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Beverage caffeine intakes in the U.S. ☆

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ABSTRACT

Caffeine is one of the most researched food components, with the vast majority of dietary contributions coming from beverage consumption; however, there is little population-level data on caffeine intakes in the U.S. This study estimated the caffeine intakes of the U.S. population using a comprehensive beverage survey, the Kantar Worldpanel Beverage Consumption Panel. A nationally representative sample of 37,602 consumers (aged ⩾ 2 years) of caffeinated beverages completed 7-day diaries which facilitated the development of a detailed database of caffeine values to assess intakes. Results showed that 85% of the U.S. population consumes at least one caffeinated beverage per day. The mean (±SE) daily caffeine intake from all beverages was 165 ± 1 mg for all ages combined. Caffeine intake was highest in consumers aged 50–64 years (226 ± 2 mg/day). The 90th percentile intake was 380 mg/day for all ages combined. Coffee was the primary contributor to caffeine intakes in all age groups. Carbonated soft drinks and tea provided a greater percentage of caffeine in the younger (<18 years) age groups. The percentage of energy drink consumers across all age groups was low (⩽10%). These data provide a current perspective on caffeinated beverage consumption patterns and caffeine intakes in the U.S. population.

1. Introduction

Caffeine is a widely consumed food constituent and as a result, the major sources, the quantity consumed, and the demographics of consumers have long been of interest. While chocolate and other cocoa-containing foods contribute small amounts of caffeine to the diet, the majority of the caffeine consumed comes from beverages (Frary et al., 2005; Somogyi, 2010). Caffeine intake varies across different types of beverages and in different population groups (Frary et al., 2005; Knight et al., 2004, 2006). Coffee typically contains more caffeine than most other beverages, and is widely and frequently consumed (Frary et al., 2005; Knight et al., 2004). Thus, it contributes significantly more to overall caffeine consumption within the population, particularly in adults. Carbonated soft drinks (CSDs), tea, energy drinks, energy shots, and some fruit or fruit-flavored and water beverages also contribute to total caffeine intake. Among children, CSDs had been shown to be the primary source of caffeine, compared to coffee in adults (Frary et al., 2005; Knight et al., 2004). Somogyi (2010) was perhaps the first to comprehensively investigate population-level data on newer categories of products such as energy drinks, energy shots, and other beverages containing caffeine. Smaller, segmented studies show that such drinks may be more commonly consumed by young adults, teenagers, college students, athletes, and military personnel (Heckman et al., 2010b; Lieberman et al., 2012; Norton et al., 2011).

Caffeine is one of many constituents in foods that can exert physiological effects. Scientific and historical evidence shows that among the healthy adult population, moderate caffeine consumption (e.g., (400 mg/day) is not associated with adverse health effects (Heckman, 2010a; Nawrot et al., 2003). Improvements in mental alertness, concentration, fatigue, and athletic performance are well documented benefits (Heckman, 2010a; Nawrot et al., 2003). Caffeine and/or coffee consumption has also been associated with weight loss, improved glucose tolerance and lower risk of type II diabetes, reduced risk for incidence of Parkinson's disease and improvement in Parkinson's symptoms, and reduced risk for

Abbreviations: CSD, carbonated soft drink; CSFII, Continuing Survey of Food Intakes in Individuals; FDA, Food and Drug Administration; KWP, Kantar Worldpanel; NDSR, Nutrition Data System for Research; NHANES, National Health and Nutrition Examination Survey; SIP, Share of Intake Panel; USDA, US Department of Agriculture.

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cancer at several sites (Butt and Sultan, 2011; Floegel et al., 2012; Higdon and Frei, 2006; Sinha et al., 2012).

While there are no specific recommendations for caffeine intakes in the U.S., the FDA released a letter in August 2012 stating that for healthy adults, caffeine intake up to 400 mg/day is not associated with adverse health effects (U.S. FDA, 2012a). The FDA clarified in a subsequent letter, issued in November 2012 that this value reflects the recommendations set forth by Health Canada based on the Nawrot 2003 review (U.S. FDA, 2012b). Health Canada issued recommendations in 2006 regarding levels of safe use to be $\leqslant$400 mg/day, and again in 2009 with specific recommendations for children (45–85 mg per day for 6–12 years; 2.5 mg/kg/day for $\geqslant$12 years) and pregnant women (<300 mg/day) (Health Canada, 2010). For certain occupational subgroups, such as military personnel, where sleep deprivation and the physical demands are a consideration, some experts have deemed 1000 mg/day and doses of 600 mg/day to be safe, though to achieve these higher levels from beverage sources alone may be challenging (Food and Nutrition Board, 2001; Lieberman et al., 2012).

Excessive caffeine intakes have been associated with anxiety, headaches, nausea, and restlessness (Heckman, 2010a; Nawrot et al., 2003). Side effects (i.e., headache, fatigue, drowsiness) may be experienced when caffeine intake is stopped suddenly; however, symptoms are generally mild and temporary (Heckman, 2010a; Nawrot et al., 2003). Some but not all studies have shown an increased risk of hypertension and cardiovascular disease (Nurminen et al., 1999; Heckman, 2010a; Mesas et al., 2011). Moderate caffeine intake (less than 400 mg/day for healthy adults) does not adversely affect cardiovascular health (Nawrot et al., 2003). Scientific data do not support adverse effects of moderate caffeine consumption below 300 mg/day on reproductive health or pregnancy outcomes (Brent et al., 2011; Kuczkowski, 2009; Peck et al., 2010).

Regardless of the longstanding consumption of caffeine-containing beverages in the diet, there is a lack of comprehensive and current population-based data on caffeine intakes. Most studies still cite information dating back to the 1980s and 1990s when Barone and Roberts (1996) highlighted results from earlier population-based surveys. In 2004 and 2006, Knight et al. published data from the Share of Intake Panel (SIP) a syndicated beverage survey conducted by NFO WorldGroup. In 2005, Frary and colleagues published caffeine intakes from the U.S. Department of Agriculture (USDA) Continuing Survey of Food Intakes in Individuals (CSFII) collected in 1994–1996 and 1998 (Frary et al., 2005). The CSFII study provided estimated caffeine intakes from both food and beverages using a different methodology than previous beverage consumption surveys (i.e., SIP) representing roughly the same time period. Other recent data on caffeine intakes and caffeinated food and beverages intakes are presented in a publically available U.S. Food and Drug Administration (FDA) report with data from the 2001–2006 National Health and Nutrition Examination Survey (NHANES) and other surveys (Somogyi, 2010).

There has also been an introduction of a greater variety of beverages in the marketplace. The introduction of functional beverages such as energy drinks, energy shots, as well as an array of specialty coffees, also highlights the importance of characterizing more recent beverage consumption patterns and caffeine intakes that may have evolved over the last decade. The objective of the present investigation was to estimate caffeine intakes in the U.S. population from the consumption of caffeinated beverages using a current (2010–2011) population-based beverage survey, the Kantar Worldpanel (KWP) Beverage Consumption Panel [formerly the SIP, conducted by NFO WorldGroup (Knight et al., 2004)].

2. Materials and methods

2.1. Survey description

KWP is a global consumer panel company focused on the continuous measurement and analysis of consumer behaviors. The Beverage Consumption Panel is the survey that was used for this study which includes a U.S. sample of panel members or respondents who are surveyed annually. This continuous survey has been conducted for over 30 years and targets U.S. consumers of all ages. The respondents for these analyses were recruited from a pool of about 1 million volunteer panel members with the goal to complete 40,000 surveys. U.S. Census demographic data are used to guide the selection of participants from the overall panel to participate in a representative Beverage Consumption Panel (U.S. Census Bureau, 2012). Sample selection characteristics included age, gender, race, Hispanic origin, geographic region, market size, household income, household size, and presence of children in the household. Only English-speaking participants were included in the survey and there were no questions or exclusions based on health conditions. Email was used to invite participants to complete a survey. Invitations were staggered in batches sent out weekly to ensure a balanced sample across all months of the year. Email invitations are sent to a parent or guardian of children aged 1–12 years asking the parent or guardian to complete a survey for their child. For teenagers aged 13–17 years, parental permission is obtained to allow their child to complete the survey on their own. The response rate for the survey was approximately 15%.

2.2. Data collection

Beverage data used for this study were collected by KWP from October 2010 through September 2011 as part of their survey of a panel of participants' aged $\geqslant$1 year. Data for children aged <2 years were excluded from the caffeine analysis since young children age 2 and above are more likely to be consuming beverages other than milk. Respondents completed an online beverage diary consisting of 7 consecutive days, recording all beverages consumed using a web-based form. Respondents are asked to enter their diary records once a day for each of the 7 days. They are also sent periodic reminders at 3 different time points throughout the week to remind them to participate regularly. Respondents cannot record beverages for future days but they are permitted to record or change beverages from prior days. The data collection included type, brand, preparation, location (home or away from home), and amount of all the beverages consumed. During the same week, respondents were also asked to record their height, weight, and demographic information. Respondents were given a small monetary incentive upon completion of the survey.

2.3. Caffeine database development

A list of all beverages consumed as part of the KWP survey was generated and provided to the Pennsylvania State University Diet Assessment Center for the development of a caffeine database. Caffeinated beverages were grouped into six general categories: coffee (e.g., specialty coffee drinks, iced coffee, brewed, instant, and decaffeinated coffee), tea (e.g., green tea, white tea and other varieties, iced tea), CSDs (both caffeinated fruit-flavored and cola beverages), chocolate drinks (including milk and cocoa), energy drinks, and energy shots. A few other beverages containing caffeine including fruit juice, flavored water, and sports drinks were also included in the energy drink category since the number of identified consumers was too low to create a separate category. There were 554 caffeinated beverages identified. Caffeine values (Table 1) were obtained from several resources since most food and nutrient databases have limited brand specificity, particularly for coffee and tea. Sources used included the USDA Food and Nutrient Database for Dietary Studies (version 4.1), the USDA National Nutrient Database for Standard Reference 24 (U.S. Department of Agriculture, 2011) and the Nutrition Data System for Research (Nutrition Coordinating Center, 2011). Other sources included food and beverage companies, websites [e.g., Energy Fiend (2012), which contains brand-specific data for caffeinated beverages], and a recent report published by the Yale Rudd Center (Harris et al., 2011). Default values were used in cases where no brand was specified or when caffeine values could not be determined for a specific brand. In general, default values were either the default value used in one of the food and nutrient database sources such as the National Nutrient Database for Standard Reference or were products that have the greatest market share. For example, most home-brewed coffee was assigned a default value of 11.9 mg per fluid ounce which is equivalent to the value in the USDA Standard Reference database for regular brewed coffee. The proportion of beverages assigned default values is dependent on the beverage category. This proportion is low (<20%) for commercial, bottled drinks (e.g., CSD's and energy drinks) but higher for coffee and tea (40–50%) where most home brewed varieties are assigned a default value.

2.4. Data analysis and measures

Caffeine database values expressed as milligrams of caffeine per fluid ounce were merged with the Beverage Caffeine Panel survey data to calculate the caffeine intake per survey respondent for each of the 7 days of beverage consumption.

Table 1
Summary of the caffeine database values by beverage category.

Beverage category	Beverage type/description	Caffeine content	
		(mg/fluid ounce)	(mg/8 fluid ounces)
Coffee			
Caffeinated	Regular, brewed, non-specialty, brand not specified	11.9	95.2
	Regular, brewed, brand specified, including K cups and other single-serve varieties	9.4–20.6	75.2–164.8
	Regular, instant, brand or no brand specified	9.4	75.2
	Prepared from flavored mix, all varieties	6.0	48.0
	Specialty coffees, with additional ingredients (e.g., latte, mocha, cappuccino, Americano)	7.9–15.8	63.2–126.4
	Specialty coffee, espresso	46.7–62.8	373.6–502.4
	Ready-to-drink, bottled or canned	4.1–20.0	32.8–160.0
Decaffeinated	All types including regular, brewed, specialty, brand or brand not specified, ready-to-drink, bottled or canned	0.25	2.0
Carbonated soft drinks			
Cola	All types, caffeinated, regular or diet, including with added flavors (e.g., cherry cola), brand not specified	3.0	24.0
Cola	All types, caffeinated, regular or diet, including with added flavors, brand specified	3.0–5.8	24.0–46.4
Citrus	All types, caffeinated, brand not specified	4.6	36.8
Citrus	All types, caffeinated, brand specified	4.6–5.9	36.8–47.2
Other flavors	All types, caffeinated, regular or diet, brand not specified	2.4–3.4	19.2–27.2
Other flavors	All types, caffeinated, regular or diet, brand specified	1.9–6.9	17.2–55.2
Tea			
Black	All types brewed, caffeinated, brand or no brand specified	5.9	47.2
Green	All types brewed, caffeinated, brand or no brand specified	3.1	24.8
White	All types brewed, caffeinated, brand or no brand specified	1.9	15.2
Powdered, instant	All types, brand or no brand specified	1.4–5.9	11.2–47.2
Ready-to-drink, bottled	Caffeinated, regular or diet, brand not specified	2.0	16.0
Ready-to-drink, bottled	Caffeinated, regular or diet, brand specified	0.625–8.1	5.0–40.8
Energy drinks/shots			
Drinks	Generic, brand not specified, diet or regular	10.0	80.0
	Brand specified, bottles or cans, diet or regular	3.4–20.5	27.2–164.0
Shots	Generic, brand not specified	60.0	480
	Brand specified	40.0–69.0	320.0–552.0
Chocolate milk or chocolate beverages	Including cocoa, bottled ready-to-drink or pre-prepared home, prepared from mix or syrup	0.2–2.0	1.6–16.0

Table 2
Mean caffeine intake of all caffeinated beverage consumers (n = 37,602) by age and each respective beverage category.

Age Group (years)	Sample (n)	%N[a]	Caffeine Intake (mg/day), mean ± SE					Caffeine Intake (mg/kg/day), mean ± SE				
			Total caffeinated beverages[b]	Total coffee	Total CSD	Total tea	Total energy drinks	Total caffeinated beverages[b]	Total coffee	Total CSD	Total tea	Total energy drinks
All ages	37,602	85.0	164.5 ± 0.9	105.4 ± 0.8	27.9 ± 0.2	27.9 ± 0.3	2.6 ± 0.1	2.2 ± 0.0	1.4 ± 0.0	0.4 ± 0.0	0.4 ± 0.0	<0.1
2–5	732	43.0	23.7 ± 1.8	6.1 ± 1.4	6.6 ± 0.5	9.7 ± 0.8	0.3 ± 0.1	1.5 ± 0.2	0.4 ± 0.2	0.4 ± 0.1	0.6 ± 0.1	<0.1
6–12	1768	63.0	36.6 ± 1.2	7.8 ± 0.8	14.7 ± 0.5	11.5 ± 0.6	1.9 ± 0.3	1.1 ± 0.0	0.2 ± 0.0	0.4 ± 0.0	0.4 ± 0.0	<0.1
13–17	1772	83.2	83.2 ± 2.2	24.3 ± 1.6	28.2 ± 0.8	23.8 ± 1.1	6.1 ± 0.8	1.3 ± 0.0	0.3 ± 0.0	0.3 ± 0.0	0.3 ± 0.0	0.1 ± 0.0
18–24	1178	85.8	122.1 ± 4.2	60.1 ± 3.6	31.4 ± 1.2	23.1 ± 1.3	6.2 ± 0.8	1.7 ± 0.1	0.8 ± 0.1	0.4 ± 0.0	0.3 ± 0.0	0.1 ± 0.0
25–34	4155	87.2	137.3 ± 2.2	80.1 ± 2.0	31.5 ± 0.7	21.3 ± 0.7	3.6 ± 0.3	1.9 ± 0.0	1.1 ± 0.0	0.4 ± 0.0	0.3 ± 0.0	<0.1
35–49	9128	92.1	199.1 ± 2.1	126.3 ± 2.0	37.6 ± 0.6	31.8 ± 0.7	2.5 ± 0.2	2.5 ± 0.0	1.6 ± 0.0	0.5 ± 0.0	0.4 ± 0.0	<0.1
50–64	12,691	93.3	225.5 ± 1.8	158.6 ± 1.7	28 ± 0.4	37.1 ± 0.6	1.3 ± 0.1	2.9 ± 0.03	2.0 ± 0.0	0.3 ± 0.0	0.5 ± 0.0	<0.1
⩾65	6178	99.6	207.3 ± 2.3	158.7 ± 2.2	15.7 ± 0.4	31.7 ± 0.7	0.9 ± 0.2	2.6 ± 0.03	2.0 ± 0.0	0.2 ± 0.0	0.4 ± 0.0	<0.1

[a] Defined as proportion of caffeinated beverage consumers in the U.S. population (i.e., weighted estimates) within each age group.
[b] Total caffeinated beverages include total coffee, carbonated soft drinks (CSDs), tea, energy drinks and a small percentage (<1–4% depending on age group) from other sources (cocoa and chocolate-containing beverages, energy shots).

Respondents who completed all days of the beverage diary but reported less than 21 total beverage occasions were excluded from the analysis. This is partially because of the implausibility of such low consumption but also because limited entries of beverages are indicative of an unengaged participant. Parental reports of data were included for all children between the ages of 2 and 12 years with the following two exceptions applied in order to control for implausible and erroneous survey entries associated with parental reporting. Children with weight data that were below the 3rd percentile and above the 97th percentile based on weight for age were excluded (Centers for Disease Control and Prevention, 2000). Children with total fluid intakes greater than 2 standard deviations above the mean fluid intake within a specific age year were also excluded.

The same procedures used for recruitment were used to apply survey weights to the respondent-level (sample) data using the current U.S. Census (U.S. Census Bureau, 2012). Weights were applied monthly to ensure balance across all demographic characteristics to obtain U.S. population estimates of caffeine intakes. All measures described below were weighted using this procedure.

Mean caffeine intakes were calculated as milligrams per day (mg/day) and as milligrams per kilogram of body weight per day (mg/kg/day) using the self-reported body weight data collected during the online survey. Body weight data were only collected in children aged 2–12 years from January 2011 to September 2011, so data for this subset of children are based on 9 months rather than the 12 months of data collected for all other age groups.

Table 3
The percentage of total daily caffeinated beverages consumed and caffeine intake by age group and each respective beverage category for consumers[a] only.

Age Group (years)	Total coffee (n = 23,103)			Total CSD (n = 22,415)			Total tea (n = 20,473)			Total energy drinks (n = 1,202)		
	% Consumers	Mean ± SE		% Consumers	Mean ± SE		% Consumers	Mean ± SE		% Consumers	Mean ± SE	
		mg/day	mg/kg/day		mg/day	mg/kg/day		mg/day	mg/kg/day		mg/day	mg/kg/day
All ages	55.3	190.8 ± 1.2	2.5 ± 0.02	62.8	44.5 ± 0.4	0.6 ± 0.01	52.6	53.0 ± 0.5	0.8 ± 0.01	4.3	60.2 ± 1.9	0.8 ± 0.03
2–5	6.9	–[b]	–[b]	51.3	12.9 ± 0.9	0.8 ± 0.07	44.8	21.6 ± 1.4	1.6 ± 0.10	1.3	–[b]	–[b]
6–12	10.3	76.1 ± 6.3	2.4 ± 0.25	69.6	21.1 ± 0.7	0.6 ± 0.02	39.2	29.4 ± 1.3	1.0 ± 0.06	3.7	–[b]	–[b]
13–17	26.5	91.5 ± 4.7	1.5 ± 0.12	77.3	36.5 ± 0.9	0.6 ± 0.01	52.6	45.3 ± 1.8	0.9 ± 0.06	10.3	58.7 ± 6.3	0.9 ± 0.10
18–24	46.2	130.3 ± 6.5	1.8 ± 0.09	70	44.9 ± 1.5	0.6 ± 0.02	53.6	43.1 ± 2.0	0.6 ± 0.03	9.1	–[b]	–[b]
25–34	52.5	152.6 ± 3.0	2.1 ± 0.06	68.4	46.0 ± 0.9	0.6 ± 0.01	51.5	41.4 ± 1.2	0.6 ± 0.02	6	60.4 ± 3.9	0.8 ± 0.08
35–49	60.6	208.5 ± 2.7	2.7 ± 0.04	66.1	56.9 ± 0.9	0.7 ± 0.01	52.4	60.7 ± 1.1	0.8 ± 0.02	4	63.3 ± 3.3	0.8 ± 0.04
50–64	71.1	223.0 ± 2.0	2.8 ± 0.03	57.4	48.9 ± 0.7	0.6 ± 0.01	56.7	65.4 ± 1.0	0.9 ± 0.02	2.2	57.7 ± 3.7	0.7 ± 0.04
⩾65	81.7	194.3 ± 2.5	2.5 ± 0.03	45	34.8 ± 0.8	0.4 ± 0.01	56.4	56.1 ± 1.2	0.7 ± 0.02	1.4	–[b]	–[b]

[a] % Consumers are defined as the proportion of the population reporting any caffeinated beverage use for the respective category (e.g., coffee drinkers). Caffeine intakes for consumers represent the amount of caffeine consumed on average for all consuming occasions. Using coffee drinkers as an example, 55.3% of all caffeinated beverage consumers consume coffee and they consume on average 190.8 mg/day from coffee.

[b] Sample size is too low (⩽88 respondents) to accurately estimate intake for this variable within this age group.

Table 4
90th Percentile caffeine intakes by age group for consumers of total caffeinated beverages and each respective beverage category.

Age group (years)	Total caffeinated beverages[a]	Caffeine, 90th percentile (mg/day)				Caffeine, 90th percentile (mg/kg/day)				
		Total coffee	Total CSD	Total tea	Total energy drinks	Total caffeinated beverages[a]	Total coffee	Total CSD	Total tea	Total energy drinks
All ages	379.5	394.4	102.2	125.7	144.2	5.0	5.3	1.3	1.8	1.9
2–5	57.8	–[b]	33.7	56.2	–[b]	3.7	–[b]	2.2	3.2	–[b]
6–12	94.0	179	51.2	69.1	–[b]	2.7	6.2	1.3	2.1	–[b]
13–17	182.9	223.7	79.5	103.7	132.9	2.9	3.2	1.3	1.6	1.8
18–24	285.9	287.7	99.4	109.9	–[b]	3.9	4.2	1.4	1.5	–[b]
25–34	299.8	316.2	108	98.1	160.0	4.2	4.4	1.3	1.3	1.7
35–49	428.1	417.9	127.4	144.8	148.6	5.4	5.5	1.6	1.9	1.9
50–64	467.4	452	108.6	153.2	126.4	5.9	5.7	1.3	1.9	1.6
⩾65	419.9	393.5	75.1	124.8	–[b]	5.4	5.1	.9	1.7	–[b]

[a] Total caffeinated beverages include total coffee, carbonated soft drinks (CSDs), tea, energy drinks, and a small percentage (<1–4% depending age group) from other sources (cocoa and chocolate-containing beverages, energy shots).

[b] Sample size is too low (⩽88 respondents) to accurately estimate the 90th percentile intake within this age group.

In addition to mean caffeine intakes, a number of other measures were also estimated from the study sample. These included the proportion of the population consuming caffeinated beverages, and the number of occasions or frequency and volume of caffeinated beverages consumed. Overall estimates of mean caffeine consumption in the population were presented as either mg/day or mg/kg/day for all caffeinated beverage consumers by age and beverage category in Tables 2 and 3 shows data for consumers for each of the major caffeinated beverage categories and by age group. The 90th percentile intakes based on mg/day and mg/kg/day of caffeine consumed are presented by age for all consumers for all caffeinated beverages as well as the 90th percentile intake for consumers only for each individual beverage category in Table 4.

3. Results and discussion

A challenge in determining exposure to caffeine is obtaining current and accurate data on the caffeine content of beverages. For commercially available energy drinks, CSDs, and bottled coffees and teas, this is less problematic. Even though the caffeine content of beverages is not required on a label, most companies make these data readily available and the values are fairly consistent across sources. A greater challenge is assigning specific values for the caffeine content of coffee and tea. The origin of the crop, processing, and preparation, including the type, temperature, and time for brewing or steeping, all affect the caffeine concentration. Tea consumption has remained relatively stable and contributes a small amount of caffeine to the diets of U.S. consumers. Coffee poses more of a question, especially with the rising popularity of specialty coffees over the last decade and possibly a low awareness of their caffeine content. For example, in one study, the caffeine content of a specialty coffee from a single location on 6 consecutive days yielded values ranging from 259 to 564 mg per 16 fluid ounces for the same variety and type sampled (McCusker et al., 2003). These data suggest that even with brand-specific caffeine values for coffee, the variability can be quite high. For this reason, most caffeine values for coffee and tea are not brand specific except for commercial bottled varieties (Nutrition Coordinating Center, 2011; U.S. Department of Agriculture, 2011). We recognize that the imprecise estimation of the caffeine content of beverages (particularly coffee) may still be a noteworthy limitation of this and other studies. However, a major strength of the current beverage survey is the development of a comprehensive database including the assignment of brand-specific caffeine values when possible, allowing for a more accurate estimate of caffeine intake than in previous reports.

Of the 42,851 respondents in the survey sample, 37,602 reported consuming at least one caffeinated beverage (Table 2). Using the survey weights, this represents approximately 85% of the U.S. population. Over 98% of all beverage caffeine consumed came from total coffee (all types including specialty drinks and decaffeinated coffee), total tea (black, green, white, and other varieties), CSDs, and energy drinks (excluding energy shots). This is in agreement with recent data reported by Somogyi (2010) for caffeine intakes from food and beverages. In children and adolescents,

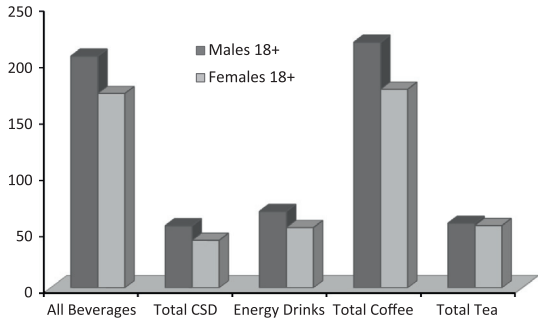

Fig. 1. Mean caffeine intake (mg/day) by gender for consumers of total caffeinated beverages and each respective beverage category for consumers only.

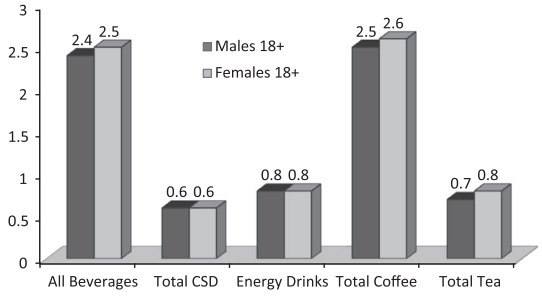

Fig. 2. Mean caffeine intake (mg/kg/day) by gender for consumers of total caffeinated beverages and each respective beverage category for consumers only.

these four beverage types comprised 96% of all caffeinated beverages consumed. In both adults and children, chocolate milk, cocoa, and energy shots contributed a relatively insignificant amount (1–2%) to total caffeine intakes. It is important to note, that the Somogyi (2010) report is based on data from food and beverages; however, the amount of caffeine from food is quite insignificant relative to the total amount of caffeine consumed. In adults, food contributes less than 2% to total caffeine whereas in children it is somewhat higher (3–8%) (Somogyi, 2010).

Of those who drank caffeinated beverages, more than half reported consuming CSDs (63%), coffee (55%), and tea (53%). Significantly fewer caffeinated beverage consumers reported drinking chocolate milk (14%) and energy drinks (4%) with less than 1% drinking energy shots (data not shown). These percentages reflect a significant number of caffeine-consuming respondents who consume more than one type of caffeinated beverage. The average number of occasions that a caffeinated beverage was consumed was 12.7 times over 7 days or 1.8 occasions per day.

Based on this survey, the mean daily caffeine intake from all consumers of caffeinated beverages in the U.S. was 165 mg/day, or 2.2 mg/kg body weight/day (Table 2). Caffeine intakes are higher (165 mg/day vs. 120 mg/day) (Table 1) for all ages for two similarly conducted beverage surveys (1999 SIP and the 2010–2011 KWP Beverage Consumption Panel) (Knight et al., 2004). Coffee was likely responsible for the majority of the shift, with 53% of caffeine intakes attributable to coffee consumption in 1999 compared to 64% in the current survey. A concomitant decrease in the caffeine contribution from CSDs (from 29% to 17%) occurred over the same time period. These data are consistent with recently reported trends in consumption of all sugar-sweetened beverages (including CSDs) showing a decline from 1999 to 2010 (Kit et al., 2013). Caffeine intakes from tea remained relatively stable. Over the past decade, there was also a slight increase (from 1.5 to 1.8) in the total number of caffeinated beverage occasions. Caffeinated beverage consumers of all ages reported consuming 176 fluid ounces in 7 days or 25 fluid ounces per day of caffeinated beverages. Coffee drinkers consumed approximately 9 fluid ounces of coffee per day, whereas CSD drinkers consumed 8, tea drinkers consumed 7, and energy drinkers consumed 1/4 fluid ounces per day, respectively (data not shown).

In this study, the proportion of caffeinated beverage consumers in the population ranged from 43% in the youngest children (aged 2–5 years) to nearly 100% in adults aged >65 years (Table 2). Caffeine intakes in adults increased with age with the highest consumption level in the group aged 50–64 years (226 mg/day) before falling slightly (207 mg/day) among adults aged >65 years. A similar trend was observed in the previous survey where caffeine intake dropped from 169 mg/day in the group aged 50–64 years to 135 mg/day in those adults aged $\geqslant$65 years (Knight et al., 2004). Coffee remains the primary contributor to total caffeine intake in adults in all surveys.

In the present study, adult ($\geqslant$18 years) men consumed somewhat more total caffeine from beverages than adult women; however, when adjusted for body weight (i.e., mg/kg/day), women consumed slightly more for all caffeinated beverages combined (Figs. 1 and 2). Women who drink coffee or tea also reported slightly higher weight-adjusted intakes than men. Caffeine intakes from consumers only of CSDs or energy drinks were similar for both genders. These data are in contrast to a recent study of active duty military personnel ($\geqslant$18 years) where women consumed less than men even after adjusting for body weight (Lieberman et al., 2012). In another study, adult men had higher intakes than women after adjusting for weight, except in the 18- to 24-year-olds where there was little difference (1.2 vs. 1.1 mg/kg/day) (Frary et al., 2005).

Caffeine intake for consumers only within each beverage category follows a similar pattern. Coffee drinkers consumed the most caffeine with the highest mean amount of caffeine (223 mg/day) ingested by adults aged 50–64 years (Table 3). Caffeine intakes from CSDs, energy drinks, and tea among consumers ranged between 13 and 67 mg of daily caffeine with the highest amounts being reported by adults. Caffeine from carbonated beverages and tea increased with age overall until age 64 years. Mean caffeine intakes in older adults ($\geqslant$65 years) from most beverage categories were slightly lower than reported by younger adults.

Based on the results of this investigation as compared to previous investigations (Frary et al., 2005; Knight et al., 2004, 2006), there has been an increase in the last decade in the amount of caffeine consumed by children (2–12 years). Overall mean caffeine intakes remain relatively low (24–37 mg/day) and are below current suggested maximum intakes for children aged $\leqslant$12 years (2.5 mg/kg/day or 45–85 mg/day depending on age) (Health Canada, 2010; Nawrot et al., 2003). At the 90th percentile, caffeine intakes were 58 mg/day or 3.7 mg/kg/day in children aged 2–5 years, and were slightly above suggested maximums (45–85 mg/day) for children aged 6–12 years at 94 mg/day or 2.7 mg/kg/day. For older children (>12 years), intakes were slightly above (2.9 mg/kg/day) the 2.5 mg/kg/day recommendations.

Overall estimation of caffeine intakes for children were possible based on a sample size of approximately 2500 children, but sample sizes for some subgroups based on age and beverage category are not robust enough to obtain a reliable estimate of caffeine intake. For example, only 50 children in the group aged 2–5 years who consumed caffeinated beverages reported consuming coffee, or approximately 7% of caffeine consumers within that age group with a mean intake of 88 mg/day or 5.5 mg/kg/day. However, for the children aged 6–12 years, where sample size was adequate (n = 175), 10% were identified as consuming coffee with a mean caffeine intake of 76 mg/day or 2.4 mg/kg/day (n = 175). The sample composition is an important feature of any large survey in which the goal is to make inferences about a population from the

sample. If a sample is too small, it can result in wide confidence intervals or risks errors in hypothesis testing. For this reason, surveys are typically designed based on sample composition in efforts to obtain large enough samples of demographic subdomains of the population (Centers for Disease Control and Prevention, 2005). The KWP Beverage Consumption Panel was not designed to examine caffeine intakes for subsets of the population where consumption of caffeinated beverages are quite low and is, therefore, a noteworthy consideration for future studies of caffeine intakes in this and other population-based research.

In the 1999 SIP data (Knight et al., 2004), there were fewer children who reported drinking coffee; however, caffeine intake data were not reported for consumers only of each beverage category, making it difficult to make direct comparisons between the two studies. Data presented in Table 1 for children (2–12 years old) consuming caffeinated beverages are comparable with the previous 1999 SIP data (Knight et al., 2004) and show an increase in caffeine intake from coffee (from <1 mg/day to 6–7 mg/day) although intakes are still quite low. While caffeine intakes from coffee are inconsistent with previous reports of caffeine consumption in younger children, it is important to note that they represent <1% of all caffeinated beverage consumers and only 9% of all children between the ages of 2 and 12 years who consume caffeinated beverages.

A notable finding was the low consumption of energy drinks and energy shots. Of all caffeinated beverage consumers, only 4.3% were consumers of energy drinks. Energy shots were excluded altogether from the analysis due to very low frequency of consumption in the overall survey ($n < 100$). Energy drinks can contain levels of caffeine that are similar to coffee; however, consumption in the current survey contributed little to total caffeine intakes. Caffeine intakes from energy drinks represent less than 2% of total daily mean caffeine values for all caffeinated beverage consumers. Similarly to coffee consumption in children, the estimated intake of energy drinks (as a separate beverage category) could not be reliably assessed in some of the age groups due to relatively few consumers energy drink consumers only, caffeine intakes ranged from 58 to 63 mg/day in the groups where sample size was sufficiently large to estimate intakes accurately. The greatest proportion (9–10%) of caffeinated beverage consumers consuming energy drinks were teenagers (13–17 years, $n = 180$) or young adults (18–24 years, $n = 83$); however, only 5–7% of total caffeine intake was attributable to energy drinks in these age groups.

Since energy drinks and shots were relatively new to the marketplace in 1999 (introduced in the U.S. in 1997), they were not included as a category in the earlier population-level studies (Barone and Roberts, 1996; Frary et al., 2005; Knight et al., 2004, 2006). Several smaller studies have suggested that energy drink consumption can vary across segments of the population. Norton et al. (2011) surveyed 685 undergraduate students who completed an online survey for course credit. Caffeine use was reported by 98% of students, with an average daily consumption of 196 mg/day. Of those reporting any caffeine consumption, 81% reported consumption in soft drinks, 42% in energy drinks and shots, 41% in coffee, 29% in tea, and 14% in espresso and lattes. The average daily consumption of caffeine from energy drinks and shots was 53 mg/day. A study conducted in military personnel ($\geqslant$18 years) (Lieberman et al., 2012) shows a higher proportion (39%) of energy drink consumers than adults in the current study ($\leqslant$10%).

For healthy adults, current recommendations are to limit caffeine consumption to moderate amounts ($\leqslant$400 mg or 5.7 mg/kg body weight per day for a 70-kg person) (Health Canada, 2010; Nawrot et al., 2003). This level has been proposed as one that is not associated with adverse effects and the level that may provide health benefits. Pregnant women who consume caffeine are advised to limit intakes to $\leqslant$300 mg/day (Health Canada, 2010; Nawrot et al., 2003). In the current study, caffeine intakes from all caffeinated beverages at the 90th percentile in all ages were 380 mg/day or 5.0 mg/kg/day, with coffee contributing about 80% of the total caffeine consumed. Caffeine intakes at the 90th percentile from all caffeinated beverages were slightly above 400 mg of caffeine per day (Table 4) for adults aged $\geqslant$35 years (420–467 mg/day or 5.1–5.7 mg/kg/day), which is in contrast to over a decade ago when the highest caffeine intakes were below this recommended level (Knight et al., 2004). In women of childbearing age, consumption at the 90th percentile was 228 mg/day (3.7 mg/kg/day) in women aged 18–24 years and 284 mg/day (4.5 mg/kg/day) in women aged 25–34 years (data not shown). At the 90th percentile, women aged 25–34 years reported slightly higher caffeine intakes (284 vs. 247 mg/day) than in the previous survey (Knight et al., 2004) but are below the suggested maximum intake during pregnancy. We did not have data on pregnancy status for these survey respondents unlike the previous study where intakes were notably lower in pregnant women than non-pregnant women.

4. Conclusions

To our knowledge, this is the first population-based study to estimate the caffeine intakes from beverages in over a decade. The results from the KWP Beverage Consumption Panel conducted in 2010–2011 showed that overall mean caffeine intakes in the U.S. remain driven by the consumption of coffee and, to a lesser extent, tea and CSDs. Energy drinks, energy shots, and chocolate milk beverages contributed minimally to total caffeine intakes. These results provide little support to the notion that the introduction of additional caffeinated beverages into the market over the past decade has contributed to proportionally higher caffeine intakes by the various populations of consumers. It may suggest that consumers have awareness of their total caffeine intake and substitute caffeinated beverage choices vs. consuming additional caffeinated beverages (e.g., increased coffee consumption and a decrease in CSD consumption). The increased accuracy afforded by the branded caffeine content information may have also played a role in the increased caffeine intake observed by this study. Given the design of this survey, it was possible to identify small percentages of subpopulations consuming higher caffeine levels within certain individual beverage categories. A more focused study with a larger sample size of these discrete populations might provide a better estimation of intakes in certain subgroups such as in children and teenagers. The current study provides a useful resource for the scientific community, regulatory agencies, industry, and public health professionals interested in beverage caffeine consumption by the general population in the U.S.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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