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Sugar-sweetened beverage purchases and intake at event arenas with and without a portion size cap

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ABSTRACT

This is the first real-world study to examine the association between a voluntary 16-ounce (oz) portion-size cap on sugar-sweetened beverages (SSB) at a sporting arena on volume of SSBs and food calories purchased and consumed during basketball games. Cross-sectional survey data from adults exiting a Brooklyn, NY, USA arena (Barclays, n = 464) with a 16-oz portion-size restriction and a Manhattan, NY, USA arena with no portion-size restriction (Madison Square Garden, control, n = 295) after the portion cap policy was put in place from March through June 2014 were analyzed. Linear regression models adjusting for sex, age, BMI, ethnicity, race, marital status, education, and income were used to compare the two arenas during the post-implementation period. The survey response rate was 45.9% and equivalent between venues. Among all arena goers, participants at Barclays purchased significantly fewer SSB oz (−2.24 oz, 95% CI [−3.95, −0.53], p = .010) and consumed significantly fewer SSB oz (−2.34 oz, 95% CI[−4.01, −0.68], p = .006) compared with MSG after adjusting for covariates. Among those buying at least one SSB, Barclays' participants purchased on average 11.03 fewer SSB oz. (95% CI = [4.86, 17.21], p < .001) and consumed 12.10 fewer SSB oz (95% CI = [5.78, 18.42], p < .001). There were no statistically significant differences between arenas in food calories and event satisfaction. In addition, no one reported not ordering a drink due to small size. An SSB portion-size cap was associated with purchasing and consuming fewer SSB oz. without evidence of decreasing satisfaction with the event experience.

1. Introduction

Overconsumption of sugar-sweetened beverages (SSB) is linked to a range of negative health outcomes, including obesity, type-2 diabetes mellitus, high blood pressure, cardiovascular disease and all-cause mortality (Malik et al., 2006; Qi et al., 2012; Hu, 2013; Bleich and Vercammen, 2018; Micha et al., 2017; Brown et al., 2011; de Koning et al., 2012; Collin et al., 2019). On any given day, about half of Americans consume SSBs, with consumption levels highest among low-income groups (Bleich et al., 2018). These beverages provide little nutritional value and are the leading source of added sugar in the American diet (Centers for Disease Control and Prevention, 2021). SSBs are inexpensive, heavily marketed, and served in large portions (Nielsen and Popkin, 2003; Powell et al., 2016; Farley et al., 2012). Over the past 70 years there has been a very large increase in the standard size of SSBs sold in the United States (U.S.). Prior to 1955, Coca-Cola was only sold in 6.5 oz (oz.) bottles (The Coca Cola Company) while the average SSB portion increased to 12 oz. in 1977 and 20 oz. in 1994 (Nielsen and Popkin, 2003). Beverages as large as 64 oz. are available in national chain restaurants and convenience stores across the U.S. Such large SSB portion sizes are associated with overall increased caloric intake (Hollands et al.; Ello-Martin et al., 2005). Furthermore, people who consume large portions of SSBs at one meal may not reduce their consumption of energy at subsequent meals (Rolls et al., 2006), which could

Abbreviations: Barclays, Barclays Center; MSG, Madison Square Garden; NBA, National Basketball Association; NYC, New York City; SSB, Sugar-Sweetened Beverages; WNBA, Women's National Basketball Association.

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promote positive energy balance and weight gain.

In 2012, the New York City (NYC) Board of Health proposed placing a portion-size cap to limit the maximum SSB package or cup size sold in restaurants to 16 oz. (New York City Board of Health). This policy was the first of its kind and generated controversy. After a prolonged court battle, the NY State Supreme Court overturned the regulation in 2014, contending that it exceeded the scope of the Board of Health's regulatory authority (Roberto and Pomeranz, 2015). The policy was never implemented in NYC, and while other states in the U.S. (e.g., California, Hawaii) have proposed this policy, no jurisdiction has implemented it. Therefore, the only evidence on the potential policy's effect comes from simulation (Cleghorn et al., 2019; Crino et al., 2017; Elbel et al., 2012; Liu et al., 2014; Wang and Vine, 2013) or lab or online studies (Flood et al., 2006; John et al., 2017; Wilson et al., 2013). Behavioral lab studies have shown that participants drink significantly more when using a larger sized cup (18 oz. vs. 12 oz.), and consume more calories at lunch meals served with SSBs compared to meals with non-caloric drinks (Flood et al., 2006). Another experiment found that if people are offered either a 16 oz. SSB or two smaller-sized SSBs (12 oz.) in a bundle vs. typical portions of 16 or 24 oz., they will consume less when offered smaller sizes, though smaller portion sizes can backfire if refills are provided (John et al., 2017). Simulation models using data from the National Health and Nutrition Examination Survey (NHANES) data (Wang and Vine, 2013) and beverage sales receipts (n = 1624) collected from fast-food restaurants in NYC, Newark, NJ and Baltimore, MD (Elbel et al., 2012) projected a 58 to 74 kcal reduction in SSB calories per person respectively from a 16 oz portion-size cap policy.

In 2013, prior to the final portion cap ruling, the Barclays Center (Barclays), an indoor arena in Brooklyn, NY and home to the Brooklyn Nets of the National Basketball Association (NBA) and New York Liberty of the Women's NBA (WNBA), voluntarily adopted the policy's maximum 16 oz SSB portion-size cap (Grynbaum, 2012). The primary aim of this study was to collect real-world data to examine the association of the Barclays SSB portion-size restriction on self-reported volume of SSBs purchased and consumed using Madison Square Garden (MSG), a nearby sports arena with no SSB portion restrictions as a control site. We hypothesized that Barclays customers would purchase fewer ounces of SSBs compared to MSG, without differences in energy from food purchased. Our secondary aim was to evaluate the association between the smaller SSB portion sizes and satisfaction with the size and price of beverages, enjoyment of beverages and food and event experience, hypothesizing that there would be no association.

2. Methods

Data were collected between March 17, 2014 and June 5, 2014. The study was initially reviewed and approved by the Harvard T. H. Chan School of Public Health IRB and exempt status was granted later by the Rutgers University Institutional Review Board to enable the first author to access and analyze the existing data.

Trained research assistants approached participants to complete a survey as they exited Barclays in Brooklyn, NY and MSG in Manhattan, NY after attending WNBA and NBA sporting events. Surveys were administered after 17 basketball games (Barclays n = 11; MSG n = 9); only 3 games were played on the same date. Participants were eligible if they were 18 years or older and able to speak and read English. After providing written informed consent, participants completed a 5-minute survey developed for this study (see Appendix A) and received $5 as compensation.

3. Measures

3.1. Primary outcomes

3.1.1. Self-reported SSB purchase and consumption

We asked participants during the arena exit interviews to report each type of beverage ordered for personal consumption (beer, juice, sparkling water/seltzer, regular soda, hot tea, water, diet soda, iced tea, wine, coffee, liquor/mixed drink, or "other, specify") while at the arena. We were not able to record differences in beverage availability or prices between the two sites. Detailed beverage information was recorded, including beverage size (No size/one size, small, medium, large, extra-large, bottle, don't know) and the number of ounces (8, 12,16, 20, 25, 40 oz., other) as well as their estimate of how much of each beverage was consumed (100%, 75%, 50%, 25%, or 0%). To calculate the primary outcome, we determined the number of ounces purchased and consumed of the following SSBs: regular sodas, lemonades and energy drinks and beverages reported as "other" that were specified as SSBs. The "other category" was a text field that we converted to a number field to capture the oz. of the "other" beverage. We then confirmed that the "other" drink was coded appropriately as either an SSB or not. This enabled us to include the "other" beverage oz. in the count for both total beverage oz. and SSB oz., if appropriate.

Nine participants (Barclays, n = 5; MSG, n = 4) purchased iced tea but these beverages were not included in the SSB count as we failed to capture if these were sweetened or unsweetened. Beverage calories was not an outcome measure because we did not capture detailed descriptions of beverage brand and composition, specifically for type of mixed-drink and alcoholic beverages and we did not assess whether participants added sweeteners or other calorie-containing additives to their coffees, iced teas and hot teas.

We asked those participants who did not purchase beverages to provide a reason (not thirsty, too expensive, did not think they would taste good, they were too big, they were too small, there were no healthy options or other, specify).

3.2. Secondary outcomes

3.2.1. Self-reported food calories purchased and consumed

We recorded detailed information for all food items purchased from the arena's fast-food and casual dining restaurants (see Appendix B), including item size and an estimate of the overall percentage of each food item consumed. We derived an estimate of the calories of the menu items by using values for similar menu items in the 2014 version of the MenuStat database (New York City Department of Health and Mental Hygiene, 2019), a nutritional database of foods and beverages served by the nation's largest chain restaurants. If a menu item was not included in the 2014 MenuStat database, we used the calorie count listed in the USDA National Nutrient Database for Standard Reference, release 8 (2015) (US Department of Agriculture, 2016). Appendix C describes the method used to assign calories to arena menu items.

3.2.2. Event experience and sociodemographic characteristics

Measures of event experience included: 1) *overall arena experience* rated from 1 (poor) to 5 (excellent); 2) *Satisfaction with the price and size of beverage items ordered* rated from 1 (not at all satisfied) to 5 (extremely satisfied); 3) *Liking of beverage and food items* rated from 1 (I did not like it at all) to 5 (I liked it a lot). We also captured self-reported sociodemographic characteristics. Due to the small number of participants with "less than high school," (n = 1) and "vocational training," (n = 1) who purchased an SSB, we collapsed "less than high school," "vocational training" and "high school or GED" into a new education category "less than some college." Similarly, the martial status category "separated" was combined with "divorced/widowed" to create a combined category. We applied the Office of Management and Budget's 1997 race and ethnicity standards (Office of Management and Budget (OMB), 1997) to code the Race response option "Other" if a country of origin was provided rather than the listed race category options. We also asked participants to self-report weight and height, which we used to calculate BMI.

3.2.3. Perception of SSB portion-size policy

We assessed participants' opinions about restaurant portion sizes by asking them if food portion sizes and beverage portions sizes at restaurants in general are "too small," "just right," "too large" or "no opinion." We also described the portion limit policy and asked, "are you in favor of or against this regulation in New York City?" (against, no opinion, in favor) and "how strongly do you feel about this regulation?" (strongly, somewhat, no opinion). The responses to these two items were combined to create a 5-point scale: −2 (strongly against); −1 (somewhat against); 0 (no opinion); 1 (somewhat in favor); 2 (strongly in favor).

3.3. Statistical analysis

Differences between Barclays and MSG arena-goers were initially assessed with chi-square and exact test statistics for categorical variables, and the Independent Samples *t*-test to compare continuous variables.

For the primary analysis, we used a general linear model (GLM) to examine the relationship between self-reported oz. of SSBs purchased and arena (Barclays vs. MSG) in the full sample and only among participants who purchased an SSB. Diagnostic tests showed assumptions of normality were met and based on assessments of residual plots, homoscedasticity was judged as tenable using fitted by residual plots. The covariates in the final model were sex, ethnicity, race, marital status, education, household income, age and BMI. For our secondary analyses, we used the same GLM procedures. "Total number of drinks purchased" and "total number of SSB purchased" were found to be non-normally distributed so Mann-Whitney U tests were used to compare differences between arenas for those variables. All data were analyzed using IBM SPSS Statistics 25, and significance for all two-sided statistical tests was considered at $p < 0.05$.

3.4. Sensitivity analysis

A non-parametric, sensitivity analysis of the primary outcome "SSB ozs. purchased" was run using inverse propensity of treatment weighting (IPTW) derived from a propensity score. The IPTW approach creates a pseudo-population in which the overall distribution of the measured baseline confounders is balanced between the two arenas, thereby reducing the bias of confounding linked to estimating the treatment effect in a non-randomized study. The propensity score was generated using a logistic regression model with arena choice as the dependent outcome and including all independent variables in the primary analysis model. The top and bottom 1% of the propensity score weights were truncated (Austin and Stuart, 2015). For Barclays' participants the weight was calculated as, IPTW = 1/Propensity Score(X) and for MSG the weight was the inverse, IPTW = 1/(1 – Propensity Score[X]). Balance was compared graphically using side-by-side boxplots. The IPTW approach does not make parametric assumptions about how the individual covariates and exposure of interest (i.e., arena) together affect the outcome and thus can check robustness of the GLM estimate of the association between arena and outcomes.

3.5. Secondary Aim: Event experience

Preliminary analyses did not reveal any statistically significant relationships between potential confounding variables associated with arena and measures of event satisfaction. Thus, bivariate statistics were computed to evaluate differences in the relationship between these outcomes and arena.

4. Results

A total of 759 participants completed the survey with an overall response rate of 45.9% (Appendix Fig. A.1). 140 participants purchased SSBs with no statistically significant difference between the proportion of participants who purchased SSBs at Barclays (17.7%) and MSG (19.7%).

4.1. Participant characteristics

Participants were predominantly male (62.6%), mean age 32.9 ± 11.3 with a mean BMI of 26.5 ± 5.3, with no significant differences

Table 1
Participant characteristics and portion-size opinions.

Characteristic	Madison Square Garden (n = 295)	Barclays Center (n = 464)	P-value[b]
Male	177 (60.0)	296 (64.3)	0.228
Age, years, Mean (SD)	33.1 (11.7)	32.7 (11.0)	0.644
BMI, Mean (SD)	26.05 (4.94)	26.79 (5.52)	0.078
Hispanic, Latina/o, Spanish	61 (20.7)	79 (17.0)	0.206
Race			**<0.001**
White	137 (46.4)	160 (34.5)	
Black or African American	100 (33.9)	195 (42.0)	
Asian	10 (3.4)	40 (8.6)	
Some other race, more than one race	25 (8.3)	24 (5.2)	
Not Reported	23 (7.8)	45 (9.7)	
Marital Status			**<0.001**
Married	61 (20.7)	90 (19.4)	
Never married	148 (50.2)	294 (63.4)	
Not married, living with significant other	69 (23.4)	48 (10.3)	
Separated, Widowed/ divorced	15 (5.1)	25 (5.4)	
Not Reported	2 (0.7)	7 (1.5)	
Education			**0.008**
< Some college	83 (28.1)	98 (21.1)	
Some college (<than 4 yrs.)	59 (20.0)	66 (14.2)	
College/ University degree (4 years)	102 (34.6)	203 (43.8)	
Graduate or professional education	49 (16.6)	89 (19.2)	
Not Reported	2 (0.7)	8 (1.7)	
Household Income			0.706
Less than $25,000	69 (23.4)	85 (18.3)	
$25,000-$50,000	68 (23.1)	111 (23.9)	
$50,001-$75,000	56 (19.0)	76 (16.4)	
$75,001- $100,000	38 (12.9)	52 (11.2)	
$100,001-$125,000	22 (7.5)	28 (6.0)	
$125,001-$150,000	9 (3.1)	22 (4.7)	
More than $150,000	23 (7.8)	34 (7.3)	
Not Reported	56 (12.1)	56 (12.1)	
Opinion about: the portion-size of SSB in restaurants			0.860
Too small	41 (13.9)	74 (15.9)	
Just right	188 (63.7)	304 (65.5)	
Too large	41 (13.9)	71 (15.3)	
No opinion or not reported	25 (8.5)	15 (3.2)	
Portion-size of food in restaurants			0.792
Too small	31(10.5)	52 (11.2)	
Just right	170 (57.6)	270 (58.2)	
Too large	61 (20.7)	110 (23.7)	
No opinion or not reported	33 (11.2)	32 (6.9)	
NYC sugary drink portion cap policy			0.180
Against	72 (24.4)	138 (29.7)	
No opinion	39 (13.2)	58 (12.5)	
In favor	66 (22.4)	156 (33.6)	
Never heard of policy or not reported	118 (40.0)	112 (24.1)	

Note: BMI (703 × weight (lbs) / [height (in)]^2); Categorical variables were compared using Chi Square tests and continuous variables were compared using Independent T-tests;

[a] Values expressed as n (%) unless otherwise noted.

[b] Significant p-values < 0.05 are in boldface.

between arenas (Table 1). A smaller proportion of participants at Barclays compared with MSG identified themselves as White (34.5% vs. 46.4%), while a greater proportion of participants at Barclays identified as Asian (8.6% vs. 3.4%) and never married (63.4% vs. 50.2%). Participants at MSG were more likely to have less than a college education (p = .033) or some college (p = .043) than participants at Barclays. There were no statistically significant differences in these characteristics among those participants who purchased SSBs (Appendix D).

4.2. Beverage ounces purchased and consumed

Among all participants, a smaller volume of beverages was purchased at Barclays (13.33 oz. (95% CI: [11.13, 15.52]) vs MSG: 15.56 (95% CI: [13.33, 17.80]), p = .024) and consumed (Barclays: 12.20 oz. (95% CI: [10.10, 14.30]) vs. MSG: 14.36 oz. (95% CI: [12.21, 16.51]), p = .023 (Table 2). The mean number of beverages and SSBs purchased at Barclays was 1.52, (95% CI [1.39,1.65]) and 0.23 (95% CI [0.18, 0.28]), respectively. This was similar to amounts at MSG, which were 1.80 (95% CI [1.55, 2.05]) and 0.26 (95% CI [0.18, 0.33]), respectively (all ps > 0.05). Similar proportions of participants purchased beverages at Barclays compared to MSG (45.2% vs 27.8%, p = .468) and SSBs (17.7% vs.19.7%, p = 491), respectively.

The GLM models confirmed that arena was significantly associated with ounces of SSB purchased and consumed among all arena goers and among participants who purchased at least one SSB (Fig. 1, Table 2 and Appendix E). Among all arena goers, participants at Barclays purchased significantly fewer SSB oz. (-2.24 oz, 95% CI [-3.95, −0.53], p = .010) and consumed significantly fewer SSB oz. (-2.34 oz, 95% CI[−4.01, −0.68], p = .006) compared with MSG after adjusting for sex, age, BMI, ethnicity, race, marital status, education, and income. Being male and Black or African American (compared with White) was associated with purchasing more SSB oz. (Barclays: 1.86 oz., MSG: 2.43 oz), while a household income of $125,000 - $150,000 was associated with purchasing 5.28 more SSB oz. compared with the highest income category (> $150,000). No other relationships were associated with the outcomes. The final model explained only 8.6% of the variance (R^2 = 0.086).

Among participants who purchased at least 1 SSB, Barclays' participants purchased and consumed (Fig. 1, Table 2) significantly fewer SSB oz. compared with MSG. Barclays participants purchased on average 11.03 fewer SSB oz. (95% CI = [4.86, 17.21], p < .001) and consumed 12.10 fewer SSB oz (95% CI = [5.78, 18.42], p < .001). Only income remained significantly related to SSB oz. purchased. The final model explained 35% of the variance (R^2 = 0.354).

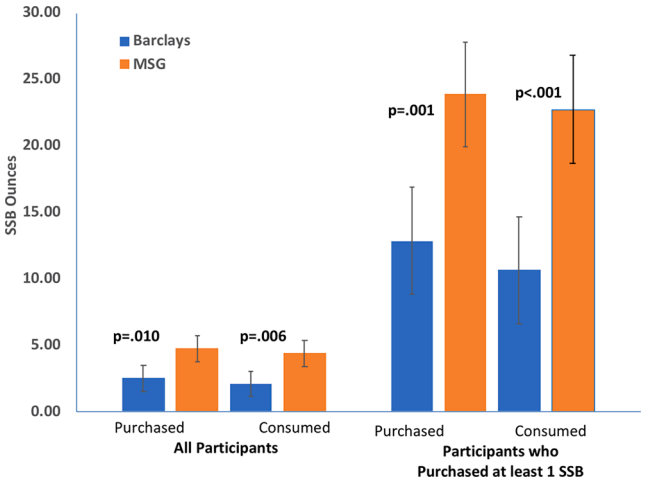

Fig. 1. SSB oz. purchased and consumed (adjusted mean ± SE) by participants at Barclays & MSG. Comparison between Barclays and MSG of the ounces of SSB purchased and consumed (adjusted mean ± SE) among all participants and among participants who purchased at least 1 SSBs. P values represent the difference between Barclays and MSG for each of the four separate comparisons.

Estimates derived from the GLM model incorporating IPTW scale weighting confirmed the findings from the primary GLM analysis and showed among all participants, significantly fewer adjusted mean SSB oz. [mean difference = -1.83; Wald = 4.26; p = .039] were purchased at Barclays (2.52, [95% CI [1.29, 3.75]) compared with MSG (4.35, 95% CI, [3.12, 5.59]). Among participants who purchased SSBs, significantly fewer SSB oz. [mean difference = -8.49; Wald = 6.26; p = .012] were purchased at Barclays (15.03, 95% CI [10.23, 19.84]) compared with MSG (23.53, 95% CI, [18.93, 28.11]).

4.3. Self-reported food calories purchased and consumed

Total food calories purchased and consumed did not differ significantly between arena. The adjusted mean self-reported food calories purchased at Barclays was 461.05 (95% CI, [362.53, 559.56]) kcals compared to 399.37 (95% CI, [299.42, 499.31]) kcals at MSG, p = .17, respectively, with a mean difference of 61.68 kcals (95% CI, [-25.67, 149.02)]. Mean self-reported food calories consumed were 388.52 (95% CI, [296.84, 480.20]) kcals and 323.39 (95% CI, [230.95, 415.83])

Table 2
Beverage purchasing and consumption patterns.

Dependent variables[1]	All participants				Participants who purchased at least one SSB			
	Barclays Mean (95% Confidence Interval)	MSG Mean (95% Confidence Interval)	Difference[2] Mean (95% Confidence Interval)	p-value[3]	Barclays Mean (95% Confidence Interval)	MSG Mean (95% Confidence Interval)	Difference[2] Mean (95% Confidence Interval)	p-value[3]
All beverages, number purchased	1.52 (1.39, 1.65)	1.80 (1.55, 2.05)		.604[4]				
SSB, number purchased	0.23 (0.18, 0.28)	0.26 (0.18, 0.33)		.519[4]				
Proportion of participants who purchased at least 1 SSB, n (%)	82 (17.7)	58 (19.7%)		.491[5]				
All beverages, ounces purchased (oz)	13.33 (11.13, 15.52)	15.56 (13.33, 17.80)	−2.24 (−4.19, −0.29)	0.024	15.30 (7.66, 22.93)	24.76 (17.04, 32.47)	−9.46 (−14.39, −4.52)	<0.001
All beverages, ounces consumed (oz)	12.20 (10.09, 14.30)	14.36 (12.21, 16.51)	−2.16 (−4.02, −0.30)	0.023	11.15 (3.43, 18.87)	21.21 (13.31, 29.10)	−10.06 (−15.09, −5.03)	<0.001
SSB ounces purchased (oz)	2.50 (0.57, 4.43)	4.74 (2.79, 6.70)	−2.24 (−3.95, −0.53)	0.010	12.86 (4.89, 20.83)	23.89 (16.10, 31.71)	−11.03 (−17.21, −4.86)	<0.001
SSB ounces consumed	2.06 (0.17, 3.94)	4.40 (2.48, 6.32)	−2.34 (−4.01, −0.68)	0.006	10.63 (2.53, 18.73)	22.73 (14.64, 30.82)	−12.10 (−18.42, −5.78,)	<0.001

[1]Values expressed as mean (95% CI) unless otherwise noted; [2]Adjusted mean difference between Barclays and MSG; [3]p values computed with univariate GLM controlling for sex, ethnicity, race, marital status, education, household income, BMI and age;.[4]Compared using Mann-Whitney Test; [5]Compared using Chi-Square tests.

kcals, p = .11 respectively, with a mean difference 65.13 kcals (95% CI, [15.72, 145.98]).

4.4. Secondary outcomes

4.4.1. Participants' portion-size opinions

There were no differences between arenas in participant opinions about typical beverage and food portion sizes served in restaurants or the NYC sugary-drink portion cap policy (Table 1). Among all participants, there was no bivariate relationship between arena and overall arena experience, beverage enjoyment, satisfaction with the size and price of beverage ordered and food enjoyment (Table 3). Among participants who purchased SSBs, however, a smaller proportion at MSG (5.5%) reported being extremely satisfied with beverage prices compared to those at the Barclays arena (25.3%), $X^2(4) = 12.12$, p < .015. In addition, a higher proportion of Barclay participants (75%) were extremely satisfied with their food purchases compared with 25% of MSG participants.

There were no differences between the arenas for participants' reasons for not purchasing a drink (p = .117). Of the 182 participants who provided a response for not purchasing a beverage, "Not thirsty" (n = 88, 48.4%) was the most frequently reported response. None of the participants at either arena reported "small drink size" as a reason for not purchasing a drink. There was a significant difference in the reason food was not purchased X^2 (6) = 12.28, p < .034 with a greater proportion of participants at Barclays compared with MSG (70.1% vs. 53.5%) reporting that they did not buy food because they were not hungry. Total food calories purchased and consumed, however, did not differ by site.

5. Discussion

Consistent with the results reported in simulation (Cleghorn et al., 2019; Crino et al., 2017; Elbel et al., 2012; Liu et al., 2014; Wang and Vine, 2013) and lab studies, (Flood et al., 2006; John et al., 2017) this cross-sectional study found that a SSB portion-cap policy, implemented at a major arena in Brooklyn, NY, was associated with purchasing and consuming fewer ounces of SSBs, compared to a control arena without the policy. There were no significant differences in food calories purchased and consumed. The smaller volume of SSBs purchased at the Barclays arena was not associated with a corresponding difference in the total number of beverages purchased or a decrease in the likelihood of purchasing SSBs. Furthermore, the policy at Barclays was not associated with diminished arena-event experience. These findings suggest that a policy limiting the portion size of SSBs to 16 oz in food service establishment may achieve its goal of reducing the amount of SSBs consumed at arena food and beverage retailers without diminishing enjoyment of the experience overall. Although there were no significant differences in self-reported food calories purchased or consumed, future studies with larger sample sizes are needed to better understand whether beverage calorie reductions are offset by increased food calories.

Among those who purchased SSBs, Barclays participants purchased 11 fewer SSB oz. than participants at MSG. Given that typical SSBs contain approximately 13 kcal/ounce (US Department of Agriculture, Agricultural Research Service, 2016), the difference amounts to a reduction of 143 kcal purchased. This exceeds previous effect estimates of a 74 kcal (50%) reduction from a simulation conducted by Elbel and colleagues based on 1,624 fast food restaurant receipts collected in NYC, Newark, and Baltimore, but consumption habits at sporting arenas vs. fast food restaurants may be very different (Elbel et al., 2012). Participants at Barclays also self-reported *consuming* approximately 12 fewer SSB oz. compared to participants at MSG, without a significant compensatory increase in the food calories. This effect is equivalent to a reduction of 156 calories and equivalent to 7.8% of the total caloric intake of adults (with estimated caloric needs for 2000 kcal/day). Considering that the Dietary Guidelines 2015–2020 recommends that all

Table 3
Comparison of event experience among all participants and participants who purchased SSB.

5-point scale	All Participants (N = 759) n (%)			Participants who purchased SSB (N = 140) n (%)		
	Madison Square Garden	Barclays Center	P[a]	Madison Square Garden	Barclays Center	P[a]
Overall Arena experience			**.22**			.74[b]
1 = Poor	1 (0.3)	5 (1.1)		1 (1.8)	1 (1.2)	
2	1 (0.3)	3 (0.6)		0 (0.0)	1 (1.2)	
3	25 (8.6)	25 (5.4)		5 (8.8)	4 (4.9)	
4	75 (25.7)	140 (30.2)		17 (29.8)	19 (23.5)	
5 = Excellent	190 (65.1)	290 (62.6)		34 (59.6)	56 (69.1)	
Beverage enjoyment			.34[b]			.25[b]
1 = Did not like it at all	3 (1.4)	(2.3)		0 (0.0)	2 (2.5)	
2	10 (4.5)	14 (4.0)		4 (6.9)	5 (6.3)	
3	35(15.9)	60 (17.2)		11 (19.0)	7 (8.8)	
4	56 (25.5)	82 (23.5)		17 (29.3)	20 (25.0)	
5 = Liked it a lot	116 (52.7)	185 (53.0)		26 (44.8)	46 (57.5)	
Satisfaction with the size of beverage ordered			.27			.06[b]
1 = Not at all	21 (3.7)	47 (8.3)		3 (5.3)	16 (20.0)	
2	17 (3.0)	41 (7.2)		4 (7.0)	8 (10.0)	
3	63 (11.1)	101 (17.8)		18 (31.6)	19 (23.8)	
4	64 (11.3)	84 (14.8)		22 (38.6)	19 (23.8)	
5 = Extremely satisfied	51 (9.0)	78 (13.8)		10 (17.5)	18 (22.5)	
Satisfaction with the price of beverage ordered			.18			**.02**[b]
1 = Not at all	45 (8.1)	86 (15.5)		10 (18.2)	20 (25.3)	
2	30 (5.4)	64 (11.6)		6 (10.9)	6 (7.6)	
3	78 (14.1)	97 (17.5)		24 (43.6)	22 (27.8)	
4	34 (6.1)	46 (8.3)		12 (21.8)	11 (13.9)	
5 = Extremely satisfied	26 (4.7)	48 (8.7)		3 (5.5)	20 (25.3)	
Food enjoyment			.34[b]			**<.01**[b]
1 = did not like it at all	3 (0.8)	8 (2.0)		(0.0)	2 (3.5)	
2	5 (1.3)	6 (1.5)		0 (0.0)	1 (1.8)	
3	32 (8.1)	57 (14.4)		5 (13.9)	9 (15.8)	
4	40 (10.1)	59 (14.9)		18 (50.0)	6 (10.5)	
5 = Liked it a lot	55 (13.9)	132 (33.2)		13 (36.1)	39 (68.4)	

[a]Comparison with Chi Square tests unless otherwise noted; [b]Exact test used due to violation of Chi square assumption (expected frequency < 5).

Americans limit their added sugar intake to no more than 10 percent of their daily caloric intake, our results suggest that a policy that reduces the maximum portion size of SSBs has the potential to improve public health. This effect is larger than predicted in a simulation study using NHANES, a nationally-representative database, which found a 102 kcal reduction in SSB calories consumed, in a scenario in which 100% of people who consumed SSBs larger than 16 oz. downsized to the 16 oz. maximum allowed under a portion cap policy (Wang and Vine, 2013). Although these results suggest that SSB portion limit policies might be an effective way to curb SSB intake without limiting freedoms or imposing an economic disincentive, there was considerable opposition in NYC when the policy was first introduced (Grynbaum, 2012). In our data, however, Barclays arena-goers did not differ from those attending games at MSG in terms of their satisfaction with the size of SSBs sold in the arena or with the food or overall arena experience. In addition, no participants indicated that the size of beverages was a reason why they did not purchase a drink.

6. Limitations and strengths

This is the first study to our knowledge to use real-world data to examine the potential impact of a 16 oz. SSB portion limit policy on the SSB beverage consumption patterns. This study has several limitations. First, information on event, food and beverage pricing as well as cup size were not collected and since this was a cross-sectional study design, we were not able to test for a causal relationship between the 16 oz. portion limit policy and a change in SSB consumption behaviors. We are encouraged, however, that our key findings are robust to sensitivity analyses using IPTW, which helps to reduce the potential of bias from confounding in a nonrandomized study, but cannot eliminate it. The propensity scoring, however, was derived using available data, thus we cannot account for unmeasured variables. Our sample was also limited to NBA and WNBA fans who attended events at Barclays and MSG in NYC. The beverage consumption habits among this sample might not generalize to other arenas or large events, and may look very different than restaurant beverage purchasing. Next, our study is limited by self-reported data. Recall bias, a poor understanding of the size or number of ounces in beverages purchased and the underreporting of portion sizes associated with dietary surveys (Baranowski, 2013), as well as our inability to assess sharing of beverages may have led to misreporting of the volume of beverages purchased and consumed (though this is unlikely to have introduced systematic error). Although the data collection occurred during the same seasons, there may have been daily temperature differences between arena data collection dates that affected drink purchases. Additionally, although we had hundreds of participants, only a small number of participants purchased SSBs. A survey, however, of SSB purchases from fast-food restaurants in the NYC region conducted during a similar period of time (2013–2014) reported a comparable rate (20%) (Taksler et al., 2016). In addition, our sample may have been too small to detect significant differences in food calories purchased.

This study has several strengths including a large number of survey respondents with similar response and completion rates between arenas and assessments of self-reported food and beverage purchasing and consumption as well as perceptions of satisfaction. This study provides some of the first real-world data on how such a policy might influence consumers.

7. Public health implication

These data suggest that SSB portion limit policies hold promise as a way to curb SSB intake at sporting arenas while preserving consumer choice. There is a need for more real-world research on such policies across diverse settings where beverages are frequently consumed.

CRediT authorship contribution statement

Sheri Volger: Data Curation, Software, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **James Scott Parrott:** Software, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Brian Elbel:** Conceptualization, Methodology, Writing – review & editing. **Leslie John:** Conceptualization, Methodology, Writing – review & editing. **Jason P. Block:** Conceptualization, Methodology, Writing - Review & Editing; **Pamela Rothpletz-Puglia:** Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Supervision. **Christina A. Roberto:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Project administration

Declaration of Competing Interest

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Appendix A. Appendices Supplementary Data

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