 (0.98, 1.03)	0.8970
Flavored Milk (n=371)	0.86 (0.43, 1.73)	1.00 (0.96, 1.04)	0.9783
Sugar Sweetened Beverages (n=1,127)	1.34 (0.72, 2.48)	1.01 (0.98, 1.05)	0.2357
6-11 years (n=3,118)			
100% Fruit Juice (n=1,055)	1.04 (0.64, 1.71)	1.00 (0.97, 1.03)	0.8872
Water (n=2,430)	1.37 (0.95, 1.98)	1.01 (1.00, 1.02)	0.0439
Milk (n=1,841)	0.95 (0.62, 1.44)	1.00 (0.97, 1.03)	0.8148
Flavored Milk (n=818)	1.31 (0.79, 2.16)	1.01 (0.98, 1.06)	0.3207
Sugar Sweetened Beverages (n=2,106)	1.11 (0.71, 1.72)	0.99 (0.98, 1.01)	0.1267
12-18 years (n=2,668)			
100% Fruit Juice (n=635)	1.05 (0.65, 1.71)	0.99 (0.97, 1.02)	0.4358
Water (n=2,027)	0.93 (0.55, 1.55)	1.00 (1.00, 1.01)	0.1855
Milk (n=1,218)	0.76 (0.46, 1.27)	0.99 (0.97, 1.02)	0.5503
Flavored Milk (n=314)	0.76 (0.43, 1.35)	0.99 (0.93, 1.04)	0.5076
Sugar Sweetened Beverages (n=1,782)	0.91 (0.59, 1.41)	1.00 (0.99, 1.01)	0.5704
	Obese		
	Consumer vs Non-consumer	**Linear Assessment of Consumption**	
	OR (LCL, UCL)	**Beta (LCL, UCL)**	**P value**
2-18 years (n=7,913)			
100% Fruit Juice (n=2,785)	0.91 (0.65, 1.25)	0.99 (0.98, 1.01)	0.1862
Water (n=6,127)	1.03 (0.71, 1.50)	1.01 (1.00, 1.01)	**0.0029**
Milk (n=4,663)	0.90 (0.67, 1.21)	1.00 (0.98, 1.01)	0.5588
Flavored Milk (n=1,503)	1.23 (0.84, 1.81)	1.01 (0.98, 1.04)	0.2829
Sugar Sweetened Beverages (n=5,015)	1.21 (0.91, 1.61)	1.00 (1.00, 1.01)	0.1102
2-5 years (n= 2,127)			
100% Fruit Juice (n=1,095)	0.71 (0.44, 1.13)	0.98 (0.94, 1.01)	0.0825
Water (n=1,670)	0.90 (0.40, 2.05)	1.01 (0.98, 1.03)	0.4342
Milk (n=1,604)	0.98 (0.54, 1.76)	1.01 (0.99, 1.03)	0.3286
Flavored Milk (n=371)	0.84 (0.54, 1.30)	0.99 (0.96, 1.02)	0.3188
Sugar Sweetened Beverages (n=1,127)	1.40 (0.90, 2.18)	1.03 (1.01 1.06)	**0.0015**
6-11 years (n=3,118)			
100% Fruit Juice (n=1,055)	0.98 (0.61, 1.56)	1.00 (0.97, 1.04)	0.8374
Water (n=2,430)	1.35 (0.85, 2.14)	1.02 (1.01, 1.02)	**<0.0001**
Milk (n=1,841)	1.02 (0.68, 1.52)	1.00 (0.97, 1.02)	0.9037
Flavored Milk (n=818)	1.15 (0.78, 1.71)	1.01 (0.97, 1.05)	0.5453
Sugar Sweetened Beverages (n=2,106)	0.95 (0.66, 1.37)	1.01 (0.99, 1.02)	0.2733
12-18 years (n=2,668)			
100% Fruit Juice (n=635)	1.02 (0.61, 1.71)	0.99 (0.97, 1.02)	0.5141
Water (n=2,027)	0.86 (0.50, 1.46)	1.00 (1.00, 1.01)	0.2014
Milk (n=1,218)	0.78 (0.49, 1.22)	0.99 (0.96, 1.02)	0.5387
Flavored Milk (n=314)	1.29 (0.71, 2.35)	1.02 (0.97, 1.07)	0.3019
Sugar Sweetened Beverages(n=1,782)	1.34 (0.84, 2.14)	1.00 (0.99, 1.01)	0.3903

(Table 3). Continued.

	Overweight or Obese		
	Consumer vs Non-consumer	Linear Assessment of Consumption	
	OR (LCL, UCL)	Beta (LCL, UCL)	P value
2-18 years (n=7,913)			
100% Fruit Juice (n=2,785)	0.97 (0.76, 1.22)	0.99 (0.98, 1.00)	0.1746
Water (n=6,127)	1.05 (0.79, 1.40)	1.00 (1.00, 1.01)	**0.0067**
Milk (n=4,663)	0.90 (0.72, 1.14)	1.00 (0.98, 1.01)	0.4760
Flavored Milk (n=1,503)	1.16 (0.88, 1.53)	1.01 (0.99, 1.03)	0.2638
Sugar Sweetened Beverages (n=5,015)	1.17 (0.96, 1.41)	1.00 (0.99, 1.01)	0.5160
2-5 years (n= 2,127)			
100% Fruit Juice (n=1,095)	0.90 (0.62, 1.29)	1.00 (0.97, 1.02)	0.6357
Water (n=1,670)	0.93 (0.55, 1.59)	1.00 (0.99, 1.02)	0.8099
Milk (n=1,604)	1.11 (0.76, 1.62)	1.00 (0.99, 1.02)	0.5717
Flavored Milk (n=371)	0.86 (0.55, 1.35)	1.00 (0.97, 1.03)	0.7703
Sugar Sweetened Beverages (n=1,127)	1.37 (0.88, 2.12)	1.02 (1.00, 1.04)	0.0187
6-11 years (n=3,118)			
100% Fruit Juice (n=1,055)	1.01 (0.69, 1.47)	1.00 (0.97, 1.03)	0.9882
Water (n=2,430)	1.37 (1.00, 1.90)	1.01 (1.01, 1.02)	**<0.0001**
Milk (n=1,841)	0.99 (0.69, 1.40)	1.00 (0.98, 1.02)	0.8882
Flavored Milk (n=818)	1.24 (0.87, 1.76)	1.01 (0.98, 1.05)	0.2886
Sugar Sweetened Beverages (n=2,106)	1.04 (0.76, 1.42)	1.00 (0.99, 1.01)	0.7712
12-18 years (n=2,668)			
100% Fruit Juice (n=635)	1.02 (0.69, 1.50)	0.99 (0.97, 1.01)	0.3239
Water (n=2,027)	0.88 (0.57, 1.35)	1.00 (1.00, 1.01)	0.1366
Milk (n=1,218)	0.77 (0.56, 1.07)	0.99 (0.97, 1.01)	0.3906
Flavored Milk (n=314)	1.06 (0.63, 1.76)	1.01 (0.97, 1.05)	0.7078
Sugar Sweetened Beverages (n=1,782)	1.14 (0.80, 1.64)	1.00 (0.99, 1.01)	0.8086

Abbreviations: OR= Odds Ratio; LCL= Lower 99th Percentile Confidence Limit; UCL= Upper 99th Percentile Confidence Limit; Beta: regression coefficient and 99th LCL/UCL per mL of beverage per Day 1 intakes.
†Covariates: Gender, ethnicity, poverty index ratio (PIR), physical activity level, smoker status.

Table 4: Likelihood of Overweight and Obesity in Children by Consumers and Non-Consumers of Various Beverages by Race/Ethnicity and Gender (Males) †

Demographics	Weight Status		
	Overweight		
	Consumer vs Non-consumer	Linear Assessment of Consumption	
	OR (LCL, UCL)	Beta (LCL, UCL)	P value
Non-Hispanic White males			
100% Fruit Juice (n=348)	1.31 (0.67, 2.54)	1.00 (0.96, 1.04)	0.8914
Water(n=878)	1.49 (0.58, 3.83)	1.00 (0.99, 1.01)	0.3078
Milk (n=767)	0.78 (0.40, 1.52)	0.98 (0.95, 1.02)	0.1538
Flavored Milk (n=234)	0.80 (0.41, 1.56)	0.97 (0.92, 1.02)	0.0742
Sugar Sweetened Beverages (n=721)	1.22 (0.65, 2.30)	1.00 (0.98, 1.01)	0.6658

(Table 4). Continued.

Non-Hispanic Black males			
100% Fruit Juice (n=403)	1.08 (0.61, 1.90)	1.00 (0.97, 1.03)	0.8356
Water (n=741)	0.81 (0.37, 1.80)	1.01 (1.00, 1.02)	0.0367
Milk (n=511)	0.91 (0.50, 1.64)	0.98 (0.95, 1.01)	0.0681
Flavored Milk (n=192)	1.24 (0.56, 2.75)	1.01 (0.95, 1.06)	0.7777
Sugar Sweetened Beverages (n=712)	0.94 (0.52, 1.72)	0.99 (0.97, 1.01)	0.1722
Hispanic males			
100% Fruit Juice (n=497)	0.92 (0.55, 1.52)	0.99 (0.96, 1.02)	0.3166
Water (n=1,602)	1.23 (0.62, 2.45)	1.00 (0.99, 1.01)	0.6308
Milk (n=878)	0.69 (0.43, 1.10)	1.00 (0.98, 1.02)	0.6520
Flavored Milk (n=299)	1.00 (0.52, 1.90)	1.01 (0.97, 1.06)	0.3977
Sugar Sweetened Beverages (n=970)	1.01 (0.59, 1.73)	1.00 (0.98, 1.02)	0.6986
Other males			
100% Fruit Juice (n=185)	0.86 (0.29, 2.59)	0.99 (0.94, 1.04)	0.6081
Water (n=421)	1.34 (0.31, 5.76)	1.01 (0.99, 1.04)	0.1506
Milk (n=296)	1.64 (0.50, 5.39)	1.02 (0.98, 1.06)	0.2330
Flavored Milk (n=85)	0.90 (0.25, 3.30)	0.98 (0.89, 1.08)	0.6410
Sugar Sweetened Beverages (n=244)	1.29 (0.52, 3.23)	1.00 (0.96, 1.04)	0.9730

	Obese		
	Consumer vs Non-consumer	**Linear Assessment of Consumption**	
	OR (LCL, UCL)	**Beta (LCL, UCL)**	**P value**
Non-Hispanic White males			
100% Fruit Juice (n=348)	1.00 (0.53, 1.91)	0.98 (0.94, 1.02)	0.2478
Water (n=878)	1.11 (0.44, 2.76)	1.00 (0.99, 1.01)	0.2431
Milk (n=767)	1.24 (0.61, 2.53)	1.00 (0.97, 1.03)	0.9143
Flavored Milk (n=234)	0.87 (0.43, 1.75)	0.98 (0.93, 1.02)	0.1821
Sugar Sweetened Beverages (n=721)	1.73 (1.04, 2.86)	1.01 (0.99, 1.02)	0.2012
Non-Hispanic Black males			
100% Fruit Juice (n=403)	0.84 (0.42, 1.69)	0.97 (0.93, 1.02)	0.0946
Water (n=741)	0.87 (0.47, 1.59)	1.00 (0.99, 1.02)	0.5413
Milk (n=511)	1.11 (0.55, 2.23)	1.00 (0.98, 1.03)	0.6680
Flavored Milk (n=192)	1.21 (0.63, 2.33)	1.01 (0.96, 1.07)	0.5643
Sugar Sweetened Beverages (n=712)	1.33 (0.66, 2.68)	1.01 (0.99, 1.04)	0.1715
Hispanic males			
100% Fruit Juice (n=497)	1.00 (0.64, 1.58)	1.00 (0.97, 1.03)	0.7535
Water (n=1,602)	1.02 (0.53, 1.96)	1.01 (1.00, 1.02)	*0.0292*
Milk (n=878)	0.81 (0.54, 1.21)	1.00 (0.98, 1.03)	0.6591
Flavored Milk (n=299)	1.16 (0.57, 2.35)	1.00 (0.95, 1.05)	0.8918
Sugar Sweetened Beverages (n=970)	1.02 (0.60, 1.73)	1.01 (0.99, 1.02)	0.3455
Other males			
100% Fruit Juice (n=185)	0.43 (0.15, 1.25)	0.92 (0.84, 1.01)	*0.0161*
Water (n=421)	0.82 (0.21, 3.11)	1.01 (0.99, 1.03)	0.2192
Milk (n=296)	1.34 (0.53, 3.36)	1.01 (0.97, 1.06)	0.4316
Flavored Milk (n=85)	0.27 (0.05, 1.60)	0.88 (0.74, 1.05)	0.0645
Sugar Sweetened Beverages (n=244)	1.58 (0.64, 3.93)	1.03 (0.99, 1.06)	*0.0450*

(Table 4). Continued.

	Overweight or Obese		
	Consumer vs Non-consumer	Linear Assessment of Consumption	
	OR (LCL, UCL)	Beta (LCL, UCL)	P value
Non-Hispanic White males			
100% Fruit Juice (n=348)	1.19 (0.76, 1.88)	1.00 (0.96, 1.03)	0.6968
Water(n=878)	1.29 (0.60, 2.79)	1.00 (1.00, 1.01)	0.1552
Milk (n=767)	0.97 (0.58, 1.61)	0.99 (0.97, 1.02)	0.4214
Flavored Milk (n=234)	0.84 (0.50, 1.42)	0.97 (0.94, 1.01)	*0.0395*
Sugar Sweetened Beverages (n=721)	1.43 (0.95, 2.15)	1.00 (0.99, 1.02)	0.6719
Non-Hispanic Black males			
100% Fruit Juice (n=403)	0.94 (0.61, 1.47)	0.98 (0.96, 1.01)	0.1254
Water (n=741)	0.84 (0.49, 1.45)	1.01 (1.00, 1.02)	0.1283
Milk (n=511)	1.00 (0.56, 1.79)	0.99 (0.97, 1.02)	0.5560
Flavored Milk (n=192)	1.24 (0.69, 2.23)	1.01 (0.96, 1.06)	0.5576
Sugar Sweetened Beverages (n=712)	1.14 (0.70, 1.85)	1.00 (0.99, 1.02)	0.6587
Hispanic males			
100% Fruit Juice (n=497)	0.95 (0.66, 1.36)	0.99 (0.97, 1.02)	0.4188
Water (n=1,602)	1.10 (0.64, 1.89)	1.01 (1.00, 1.01)	0.0663
Milk (n=878)	0.75 (0.55, 1.02)	1.00 (0.98, 1.02)	0.9764
Flavored Milk (n=299)	1.06 (0.61, 1.84)	1.00 (0.97, 1.04)	0.7876
Sugar Sweetened Beverages (n=970)	1.04 (0.68, 1.58)	1.00 (0.99, 1.02)	0.6901
Other males			
100% Fruit Juice (n=185)	0.60 (0.24, 1.48)	0.96 (0.91, 1.01)	*0.0370*
Water (n=421)	1.05 (0.36, 3.05)	1.01 (0.99, 1.03)	0.1194
Milk (n=296)	1.52 (0.72, 3.21)	1.01 (0.99, 1.04)	0.1964
Flavored Milk (n=85)	0.51 (0.20, 1.31)	0.94 (0.87, 1.01)	*0.0246*
Sugar Sweetened Beverages (n=244)	1.47 (0.66, 3.27)	1.01 (0.99, 1.04)	0.1916

Abbreviations: OR= Odds Ratio; LCL= Lower 99th Percentile Confidence Limit; UCL= Upper 99th Percentile Confidence Limit; Beta: regression coefficient and 99th LCL/UCL per mL of beverage per Day 1 intakes.
†Covariates: Age, poverty index ratio (PIR), physical activity level, smoker status.

Table 5: Likelihood of Overweight and Obesity in Children by Consumers and Non-Consumers of Various Beverages by Race/Ethnicity and Gender (Females)†

Demographics	Weight Status		
	Overweight		
	Consumer vs Non-consumer	Linear Assessment of Consumption	
	OR (LCL, UCL)	Beta (LCL, CL)	P value
Non-Hispanic White females			
100% Fruit Juice (n=323)	0.95 (0.49, 1.86)	0.99 (0.93, 1.05)	0.6056
Water (n=861)	0.91 (0.36, 2.32)	1.00 (0.98, 1.01)	0.5842
Milk (n=684)	1.47 (0.74, 2.92)	1.02 (0.99, 1.06)	0.1156
Flavored Milk (n=218)	1.15 (0.48, 2.76)	1.02 (0.96, 1.09)	0.3215
Sugar Sweetened Beverages (n=615)	1.01 (0.51, 1.96)	1.00 (0.97, 1.03)	0.7274

(Table 5). Continued.

Non-Hispanic Black females			
100% Fruit Juice (n=361)	1.12 (0.56, 2.25)	1.02 (0.98, 1.06)	0.2959
Water (n=685)	0.81 (0.46, 1.44)	1.00 (0.98, 1.01)	0.5170
Milk (n=455)	0.69 (0.31, 1.54)	0.98 (0.92, 1.05)	0.4963
Flavored Milk (n=157)	1.80 (0.89, 3.64)	1.04 (0.96, 1.11)	0.2162
Sugar Sweetened Beverages (n=629)	1.43 (0.81, 2.544)	1.01 (0.98, 1.04)	0.4007
Hispanic females			
100% Fruit Juice (n=499)	0.80 (0.42, 1.52)	0.99 (0.97, 1.02)	0.5917
Water (n=1,012)	0.97 (0.51, 1.85)	1.01 (1.00, 1.02)	**0.0065**
Milk (n=774)	0.78 (0.49, 1.24)	0.98 (0.94, 1.01)	0.0525
Flavored Milk (n=232)	1.46 (0.78, 2.75)	1.03 (0.97, 1.09)	0.2080
Sugar Sweetened Beverages (n=877)	1.08 (0.63, 1.87)	0.99 (0.97, 1.01)	0.0862
Other females			
100% Fruit Juice (n=169)	0.60 (0.21, 1.56)	0.98 (0.91, 1.06)	0.6039
Water (n=467)	0.92 (0.25, 3.44)	0.98 (0.96, 1.01)	0.0806
Milk (n=298)	0.99 (0.33, 2.98)	1.01 (0.95, 1.08)	0.6024
Flavored Milk (n=86)	1.15 (0.30, 4.46)	1.02 (0.90, 1.15)	0.7358
Sugar Sweetened Beverages (n=247)	0.74 (0.23, 2.42)	0.99 (0.92, 1.07)	0.7969

	Obese		
	Consumer vs Non-consumer	**Linear Assessment of Consumption**	
	OR (LCL, UCL)	**Beta (LCL, CL)**	**P value**
Non-Hispanic White females			
100% Fruit Juice (n=323)	0.91 (0.34, 2.40)	1.01 (0.94, 1.08)	0.7287
Water (n=861)	0.68 (0.27, 1.72)	1.00 (0.99, 1.01)	0.8915
Milk (n=684)	0.70 (0.35, 1.43)	0.98 (0.94, 1.01)	*0.0441*
Flavored Milk (n=218)	1.92 (0.71, 5.24)	1.07 (1.01, 1.14)	*0.0161*
Sugar Sweetened Beverages (n=615)	1.14 (0.52, 2.52)	0.99 (0.97, 1.02)	0.5483
Non-Hispanic Black females			
100% Fruit Juice (n=361)	0.74 (0.38, 1.45)	1.00 (0.96, 1.04)	0.8063
Water (n=685)	2.32 (0.79, 6.79)	1.01 (1.00, 1.02)	*0.0293*
Milk (n=455)	0.72 (0.37, 1.38)	1.00 (0.95, 1.06)	0.9657
Flavored Milk (n=157)	1.28 (0.66, 2.48)	1.00 (0.93, 1.07)	0.9111
Sugar Sweetened Beverages (n=629)	0.84 (0.56, 1.27)	1.00 (0.97, 1.02)	0.5929
Hispanic females			
100% Fruit Juice (n=499)	0.91 (0.51, 1.64)	0.99 (0.97, 1.02)	0.4911
Water (n=1,012)	1.56 (0.87, 2.79)	1.01 (1.00, 1.02)	*0.0256*
Milk (n=774)	0.93 (0.53, 1.63)	0.99 (0.96, 1.03)	0.4882
Flavored Milk (n=232)	1.36 (0.65, 2.86)	1.02 (0.96, 1.08)	0.4142
Sugar Sweetened Beverages (n=877)	0.72 (0.40, 1.28)	0.98 (0.96, 1.00)	*0.0209*
Other females			
100% Fruit Juice (n=169)	0.95 (0.27, 3.35)	1.01 (0.96, 1.06)	0.5560
Water (n=467)	0.47 (0.16, 1.34)	0.98 (0.96, 1.01)	0.0628
Milk (n=298)	0.46 (0.19, 1.15)	0.97 (0.92, 1.03)	0.1616
Flavored Milk (n=86)	1.82 (0.64, 6.09)	1.02 (0.91, 1.14)	0.6996
Sugar Sweetened Beverages (n=247)	1.15 (0.46, 2.89)	1.00 (0.94, 1.06)	0.9901

(Table 5). Continued.

	Overweight or Obese		
	Consumer vs Non-consumer	Linear Assessment of Consumption	
	OR (LCL, UCL)	Beta (LCL, CL)	P value
Non-Hispanic White females			
100% Fruit Juice (n=323)	0.93 (0.51, 1.70)	1.00 (0.95, 1.05)	0.9221
Water (n=861)	0.80 (0.37, 1.74)	1.00 (0.99, 1.01)	0.8879
Milk (n=684)	1.00 (0.57, 1.71)	1.00 (0.97, 1.03)	0.7828
Flavored Milk (n=218)	1.51 (0.75, 3.03)	1.05 (1.00, 1.10)	*0.0156*
Sugar Sweetened Beverages (n=615)	1.09 (0.62, 1.91)	1.00 (0.97, 1.02)	0.6149
Non-Hispanic Black females			
100% Fruit Juice (n=361)	0.91 (0.55, 1.52)	1.01 (0.98, 1.04)	0.5937
Water (n=685)	1.33 (0.78, 2.28)	1.01 (0.99, 1.02)	0.2680
Milk (n=455)	0.70 (0.43, 1.16)	0.99 (0.95, 1.04)	0.6684
Flavored Milk (n=157)	1.49 (0.87, 2.57)	1.02 (0.96, 1.08)	0.4171
Sugar Sweetened Beverages (n=629)	1.08 (0.74, 1.56)	1.00 (0.98, 1.03)	0.7308
Hispanic females			
100% Fruit Juice (n=499)	0.86 (0.50, 1.45)	0.99 (0.97, 1.02)	0.4244
Water (n=1,012)	1.21 (0.74, 1.98)	1.01 (1.00, 1.02)	**0.0082**
Milk (n=774)	0.86 (0.56, 1.31)	0.98 (0.96, 1.01)	0.1065
Flavored Milk (n=232)	1.41 (0.81, 2.48)	1.02 (0.97, 1.08)	0.2142
Sugar Sweetened Beverages (n=877)	0.86 (0.54, 1.39)	0.98 (0.97, 1.01)	**0.0086**
Other females			
100% Fruit Juice (n=169)	0.77 (0.30, 1.94)	1.00 (0.96, 1.05)	0.9083
Water (n=467)	0.66 (0.28, 1.55)	0.98 (0.97, 1.00)	*0.0131*
Milk (n=298)	0.67 (0.32, 1.43)	1.00 (0.95, 1.05)	0.9638
Flavored Milk (n=86)	1.37 (0.49, 3.83)	1.01 (0.93, 1.11)	0.6932
Sugar Sweetened Beverages (n=247)	0.94 (0.39, 2.45)	1.00 (0.95, 1.05)	0.8888

Abbreviations: OR= Odds Ratio; LCL= Lower 99th Percentile Confidence Limit; UCL= Upper 99th Percentile Confidence Limit; Beta: regression coefficient and 99th LCL/UCL per mL of beverage per Day 1 intakes.
†Covariates: Age, poverty index ratio (PIR), physical activity level, smoker status.

assessment of beverage consumption, the risk of being overweight or obese was not significant (p<0.01) for the five beverage categories. Using a less conservative p-value of <0.05, the risk of being obese was significant for Hispanic males for every 29.6 mL of water consumed [beta=1.01; p=0.0292] and for 100% FJ [beta=0.92; p=0.0161] and SSB [beta=1.03; p= 0.0450] for other males. Albeit, the significant increase in risk of obesity was very small (i.e. ≤3%). The likelihood of being overweight or obese in female children by race/ethnicity was not significant for the five beverage categories studied. With regard to linear assessment of beverage consumption, the risk of being overweight or obese was not significant (p>0.01) for the five beverage categories. Using a less conservative p-value of <0.05, the risk of being obese was significant for White females for every 29.6 mL of milk [beta=0.98; p=0.0441] or flavored milk [beta=1.07; p=0.0161] consumed and water consumption for both Black females [beta=1.01; p=0.0293] and Hispanic females [beta=1.01; p=0.0256]. Albeit the significant increase in risk of obesity was very small (i.e. ≤7%).

DISCUSSION

The results of this risk analysis study showed that the likelihood of being overweight or obese was not consistently significant for any of the beverages studied between consumers and non-consumers. In some cases, the increased risk was very small. In children 2-

18 years this was a consistent finding when the data were looked at by age group and by gender, race, and ethnicity. Using linear assessment of beverage consumption, the increased risk of overweight or obesity varied depending on the significance of the p value that was used. For the total sample, for every 29.6 mL of water consumed the risk of being obese was 1%. One could also interpret the results in that for every 29.6 mL of water not consumed the risk of obesity would decrease by 1%. Albeit the magnitude of change in risk was very small and the public health significance is questionable. Some age differences were found in that for ages 6-11 years water consumption increased the risk of being obese and in ages 2-5 years, consumption of SSB increased the risk of being obese. It is important to note the increased risk was very small. No associated increased risk of overweight or obesity by gender and race and ethnicity was found using the conservative significant p value of <0.01. However, using a less conservative p value <0.05, the risk of being obese was significant for Hispanic males for every 29.6 mL of water consumed and for 100% FJ and SSB for other males. Once again the increased risk was ≤3%. The risk of being obese increased for White females for every 29.6 mL of flavored milk consumed and water consumption for both Black females and Hispanic females; the significant increased risk of obesity was ≤7% at a p value <0.05.

Two reviews were conducted on the impact of 100% FJ consumption on weight status in children [12, 39]. One of the evidence-based reviews [12] found statistically significant differences between higher and lower FJ consumers in weight status only in studies that did not adjust for energy intake. None of the 11 comparisons that adjusted for total energy intake reported a statistically significant difference between higher and lower fruit juice consumers in weight status. Similar results were found with BMI. The majority of studies found no significant association between 100% FJ intake and BMI. Only three studies showed a positive relationship, yet only one of the studies adjusted for total energy intake. The effect sizes were minimal and they were regional studies with limited racial/ethnic and socioeconomic diversity among participants. Evidence from this review suggests that 100% FJ consumption may have no independent effect on weight status apart from energy intake. Variations in intake measurement and covariates, definition of fruit juice, and potential residual confounding limits the interpretation of the estimated small pooled effects and any potential clinical public health significance.

The second meta-analysis of eight prospective cohort studies found that 1 daily 6-to-8-oz (177.4-to-236.6 mL) serving increment of 100% FJ was associated with a 0.003 unit increase in BMI z-score over one year in children (0%) increase in BMI percentile [39]. For children 1 to 6 years, a 4% increase in BMI percentile was shown. For older children, 7 to 18 years, 100% FJ consumption was not associated with BMI z-score. Although consumption of 100% FJ was associated with a small amount of weight gain in children ages 1 to 6 years it was not clinically significant and consumption was not associated with weight gain in older children. Of note, all observational studies differed in covariate adjustment and in exposure assessment. These two reviews clearly emphasized that more studies are needed with standardization of 100% FJ exposure, outcomes (e.g. weight), covariates used in the analyses, and to perform subgroup analyses looking at demographic differences.

Drinking large quantities of water is believed to support weight loss efforts or maintenance of weight and has become a commonly used practice for weight control [40]. According to NHANES data, approximately 30% of all adults in the US who tried to lose weight reported that they drank “a lot of water” [41]. In a smaller survey, 59% of all adults reported frequently drinking “plenty of water” as a weight-control practice [40]. However, comprehensive systematic reviews on water consumption and body weight is lacking, particularly in children. On the cross-sectional level, higher water consumption was associated with higher weight status in children and adolescents [42]. In contrast, longitudinal studies suggested a weight reducing effect of water consumption, but evidence for a causal association was still low.

Two systematic reviews looked at the association between water consumption and body weight outcomes in adults only [43, 44]. One review [43] showed that studies of adults dieting for weight loss or maintenance suggested a weight-reducing effect of increased water consumption. Whereas studies, in general, yielded inconsistent results possibly because of the lack of good quality studies and the limited data on reported total water intake [45].

Another systematic review [44] examined the effects of drinking water and various beverage alternatives on energy intake and/or weight status. This review emphasized the importance of looking at beverage consumption with varying total energy content before a single meal. Total energy intake increased 7.8% when SSB vs water were consumed. The evidence was less clear when replacing water with milk and 100% FJ prior to a single meal. Overall, the authors concluded that more studies were needed because the review suggested promising results for replacing consumption of high energy beverages with water, particularly with regard to compensation of energy intake at single meals which subsequently reduced total energy intake. Several studies suggested that water consumption may have a role in body weight homeostasis by affecting overall dietary energy density [46] ; water intake was a determinant of hydration status in that obese children were less hydrated than normal weight children [47]. Further, water consumption induced thermogenesis through osmosensitive mechanisms [48, 49] and could elevate resting energy expenditure [50]. Therefore, water-induced thermogenesis may assist in weight loss and weight maintenance [50]. As noted in this study, the positive association between water consumption and increased odds of obesity may reflect a behavioral strategy in that obese individuals may increase water consumption as a weight loss approach to decrease the amount of energy consumed overall. This brings up a very important limitation which requires consideration when interpreting the results. Reverse causality bias in observational studies can be a real possibility, yet the occurrence of such bias is weak and inconsistent [51]. Reverse causality usually refers to the situation in which the outcome precedes and causes the exposure rather than the other way around [52-54]. Specifically, is the association of water consumption with increased risk of obesity truly the case or does the association reflect the opposite in that obese individuals drink more water as one behavioral strategy to decrease energy intake? Although it may be premature to consider reverse causation as an important cause of bias, more research is needed to determine potential effects and significance of reverse causation bias in cohort studies before one can determine statistical approaches to control potential bias.

A review specifically examined the role of dairy products in healthy weight and body composition in children and adolescents [21]. There is little direct evidence that dairy consumption adversely affects body weight in children and adolescents. However, the majority of cross-sectional and potential prospective studies indicated a beneficial relationship between the consumption of milk and/or calcium and body weight and body composition in children and adolescents. Yet, the authors concluded more research was needed.

Beverage consumption is ubiquitous among the US population and has become a staple in the US diet at most meals and throughout the day. Beverages contribute 19% of total energy intake. Of this 19% of energy, major food sources are SSB (35%), milk and milk drinks (26%) and 100% FJ (10%) [6]. The types of beverages contribute varying amounts of energy and nutrients in the diet [8, 9]. SSB contribute the most to energy intake but provide virtually no vitamins and minerals, unlike milk and milk drinks and 100% FJ. Given the variation in energy contribution, studies have been conducted to look at the relationship of beverage consumption to energy intake and weight status, specifically SSB.

The contribution of SSB to weight gain and maintenance has been an ongoing contentious scientific debate. This debate has been based on the propositions that the consumption of SSB contributes significantly to the development and maintenance of overweight and obesity and reducing the consumption of SSB will lead to weight loss or weight gain [14-19]. These suggestions are plausible because epidemiologic studies support an association between SSB consumption and obesity [20]. Yet, there are other epidemiologic studies that do not show such associations and more definitive randomized control trials are needed [20]. Critical reviews and meta-analyses on the role of SSB in overweight and obesity have yielded discrepant findings [14-20]. Although the use of meta-analysis can provide valuable information it is also not without controversy. This analytical technique has inherent limitations that confounds any scientific interpretation of the totality of the evidence [55, 56]. Many of the studies evaluated did not target a common hypothesis, address a common research question, or estimated common parameter [55, 57]. Moreover, when conducting a meta-analysis, the analyses are a product of faulty methods and misleading results and interpretation. Comparing studies is confounded with the demographics of the participants and study methods vary considerably. Specifically this includes inclusion/exclusion criteria for sample selection, criteria for omission of data, the statistical approaches and covariates used in the analyses were not consistent, and residual confounding was often ignored. Most studies neglected to report on effect size making it difficult to determine if the results were of public health clinical significance. Data from this cross-sectional study generates the hypothesis that the risk of obesity from SSB beverage consumption was small and there may be demographic variations that need to be considered. Based on the apparent and inconsistent findings, evidence on a direct association between SSB and weight gain, maintenance or weight loss are needed from more definitive randomized-control trials [20].

This study had a number of limitations. NHANES is a cross-sectional study, thus cause and effect relationships cannot be determined. Another limitation is the use of dietary recalls to assess intake in NHANES. Participants relied on memory to self-report dietary intakes; therefore, data were subject to non-sampling errors, including under or over-reporting of energy and foods, and possibly beverage consumption. Parents reported or assisted their children 2-11 years with the 24-hour recalls; parents often report accurately what children eat in the home [58] but may not know what their children consume outside the home [59], which could also result in reporting errors [60]. Under-reporting is related to energy intake and is higher in overweight and obese individuals [61, 62]. Although energy intake was not controlled for in the analyses, it is possible that mean differences in energy intake was not only from beverages but also from foods consumed overall. This limitation needs to be considered when interpreting the results. We only used the first data of dietary recall for our analyses and this may have led to some misclassification of consumers and non-consumers. However, a single 24-hour dietary recall administered in a sufficiently large population sample can adequately provide data to estimate population mean intakes [63]. The results could also reflect other foods consumed/not consumed throughout the day among the beverage category groups. It is possible that residual confounding exists (e.g. other foods concomitantly consumed with beverages and may, in part be responsible for some of our results; thus, results should be interpreted with caution. When interpreting the results one needs to consider the methodological limitations in defining types of beverages and methods of analytical approaches. In addition an update on NHANES dietary data with a focus on collection, analytical considerations, and uses to inform public policy has been published [27].

In addition to the limitations of using varying p-values for determining significance, findings from meta-analyses pose other limitations [55, 56]. One can appreciate that combining results of individual studies increases the number of participants and more participants should mean more statistical power to detect any effects. However, when the demographics of the participants and study methods, particularly inclusion/exclusion criteria for sample selection and covariates used in the individual studies used in the meta-analyses, vary considerably. Thus, combining studies can increase variability in findings that can reduce statistical power, making real effects more difficult to identify [55, 56]. One needs to critically evaluate meta-analyses when interpreting the findings from the reviews. Finally, few studies address the potential for residual confounding in study results that could have reduced the observed effect which is a real possibility when looking at intakes of single foods or single nutrients and health outcomes.

The statistical significance of an effect (i.e., rejecting the null hypothesis) does not mean that the effect is important or of clinical significance [64-66]. Concluding that a statistically significant test result implies with certainty that the effect is present in the population which may be incorrect because such a conclusion ignores the possibility of a Type 1 error [66]. The practice of calculating and reporting standard yet arbitrary cut-off p values is nearly ubiquitous in statistical practice. However, one needs to recognize the inherent assumptions and limitations and the prevalent misuses of and misconceptions concerning p values.

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CONFLICT OF INTEREST

VLF as Vice President of Nutrition Impact, LLC performs data analyses of large government databases like NHANES for numerous members of the food, beverage, and dietary supplement industry. T.A.N has received numerous grants from the food and beverage industry and federal agencies throughout her career. CO'N has received a number of federal grants throughout her career, including those from the Economic Research Service and National Institutes of Health.

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