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<ATL> Toxic trauma: Household water quality experiences predict posttraumatic stress disorder symptoms during the Flint, Michigan, water crisis </ATL>

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<H2> Abstract

<ABS>We examined the relationship between perceptions of household tap water quality and posttraumatic stress disorder (PTSD) symptoms during the Flint, Michigan, water crisis in 2015–2016. The Speak to Your Health Community Survey is a community-based participatory component of the health surveillance system in Genesee County, Michigan. Perceptions of household tap water quality was added to the 2015–2016 survey wave after inadequate official response to concerns over water quality after a change in Flint’s municipal water supply. Respondents ($N = 786$) also completed a brief PTSD screening tool. We examined the relationships of perceived household tap water quality to PTSD symptomatology and positive screening criteria for PTSD, controlling for sociodemographics. Perceived tap water quality predicted PTSD symptomatology and positive screening criteria for PTSD, independent of sociodemographics. The adverse mental health impact of municipal toxic contamination may generalize to other similar environmental contamination incidents. </ABS>

<P>We examined the relationship between tap water quality experiences and symptoms of posttraumatic stress disorder (PTSD) among Genesee County residents during the Flint, Michigan, water crisis in 2015–2016. Posttraumatic stress disorder (PTSD) is defined as a mental illness that can result from experiences of traumatic events (American Psychiatric Association [APA], 2013) and is identified by frequently occurring intrusive reexperiencing and remembering of a previous traumatic experience, which can result in various emotional and social changes in an

individual (Iribarren, Prolo, Neagos, & Chiappelli, 2005; Kearney, McDermott, Malte, Martinez, & Simpson, 2012). Only some individuals experiencing traumatic events develop PTSD (National Center for PTSD, 2015; Zoladz, 2013). Although the term was coined regarding U.S. military veterans were returning from the Vietnam War, the phenomenon (formerly known as "shell shock") has long been associated with experiences of warfare. PTSD can also result from other traumas such as sexual assault, violent crimes, serious accidents, and natural disasters (National Center for PTSD, 2015; Zoladz, 2013).

Symptoms of PTSD, which often persist for years and even decades, can result in serious interruptions in an individual's ability to function in day-to-day life (Iribarren et al., 2005; Kearney et al., 2012). These symptoms are divided by the National Center for PTSD into four subgroups. The first is "reliving the event," which includes any sort of reexperiencing of the trauma through nightmares, or flashbacks, and the sensory triggers that cause them. The second category of symptoms involves "avoiding situations that remind one of the event." Examples of avoidance include circumventing people, situations, sounds, smells, or any other kind of stimuli that might trigger a memory about the traumatic event. The third subgroup of symptoms includes "negative changes in beliefs and feelings" and most frequently includes feelings of depression, paranoia, and anxiety. The final cluster of symptoms involves a state of "hyperarousal," in which an individual can become easily agitated, jittery, and hyper-alert, and can result in difficulty sleeping and concentrating (Iribarren et al., 2005; Kearney et al., 2012; National Center for PTSD, 2015).

In April 2014, the municipal water supply in Flint, the urban center of Genesee County, changed sources from Lake Huron and the Detroit River to the

Flint River as a cost-saving measure while a new pipeline from Lake Huron was under construction (Associated Press, 2016). Although water from the Flint River was more corrosive than the previous supply from the Detroit Water and Sewerage Department, officials considered corrosion inhibitors too costly and thus failed to apply them (Associated Press, 2015). The higher corrosiveness and inadequate treatment of the water resulted in elevated levels of contaminants including disinfection byproducts, bacteria, and lead (Payne & Burnside, 2016). Local residents reported concerns about the smell, taste, and appearance of their tap water soon after the water source changed (Heavey, 2016). Some community members reported health concerns in adults and children, attributed to contaminated tap water, such as skin rashes and hair loss (Associated Press, 2015).

Community members expressed their concerns at municipal meetings, organized marches and protests, and attended and reached out to media (Burke, 2016). In response, Flint officials continued to insist that the city water was safe to drink and that there was no relationship between health problems and tap water quality (Associated Press, 2016). On September 8, 2015, a research team from Virginia Tech reported that approximately 40% of Flint homes have elevated levels of lead in their water supply (Burke, 2016). On September 24, 2015, local physicians urged Flint residents to stop using their tap water after finding high blood lead levels in local children (Associated Press, 2016). These events brought national and international media attention to the water issues in Flint, leading to declarations of a state of emergency by Flint's mayor and Michigan's governor in December 2015 and January 2016, respectively.

<P>The current study was initiated as participatory action research project to address community concerns regarding water quality after the lack of official response. The community–academic partnership facilitating the biennial countywide health survey decided to assess perceptions of tap water quality in the 2015–2016 survey wave. The partnership also decided to add a measure assessing symptoms of PTSD. Experiencing poorer tap water quality and then being informed of the toxic contamination in the Flint municipal water supply may have induced considerable trauma among local residents. These individuals received frequent reminders of the water crisis and possible effects of exposure to contaminants through the pervasive media coverage and ongoing community concern. They may consider the possible long-term adverse health effects of drinking and otherwise using the contaminated water for themselves, loved ones, and other community members.</P>

<P>This study examined the relationship between tap water quality experiences and PTSD symptomatology, controlling for demographic factors and weighting data for demographic representation. Previous survey results have been used to leverage local health policy change such as tobacco-free environments and the implementation of a county health plan (Kruger, Shirey, Morrel-Samuels, Skorcz, & Brady, 2009). Thus, the partnership sought evidence that could be used to support the concerns of community residents regarding water quality. Survey data collection began shortly after reports of elevated levels of lead in blood and water became public.</P>

<H1>METHOD</H1>

<P>A survey committee comprising community, health sector, and academic partners facilitates the Speak to Your Health Community Survey in Genesee County, Michigan, through a community-based participatory research process (Kruger et al., 2009). Conducted biennially since 2003, the survey monitors local health and health related concerns, assesses the effect of health initiatives on health outcomes, and promotes change to improve the health of Genesee County residents.</P>

<P>Respondents ($N = 786$ with complete data) were recruited through a combination of methods. Postcards were mailed to randomly selected specific adults in each residential Census Tract of the county included in U.S. Post Office address lists. These individuals could complete an online questionnaire on the Qualtrics survey platform or a hard copy survey returned via a postage paid envelope upon request. Participants were also recruited via e-mails to participants in previous survey waves, postings on electronic social media, and community-based data collection events. Recruitment efforts were informed by ongoing demographic analysis of current survey participants to maximize the population representativeness of the survey sample. Surveys were completed between September 30, 2015 and September 28, 2016; 77% of initiated surveys were completed, and the overall response rate was 39%. Recruitment and consent materials were adapted from previous survey waves and did not mention either the water crisis or PTSD.</P>

<P>The survey included the Short Screening Scale for PTSD (Breslau, Peterson, Kessler, & Schultz, 1999). The item stem read, "In your life, have you ever had any experience that was so frightening, horrible, or upsetting that, in the past month you..." and contained seven items such as "...were jumpy or easily startled by

ordinary noises or movements?” Those who answered yes to four or more items met screening criteria for PTSD, a definition with a sensitivity of 80%, specificity of 97%, positive predictive value of 71%, and negative predictive value of 98% in the original study (Breslau et al., 1999). Respondents rated “How would you rate the quality (taste, smell, appearance) of your tap water?” on a 5-point scale ranging from as 1 (*poor*) to 5 (*excellent*), after completing the PTSD and demographic items.

We used hierarchical regression analyses to predict PTSD symptomatology as a continuous measure (linear regression) and whether respondents met the screening criteria for PTSD as a binary outcome (logistic regression). We entered sociodemographic characteristics in the first step, including age in years, sex, years of education, and whether respondents were African American or Hispanic/Latino/a. We allowed tap water quality to enter in the second step if it accounted for unique variance beyond that of sociodemographic characteristics. These analyses were proportional weighted by age, sex, race (proportional Black or African American and Hispanic or Latino/a), and educational attainment based on population estimates in the 2014 American Community Survey (U.S. Census Bureau, 2016). Because the Flint municipal water supply includes all of the City of Flint and some but not all of the surrounding suburban and rural areas, we conducted additional analyses limiting the sample to known residents of Flint.

RESULTS

On average, respondents were 51 years of age (standard deviation [*SD*] = 17, *median* = 53), had 14 years of education (*SD* = 2), and had a score of 2 (*SD* = 2) on the PTSD screening scale. Of the respondents, 72% were women, 26% were

Black or African American, 2% were Hispanic or Latino/a, and 20% met the screening criteria for PTSD. The most recent population data available (2014) estimates the population of Genesee County as 52% women, 22% Black or African American, 3% Hispanic or Latino/a, with a median age of 39 years, 89% with an educational level of high school graduate or higher, and 19% with a bachelor's degree or higher (U.S. Census Bureau, 2016). In our sample, 97% had an educational level of high school graduate or higher, and 39% had a bachelor's degree or higher.

Respondents rated their tap water quality as poor (35%), fair (18%), good (20%), very good (17%), and excellent (10%). Perceptions of lower quality tap water uniquely predicted higher PTSD symptomatology, and whether respondents screened positive for PTSD (see Table 1 (TBL 1)). Participant ratings of their tap water quality improved the power of prediction for PTSD above sociodemographic factors, both as a continuous indicator of symptomatology, and a binary category of PTSD status. Younger respondents and those with fewer years of education also had higher PTSD symptomatology and were more likely to screen positive for PTSD. We note that our sample is biased toward those with older age and more years of education, both characteristics associated with lower PTSD symptomatology; however, our analyses control for age and educational differences between the sample and population represented. Limiting the sample size to those known for certain to be residents of Flint (and thus on the affected water supply) reduced the sample size and statistical power. Although the relationship between reported tap water quality and level of PTSD symptomatology remained significant, there were no longer any significant predictors of positive screens for PTSD.

DISCUSSION

Those who experienced poorer tap water quality in the midst of a community health crisis over an unsafe municipal water supply experienced greater PTSD symptomatology. This relationship was independent of sociodemographic attributes that could influence PTSD symptomatology. The findings of our study underscore the negative effects of the Flint water crisis on adults and demonstrate the need for psychological interventions addressing the psychosocial effects of the crisis. Although considerable resources have been allocated for the lengthy process of replacing water pipes, human-focused efforts are small in comparison. Nearly all of the attention to community members affected by the crisis is focused on lead poisoning in children (e.g., Hanna-Attisha et al., 2016). This is a worthy issue because lead poisoning has serious adverse consequences, especially for young children (Lidskya & Schneiderb, 2006). The effects of lead poisoning on the central nervous system last long after lead has left the body (Rubin & Strayer, 2008). However, even a small portion of the funding currently allocated to physical infrastructure could bring considerable psychological benefit to those affected by the crisis.

Educational handouts should emphasize the potential mental health implications of the water crisis for adults and provide contact information for mental health treatment and support groups. Our study suggests that many local residents require and would benefit from mental health services in addition to changes needed in the water infrastructure and remediation of lead poisoning. The two most common treatments for PTSD are cognitive behavior therapies (CBTs) and

pharmacological selective serotonin reuptake inhibitors (SSRIs; Schneier et al., 2012). Both have been shown to have potentially beneficial effects in the treatment of PTSD symptoms in populations suffering from noncombat induced PTSD (Beck & Coffey, 2005; Marshall et al., 2007; Schneier et al., 2012; Van Apeldoorn, et al., 2008). Studies have demonstrated that traditional treatment methods for PTSD, SSRIs, and CBTs are just as effective among minority and low-income populations as other demographic groups (Feske, 2008).

Future research might assess the relationships between water crisis experiences and PTSD subgroups, the long-term influence of PTSD in the community, factors that promote resilience to the crisis, and the effectiveness of community-based interventions to alleviate PTSD. A systematic review showed that PTSD symptoms tended to dissipate within one year for the majority of an afflicted population (Galea, Nandi, & Vlahov, 2005). Symptoms of PTSD may endure longer in Flint residents because the other detrimental consequences are ongoing.

The associations found in this study may generalize to other individuals affected by toxic water supplies resulting from various human causes such as hydraulic fracturing (e.g., Franko, 2016 January 24), high-pressure injections of water, sand, and thickening agents into a wellbore to enable the extraction of petroleum and natural gas. A decade before the water crisis in Flint, residents of Washington, D.C., experienced a similar event in which exposure to lead-contaminated drinking water was associated with higher rates of miscarriage, low birth weight, and fetal death (Edwards, 2014). A Reuters investigation found rates of lead poisoning at least double those in Flint during the water crisis in nearly 3,000 areas across the United States (Pell & Schneyer, 2016).

<H2> Limitations

<P>This study has several limitations. We did not use measures of the actual toxicity levels of household water, only perceptions of water quality based on its sensory qualities. Thus, we are gauging psychological effects of poor household water quality experiences during the crisis. Our data do not represent actual PTSD diagnoses performed in a clinical setting, but results of a commonly used screening tool. We also recognize that our study is correlational; however, we have confidence in the causal direction of the effect. Those with PTSD can experience changes in the perceptions of themselves and other individuals; however, PTSD is not associated with alterations in sensory perceptions of inanimate objects (APA, 2013).</P>

<H2> Conclusion

<P>In conclusion, this participatory action research project demonstrates how community–academic research partnerships can effectively address issues of community concern when the response from municipal authorities is inadequate. The results of the study indicate that the negative effects of the water crisis on the mental health of local adults should not be overlooked. Appropriate interventions should be developed to alleviate the aftermath of the Flint water crisis on the physical and mental health of community residents. This study also identifies a novel factor related to PTSD, as most prior research on PTSD has focused on causes, such as military combat, natural disasters, and abuse.</P>

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<<enote>>AQ1: Please specify if this is referring to the Flint water crisis (note that, per APA style, water crisis is not capitalized).

<<enote>>AQ2: Please insert the superscript lowercase 'a' in the table body, or delete the footnote in the footnote section that refers to it.</REF>

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{TBL1}<TC>TABLE 1. Hierarchical regression analyses for PTSD symptomatology and positive PTSD screening

<TH>Variables	PTSD		PTSD screening	
	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>
<TB>Genesee (constant)	5.02***	0.52	0.76***	0.10
Age in years	-0.13**	0.04	-0.02*	0.01
Sex	0.12	0.16	0.07	0.03
Years of education	-0.11**	0.04	-0.02**	0.01

	Black or African American	-0.20	0.20	-0.03	0.04
	Hispanic or Latino/a	-1.14	0.92	-0.21	0.18
	Tap water quality	-0.41***	0.06	-0.06***	0.01
	R²	.104***		.081***	
Flint (n = 268)	(constant)	2.69**	0.87	0.19	0.17
	Age in years	-0.12	0.08	0.00	0.02
	Sex	0.41	0.27	0.07	0.05
	Years of education	0.02	0.06	0.01	0.01
	Black or African American	-0.53	0.29	-0.08	0.06
	Hispanic or Latino/a	-0.76	1.33	-0.03	0.26
	Tap water quality	-0.33**	0.12	-0.03	0.02
	R²	.077***		.023	

Note. PTSD = posttraumatic stress disorder; SE = standard error. For sex, 1 = female =, 2 = male; for tap water quality, 5 = excellent, 4 = very good, 3 = good, 2 = fair, 1 = poor; for African American, Hispanic/Latino/a, and PTSD screening, yes = 1, no = 0. Age in years was divided by 10 in analyses to facilitate interpretation of coefficients.

^a Higher score indicates more severe symptoms (total score: 0–7).

*p < .05. **p < .01. ***p < .001.