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Association of park drinking water source characteristics and water intake in San Francisco Bay Area parks

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ABSTRACT

Over half of U.S. adults visit parks regularly. Thus, it is important to understand how park drinking water sources affect visitors' water consumption. In this cross-sectional study of 30 San Francisco Bay Area parks, 4 day-long direct observations of visitors' drinking water and other beverages were conducted, along with audits of sugar-sweetened beverage access and drinking water source conditions, including flow, appeal, and obstructions. Outcomes were log-transformed to account for skewness, and results were analyzed using mixed-effects regression models to account for matching and clustering by park and observation day. A greater proportion of water sources in low-income parks were unappealing (57.14 vs. 25.00%, $P = 0.01$) or in a poor condition (69.70 vs. 43.24%, $P = 0.03$). A lower proportion of visitors drank water from park fountains that were unappealing (−31%), had poor flow (−22%), or had obstructions (−58%) than those without these conditions. Although only obstructions to the source and water intake were significantly related after adjustment, we observed important effects on water intake by water source appeal and flow. As park water source conditions contribute to water intake, cities should consider installing appealing, functional, and easy to access water sources in parks, particularly those in lower-income neighborhoods.

Key words: drinking water, obesity, parks, sugar-sweetened beverages

HIGHLIGHTS

- This study is the first to assess how drinking water source conditions influence water intake in park settings.
- Water sources were in poorer condition in parks located in lower-income neighborhoods.
- Water source conditions influence water intake in park settings.
- Water sources were in poorer condition in parks located in lower-income neighborhoods.

INTRODUCTION

Sugar-sweetened beverages (SSBs) are the largest contributor of added sugar and a major dietary calorie source (Reedy & Krebs-Smith 2010; Bailey *et al.* 2018). Consumption of water, in place of SSBs, can help prevent obesity and dental caries (Ebbeling *et al.* 2006; Brooks *et al.* 2017). Drinking water can also improve cognition, hydration, and bowel and bladder function (Brooks *et al.* 2017). Despite the benefits of drinking water, many, especially those that are lower-income and ethnic minority, do not consume recommended daily allowances for water (Park *et al.* 2012a; Drewnowski *et al.* 2013; Patel *et al.* 2013; Brooks *et al.* 2017).

Tap water has a lower cost and environmental footprint than bottled water. Yet, a lack of access to safe, affordable tap water and mistrust of its safety contribute to lower tap water intake among African Americans and Latinos compared with other groups (Gorelick *et al.* 2011; Drewnowski *et al.* 2013). These disparities in tap water intake lead to increased spending on bottled drinks that may displace other essential purchases (Gorelick *et al.* 2011; VanDerslice 2011; Brooks *et al.* 2017). Individuals who consume bottled water may also be deprived of fluoride in tap water, which can prevent dental caries (Centers for Disease Control and Prevention 2001).

School-based interventions that have improved the provision of safe, appealing tap water have increased water consumption, decreased SSB intake, and prevented obesity (Patel *et al.* 2011; Schwartz *et al.* 2016). Given that over half of U.S. adults visit parks regularly, it is important to understand how park drinking water sources affect visitors' water consumption (Park *et al.* 2012b). A few studies have examined park drinking water sources and public perception of their safety, but none have related water source condition to beverage intake (Pearson *et al.* 2014; Avery & Smith 2018; Long *et al.* 2018).

In this study, we fill this research gap by (1) describing the characteristics of drinking water sources in 30 parks in low-income San Francisco (SF) Bay Area communities and (2) examining how characteristics of water sources influence park visitors' water intake. We hypothesized that water sources in lower-income neighborhoods would have more negative conditions than those in higher-income areas. We also postulated that water intake would be lower when park water sources were less appealing, obstructed, or had poor flow.

METHODS

Research context

This study stems from focus groups conducted by the SF Health Improvement Partnership (SFHIP), a community-academic partnership between community-based organizations and the University of California San Francisco's Clinical and Translational Sciences Institute (Grumbach *et al.* 2017). The SFHIP found that low-income Latino, African American, and Asian Pacific Islander (API) San Franciscans had limited access to clean tap water in public spaces and that this was a barrier in substituting SSBs with tap water. In response, SF policymakers joined local health advocates and the SF Public Utilities Commission that supplies the city's tap water to install reusable water bottle filling stations in parks and public spaces located in low-income neighborhoods. The overall goal of this study was to examine the water and SSB consumption habits of visitors to parks at baseline before water stations were installed and tap water was promoted. The current study reports on cross-sectional data collected prior to any beverage-related interventions.

Sample selection and study design

Thirty parks in racially/ethnically diverse, low-income neighborhoods in Oakland and SF were included in this study. Ten parks in SF were selected for water station installation based on the following criteria: location in low-income areas with a high proportion of minorities, high traffic area, and well lit. Ten parks in Oakland and 10 parks in SF were selected as matched controls for the 10 SF parks slated to receive water stations. Parks were matched based on park amenities (e.g., skate park and athletic fields) and the income-level and racial/ethnic composition of the neighborhood where the park was located.

Researchers used a modified version of the validated Harvard Water Audit Tool to examine the conditions of park drinking water sources and to document the presence of any SSB sources and beverage promotion signage (Harvard School of Public Health 2013). Photos were taken of water sources, SSB sources, and signage promoting water or SSB intake in the park.

Observations of the park beverage environment and park visitors' beverage intake were collected at each park between May and July 2016. Researchers conducted a total of 480 four hour-long observations (9:30–10:30 am, 12:30–1:30 pm, 3:30–4:30 pm, and 6:30–7:30 pm) of park visitors on Mondays, Wednesdays, Fridays, and Saturdays in each park to account for weekday vs. weekend variation in park activities and beverage intake.

In the 10 SF parks slated to receive water stations, researchers observed a 100-foot area proximal to the fountain that was to be replaced. In the other parks, researchers observed the area around the water source that served as a matched control based on the water source's proximity near key park amenities (e.g., tennis courts, basketball courts, picnic area, etc.). Researchers documented the proportion of park visitors consuming different types of beverages and using the existing drinking water source. Researchers wore identification badges at all times and did not collect identifiable information about visitors observed.

This study was approved by the Human Research Protection Program at the University of California, San Francisco and the Institutional Review Board at Stanford University. The study approval was also obtained from the Parks and Recreation Departments in San Francisco and Oakland.

Measures

During the observations, researchers documented the number of individuals consuming different categories of beverages (water, SSBs, juice, coffee, plain milk, and alcoholic beverages) and the total number of individuals in the observed park location. The primary outcome was the proportion of park visitors consuming any type of water. Subcategories of interest included water consumed from (1) existing park drinking water source and from (2) outside sources such as (a) single-use plastic water bottles, (b) cups, and (c) reusable water bottles. The secondary outcome was the proportion of visitors consuming any SSBs.

The independent variables in this study included park drinking water source conditions. Using the water audit tool, trained researchers assessed the type of drinking water source (e.g., drinking fountain, sink, etc.), flow rate (too high, satisfactory, too low, erratic, none), presence of any obstructions impeding access such as trash cans, cleaning equipment, etc. (yes, no), appeal of the water source (presence of debris, bird excrement, hair, trash, food, grime, gum, rust, mold, water stains, clogged drain, insects, bodily fluids, other), and presence of signs encouraging water consumption (yes/no). The appeal of the water source was calculated for each water source by summing characteristics, with a possible range of 0–37.

Covariates hypothesized to influence water intake in parks were also included in statistical models. Income and poverty level of the park neighborhood location were obtained using census block information from the U.S. Census 2012–2016 American Community Survey (United States Census Bureau. American FactFinder 2016; United States Census Bureau. U.S. Census Bureau QuickFacts 2016). Parks were characterized as lower-income parks if the percent of individuals in the neighborhood living in poverty was higher than the city's poverty level (Oakland >18.70%; SF >11.70%). As the SF Bay Area has microclimates with varying temperatures that can affect water intake, ambient temperature was recorded using a smart phone weather application at the beginning and end of each observation period.

Statistical analysis

All statistical analyses were performed in Stata/SE 15.1 (StataCorp, College Station, TX, USA). Means and standard deviations or proportions were used to describe variables. We used range checks and variable distributions along with the existing literature to establish appropriate cut-points for categorical variables. Fisher's exact tests were used to examine if park water source conditions varied by the income-level of the park's neighborhood location.

The proportion of visitors drinking park water was log-transformed to account for skewness in its distribution. Mixed-effects regression models were used to investigate whether the water source conditions were associated with visitors' water intake. Results were exponentiated to derive the percent difference in water intake based on water source conditions. Mixed-effects regression models included random effects for match, park, and day to account for the matching as well clustering of observations within parks and days. Analyses controlled for neighborhood income-level, time of observation, and average ambient temperature.

RESULTS

Park characteristics and observed beverage consumption

The income-level and racial/ethnic composition of neighborhood locations of the 30 study parks are shown in Table 1. Overall, 14% of individuals living in park neighborhoods had incomes below the federal poverty level. Fifty-seven percent (17 out of 30) of the parks were in lower-income neighborhoods, in which the individuals living in park neighborhood had a higher poverty rate than the city's poverty rate. Individuals in park neighborhoods were predominately from API backgrounds (30.8%). While the demographics of residents in SF study park neighborhoods were representative of the city as a whole, demographics of Oakland study park neighborhoods had a higher proportion of API and a lower proportion of African American and Latino residents as compared with Oakland overall.

There were 73 drinking water sources in the 30 study parks, including 71 drinking water fountains and two sinks. Every park had at least one source of drinking water. The majority (59.2%) of the drinking water sources were categorized as appealing and as having a satisfactory flow rate (87.7%). Ten percent of drinking water sources had obstructions, such as trash cans and cleaning supplies, that blocked easy access by park patrons. Only two parks sold SSBs, in both cases through vending machines. There were no advertisements promoting water or SSBs in any of the study parks.

Across all study parks, a total of 48,672 park visitors were observed (Table 2). Overall, 13.4% of park visitors were observed drinking water while in the park observation area. Of these visitors, 4.9% were observed utilizing

Table 1 | Socio-demographic characteristics of neighborhoods of study parks and cities, SF Bay Area, 2016[a,b,c]

	SF study parks ($n = 20$ parks), % (SD)	SF overall (%)	Oakland study parks ($n = 10$ parks), % (SD)	Oakland overall %	All study parks ($n = 30$ parks), % (SD)
Residents living below the federal poverty level	11.70 (7.14)	11.70	17.83 (12.41)	18.70	13.72 (9.48)
Race/ethnicity of residents					
African American	5.81 (7.90)	5.40	14.46 (9.36)	24.70	8.69 (9.23)
Latino	15.37 (14.34)	15.30	17.54 (18.78)	26.70	16.09 (15.66)
Asian/Pacific Islander	32.16 (20.76)	34.30	28.08 (27.24)	16.60	30.80 (22.73)

[a]Park neighborhood based on park zipcode.
[b]Data from United States Census Bureau. American FactFinder.
[c]Data from U.S. Census Bureau QuickFacts.

Table 2 | Visitors drinking water and SSBs in study parks by neighborhood income level, SF Bay Area, 2016[a,b]

Beverage consumption observed by visitors	All park visitors ($N = 48,675$) % (SD)	Visitors to parks in lower-income neighborhoods ($N = 28,312$) % (SD)	Visitors to parks in higher-income neighborhoods ($N = 20,363$) % (SD)	*P*-value
Any water	13.44 (12.78)	12.64 (13.68)	14.48 (11.43)	0.21
Water from park fountain				
Sips	3.88 (5.71)	3.60 (5.28)	4.25 (6.23)	0.53
Filled bottle	0.67 (1.83)	0.76 (2.11)	0.54 (1.36)	0.54
Filled cup	0.31 (2.68)	0.40 (3.50)	0.20 (0.76)	0.96
Beverages brought into park from outside source				
Single-use water bottle	3.44 (5.44)	3.53 (6.15)	3.32 (4.35)	0.68
Reusable water bottle	5.14 (7.14)	4.36 (6.72)	6.18 (7.54)	0.15
SSB	2.30 (4.02)	2.76 (4.76)	1.69 (2.64)	0.11

[a]Mixed-effects regressions models conducted to examine differences in water and SSB consumption in parks by park neighborhood income level.
[b]Data from U.S. Census Bureau QuickFacts. Parks were characterized as lower-income parks if the percent of individuals in a zip code living in poverty was higher than the city poverty level: Oakland (>18.7%); SF (>11.7%).

park drinking water sources and 8.6% were observed drinking water that they brought in from outside (e.g., single-use water bottle and reusable water bottle). Only 2.3% of visitors were observed drinking SSBs.

Beverage environments and beverage intake patterns in parks by park neighborhood's income level

A greater proportion of drinking water sources in parks in lower-income neighborhoods were unappealing compared with water sources in higher-income neighborhoods (57.1 vs. 25.0%; *P*-value = 0.01) (Figure 1). There was a trend for park water sources in lower-income neighborhoods to have poorer water flow as compared with parks in higher-income neighborhoods (21.2 vs. 5.7%; *P*-value = 0.06). Parks in higher-income neighborhoods had a greater number of water sources with an obstruction as compared with parks in lower-income neighborhoods (18.9 vs. 0%; *P*-value = 0.01). Overall, a greater proportion of park drinking water sources in lower-income neighborhoods were in a poor condition as compared with those in higher-income neighborhoods (69.7 vs. 43.2%; *P*-value = 0.03)

The proportion of individuals observed drinking from park water sources did not differ by the park neighborhood's income level (Table 2). While not statistically significant, compared with lower-income areas, there was a trend for a greater proportion of park visitors in higher-income neighborhoods to use reusable water bottles to drink water (6.2 vs. 4.4%; $P = 0.15$). There was also a trend for a lower proportion of visitors in higher-income areas to drink SSBs when compared with those in lower-income neighborhoods (1.7 vs. 2.8%; $P = 0.11$). Of the two parks with an SSB vending machine, one was located in a lower-income neighborhood and one was in a higher-income neighborhood.

Although not statistically significant, a greater proportion of park visitors consumed water directly from park water sources when it was appealing vs. unappealing (5.82 vs. 4.04%; $P = 0.22$), had a satisfactory vs. unsatisfactory flow (5.28 vs. 3.91%; $P = 0.38$), and had no obstructions vs. obstructions (5.06 vs. 2.14%; $P = 0.15$) (Table 3).

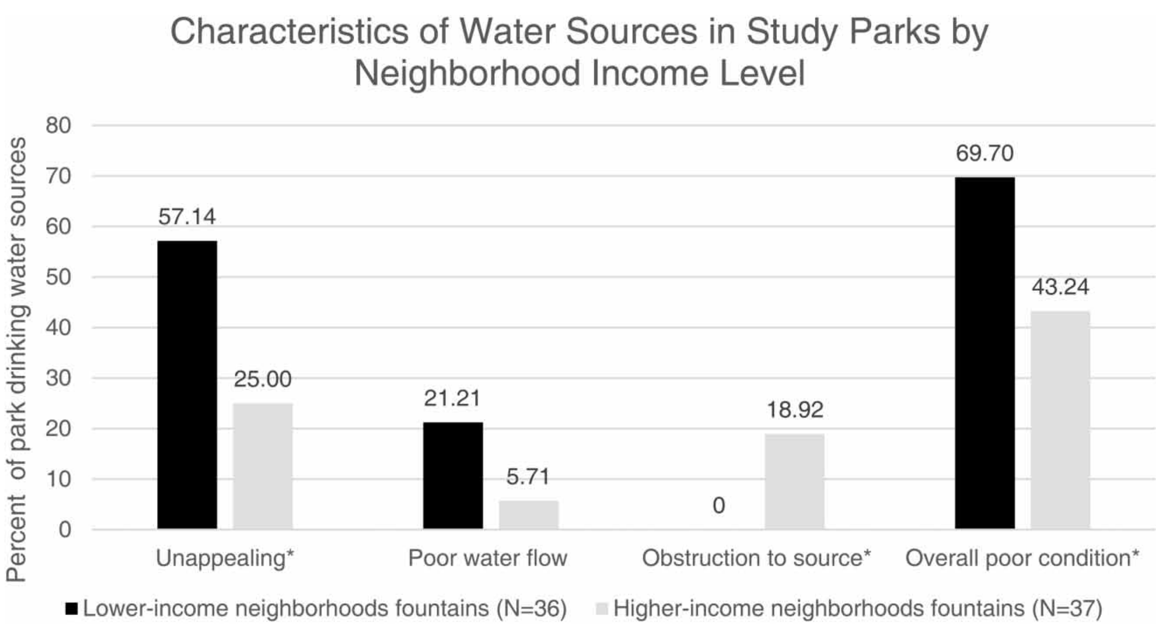

Figure 1 | Characteristics of drinking water sources ($n = 73$) in SF Bay Area parks ($n = 30$) by neighborhood income, 2016. Drinking water characteristics with an asterisk (*) indicated a significant difference in quality based on income. A greater proportion of water sources in parks in lower-income neighborhoods were unappealing (57.1 vs. 25.0%, $P = 0.01$) and had an overall poor condition as compared with those in parks in higher-income areas (69.70 vs. 43.2%, $P = 0.03$). Water sources in parks in higher-income neighborhoods had a greater proportion of water sources with obstructions than those in lower-income neighborhoods (18.9 vs. 0%, $P = 0.01$). Ns may sum to less than 73 due to missing data.

Table 3 | Association between park water source characteristics and visitors drinking water, SF Bay Area, 2016

Drinking water source characteristics	Visitors' drinking from fountain, unadjusted mean % (SD)[a]	*P*-value	Percent reduction in visitors' drinking from fountain, mean % (95% CI)[b]	*P*-value
Appeal of water source		0.22		0.07
Appealing	5.82 (7.93)		1.0 (Reference)	
Unappealing	4.04 (5.77)		0.31 (−0.03, 0.54)	
Water flow		0.38		0.30
Good	5.28 (7.41)		1.0 (Reference)	
Poor	3.91 (5.49)		0.22 (−0.27, 0.51)	
Obstructions to source		0.15		0.04
No	5.06 (7.09)		1.0 (Reference)	
Yes	2.14 (2.23)		0.58 (0.07, 0.81)	

[a]Mixed-effects regression models used to examine differences in water consumption in parks by drinking water source characteristics.
[b]Multivariable mixed-effects regression model accounting for clustering of observations in parks, examined differences in park visitors drinking water from fountains by water source characteristic, adjusting for the poverty level of park neighborhood, ambient temperature during observation, and time of day.

The estimated associations between drinking water source conditions and water intake from park sources were meaningful from a public health standpoint (the poor condition of drinking water sources was associated with a 22–58% reduction in consumption of water from sources) (Table 3). However, after adjustment, only the relationships between the presence of an obstruction to the water source and water intake were statistically significant ($P = 0.04$). The presence of an obstruction to the water source was associated with a 58% reduction in park visitors drinking from the fountain.

DISCUSSION

To our knowledge, this is the first study to examine how drinking water source conditions in public parks influences water intake among park visitors. The current study is also one of the first to examine how beverage access, beverage marketing, and beverage intake in parks varies by the park neighborhood income level.

In this study, the overall use of park water sources was low: approximately 5% of park visitors drank water from park sources, which were predominately drinking fountains. The rates of water consumption from park sources observed in this study are similar to those observed in previous studies, conducted primarily in schools (Patel *et al.* 2012; Kenney *et al.* 2015). The overall proportion of park visitors observed with SSBs was also low; however, there was a trend for higher rates in lower-income neighborhoods as compared with higher-income neighborhoods. We also observed a trend for lower rates of water intake and a lower use of reusable water bottles in parks located in lower-income neighborhoods as compared with parks in higher-income areas.

Income-related disparities in beverage intake may stem from differences in beverage environments. In the current study, we found income-related disparities in the condition of drinking water sources; parks in lower-income areas had 1.6 times the proportion of drinking water sources that were in the poor condition as compared with parks in higher-income neighborhoods. This finding runs counter to two other studies in New Zealand and Berkeley, California that found no differences in park drinking water source conditions by neighborhood poverty status (Pearson *et al.* 2014; Avery & Smith 2018). These divergent findings may be due to differences in the way that the condition of drinking water sources was collected and categorized. Future studies should use consistent measures for comparison across studies. Variations in the racial/ethnic composition and income level of the communities in the studies may have also contributed to the different findings.

Many studies have documented negative perceptions of tap water in racial ethnic minority and low-income populations (Onufrak *et al.* 2014). Providing safe, appealing, clean, and functional drinking water sources in parks are a first step in promoting healthy hydration. However, to substantially impact SSB intake, the promotion of tap water as a replacement for SSBs may be needed (Moghadam *et al.* 2019). Previous studies in other community settings suggest that coupling appealing water sources with promotional activities, such as signage, can significantly increase water intake (Patel *et al.* 2019; Lawman *et al.* 2020). Despite the importance of promotion efforts, no parks in this study marketed tap water via posters, signage, or other materials. This is an important opportunity for future efforts.

Limitations

There are several limitations in this study.

Although a randomized controlled trial is the gold standard study design, as evaluators of a city program, we were unable to randomize the parks that were to receive water bottle filling stations in this study. However, intervention and comparison parks were matched on their amenities and the socio-demographic composition of their neighborhood location.

A second limitation is that the condition of the park drinking water sources was recorded only once during the 4-day observation period. It is possible that the condition of the water sources could have changed during the 4-day observation period, thereby affecting consumption. However, as the water source condition was recorded on a day selected at random, it should be representative of the condition during the observation period.

It is also possible that opaque reusable bottles or beverage containers without visible labels were classified as unsweetened beverages. However, all researchers were trained at multiple study time points to ensure observation validity.

This study may not be sufficiently powered to examine all study hypotheses, as models with meaningful, relatively large, effect sizes were not always statistically significant. Larger, more representative studies including a greater number of parks are needed to deepen and confirm this study's findings.

Lastly, we acknowledge that understanding parks visitors' motivations for using park drinking water sources is important. While we did conduct surveys with park visitors to understand their perceptions of existing park water sources as well as their ideas for improving their use, due to word count limitations, these findings will be included in a separate forthcoming publication.

Despite these limitations, this study has several strengths. This study utilized observations, which are the gold standard for observing beverage environments and beverage intake. Second, researchers used a validated water audit tool to assess the condition of drinking water sources in parks. Although study findings in the SF Bay Area may not be representative of other regions, park neighborhoods were diverse in terms of racial/ethnic composition and income.

CONCLUSION

Since most Americans live in close proximity to parks and regularly use them, these settings offer a novel environment for promoting population health. This study suggests that appealing, safe, and functional drinking water sources can promote water intake among park visitors. Given disparities observed in park drinking water source conditions by neighborhood income status, it may be particularly important to increase the quality of drinking water source conditions in parks in lower-income areas. One policy consideration is for cities to pass ordinances to install reusable water bottle filling stations instead of traditional fountains during new construction or renovation. This is particularly salient during the pandemic when many cities have shut off fountains in parks due to concerns about COVID-19 transmission. Another policy consideration is to couple improvements in drinking water access with marketing or community campaigns to promote tap water as the beverage of choice. Future studies should also evaluate the impact of park-based water access and promotion efforts on beverage intake and health outcomes such as obesity.

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DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

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