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Added sugars, saturated fat, and sodium intake from snacks among U.S. adolescents by eating location

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ABSTRACT

Snacking away from home is thought to contribute to excess intake of energy, added sugars, saturated fat, and sodium compared to snacking at home. Using data from the National Health and Nutrition Examination Survey 2009–2016, we examined associations between location of snack consumption (at home or away from home) and added sugars, saturated fat, and sodium intake from food and beverage snacks in U.S. adolescents aged 12–19. We also compared top snack contributors to intakes of these nutrients by location of consumption. Nutrient intake (added sugars, saturated fat, and sodium) from food and beverage snacks was estimated by the average intake from two 24-hour dietary recalls, and location of consumption for each snack was reported by participants as at home or away from home. Adjusted mixed effects models were performed to examine associations between nutrient intakes and the location of consumption. Adolescents (n = 3,869) had lower intakes of added sugars (−5.20 g/day), saturated fat (−2.06 g/day) and sodium (−170.15 mg/day) from food snacks consumed away from home compared to at home ($p < 0.0001$). Similarly, adolescents had lower intake of added sugars (−2.74 g/day), saturated fat (−0.32 g/day) and sodium (−16.04 mg/day) from beverage snacks consumed away from home compared to at home ($p < 0.0001$). The top contributors to the target nutrients were similar irrespective of location. Taken together, our results demonstrate that adolescents consumed more target nutrients from snacks at home than away from home. Larger snack portion sizes and higher frequency of snacking at home may explain these findings and requires further study.

1. Introduction

Currently, one fifth of adolescents in the U.S. have obesity, defined as a Body Mass Index (BMI) at or above the 95th percentile (Centers for Disease Control and Prevention, 2019a). Obesity is a complex, multifactorial disease, with genetic, behavioral, socioeconomic, and environmental origins (Hruby and Hu, 2015). Among the many factors that contribute to obesity, excess energy intake is a key contributor to weight gain (Duffey and Popkin, 2007; Swinburn et al., 2009). Consumption of energy-dense foods and beverages (i.e. pizza, sugars-sweetened beverages [SSB]), frequency of eating/drinking occasions, large portion sizes, consumption of food away from home (i.e. at restaurants), and snacking are positively associated with excess weight gain in children and adults (Bellisle et al., 1997; Kant and Graubard, 2006; Martin et al., 2020; Nicklas et al., 2003; Piernas and Popkin, 2010a; Popkin and Duffey, 2010; Todd, 2010).

Snack consumption, defined as foods or beverages eaten between regular meals, (Hess et al., 2016) increased among U.S. children and adolescents between 1997 and 2014 (Dunford and Popkin, 2018). Among 12–18-year-olds, the number of snacks consumed per day more than doubled, from 1.0 to 2.1 (Dunford and Popkin, 2018), which resulted in an increase in per capita energy intake from snacks from 307 kcal to 461 kcal over this time period (Dunford and Popkin, 2018). Increases in energy intake from snacks are explained by higher consumption of added sugars (i.e. desserts and SSBs) (Piernas et al., 2013) and saturated fats (i.e. sweet bakery products, pizza, milk) (O'Neil et al., 2018) in both foods and beverages.

The 2020–2025 Dietary Guidelines for Americans recommend that

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individuals 2 years and older limit calories from added sugars to no more than 10%, and saturated fats to <10%, of total daily calorie consumed. It is also recommended that sodium intake be limited to <2300 mg per day (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2020–2025). Meanwhile, national data indicate that snacks account for 35% and 39% of total daily added sugar intake, 22% and 24% of total daily saturated fat, and 15% and 16% of total daily sodium intake among male and female 12–19-year-old adolescents, respectively (Centers for Disease Control and Prevention).

Given the significant contribution of snacks to total energy intake and intakes of added sugars, saturated fat and sodium, there is a growing interest in the location (at home, away from home) of snack consumption, which may influence the types, nutrient content, and portion sizes of snacks consumed (Vatanparast et al., 2020; Williams, 2016; Liu et al., 2015; Todd, 2010). Eating away from home is positively associated with higher frequency of snack consumption (Williams, 2016), and higher intake of snacks that are nutrient poor (Hess et al., 2016). It is estimated that each snack eaten away from home adds more than 100 kcal to daily intake among U.S. adults (Todd, 2010).

While consumption of food away from home is associated with greater weight gain over time and poorer diet quality in children and adolescents (Powell and Nguyen, 2013), the prevalence of snacking at home versus away from home among US adolescents is presently unknown. While snacking at home has been reported to be more prevalent than snacking away from home in 13–18 year-old Canadians (74%) (Vatanparast et al., 2020), the prevalence of snacking at home versus away from home among U.S. children and adolescents has been documented only in toddlers (73% at home) and preschoolers (67% at home) (Jacquier et al., 2018). Furthermore, the contribution of snacks consumed at home versus away from home to intakes of added sugars, saturated fats, and sodium has not been evaluated. It is important to include adolescents in the research on snacking, as adolescents experience more autonomy over their food choices than younger children (Wray-Lake et al., 2010) and unhealthy eating habits in adolescence are known to track into adulthood (Craigie et al., 2011), which can have implications on long term health. Knowing the location of snack consumption could inform interventions or policy strategies aimed at improving the diet and health of U.S. adolescents.

The objective of the present study was to examine associations between the location of snack consumption (at home or away from home) and added sugars, saturated fat, and sodium intake from food and beverage snacks in U.S. adolescents 12–19 years old. Given that the type of food or beverage snacks (i.e. cookies, cereal, juice drinks) consumed by adolescents may vary depending on the eating location, we also compared the top food and beverage snack contributors to total daily intakes of added sugars, saturated fat, and sodium.

2. Methods

2.1. Study sample

The NHANES is an ongoing, cross-sectional nationally representative study of the diet and health of the non-institutionalized civilian U.S. population (Johnson et al., 2014). NHANES utilizes a multi-stage, clustered, probability sampling method. Questionnaire and physical examination data are collected by trained staff during in-home interviews and study visits at mobile examination centers (Johnson et al., 2014). The present analysis utilized data from adolescents aged 12–19 years collected during the 2009–2016 cycles of NHANES. Given that this analysis used publicly available, deidentified, data collected in NHANES, the study was determined to be exempt by the Institutional Review Board at the George Washington University.

2.2. Assessment of dietary intake from snacks

During the dietary interview component of NHANES, called What We Eat in America (WWEIA), participants completed two 24-hour dietary recalls (one weekday and one weekend day). The first dietary recall was completed in person and the second was conducted via phone. Information on the type of meal (i.e. breakfast, lunch, dinner, snack) was collected for each eating occasion reported in each dietary recall. A food and/or beverage was considered a snack if it was reported as "snack," "drink," "extended consumption," "merienda/bocadillo/tentempie (snack)," "entre comida (between meals)," or "bebida (drink)" (Centers for Disease Control and Prevention National Health and Nutrition Examination Survey, 2020b). To ensure that all snacks were properly categorized as either a "food" or "beverage", research team members (C. C. Q.H.) reviewed each individual food or beverage description in the Food and Nutrient Database for Dietary Studies (FNDDS).

NHANES assigns "combination food type" codes, which describe foods and beverages with additions, or multi-component foods, such as sandwiches, salads, foods with toppings, or beverages with additions. This code was utilized to properly label snacks as a "food" or a "beverage" (i.e. milk that was coded as "cereal w/ additions" was labeled as a "food" and sugars coded as a "beverage w/ additions" was labeled as a "beverage"). Unsweetened water in any form (i.e. plain, carbonated) was not considered to be a meal or snack and excluded from the analysis, consistent with prior analyses (Sebastian R, 2010).

The added sugars content of food and beverages categorized as snacks was obtained from the Food Patterns Equivalents Database (FPED). The FPED is a research tool that converts foods and beverages in the FNDDS to the 37 USDA Food Patterns components (United States Department of Agriculture Agricultural Research Service, 2020). Added sugars intake was calculated using the added sugars content of the snack (grams added sugars/grams snack) and the amount of the snack consumed. Saturated fat and sodium intakes from food and beverage snacks were obtained from the dietary intake files in NHANES. The average intake of added sugars, saturated fat and sodium intake from two 24-hour dietary recalls were used in analyses. The WWEIA food groups were utilized to identify the top food group contributors of added sugars, saturated fat, and sodium in food and beverage snacks. (United States Department of Agriculture Agricultural Research Service, 2020) Total energy intake (kcal/day) was estimated using dietary files.

2.3. Location of snack consumption

Participants provided information on location of snack consumption by responding to the question "Did you eat this meal at home?" A "yes" response was considered as a food or beverage eaten at home. A "no" response was considered as a food or beverage eaten away from home (Centers for Disease Control and Prevention National Health and Nutrition Examination Survey, 2020b).

2.4. Covariates

Age (years), sex (male, female), race/Hispanic origin (non-Hispanic White, non-Hispanic Black, Hispanic origin, other), education level ($\leq 8^{th}$ grade, greater than 8th grade), household size ($\leq$3, >3) and household income (<$35,000, $35,000–74,999, ≥$75,000) were either self-reported, or reported by a proxy during the in-home interview. A proxy was used for those under the age of 16 and those that could not report on their own. Body mass index (BMI, weight in kg divided by height as m^2) was calculated using participant's height and weight, as measured by trained staff in the mobile examination center (Centers for Disease Control and Prevention, 2017). BMI z-score and corresponding BMI percentile were computed using the statistical program provided by the Centers for Disease Control (Centers for Disease Control and Prevention, 2019b), and further categorized as <15th percentile (underweight), 15th–85th percentile (healthy weight), 85th to <95th percentile (overweight) and ≥95th percentile (obesity). Physical activity was calculated as metabolic equivalent of task (MET, minutes/week) using self-reported number of days of each activity in a week, number of

minutes of each activity, and the MET score corresponding to each activity (Centers for Disease Control and Prevention National Health and Nutrition Examination Survey, 2020b). We chose these covariates based on their associations with diet quality in the literature (Hiza et al., 2013).

2.5. Statistical analysis

Descriptive statistics, including means (standard error) and frequencies of sample characteristics, were calculated. Linear mixed effects models were conducted to examine differences in the intake of added sugars, saturated fat, and sodium, as well as total calories from added sugars and saturated fat, between snacks consumed at home and away from home by snack type. Additional mixed effects models were performed to examine associations between the intake of added sugars, saturated fat, and sodium from snacks, and the location of the eating occasion, adjusting for potential confounders including age, sex, race/Hispanic origin, education, household size, household income, BMI-z score, total energy intake, total added sugars intake (added sugars intake model only), total saturated fat intake (saturated fat intake model only), total sodium intake (sodium intake model only) and physical activity (MET mins/week).

To identify major food group and food contributors to added sugars, saturated fat, and sodium intake, by type and location of snack consumption, percentage contributions (total intake from food or food group divided by total intake from all snacks combined) of each food groups were estimated.

Day-2 dietary weights, clustering, and stratification were incorporated in all analyses to account for the complex survey design in NHANES (Centers for Disease Control and Prevention National Health and Nutrition Examination Survey, 2020a,c). The day-2 dietary weights accounted for unequal probabilities of selection of the sample, planned oversampling of certain subgroups, nonresponse to dietary recalls, differential allocation by day of the week for the recall, and proportion of weekend and weekday combinations of two recalls. Data will be expressed as beta coefficients, along with 95% confidence intervals (CI). An alpha level of 0.008 was used to adjust for multiple comparisons. All analyses were performed using SAS 9.4.

3. Results

Among the 40,439 participants in the NHANES 2009–2016 cycles, 5360 were between the ages of 12 and 19. Of these, 4242 completed both days of dietary recalls; 373 participants were excluded due to missing demographic data. The final analytic sample size was 3869 (n [%]) for men was 1971 (50.2) and women 1898 (49.8). In the sample, 93.1% of adolescents reported snack intake.

As shown in Table 1, 15.7% of adolescents had a BMI between the 85th and 95th percentiles, and 20.9% had a BMI in the 95th percentile or higher. Overall, the mean number of snacks consumed (mean (SE)) was 2.4 (0.04) snacks/day. Mean number of snacks consumed at home was 1.7 (0.03) per day and mean number of snacks away from home was 0.7 (0.03) per day. Mean total energy intake was 2027 (22.3) kcal/day. Total calories from added sugars and saturated fat combined were 99.3 (3.5) kcal/day and 69.4 (3.6) kcal/day in food and beverage snacks respectively. Reported intakes of added sugars (g/day), saturated fat (g/day), sodium (mg/day), calories from added sugars and saturated fats (kcal/day) were higher from food and beverage snacks eaten at home than compared with those consumed away from home (Table 2). Mean and SE of added sugars in g/1000 kcal, saturated fat in g/1000 kcal and sodium in mg/1000 kcal values are in Appendix Table A.

Adjusted associations between location of snack consumption and added sugars, saturated fat and sodium intake from foods and beverage snacks are shown in Table 3. For food snacks, adolescents had a significantly lower intake of added sugars (−5.2 g/day; 95% CI −5.8, −4.6; $p < 0.0001$), saturated fat (−2.1 g/day; 95% CI −2.3, −1.9; $p < 0.0001$) and sodium (−171.2 mg/day; 95% CI −186.1, −154.2; $p < 0.0001$) from snacks consumed away from home compared to snacks consumed at home. Similarly, for beverage snacks, adolescents had a significantly lower consumption of added sugars (−2.7 g/day; 95% CI = −3.7, −1.8; $p < 0.0001$), saturated fat (−0.3 g/day; 95% CI = −0.4, −0.3; $p < 0.0001$) and sodium (−16.0 mg/day; 95% CI = −19.6, −12.5; $p < 0.0001$) from snacks consumed away from home compared to snacks consumed at home.

Rank order of the top contributors to added sugars, saturated fat, and sodium intake from food and beverage snacks, by location of consumption, are presented in Tables 4 and 5. Interestingly, top

Table 1
Characteristics of U.S. adolescents aged 12–19 years (n = 3869; 1971 men, 1898 women): National Health and Nutrition Examination Survey, 2009–2016.

	Overall		Males		Females	
Characteristic	Mean	SE	Mean	SE	Mean	SE
Age (years)[c]	15.5	0.1	15.6	0.1	15.4	0.1
	n[a]	%[b]	n[a]	%[b]	n[a]	%[b]
Body Mass Index category						
<15th percentile	295	7.3	177	8.5	118	6.2
15–85th percentile	2076	56.1	1055	55.8	1021	56.4
85–95th percentile	669	15.7	313	14.8	356	16.5
≥95th percentile	829	20.9	426	20.9	403	20.9
Education						
8th grade or lower	1720	42.9	904	42.2	816	43.6
Higher than 8th grade	2149	57.1	1067	57.8	1082	56.4
Race/Hispanic origin						
Non-Hispanic White	1078	55.1	590	55.3	488	55.0
Non-Hispanic Black	967	14.8	481	14.0	486	15.5
Hispanic origin	1278	21.8	629	22.3	649	21.2
Other (other non-Hispanic races or multiple races)	546	8.3	271	8.3	275	8.3
Household size						
≤3	914	25.5	469	25.1	445	25.9
>3	2,955	74.5	1502	74.9	1453	74.1
Household income						
<$35,000	1,664	33.0	815	31.0	849	35.0
$35,000-$74,999	1,119	29.1	559	28.5	560	29.7
≥$75,000	1,086	37.9	597	40.6	489	35.3
	Mean	SE	Mean	SE	Mean	SE
Total snacks consumed/day	2.4	0.04	2.4	0.1	2.3	0.1
Snacks consumed at home/day	1.7	0.03	1.7	0.1	1.6	0.1
Snacks consumed away from home/day	0.7	0.03	0.7	0.0	0.7	0.0
Total energy intake (kcal/day)[c]	2,027.7	22.3	2299.9	40.8	1753.3	21.3
Total calories from added sugar and saturated fat (kcal/day)						
All foods and beverages consumed[c]	555.0	8.2	624	13.5	484.8	8.6
All snacks[c]	168.7	5.4	189.3	8.0	148.0	6.5
Food snacks only[c]	99.3	3.5	106.1	5.0	92.4	5.0
Beverage snacks only[c]	69.4	3.6	83.1	6.3	55.6	3.8
% of total daily added sugar intakes came from snacks[c]	33.5	0.7	33.7	1.0	33.3	1.3
% of total daily saturated fat intakes came from snacks[c]	19.5	0.5	18.8	0.7	20.2	0.7
% of total daily sodium intakes came from snacks[c]	13.0	0.3	13.3	0.4	12.8	0.5

[a] unweighted count.
[b] weighted percentage using day 2 dietary weights.
[c] Statistically significant ($p < 0.05$).

Table 2
Intake of and calories from selected nutrients from food and beverage snacks by location of consumption in U.S. adolescents aged 12–19 years: National Health and Nutrition Examination Survey, 2009–2016.

		Food snacks					Beverage snacks			
		At home		Away from home[a]			At home		Away from home[a]	
		Mean	SE	Mean	SE		Mean	SE	Mean	SE
Added sugar intake (g/day)[b]	Overall	9.5	0.4	4.3	0.3	Overall	9.4	0.6	6.7	0.7
	Males	10.5	0.6	4.2	0.5	Males	11.5	0.9	7.9	1.1
	Females	8.5	0.6	4.5	0.4	Females	7.3	0.7	5.5	0.6
Saturated fat intake (g/day)[b]	Overall	3.5	0.1	1.4	0.1	Overall	0.4	0.0	0.1	0.0
	Males	3.9	0.2	1.4	0.1	Males	0.5	0.1	0.1	0.0
	Females	3.0	0.2	1.5	0.2	Females	0.4	0.0	0.1	0.0
Sodium intake (mg/day)[b]	Overall	283.8	10.5	113.7	7.3	Overall	34.7	1.9	18.7	3.3
	Males	330.9	16.9	119.7	11.6	Males	43.4	3.5	24.9	6.5
	Females	236.4	11.2	107.7	8.7	Females	26.0	1.8	12.4	1.6
Calories from added sugar in snacks (kcal/day)[b]	Overall	38.1	1.6	17.3	1.3	Overall	37.7	2.4	26.8	2.7
	Males	42.1	2.4	16.7	1.9	Males	46.1	3.6	31.4	4.6
	Females	34.1	2.2	17.9	1.7	Females	29.3	2.8	22.0	2.4
Calories from saturated fat in snacks (kcal/day)[b]	Overall	31.2	1.2	12.7	1.0	Overall	3.9	0.3	1.0	0.2
	Males	35.1	1.9	12.2	1.1	Males	4.6	0.5	1.0	0.2
	Females	27.3	1.5	13.1	1.7	Females	3.2	0.4	1.0	0.2

[a] Away from home is any location outside of home that includes school, any food outlet (i.e. restaurant, fast food place), friend's house or other.
[b] Statistically significant ($p < 0.0001$) between food or beverage snacks consumed at home and away from home in the total sample, among males, and among females.

Table 3
Association between location of snack consumption and added sugar (g/day), saturated fat (g/day), and sodium (mg/day) intake from food and beverage snacks in U.S. adolescents aged 12–19 years: National Health and Nutrition Examination Survey, 2009–2016.

	Food snacks[a]					
	Added sugar intake		Saturated fat intake		Sodium intake	
	β	95% Confidence Interval	β	95% Confidence Interval	β	95% Confidence Interval
Location of consumption[c]						
At home (ref)						
Away from home	−5.20	−5.79, −4.61	−2.06	−2.26, −1.86	−170.15	−186.05, −154.24
	Beverage snacks[b]					
	Added sugar intake		Saturated fat intake		Sodium intake	
	β	95% Confidence Interval	β	95% Confidence Interval	β	95% Confidence Interval
Location of consumption[c]						
At home (ref)						
Away from home	−2.74	−3.65, −1.84	−0.32	−0.38, −0.27	−16.04	−19.56, −12.51

[a,b] Models adjusted for age, sex, race/Hispanic origin, education, household size, household income, BMI-z score, total energy intake, total added sugar intake (added sugar intake model), total saturated fat intake (saturated fat intake model), total sodium intake (sodium intake model) and physical activity (MET mins/week).
[c] All associations were statistically significant, $p < 0.0001$.

contributors were similar regardless of the location of snack consumption. Top contributors to added sugars intake for food snacks were candy, sweet bakery products and desserts other than bakery products; while for beverage snacks, top contributors were nutritive sweeteners added to beverages, soft drinks, and fruit drinks for snacks consumed at home and away from home. Top contributors to saturated fat intake for food snacks were sweet bakery products, desserts other than bakery products, candy, and savory snacks; while for beverage snacks, top contributors were milk, dairy drink substitutes, sugar sweetened coffee and tea and flavored milk for snacks consumed at home and away from home. Top contributors to sodium intake for food snacks were savory snacks, sweet bakery products, breads, rolls and tortillas, and mixed dishes sandwiches; while for beverage snacks, top contributors were milk, sports drinks, soft drinks and fruit drinks for snacks consumed both at home and away from home.

4. Discussion

Among adolescents 12–19 years old in the U.S., the number of food and beverage snacks consumed and intakes of added sugars, saturated fat, and sodium from food and beverage snacks were significantly greater at home compared to away from home. This is consistent with an analysis of data collected during two earlier cycles of NHANES (2005–2006, 2007–2008), which indicated that 12–19-year-old adolescents consumed more added sugars from food (54.4%) and beverages (65.8%) at home than away from home (Ervin et al., 2012). Similarly, among children and adolescents 2–19 years old in the U.S., 55–70% of calories consumed from SSBs, were consumed in the home (Wang et al., 2008). However, others have reported that the frequency of highly caloric food (i.e. fast food) and snack intake away from home is associated with higher energy, SSB, sodium and fat intake among children (Paeratakul et al., 2003; Powell and Nguyen, 2013; Sebastian et al., 2009).

Our results also demonstrate that the top contributors to added sugars, saturated fat, and sodium intake were overall similar at home and away from home. This was the case for both food snacks and beverage snacks, and is consistent with the findings of Neumark-Sztainer et al., who reported that food choices of U.S. adolescents were largely

Table 4
Top contributors to added sugar, saturated fat, and sodium intake from food snacks, by location of consumption in U.S. adolescents aged 12–19 years: National Health and Nutrition Examination Survey, 2009–2016.

	At home			Away from home			
	Added sugar						
Rank	Category	% Contribution	Top contributors within category (%)[a]	Rank	Category	% Contribution	Top contributors within category (%)[a]
1	Candy	36.6	Hard candy (21.8), gumdrops (9.5), taffy (6.6)	1	Candy	54.5	Hard candy (21.6), gumdrops (8.6), skittles (6.9)
2	Sweet bakery products	29.8	Chocolate chip cookie (20.7), chocolate cookie sandwich (8.4), brownie (4.5)	2	Sweet bakery products	24.1	Chocolate chip cookie (21.2), brownie (5.4), chocolate cake/ cupcake (4.8)
3	Desserts other than bakery products	8.2	Ice cream, other than chocolate (39.9), chocolate ice cream (8.0), ice pop (6.4)	3	Desserts other than bakery products	5.7	Ice cream, other than chocolate (37.7), ice cream cones (5.2), ice cream sandwich (4.6)
	Saturated fat						
Rank	Category	% Contribution	Top contributors within category (%)[a]	Rank	Category	% Contribution	Top contributors within category (%)[a]
1	Sweet bakery products	20.6	Chocolate chip cookie (20.9), cinnamon bun, frosted (7), chocolate cake/cupcake (6.7)	1	Sweet bakery products	23.3	Chocolate chip cookie (19.6), cinnamon bun, frosted (9.1), chocolate cake/cupcake (6.2)
2	Desserts other than bakery products	18.0	Ice cream, other than chocolate (61.0), chocolate ice cream (10.2), ice cream, rich, other than chocolate (4.3)	2	Candy	15.0	Snickers bar (10.7), milk chocolate (9.3), coconut flavored chocolate (6.8)
3	Savory snacks	11.2	Buttered/oiled popcorn (13.9), corn tortilla chips (12.1), corn puffs (11.9)	3	Desserts other than bakery products	14.0	Ice cream, other than chocolate (58.4), light ice cream (4.7), chocolate ice cream (4.6)
	Sodium						
Rank	Category	% Contribution	Top contributors within category (%)[a]	Rank	Category	% Contribution	Top contributors within category (%)[a]
1	Savory snacks	17.4	Corn puffs (14.6), corn tortilla chips (10.5), potato chips (9.6)	1	Savory snacks	20.9	Corn puffs (20.4), potato chips (7.1), pretzels (6.9)
2	Sweet bakeryproducts	12.3	Chocolate chip cookie (15.0), chocolate cake/cupcake (7.5), chocolate sandwich cookie (5.8)	2	Sweet bakeryproducts	14.5	Chocolate chip cookie (14.9), chocolate cake/cupcake (7.5), donut (6.2)
3	Breads, rolls, tortillas	6.4	White bread (24.1), wheat bread (13.7), wheat flour tortilla (7.9)	3	Mixed dishes-sandwiches	8.2	Chicken patty sandwich (18.9), double cheeseburger in bun (10.7), cheeseburger in bun (7.7)

[a] Only top three contributors are listed.

determined by availability, convenience, and food preferences, regardless of location (Neumark-Sztainer et al., 1999). In the present study, the similarity of adolescents' snack choices at home and away from home was likely also influenced by their food preferences as well as the availability of these snacks at home. Adolescents may have been greatly exposed to food and beverage snack sources of the nutrients under study at home, which in turn could have influenced greater frequency of consumption. Potential at home intervention strategies include nutrition education to parents on making healthy snacks (i.e. low saturated fat, low added sugar yogurt, whole grain rich) available and accessible to adolescents, and parenting food strategies such as encouraging adolescents to consume nutrient dense foods as snacks (i.e. fruits). Notably, among children in the United Kingdom, energy dense snacks were consumed most frequently at home, yet portion sizes were greater when these same snacks were consumed outside of the home (Blundell-Birtill and Hetherington, 2019). Higher frequency of snacking at home is also consistent with data from Canada, which demonstrate that 73% of snacking in Canadians over 2 years of age occurs at home (Vatanparast et al., 2020).

It is also important to note that our sample consisted of adolescents 12–19 years old, among whom dietary choices are reported to be less nutritious compared to younger children (Piernas and Popkin, 2010b). Seminal research suggests that younger children may be better at self-regulating their energy intakes compared to older children, which may have further encouraged consumption of snacks at home (Birch and Deysher, 1986). Given that adolescents have greater autonomy to acquire food and beverage snacks, it is possible that adolescents purchased snacks away from home but consumed them at home. For example, it was previously reported that about one-half of food purchased by US adolescents, at fast food restaurants was eaten at home (Poti and Popkin, 2011). This was not disentangled in the present study, however, as only the location of consumption and not the location of purchase, was included in analysis.

Data from a 2014 study indicate that U.S. adolescents 12–19 years old consume 17% of their total calories from added sugars (Drewnowski and Rehm, 2014), which exceed the recommendation of no more than 10% of calories from added sugar provided by the 2020–2025 Dietary Guidelines for Americans (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2020–2025). Our analysis revealed that snacks contributed to one third of total calorie intake from added sugars and over half of the national recommended intake of added sugars. Saturated fat from snacks contributed 2.4% of daily saturated intake, which accounts for one-quarter of the recommended up to 10% of daily calories from saturated fat. Snacks also accounted for 19.6% of the recommended amount of total sodium. Adolescents may benefit from multiple interrelated approaches such as nutrition education and healthy food environments (at home and away from home) to help them support healthy dietary habits. Increasing food knowledge, acquiring cooking skills, living in cities in which food policies make choosing health food the easy choice or with zoning regulations to limit fast-food outlets may facilitate adherence to recommendation for daily added sugar intake, saturated fat, and sodium.

Table 5
Top contributors to added sugar, saturated fat, and sodium intake from beverage snacks, by location of consumption in U.S. adolescents aged 12–19 years: National Health and Nutrition Examination Survey, 2009–2016.

	At home				Away from home		
Added sugar							
Rank	Category	% Contribution	Top contributors within category (%)[a]	Rank	Category	% Contribution	Top contributors within category (%)[a]
1	Nutritive sweeteners added to beverages	38.2	White sugar (79.4), honey (9.4), sugar, no further specified (2.9)	1	Soft drinks	32.6	Fruit flavored soft drink caffeine free (28.8), cola-type soft drink (17.9), fruit flavored soft drink with caffeine (16.3)
2	Soft drinks	25.6	Fruit flavored soft drink caffeine free (31.0), fruit flavored soft drink with caffeine (16.9), cola-type soft drink, (16.0)	2	Nutritive sweeteners added to beverages	23.9	White sugar (83.7), honey (4.2), chocolate syrup (3.8)
3	Fruit drinks	13.8	Fruit juice drink with vitamin C (29.0), fruit flavored drink made from powdered mix (12.8), fruit flavored drink (11.3)	3	Fruit drinks	13.3	Fruit juice drink with vitamin C (29.3), fruit juice drink (16.5), fruit flavored drink (9.4)
	Saturated fat						
Rank	Category	% Contribution	Top contributors within category (%)[a]	Rank	Category	% Contribution	Top contributors within category (%)[a]
1	Milk	67.8	Milk 2% fat (27.1), whole milk (24.3), reduced fat milk (22.8)	1	Dairy drinksandsubstitutes	32.3	Fast food milk shake, other than chocolate (38.7), chocolate fast food milk shake (20.6), homemade milk shake, other than chocolate (18.2)
2	Dairy drinksand substitutes	8.8	Milk shake, other than chocolate (21.5), homemade/fountain type milk shake, other than chocolate w/ skim milk (18.7), fast food milk shake, other than chocolate (12.9)	2	Sugar-sweetened coffee andtea	21.2	Frozen coffee drink, with whipped cream (22.6), sweetened caffeinated blended coffee with milk, ice, whipped cream (16), coffee, latte with soy milk (8.0)
3	Flavored milk	8.8	Whole milk chocolate (10.8), chocolate syrup, whole milk added (10.4), whole milk chocolate ready to drink, (7.4)	3	Milk	15.5	Reduced fat milk (34.7), milk 2% fat (25.9), whole milk (24.0)
	Sodium						
Rank	Category	% Contribution	Top contributors within category (%)[a]	Rank	Category	% Contribution	Top contributors within category (%)[a]
1	Milk	34.5	Milk 2% fat (26.7), reduced fat milk (22.4), whole milk (14.7)	1	Sports drinks	38.4	Gatorade™ thirst quencher sports drink (39.4), Powerade™ sports drink (17.7), Gatorade™ G sports drink (11.6)
2	Sports drinks	17.2	Gatorade™ thirst quencher sports drink (30.9), Powerade™ sports drink (15.3), Gatorade™ G sports drink (12.8)	2	Soft drinks	12.0	Fruit flavored soft drink caffeine free (35.1), fruit flavored soft drink with caffeine (26.0), soft drink, cola type (10.4)
3	Fruit drinks	12.1	Fruit flavored drink (16.9), fruit flavored drink made from powdered mix (14.7), fruit flavored drink with vitamin C (12.6)	3	Fruit drinks	7.4	Fruit juice drink (21.7), fruit juice drink, with vitamin C (19.0), fruit flavored drink (11.4)

[a] Only top three contributors are listed.

The present study has several important strengths and some limitations. First, the study sample is nationally representative, and results can be generalized to the U.S. adolescent population. In addition to assessing the contribution of snacks, both at home and away from home, to adolescents' added sugar, saturated fat, and sodium intake, we also identified key contributors to each of these nutrients by consumption location. This finding has the potential to inform targeted interventions focusing on specific snack foods and beverages that contribute the greatest amount of added sugars, saturated fat and sodium to adolescents' diet. For example, interventions that increase knowledge about portion sizes and teach healthy food alternatives to processed food (i.e. lower saturated fat, low sugar snacks *v* sweet bakery products) or provide strategies to deal with sweet, savory foods cravings.

Study limitations include the lack of inclusion of where snacks were obtained and, the inability to examine home or outside the home environmental factors that may explain snacking behaviors. Additionally, the only available data regarding place of consumption is "at home" or "away from home", which restricts analysis of the role of the school environment on snacking. Another limitation is the definition of what constitutes a snack. While our study considered a snack to be any food or beverage consumed outside of breakfast, lunch, or dinner, what constitutes a snack is highly variable across studies. For example, others have used the eating occasion, the type of food consumed, the amount of food consumed, or location of consumption to define food or beverage snacks (Hess et al., 2016). Given this heterogeneity, a standardized definition of what constitutes a snack is needed to better understand the role of snacking on adolescents' dietary intake. Finally, our study included adolescents ages 12–19, regardless of school grade. Future studies may include college or post high school adolescents, whose snacking habits may differ from those in high school.

5. Conclusion

Our study found that while the types of food and beverage snacks were similar at home and away from home, the amount of added sugars, saturated fat and sodium from food and beverage snacks consumed at home were greater than away from home. Given the influential role of the home food environment on adolescents' food choices, the home environment can be targeted to improve the adolescent diet. More research is needed to examine adolescents' and family members' snack-related behaviors, specifically regarding the location and source of snack acquisition, as well as snack eating frequency and portion sizes.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2021.101630.

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