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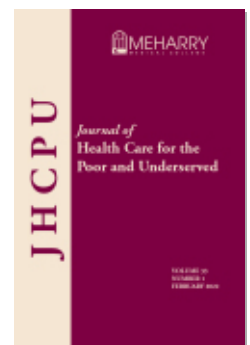
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## Before and After the Flint Water Crisis: Changes in the Consumption of Sugary Beverages in Residents Affected by Lead Contamination

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*Abstract:* The present study examines the changes in the type and frequency of beverage consumption of Genesee County, Michigan residents before and after the Flint water crisis (FWC). Employing *Speak to Your Health!* Community Survey data of adults (N=1,825) and random-effects longitudinal ordered logistic regression, we examined between the frequency of daily soda, juice, and other sweetened drinks (OSD) intake in two subpopulations: respondents residing in ZIP codes affected and not affected by lead contamination. After the FWC, African Americans were more likely to consume all three beverage types compared with Whites. It should be noted that the context of the FWC made this a time when mistrust in local government messaging might have been a factor. Within the affected area, African Americans' likelihood of soda, fruit juice, and OSD consumption increased significantly by 156%, 146%, and 924%, respectively.

*Key words:* Water lead contamination, sugar-sweetened drinks, fruit juice, soda, other sweetened drinks.

There is growing evidence of inequities in the United States' water system, such as the human-induced emergency affecting the safety of municipal water in Flint, Michigan, a city within Genesee County crippled by years of racism, disinvestment, unemployment, poverty, and violence.<sup>1</sup> Water contamination leaves the most vulnerable communities at risk, as it disproportionately affects low-income and minority populations.<sup>2</sup> Contaminated water can give rise to fear, and fear perpetuates stress, anxiety, depressed mood, and distrust within the affected community.<sup>3,4</sup> Distrust in tap water arises from the water's unpleasant taste, dirty or yellow appearance, and/or general contamination.<sup>5</sup> The degree of distrust varies by age, income, education, and race/ethnicity, as distrust is greatest among younger adults, those of lower socioeconomic status, less education, and non-White racial/ethnic groups.<sup>6</sup>

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In October 2015, Genesee County Board of Commissioners and Genesee County Health Department declared a public health emergency and advised residents, nearly 100,000 individuals, of Flint, Michigan not to drink unfiltered tap water.<sup>7</sup> Nearly 18 months prior (April 2014), the city discontinued the water service of the Detroit Water and Sewer Department and began treating and distributing Flint River water under the guidance of the state-appointed emergency management team.<sup>7</sup> Flint River water was an unstable water source that resulted in the corrosion of water distribution pipes and the leaching of lead and other contaminants into municipal water.<sup>8</sup> Lead is a potent neurotoxin and can manifest as acute severe encephalopathy or as chronic cognitive and behavioral symptoms causing irreversible harm.<sup>1</sup> Shortly after the change in the water source, Flint residents voiced their concern about tap water being discolored, smelling and tasting poorly, and leading to health problems.<sup>9</sup> Initially, the majority of complaints were dismissed by the state and city officials.<sup>9</sup> In October 2015, Flint's water source was converted back to Detroit-supplied Lake Huron water; however, the problems with the quality of tap water persisted.<sup>3,7</sup> As a result, the mistrust in the community of the tap water formed when lead leaked into the municipal water due to the lack of proper corrosion control; public officials on multiple levels delayed acknowledgment, responsibility, and response to this water crisis. This mistrust persisted even after the distribution of faucet filters and the replacement of lead pipes with a safe, modern copper alternative.<sup>3,4</sup>

Lack of trust in tap water safety can affect drinking behavior. When tap water is perceived to be unsafe for consumption, beverage intake shifts toward alternatives such as filtered tap water, bottled water, and other beverages such as juice, sugar-sweetened beverages (SSBs), alcohol, or other caloric drinks.<sup>10,11</sup> This shift is more prominent among minorities, low-educated, and low-income populations.<sup>12</sup> Based on data collected from the 2010 HealthStyles Survey, significantly more Hispanics who mistrusted their tap water consumed one or more SSBs per day than Hispanics who trusted their tap water to be safe.<sup>2</sup>

Beverage consumption is a health behavior that continues to be one of the most publicized public health targets. This ongoing attention to beverage consumption is related to the strong evidence of a link between beverages that contribute to excessive sugar and energy intake and numerous adverse health outcomes, including obesity.<sup>13</sup> Increasing the intake of SSBs and fruit juices is positively associated with long-term weight gain, while increasing the intake of water is negatively related to long-term weight gain in adults.<sup>14</sup>

Beverage consumption is driven by a variety of factors, including sensory characteristics—e.g., smell, taste, and texture; environment; and policy, marketing, and role modeling.<sup>3-5</sup> Undoubtedly, beverage consumption patterns vary across age, income, education, and race/ethnicity, as racial minorities and low-educated and low-income individuals are more likely to consume SSBs.<sup>12</sup> Moreover, non-Hispanic Blacks and Hispanics are significantly less likely to drink non-caloric beverages, including tap water, diet drinks, and unsweetened coffee and tea than non-Hispanic Whites.<sup>10</sup> Hence, these populations can be at higher risk of consuming more SSBs at the time of water crisis and mistrust of tap water.

While the impact of sociodemographic factors on beverage intake is well-established,

less is known about beverage consumption when tap water is not trusted. The gap in the literature is even wider pertaining to beverage consumption following a formally recognized water crisis. Comparing beverage consumption before and after the Flint water crisis (FWC) can provide preliminary insight on this unknown. Hence, the primary objective of this study is to assess the frequencies of soda, 100% fruit juice, and other sweetened drink (OSD) consumption before and after the FWC. We hypothesize after a water crisis the daily frequency of SSB intake can significantly increase.

## Methods

**Design.** The secondary data from the *Speak to Your Health!* (STYH) Community Survey, a biennial self-reported health survey and part of a community-based participatory research project (CBPR) that originated in 2003 in Genesee County, Michigan, was used.<sup>15,16</sup> The STYH Community Survey recruits respondents who are 18 years of age or older throughout the community, and respondents complete the survey on paper or on-line.<sup>16</sup> After cleaning the dataset, considering the demography of Genesee County, only those qualified participants who represent the residents of the county remain in the dataset. The de-identified data of 2013 (before the FWC) and 2017 (after the FWC) were used. The study was deemed exempt by the University of Michigan Institutional Review Board for Health Sciences and Behavioral Sciences (the STYH Community Survey was approved prior to data collection by the University of Michigan Institutional Review Board for Health Sciences and Behavioral Sciences).

*Dependent variables.* The frequencies of drinking soda, OSD, and 100% fruit juices were the dependent variables. Since the optional frequency responses were different between the 2013 and 2017 survey instruments, all responses were converted to daily consumption. The frequencies were grouped into six ordinal categories: none, one, two, three, four, and more than four drinks per day.

*Independent variable.* The FWC was the independent variable. The respondents determined to be affected by the FWC were those who identified as residing in ZIP codes of 48502 and 48503. The two ZIP codes of 48502 and 48503 are the only two ZIP codes solely associated with Flint proper. The year 2013 was selected as the survey period before the crisis and the year 2017 as survey period after the crisis.

*Control variables.* The covariates used in the analyses of beverage consumption changes were the year of assessment (2013 or 2017), ZIP code, age, sex (male and female), racial/ethnic background (non-Hispanic White, Black or African American, Hispanic or Latino/a, and Other), educational attainment (less than high school, high school graduate or other, some college [no degree], and college degree), and employment status (employed full-time, employed part-time, unemployed, and other). All variables were made into global variables, excluding the ZIP code and survey year.

**Sample.** Since the respondents of 2013 and 2017 were different, we appended the dataset. Of the 1,825 respondents, there were 970 and 855 respondents of the 2013 and 2017 surveys, respectively. Of those respondents, 1,428 reported residing in a ZIP code associated with Genesee County, Michigan: 704 (2013) and 724 (2017). In total, 225 respondents were determined to be affected by the FWC, with 90 respondents to the 2013 survey and 135 respondents to the 2017 survey. After identifying for additional

**Table 1.**

**FREQUENCY OF SODA, FRUIT JUICE, OTHER SWEETENED DRINKS CONSUMPTION PER DAY BEFORE AND AFTER THE FLINT WATER CRISIS IN THE AFFECTED AND NOT AFFECTED ZIP CODES (2013 AND 2017)**

Beverage	Frequency	Affected						Not Affected					
		None	1	2	3	4	>4	None	1	2	3	4	>4
Soda	2013	58	17	5	3	1	1	456	77	16	8	4	7
	2017	68	22	18	7	7	12	267	104	59	47	22	81
Fruit Juice	2013	44	29	5	3	0	0	385	155	16	11	0	2
	2017	43	30	28	12	2	19	240	156	72	48	20	46
OSD	2013	63	11	3	3	2	2	473	76	9	7	4	3
	2017	69	19	18	11	4	13	303	96	68	44	30	41

Notes:

OSD= Other Sweetened Drinks

missing data in the dependent and independent variables, the samples were reduced accordingly.

**Statistical methods.** Since the outcome measures were categorized into six levels, random-effects longitudinal ordered logistic regression was used to examine the correlation between the frequencies of daily soda, juice, and OSD intake and the affected and not affected. The analytic sample included two subpopulations: respondents residing in ZIP codes affected by lead contamination and those residing in ZIP codes not affected by lead contamination. (Table 1).

**Results**

**Soda.** Participants who were living in the affected ZIP codes were approximately 13% less likely to drink soda compared with their counterparts living in the not affected ZIP codes. The likelihood of drinking soda after the FWC increased by 43%. However, the risk was not the same between affected and not affected ZIP codes. In the former, after the FWC, the likelihood of drinking soda increased by 24% whereas in the latter by 49%. One year increase in age could reduce the possibility of drinking soda by 2%, which is statistically significant. Men were more likely to drink soda in all areas; however, the difference between men and women was not statistically significant. Concerning ethnicity, African Americans were approximately 80% more likely to drink soda compared with White participants. African American participants living in the affected and not affected ZIP codes were approximately 156% and 65% more likely to drink soda compared with their White counterparts, respectively. Although Hispanic participants were more likely to drink soda compared with Whites, the differences

**Table 2.**

**SODA CONSUMPTION BETWEEN AND WITHIN AFFECTED AND NOT AFFECTED ZIP CODES BEFORE AND AFTER THE FLINT WATER CRISIS (2013 AND 2017)**

	Model 1 Affected vs. Not Affected		Model 2 Within Affected		Model 3 Within Not Affected	
	OR (SE)	95% CI	OR (SE)	95% CI	OR (SE)	95% CI
Affected ZIP	0.866 (0.135)	0.637–1.176	-	-	-	-
Year (Before vs. After FWC)	1.429 (0.048)***	1.338–1.536	1.243 (0.098)**	1.066–1.450	1.494 (0.066)***	1.371–1.629
Age	0.982 (0.004)***	0.974–0.990	0.980 (0.009)*	0.963–0.998	0.982 (0.005)***	0.973–0.991
Sex <sup>a</sup>	1.234 (0.166)	0.947–1.606	1.160 (0.380)	0.610–2.203	1.257 (0.190)	0.935–1.691
Race/Ethnicity <sup>b</sup>						
African American	1.802 (0.239)***	1.389–2.336	2.555 (0.853)**	1.328–4.915	1.649 (0.249)**	1.227–2.215
Hispanic	1.331 (0.497)	0.641–2.766	3.275 (2.673)	0.661–16.215	1.107 (0.476)	0.477–2.568
Other	1.579 (0.343)*	1.031–2.418	4.839 (2.254)**	1.942–12.058	1.172 (0.301)	0.708–1.930
Education	0.734 (0.051)***	0.641–0.840	0.872 (0.143)	0.632–1.204	0.702 (0.056)***	0.600–0.822
Employment <sup>c</sup>						
Part-time	1.166 (0.226)	0.798–1.704	2.809 (1.386)*	1.068–7.388	1.010 (0.218)	0.661–1.543
Unemployed	1.637 (0.434)	0.973–2.754	2.298 (1.374)	0.711–7.420	1.590 (0.483)	0.887–2.883
Other	1.101 (1.169)	0.815–1.487	1.788 (0.725)	0.808–3.958	1.045 (0.178)	0.748–1.460
	N=1,297		N=209		N=1,088	
	Wald Chi2(11)=218.73***		Wald Chi2(10)=35.59***		Wald Chi2(10)=127.90***	
	Log Likelihood=-1434.1796		Log Likelihood=-251.0969		Log Likelihood=-1172.3387	

*Notes:*

<sup>a</sup>Female is the reference group.

<sup>b</sup>White is the reference group.

<sup>c</sup>Full-time is the reference group.

\*p<.05; \*\*p<.01; \*\*\*p<.001

FWC= Flint Water Crisis

were not statistically significant. Unemployed and part-time employed participants were more likely to drink soda compared with full-time employed participants. Only within the affected ZIP codes, part-time employed participants were significantly more likely to drink soda (Table 2).

**Fruit juice.** Participants who were living in the affected ZIP codes were approximately 42% more likely to drink fruit juice compared with their counterparts living in the not affected ZIP codes. The likelihood of drinking fruit juice after the FWC increased by 40%. However, the risk was not the same between affected and not affected ZIP codes. In the former, after the FWC, the likelihood of drinking fruit juice increased by 55% whereas in the latter by 39%. Men were significantly more likely to drink fruit juice in the not affected ZIP codes compared with women in the not affected ZIP. Concerning ethnicity, African American participants were approximately 138% more likely to drink fruit juice compared with non-Hispanic White participants. African American participants living in the affected and not affected ZIP codes were approximately 146% and 152% more likely to drink fruit juice compared with their White counterparts, respectively. Although Hispanic participants were less likely to drink fruit juice compared with Whites, the differences were not statistically significant. Other employment was a significant predictor of drinking fruit juice as these participants were approximately 59% more likely to drink fruit juice compared with full-time employed participants. This risk increased to 121% and 146% in the affected and not affected ZIP codes, respectively (Table 3).

**Other sweetened drinks.** Participants who were living in the affected ZIP codes were approximately 10% less likely to drink OSD compared with their counterparts living in the not affected ZIP codes. The likelihood of drinking OSD after the FWC increased by 41%. The risk was similar between affected and not affected ZIP codes. A one-year increase in age could reduce the likelihood of drinking OSD by 3%. Men were significantly more likely to drink OSD in the not affected area compared with women in the same area. Concerning ethnicity, African American participants living in the affected and not affected ZIP codes were approximately 924% and 301% significantly more likely to drink OSD compared with their White counterparts, respectively. Although Hispanic participants were more likely to drink OSD compared with Whites, the differences were not statistically significant. Compared with White participants, participants of other races/ethnicities were more likely to drink OSD by 882% and 60% in the affected and not affected areas, respectively; the difference was significant only in the former. Part-time employed and unemployed participants and those with other employment were more likely to drink OSD (Table 4).

**Demographic characteristics.** One thousand eight hundred and twenty-five (1,825) residents of Genesee County, Michigan completed the STYH Community Survey with 225 and 1,202 respondents reporting residing in the affected and not affected areas, respectively. Among the participants, nearly three-fourths were female (72%, n=1,282). More than half of the participants were White (59%, n=1,055), while 32% (n=573) were African American, 2% (n=24) were Hispanic, and 6% (n=111) were of another ethnicity. However, between the affected and not affected ZIP codes, there were significant differences in participants' ethnicity. African Americans made up 46% (n=101) of the affected ZIP codes, but only 27% (n=314) of the not affected ZIP codes (Pr=0.0000).

**Table 3.**

**FRUIT JUICE CONSUMPTION BETWEEN AND WITHIN AFFECTED AND NOT AFFECTED ZIP CODES BEFORE AND AFTER THE FLINT WATER CRISIS (2013 AND 2017)**

	Model 1 Affected vs. Not Affected			Model 2 Within Affected			Model 3 Within Not Affected		
	OR (SE)	95% CI		OR (SE)	95% CI		OR (SE)	95% CI	
Affected ZIP	1.423 (0.209)*	1.067–1.897	-	-	-	-	-	-	-
Year (Before vs. After FWC)	1.402 (0.044)***	1.318–1.491	1.552 (0.244)**	1.141–2.112	1.394 (0.048)***	1.303–1.492			
Age	0.996 (0.004)	0.988–1.003	0.989 (0.010)	0.970–1.008	0.998 (0.004)	0.990–1.000			
Sex <sup>a</sup>	1.443 (0.178)**	1.133–1.838	1.916 (0.789)	0.855–4.293	1.351 (0.184)*	1.034–1.765			
Race/Ethnicity <sup>b</sup>									
African American	2.381 (0.305)***	1.853–3.060	2.456 (1.085)*	1.033–5.840	2.524 (0.362)***	1.906–3.343			
Hispanic	0.688 (0.287)	0.304–1.557	0.193 (0.262)	0.013–2.761	0.935 (0.424)	0.385–2.273			
Other	1.231 (0.267)	0.804–1.884	2.213 (1.318)	0.689–7.113	1.005 (0.254)	0.612–1.649			
Education	0.906 (0.059)	0.797–1.030	0.839 (0.162)	0.575–1.224	0.940 (0.068)	0.816–1.083			
Employment <sup>c</sup>									
Part-time	1.310 (0.243)	0.910–1.886	1.019 (0.562)	0.346–3.001	1.345 (0.271)	0.907–1.995			
Unemployed	1.520 (0.388)	0.922–2.508	1.618 (1.122)	0.415–6.301	1.469 (0.420)	0.839–2.570			
Other	1.591 (0.234)**	1.192–2.124	2.212 (1.010)	0.904–5.412	1.462 (0.237)*	1.065–2.008			
	N=1,297		N=197		N=1,086				
	Wald Chi2(11)=218.73***		Wald Chi2(10)=10.09		Wald Chi2(10)=164.51***				
	Log Likelihood=-1434.1796		Log Likelihood=-273.147		Log Likelihood=-1245.4288				

Notes:

<sup>a</sup>Female is the reference group.

<sup>b</sup>White is the reference group.

<sup>c</sup>Full-time is the reference group.

\*p<.05; \*\*p<.01; \*\*\*p<.001

FWC= Flint Water Crisis



**Table 4.**

**OTHER SWEETENED DRINKS CONSUMPTION BETWEEN AND WITHIN AFFECTED AND NOT AFFECTED ZIP CODES BEFORE AND AFTER THE FLINT WATER CRISIS (2013 AND 2017)**

	Model 1 Affected vs. Not Affected		Model 2 Within Affected		Model 3 Within Not Affected	
	OR (SE)	95% CI	OR (SE)	95% CI	OR (SE)	95% CI
Affected ZIP	0.899 (0.147)	0.652–1.240	-	-	-	-
Year (Before vs. After FWC)	1.409 (0.050)***	1.314–1.511	1.444 (0.245)*	1.035–2.010	1.440 (0.57)***	1.332–1.556
Age	0.972 (0.004)***	0.964–0.981	0.967 (0.015)*	0.938–0.997	0.972 (0.005)***	0.963–0.982
Sex <sup>a</sup>	1.504 (0.214)**	1.137–1.988	1.760 (0.886)	0.656–4.719	1.513 (0.239)**	1.110–2.062
Race/Ethnicity <sup>b</sup>						
African American	4.246 (0.586)***	3.240–5.565	10.237 (9.820)*	1.562–67.090	4.005 (0.606)***	2.978–5.387
Hispanic	1.545 (0.607)	0.716–3.338	3.622 (4.754)	0.277–47.420	1.398 (0.612)	0.593–3.295
Other	2.122 (0.505)**	1.331–3.383	9.821 (11.194)*	1.052–91.690	1.599 (0.453)	0.917–2.786
Education	0.705 (0.517)***	0.610–0.814	0.928 (0.211)	0.594–1.449	0.664 (0.054)***	0.565–0.779
Employment <sup>c</sup>						
Part-time	1.756 (0.349)**	1.190–2.592	2.204 (1.514)	0.573–8.474	1.694 (0.365)*	1.110–2.584
Unemployed	1.733 (0.470)*	1.018–2.950	3.026 (2.685)	0.531–17.220	1.628 (0.495)	0.897–2.956
Other	1.344 (0.221)	0.973–1.857	2.352 (1.352)	0.762–7.256	1.246 (0.225)	0.875–1.774
	N=1,302		N=208		N=1,094	
	Wald Chi2(11)=292.27***		Wald Chi2(10)=8.09		Wald Chi2(10)=248.26***	
	Log Likelihood=-1270.1118		Log Likelihood=-231.49125		Log Likelihood=-1031.3823	

Notes:

<sup>a</sup>Female is the reference group.

<sup>b</sup>White is the reference group.

<sup>c</sup>Full-time is the reference group.

\*p<.05; \*\*p<.01; \*\*\*p<.001

FWC= Flint Water Crisis

**Table 5.****SEX, ETHNICITY, EDUCATION, AND EMPLOYMENT BEFORE AND AFTER THE FLINT WATER CRISIS IN THE AFFECTED AND NOT AFFECTED ZIP CODES (2013 AND 2017)**

	Affected		Not Affected	
	2013 (N=90)	2017 (N=135)	2013 (N=613)	2017 (N=589)
Sex				
Female	59 (66.29%)	101 (76.52%)	416 (69.33%)	452 (77.93%)
Male	30 (33.71%)	31 (23.48%)	184 (30.67%)	128 (22.07%)
Race/Ethnicity				
White	32 (36.36%)	57 (43.85%)	443 (73.47%)	327 (56.97%)
African American	48 (54.55%)	53 (40.77%)	134 (22.22%)	180 (31.36%)
Hispanic	2 (2.27%)	3 (2.31%)	9 (1.49%)	15 (2.61%)
Other	6 (6.82%)	17 (13.08%)	17 (2.82%)	52 (9.06%)
Education				
Less than High School Degree	6 (6.74%)	9 (6.82%)	32 (5.28%)	11 (1.90%)
High School Graduate	24 (26.97%)	19 (14.39%)	175 (28.88%)	98 (16.90%)
Some College, No Degree	21 (23.60%)	36 (27.27%)	149 (24.59%)	157 (27.07%)
College Degree	38 (42.70%)	68 (51.52%)	250 (41.25%)	314 (54.14%)
Employment				
Full-time	20 (22.99%)	48 (36.64%)	122 (20.27%)	238 (41.18%)
Part-time	5 (5.75%)	19 (14.50%)	53 (8.80%)	88 (15.22%)
Unemployed	7 (8.05%)	9 (6.87%)	32 (5.32%)	31 (5.36%)
Other	55 (63.22%)	55 (41.98%)	395 (65.61%)	221 (38.24%)

When asked about participants' education, 4% (n=73) reported not earning a high school degree, 23% (n=411) earned a high school degree, 27% (n=476) attended college but did not earn a degree, and 46% (n=830) earned a college degree, and this was not significantly different between the affected and not affected areas ( $p=.134$ ). As for employment, the majority of respondents (52%, n=921) reported having employment such as being a homemaker, student, or retired—which are not considered full-time or part-time employment—or being unemployed. The mean age of respondents was 53 years with younger individuals completing the survey in 2017 than 2013. In 2017, the average age of respondents was 46 and 47 years in the affected and not affected areas, respectively (Table 5).

## Discussion

Our research suggested that within the affected and not affected ZIP codes the likelihood of the frequencies of soda, fruit juice, and OSD consumption increased significantly after the FWC in 2017 compared with 2013 (before the water crisis). These findings are the reverse of the overall downward trend of beverage consumption among adults

in the United States. Based on the nationally representative data from National Health and Nutrition Examination Surveys of 2003 to 2014, there was a decline in the consumption of sugary drinks among American adults 20 years of age and older—White Americans had the biggest decline in sugary drink intake at 21%, compared with 15% less for African American adults and roughly 8% less for Hispanic adults.<sup>17</sup> The prevalence of 100% fruit juice consumption significantly decreased for individuals 60 years of age and older. Additionally, in 2017, market research continued to show an annual decrease in carbonated soft drink sales.<sup>18</sup>

In the current study, the likelihood of increased frequencies of soda, juice and OSD consumption found within both the affected and not affected ZIP codes could be related to fear associated with the mistrust of tap water. In the midst of the water crisis and more than a year after residents of Flint were advised not to drink unfiltered tap water, two-thirds of the households in Flint reported having “some” or “a lot of” fear of using filtered tap water.<sup>3</sup> A majority of households reported only trusting themselves, trusting no one or none of the listed sources—i.e., government officials. Trust in government is dependent on the perception of a variety of factors, including economic competency, ability and integrity of both the politicians and the structures, and effectiveness and efficiency of public services.<sup>19–22</sup>

This fear may not have been limited to residents within the affected ZIP codes but felt by residents within the not affected ZIP codes as well. A similar expression of fear can spread to residents of neighboring areas, such as the Greater Flint Area, even though the residents do not face a direct physical threat. This shared expression of fear can occur if there is shared geography, social network ties, and/or direct personal experience(s) in the areas affected.<sup>23</sup> For example, African American participants living in the not-affected ZIP codes were 6% more likely to drink fruit juice than African American participants living in the affected ZIP codes (152% and 146%, respectively).

This insight on fear has the potential to shed light on the relationship between psychosocial stressors and decision-making, which ultimately allows for vulnerable populations to be provided with physical and mental health resources. Psychosocial stress can be incorporated into decision-making by evaluating potential community psychosocial stress in planning and determining opportunities for action within the Greater Flint community, establishing a strong relationship with local leadership and community groups in the process of ridding lead from the environment, collaborating with government agencies for knowledge-sharing and pooling of resources, acknowledging the distinct culture(s) of the Greater Flint community, and creating assessments to understand and evaluate the environmental contamination and its ongoing effects.<sup>24</sup>

As the likelihoods of the frequencies of soda, fruit juice, and OSD intake increased within the affected and not affected ZIP codes between 2013 and 2017, soda and other sweetened drink frequencies of consumption were not significantly greater within the ZIP codes affected by lead contamination compared with the not affected ZIP codes. In contrast, we found there was a 42% increase in the frequency of fruit juice intake in the affected ZIP codes compared with the not affected ZIP codes. A possible reason for this increase could be the perceived nutritional benefits of fruit juices.

Characteristics associated with increased likelihood in frequencies of soda, fruit

juice, and OSD consumption were similar between both the affected and not affected ZIP codes, as African Americans were more likely to consume all three beverage types compared with Whites. The likelihood of increases in the frequencies of soda, fruit juice, and OSD consumption among racial minorities are supported by previous studies that found racial minorities more likely to consume SSBs and significantly less likely to drink non-caloric beverages.<sup>10,12</sup> Additionally, as age increased participants were less likely to drink soda and OSD as frequently.

Our research provided additional insight on minority beverage consumption. In the affected ZIP codes, African Americans were 146% significantly more likely to drink soda compared with Whites living in the same region when this difference was 152% in the not affected ZIP codes. For fruit juice, African Americans consumed 1.5 times more than Whites in both affected and not affected ZIP codes. African Americans were 9.2 times more likely to drink OSD than Whites in the affected ZIP codes compared with 3.0 times in the not affected ZIP codes. Other minority participants were more likely to drink OSD by 882% and 60% in the affected and not affected areas, respectively. However, due to the limited sample size, we are unable to consider the employment status of African Americans, Hispanics, and other minority groups. These differences in the soda, fruit juice, and OSD consumption in minority populations compared with Whites highlighted the vulnerability of minority populations during a crisis, particularly a water crisis. The differences in beverage consumption could be related to emotional responses, sensory characteristics, marketing, and role-modeling influences; perceived health benefits, risks, and consequences; and/or access that are linked to the larger society and built environment.

The differences in likelihood of beverage consumption by sociodemographic characteristics highlight the need for reducing disparities in sugar-containing beverage consumption by racial/ethnic background. Furthermore, beverage consumption among members of minority groups, particularly African Americans, may also be affected by how risk is perceived, as racial and ethnic minorities perceive risk to be greater.<sup>24</sup> This fear, as well as other mental health implications, needs to be reduced or else long-term health disparities faced by Flint's African American residents may be even more exaggerated than the general population.<sup>9,25</sup> The most vulnerable in the community may benefit from community leaders addressing perceptions of poor municipal water quality and by addressing fear and mistrust in messaging, as well as continuing to support community mental health services.<sup>9,26</sup>

The likelihoods of frequencies of consumption of soda, fruit juice and OSD consistently increased as individuals were younger in age and male. However, both age and gender differences were not found to be significant across all ZIP codes.

There are several potential limitations in the study. First, we may have underestimated or overestimated the number of respondents directly affected by the FWC. Those determined to be affected were those respondents residing in a ZIP code associated with only Flint, Michigan (many ZIP codes are associated with Flint and other cities and towns), and even within the affected ZIP codes there may have been residents not affected by water contamination. Second, survey responses were vulnerable to participation bias and over-reporting, especially since there was a great deal of media

attention brought to the water crisis.<sup>9</sup> Additionally, the STYH Community Survey data were self-reported and subject to bias. Furthermore, respondents were not asked why they consumed a particular beverage, just simply how frequently they did so. Lastly, 2013 and 2017 survey instruments were not identical in question or available answer selection and/or format.

Future studies exploring ways to modify health behavior through local policies, messaging, and health education that take fear of water into account may be warranted. It may be beneficial for additional assessments to evaluate reasons for beverage consumption in the future, such as measuring mistrust in a future STYH Community Survey. We suggest future research projects to include more participants to allow for the testing of the interactions between employment and ethnicity and sex and ethnicity to test the impact of employment and sex on beverage consumption while controlling for ethnicity. It was not feasible to test these interactions here due to the number of participants.

The emotional responses of fear and mistrust, particularly in an area stricken with inequalities, have the capacity to modify beverage consumption. Such factors influencing beverage consumption may be amplified following a disaster, as indicated by the changes we found in the frequencies of beverage consumption before and after the FWC in both Flint residents affected by lead contamination and residents of the Greater Flint area. In particular, the differences in likelihood of beverage consumption by sociodemographic characteristics highlight the need for reducing disparities in sugar-containing beverage consumption by racial/ethnic background. Additional research is needed, however, it is plausible that Flint residents will need to trust their local, state, and/or federal government prior to decreasing sugary beverage intake. Local, state, and federal public health efforts may be helpful in reducing disparities by narrowing the gap through reinforcing efforts regarding behaviors, environments, and policies that create change to support health and provide justice (including distributive justice, procedural justice, corrective justice, and social justice).<sup>5</sup>

From the social environment model perspective, the environment and society around individuals interact and influence health behavior. It is particularly important to consider these relationships in Flint, as Flint residents have spent years or decades not receiving support and/or being misled by those who were supposed to be working to protect their wellbeing. Flint residents witnessed major employers leave the city, economic blight, decrease in the quality of services, and multiple state-appointed emergency managers.<sup>19,22</sup> Nonetheless, at the time of the water crisis, officials at different levels resisted acknowledging that the water was contaminated and resisted taking responsibility for the contamination, resulting in residents losing trust in city, state, and federal officials. This lack of trust paired with decreasing control and predictability of the environmental factors (i.e., water) can cause disengagement between meso (i.e., the community) and macro levels. Consequently, people may rely only on the available, trusted resources and shrink their social environment to those individuals they trust more. This combination of circumstances paves the way for unhealthy behaviors, such as drinking sugary beverages as an alternative to tap water. In order not to repeat the history of Flint, the flexibility of the organizations and support systems (i.e., government) is critical in maintaining people's health and quality of life when environmental factors are unstable, in particular, among vulnerable populations.

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