Tap Water Consumption and Perceptions in US Latinx Adults

by

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ABSTRACT

The purpose of this investigation was to evaluate the influence of tap water safety perceptions on plain water intake (PWI) and hydration status in US Latinx adults. Participants (n=492; age, 28±7 y; 37.4% female) completed an Adapted Survey of Water Issues in Arizona and household water security experience-based scales. A sub-sample (n=55; age, 33±14 y; body mass index, 27.77±6.60 $kg \cdot m^2$) completed dietary recalls on two weekdays and one weekend day via Automated Self-Administered 24-hour Dietary Assessment Tool to determine average PWI and total water intake (TWI). A 24-h urine sample was collected on one recall day and analyzed for urine osmolality (U_{Osm}). Binary logistic regression determined odds ratios (OR) for the odds of perceiving tap water to be unsafe. Hierarchical linear regression was employed with 24-h U_{Osm} and PWI as primary outcomes for the sub-sample. Overall, 51.2% of all participants and 52.7% of the sub-sample mistrust their tap water safety. The odds of mistrusting tap water were significantly greater (P<0.05) for each additional favorable perception of bottled over tap water (OR=1.94, 95% CI=1.50, 2.50), each additional negative home tap water experience (OR=1.32, 95% CI=1.12, 1.56), each additional use of alternatives and/or modifications to home tap water (OR=1.25, 95% CI=1.04, 1.51), and decreased water quality and acceptability (OR=1.21, 95% CI=1.01, 1.45). The odds of mistrusting tap water were significantly lower (P<0.05) for those whose primary source of drinking water is the public supply (municipal) (OR=0.07, 95% CI=0.01, 0.63) and for those with decreased water access (OR=0.56, 95% CI=0.48, 0.66). There were no differences (n=55, P>0.05) in TWI (2,678±1,139 mL), PWI (1,357±971), or 24-h U_{Osm} (460±234 $mosm \cdot kg^{-1}$). Tap water safety perceptions did not significantly explain variance in PWI or 24-h U_{Osm} (P > 0.05). In conclusion, Latinx mistrust in tap water safety is prevalent. Mistrust appears to be influenced by organoleptic perceptions and to lead to reliance on alternatives to the home drinking water system. Perceptions of tap water safety do not appear to be related to PWI, TWI, or hydration status in Latinx adults.

To Grammy,

I wouldn’t have been able to survive the past four years without our phone calls.

I’m glad your arms are long enough to send hugs from across the country.

Thank you for the endless love and support. I love you.

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CHAPTER 1

INTRODUCTION

Underhydration, dehydration, and low water intake are consistently associated with adverse health outcomes. The National Academy of Medicine (NAM) has linked dehydration to numerous health outcomes, including cardiovascular dysfunction, urinary tract infections, several chronic diseases, and death (National Academy of Medicine, 2005). Low water intake has been associated with chronic kidney disease and diabetes (Clark et al., 2016; Enhorning et al., 2010; Sontrop et al., 2013), while increased water intake has been associated with positive health outcomes, including augmented cognitive performance in children (Fadda et al., 2012), less frequent urinary tract infections (Hooton et al., 2018), and enhanced glucose regulation (Enhorning et al., 2017). The NAM recommends adult men and women in the United States (US) to consume 3.7 L and 2.7 L per day, respectively, to maintain euhydration (National Academy of Medicine, 2005). Adherence to NAM total water intake (TWI) recommendations has been low in recent decades, ranging from 17.4 – 59.4% in adults > 18 y from 2005 to 2016 (Drewnowski et al., 2013; Vieux et al., 2020).

TWI has been consistently lower in Latinx adults compared to non-Hispanic (NH) white adults (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018). Across 2009 – 2012 specifically, average TWI was significantly lower among Hispanic than NH white adults by 341 mL (Brooks et al., 2017). Accordingly, Hispanic adults were 1.42 times more likely to be inadequately hydrated (spot urine osmolality > 800 $mmol \cdot kg^{-1}$) compared to NH white adults (Brooks et al., 2017). Interestingly the odds of inadequate hydration were slightly lower for Hispanic adults who consumed any tap water (odds ratio [OR] = 1.37; 95% CI = 1.18, 1.59) (Brooks et al., 2017). For the entire sample, 29.5% of individuals were inadequately hydrated, and the risk of inadequate hydration was lower for adults consuming any tap water (OR = 0.83; 95% CI = 0.70, 0.98) (Brooks et al., 2017). While overall PWI has mostly been similar between NH white and Latinx adults, sources of PWI have consistently been different. Specifically, NH white adults consume more tap water while Latinx adults consume more bottled water (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018).

Water losses occur continuously throughout the day, while fluid intake is episodic and deliberate. Voluntary dehydration can occur when individuals delay compensating for water losses despite access to water (Greenleaf & Sargent, 1965). While voluntary dehydration has been described in relation to stressors that accentuate water losses (e.g., physical activity and environmental heat stress), it is evident from NHANES data that a similar phenomenon occurs in the absence of stressors or water deficits that allows for underhydration. The decision to drink water is complex and is influenced by a myriad of factors including context (Zoellner et al., 2012), environment (Sebastian et al., 2011; Zoellner et al., 2012), eating behaviors (Zoellner et al., 2012), geography (Goodman et al., 2013), and beverage attributes (Block et al., 2013; Zoellner et al., 2012).

Plain water preferences, specifically, appear to be related, in part, to perceptions of tap water safety as Latinx adults are significantly more likely to perceive their tap water as unsafe compared to NH white adults. Although recent investigations have not consistently or comprehensively evaluated the same factors perceptions appear to be influenced by geography, household and neighborhood characteristics, demographics, prior experiences, organoleptic (sensory) perceptions and availability and sources of information. Existing interventions designed to improve TWI primarily focus on improving access to water and/or educating individuals on the importance of hydration. However, this may not be sufficient in Latinx populations where water is not trusted. Future work should comprehensively assess these factors in Latinx samples and include validated plain water intake, TWI, and hydration status measures. A greater understanding of these relationships could inform interventions to improve TWI and hydration status in Latinx adults.

Therefore, the **purpose** of this exploratory cross-sectional investigation is to evaluate associations between tap water perceptions, water consumption behaviors, and hydration status in Latinx adults. Our **objective** is to identify perceptual determinants that explain the associations between tap water avoidance and PWI and hydration status in Latinx adults (18 – 65 y). We will accomplish our objective through the following aims:

Aim 1: Characterize the degree to which perceptions, knowledge, behaviors, and experiences related to drinking water uniquely predict the perception that tap water is not safe in Latinx adults. Participants will complete an Adapted Survey of Water Issues in Arizona and household water security experience-based scales developed for low-income peri-urban communities on the US-Mexico border. Demographics, prior experiences with poor tap water quality, current water insecurity, organoleptic (sensory) perceptions (individual-level factors), availability and sources of information, and household and neighborhood characteristics (community-level factors) will be included as predictors of tap water safety perception in a binary logistic regression analysis.

Aim 2: Evaluate household income, education level, and US nativity as potential moderators of the associations between predictors and perceptions of tap water safety. Moderation effects will be evaluated through interaction terms in the binary logistic regression model.

Aim 3: Evaluate the influence of tap water safety perceptions on PWI and 24-h hydration status, after adjustment for predictors of tap water safety perceptions, in a sub-sample of Latinx adults. Participants will complete three 24-h dietary recalls through the validated Automated Self-Administered 24-h Dietary Assessment Tool (Subar et al., 2020) and collect one 24-h urine sample. PWI will be derived from the average consumption across the three recalls. Hydration status will be assessed through 24-h urine osmolality. Hierarchical linear regression will be utilized to evaluate the residual variance in tap water safety perceptions on PWI and 24-h urine osmolality.

CHAPTER 2

TAP WATER CONSUMPTION AND PERCEPTIONS IN UNITED STATES LATINX ADULTS

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Abstract

Insufficient water intake is associated with adverse health outcomes, including chronic disease prevalence and mortality. Adherence to National Academy of Medicine total water intake (TWI) recommendations has been low in recent decades, and TWI has been consistently lower in Latinx adults compared to non-Hispanic (NH) white adults. While overall plain water intake is similar between Latinx and NH white adults, Latinx adults consistently consume significantly more bottled water and less tap water. The purpose of this review is to identify factors that may contribute to low water intake and low tap water intake, particularly in Latinx adults. The decision to drink water is complex and is influenced by a myriad of factors including context, environment, eating behaviors, geography, and beverage attributes. Plain water preferences appear to be related, in part, to perceptions of tap water safety as Latinx adults are significantly more likely to perceive their tap water as unsafe compared to NH white adults. Although recent investigations have not consistently or comprehensively evaluated the same factors, we have compiled their findings to describe the complex, interrelated determinants of tap water safety perceptions in Latinx adults. The present review proposes that perceptions are influenced by water insecurity, demographics, prior experiences, organoleptic (sensory) perceptions and availability and sources of information. Existing interventions designed to improve TWI primarily focus on improving access to water and/or educating individuals on the importance of hydration. However, this may not be sufficient in Latinx populations where water is not trusted. Future work should comprehensively assess these factors in Latinx samples and include validated plain water intake, TWI, and hydration status measures. A greater understanding of these relationships could inform interventions to improve TWI and hydration status in Latinx adults.

Keywords

hydration; total water intake; plain water intake; tap water; bottled water; Latino adults; Hispanic adults

Hydration and Water Intake

Hydration and Health

The National Academy of Medicine (NAM) recommends adult men and women in the United States (US) to consume 3.7 L and 2.7 L per day, respectively, to maintain euhydration (National Academy of Medicine, 2005). These recommendations for total water intake (TWI) can be met through plain water intake (PWI; water consumed via tap water and bottled water) as well as through water consumed via beverages and foods (National Academy of Medicine, 2005). Water needs can vary between and within individuals due to factors such as physical activity level, environmental conditions (i.e., ambient temperature, humidity), diet (i.e., solute load, macronutrient composition), and body composition (National Academy of Medicine, 2005). Insufficient water intake can lead to underhydration (i.e., stimulation of water conservation mechanisms without changes in total body water) and dehydration (i.e., stimulation of water conservation mechanisms with deficits in total body water) (Kavouras, 2019).

Underhydration, dehydration, and low water intake are consistently associated with adverse health outcomes. Recent cross-sectional analysis of the nationally representative National Health and Nutrition Examination Survey (NHANES) reported a significantly greater prevalence of obesity, high waist circumference, insulin resistance, low high-density lipoprotein, and metabolic syndrome in underhydrated compared to hydrated adults (51-70 y). The prevalence of having no chronic health conditions in this sample was significantly lower. In contrast, chronic disease mortality was estimated to be 4.2 times greater in underhydrated adults than in euhydrated adults (Stookey et al., 2020). The NAM has similarly linked dehydration to numerous health outcomes, including cardiovascular dysfunction, urinary tract infections, several chronic diseases, and death (National Academy of Medicine, 2005). Moreover, low water intake has been associated with chronic kidney disease and diabetes (Clark et al., 2016; Enhorning et al., 2010; Sontrop et al., 2013), while increased water intake has been associated with positive health outcomes, including augmented cognitive performance in children (Fadda et al., 2012), less frequent urinary tract infections (Hooton et al., 2018), and enhanced glucose regulation (Enhorning et al., 2017).

Population-level TWI and PWI in adults ≥ 20 y have been estimated from numerous recent NHANES cohorts: 2005 – 2010 cycles (n = 15,702) (Drewnowski et al., 2013), 2009 – 2012 cycles (n = 8,258) (Brooks et al., 2017), 2011 – 2014 cycles (n = 9,666) (Rosinger et al., 2018), and 2011 – 2016 NHANES cycles (n = 15,263) (Vieux et al., 2020). All water intake values were estimated from 24-h dietary recall interviews and data are reported as mean ± standard error (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018). The United States Department of Agriculture's Automated Multiple-Pass Method was utilized to conduct 24-h dietary recalls, which is a validated method for energy and nutrient intake (Blanton et al., 2006). Although this method has not been validated for TWI or PWI, it includes many mechanisms to help with accuracy of reporting (e.g., provides visual cues for estimating food and beverage amounts and reminds interviewers about missing data (Raper et al., 2004)). Average TWI and adherence to NAM adequate intake recommendations from 2005 to 2010 (Drewnowski et al., 2013) and 2011 to 2016 (Vieux et al., 2020) are presented in Table 2-1. Average TWI was similar for adults > 70 y across both time periods but appeared to decrease for younger adults in more recent years. Adherence to NAM recommendations was low across all age groups, with the lowest prevalence in those > 70 y. Moreover, adherence was more prevalent in women than men across all age groups.

Table 2-1. Total water intake and percentage of individuals meeting NAM adequate intake recommendations for water by age group from recent NHANES cohorts.

NHANES Years	**Measures**	**Age Groups**			
2005–2010 (Drewnowski et al., 2013)		20–50 y (*n* = 8,389)	51–70 y (*n* = 4,737)	≥ 71 y (*n* = 2,576)	
	Total water intake (mL)[1,2]	3,560 ± 30	3,229 ± 27	2,251 ± 17	
	Men meeting NAM recommendations (%)	57.3	40.9	5.3	
	Women meeting NAM recommendations (%)	59.4	55.1	17.4	
2011–2016 (Vieux et al., 2020)		19–30 y (*n* = 3,248)	31–50 y (*n* = 5,071)	51–70 y (*n* = 4,873)	> 70 y (*n* = 2,071)
	Total water intake (mL)[1,2]	2,936 ± 52	3,166 ± 36	2,997 ± 43	2,355 ± 28
	Men meeting NAM recommendations (%)[3]	~36.0	~41.0	~32.0	~5.0

Women meeting NAM recommendations (%)[3]	~44.0	~56.0	~53.0	~24.0

Abbreviations: NAM, National Academy of Medicine; NHANES, National Health and Nutrition Examination Survey. [1] Data are presented as mean ± standard error; [2] Total water intake refers to the total amount of water consumed via plain water, beverages, and water of solid food; [3] Values were determined from visual inspection of a figure

Hydration Status and TWI in Latinx Adults

TWI has been consistently lower in Latinx adults compared to non-Hispanic (NH) white adults (Table 2-2) (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018). Across 2009 – 2012 specifically, average TWI was significantly lower among Hispanic than NH white adults by 341 mL (95% CI = -472, -209 mL) (Brooks et al., 2017). Accordingly, Hispanic adults were 1.42 times (95% CI = 1.21, 1.67) more likely to be inadequately hydrated (spot urine osmolality > 800 $mmol \cdot kg^{-1}$) compared to NH white adults (Brooks et al., 2017). Interestingly the odds of inadequate hydration were slightly lower for Hispanic adults who consumed any tap water (odds ratio [OR] = 1.37; 95% CI = 1.18, 1.59) (Brooks et al., 2017). For the entire sample, 29.5% of individuals were inadequately hydrated, and the risk of inadequate hydration was lower for adults consuming any tap water (OR = 0.83; 95% CI = 0.70, 0.98).

While there is no gold standard marker of hydration status, it has been recommended to incorporate multiple markers to determine a more accurate assessment (Armstrong, 2007). Adults 51 – 70 y from the same NHANES cohorts (2009 – 2012) were classified as underhydrated based on serum sodium > 145 $mmol \cdot L^{-1}$, spot urine volume < 50 mL, and/or spot urine osmolality ≥ 500 $mmol \cdot kg^{-1}$ (Stookey et al., 2020). Utilization of these markers estimated 69.4% of the sample was underhydrated (Stookey et al., 2020). Moreover, a urine osmolality cut-off of 500 $mmol \cdot kg^{-1}$ may be more appropriate than a cut-off of 800 $mmol \cdot kg^{-1}$, as antidiuretic mechanisms have been observed to be activated via elevated plasma osmolality when urine osmolality is 500 – 800 $mmol \cdot kg^{-1}$ (Perrier et al., 2015). Therefore, discrepancies in risk for underhydration and associated deleterious health outcomes may be greater than currently reported.

Table 2-2. Total water intake and plain water intake by race/Hispanic origin from recent NHANES cohorts[1].

NHANES Years	Race/Hispanic Origin	Tap Water Intake (mL)	Bottled Water Intake (mL)	Plain Water Intake (mL)[2]	Total Water Intake (mL)[3]
2005 – 2010 (Drewnowski et al., 2013)	Non-Hispanic White (n = 7,610)	703 ± 17	437 ± 12	1,134 ± 19	3,439 ± 24
	Mexican American (n = 2,899)	383 ± 22*	729 ± 33*	1,095 ± 25	3,037 ± 36*
	'Other' Hispanic (n = 1,322)	455 ± 35*	758 ± 48*	1,208 ± 41	3,156 ± 44*
2009 – 2012 (Brooks et al., 2017)	Non-Hispanic White (n = 3,541)	828 ± 47[4]	379 ± 24[4]	1,183 ± 47[4]	3,341 ± 53
	Hispanic (n = 2,048)	544 ± 47[4]*	710 ± 47[4]*	1,207 ± 47[4]	3,005 ± 57*
2011 – 2014 (Rosinger et al., 2018)	Non-Hispanic White (n = 5,277)	813 ± 38	345 ± 19	1,158 ± 34	NR
	Hispanic (n = 3,095)	550 ± 40*	731 ± 39*	1,281 ± 48*	NR

Abbreviations: NHANES, National Health and Nutrition Examination Survey; NR, not reported
[1]Data are presented as mean ± standard error; [2]Plain water intake refers to the total amount of water consumed via tap water and bottled water; [3]Total water intake refers to the total amount of water consumed via plain water, beverages, and water of solid food; [4]Values were converted from # 8-fl oz servings to mL (29.57 mL•fl oz^{-1})
*Significantly different from non-Hispanic white adults (*P* < 0.05)

Overall PWI has mostly been similar between NH white and Latinx adults (Table 2-2). While PWI was significantly greater in Hispanic adults than NH white adults from 2011 – 2014 (Rosinger et al., 2018), 120 mL (~ 4 oz) of water is not a clinically meaningful difference. Interestingly, sources of PWI have consistently been different between Latinx and NH white adults. Among all adults from 2005 – 2010, 56.0% of PWI came from tap water (Drewnowski et al., 2013). NH white adults consumed the most tap water and least bottled water compared to Mexican American and Other Hispanic adults who consumed the least tap water and most bottled water (Drewnowski et al., 2013). Similarly, from 2009 – 2012, Hispanic adults significantly consumed 1.38 fewer servings of tap water (-326 mL; 95% CI = -1.86, -0.54 servings) compared to NH white adults (Brooks et al., 2017). Conversely, Hispanic adults significantly consumed 1.29 more servings of bottled water (306 mL; 95% CI = 0.83, 1.75) compared to NH white adults (Brooks et al., 2017). Across 2011 – 2014, tap water comprised 62.2% of PWI for all adults

(Rosinger et al., 2018). Compared to NH white adults, Hispanic adults were significantly less likely to consume tap water (OR = 0.55, 95% CI = 0.45, 0.66) and significantly more likely to consume bottled water (OR = 2.37, 95% CI = 1.79, 2.69) (Rosinger et al., 2018). Furthermore, compared to NH white adults, tap water intake was significantly lower (B = -180 ± 64 mL; $P < 0.05$) and bottled water intake was significantly greater (B = 243 ± 42 mL; $P < 0.01$) in Hispanic adults (Rosinger et al., 2018). While overall PWI is similar, Latinx adults are particularly averse to tap water.

The purpose of this review is to identify factors that may contribute to low water intake and low tap water intake, particularly in Latinx adults. The PubMed database was utilized to search for potential research articles related to the current topics: 1) voluntary low total water intake and 2) tap water safety perceptions in US Latinx adults. Articles were included for voluntary low total water intake if they evaluate physiological, social, and/or behavioral cues related to water and/or beverage consumption. Articles that identify characteristics of individuals who consume low volumes of water were also included. Exercise- and physical activity-related articles were excluded. Quantitative articles were included for tap water safety perceptions in US Latinx adults if their primary outcome is drinking water perceptions. Articles were excluded if the sample did not include adults ≥ 18 y, if the study was conducted outside of the United States, or if the sample did not include Latinx individuals. Additional articles were included to provide context to these findings if the sample includes US Latinx individuals and/or the article focused on a specific aspect of water perceptions (e.g., organoleptic perceptions).

Voluntary Low Total Water Intake

Water losses occur continuously throughout the day, while fluid intake is episodic and deliberate. Voluntary dehydration can occur when individuals delay compensating for water losses despite access to water (Greenleaf & Sargent, 1965). While voluntary dehydration has been described in relation to stressors that accentuate water losses (e.g., physical activity and environmental heat stress), it is evident from NHANES data that a similar phenomenon occurs in the absence of stressors or water deficits that allows for underhydration.

Thirst has been believed to be a sufficient stimulus to maintain water balance via fluid intake in daily life (Greenleaf, 1992). However, vasopressin secretion is more sensitive to changes in plasma osmolality than thirst activation. Accordingly, vasopressin will induce water conservation mechanisms (e.g., decreased urine output and increased urine concentration) to regulate plasma osmolality before thirst is needed to prompt water consumption in underhydrated individuals (Robertson, 2013). Furthermore, thirst may not lead to adequate fluid replacement. Swallowing while consuming fluids can activate oropharyngeal receptors and subsequently terminate drinking prematurely via inhibition of vasopressin secretion and thirst despite elevated plasma osmolality (Figaro & Mack, 1997).

Plain water intake

The decision to drink is influenced by context and environment. Regarding beverage consumption in general, rural south-west Virginia adults believed their behaviors were impacted by time of day, food consumption (e.g., beverage choice depends on food choice), location (e.g., greater likelihood of choosing a sugar-sweetened beverage when going out to eat), time of week (e.g., drinking behaviors are different on weekends compared to weekdays), availability or convenience of a beverage, and the behaviors of other members living in their household (Zoellner et al., 2012). Similarly, the ability of university students to acutely (daily across the upcoming week) choose plain water over sugar-sweetened beverages appears to be predicted by behavioral confidence (i.e., the ability to choose plain water while eating out, while watching TV or sports, and without missing caffeine or carbonation) and changes in the physical environment (i.e., the ability to remove sugar-sweetened beverages from their physical environment, choose water when around someone consuming sugar-sweetened beverages, and choose to purchase water instead of sugar-sweetened beverages) (Sharma et al., 2017). Regarding water consumption specifically, more than two thirds of plain water is consumed at home (Sebastian et al., 2011). Experiments with vagotomized rats suggested that eating may activate physiological signals for thirst and drinking (Kraly, 2004). However, previous NHANES data has shown that 73.0% of water was consumed outside of meals, with the least amount consumed during breakfast (6.0%) (Sebastian et al., 2011). Moreover, more than half of plain water was consumed independently (with no other food or beverages) (Sebastian et al., 2011). Interestingly, worksite beverage environment (i.e., quantity of water coolers, water fountains, vending machines, and regular soda slots) has not been observed to impact overweight or obese employees' water consumption (Davy et al., 2014).

Additional factors likely influence the decision to drink plain water, such as age, geographic location, and health-related behaviors and attitudes. Specifically, low plain water intake is more likely in adults ≥ 55 y, adults living in the US Northeast, and adults who are not trying to change their weight (compared to adults trying to lose weight) (Goodman et al., 2013). Low plain water intake has also been associated with unhealthful behaviors such as moderate physical activity < 150 $min \cdot wk^{-1}$ (Goodman et al., 2013; Sebastian et al., 2011) and fruit or vegetable consumption ≤ 1 $c \cdot d^{-1}$ (Goodman et al., 2013). Similarly, consumption of any plain water was observed in US adults with healthful eating patterns (i.e., greater consumption of fruits, vegetables, and low- and medium-fat dairy products) whereas consumption of no water was observed in adults with unhealthful eating patterns (i.e., high consumption of desserts, high-fat meats, non-caloric and caloric beverages, high-fat dairy, salty snacks, and fast food) (Popkin et al., 2005).

Finally, the decision to drink plain water is related to beverage attributes, preferences, and habits. Perceived health outcomes were identified as both positive (e.g., helps body, flushes kidneys, keeps you hydrated, refreshing, and helps metabolism) and negative (e.g., health complications associated with drinking too much water and perceptions that cancer is related to water intake) attributes of water (Zoellner et al., 2012). Concern was expressed regarding chemicals or contamination of water sources, particularly due to fear from health department letters (Zoellner et al., 2012). Taste and cost can similarly be both positive and negative beverage attribute for water (Zoellner et al., 2012). Taste as a negative attribute may be related to municipal water treatment (e.g., city water was described as bleach water) while cost as a negative attribute was commonly described in reference to bottled water (Zoellner et al., 2012). Taste may be the most influential factor as some have expressed that they would only choose a cheaper beverage if taste was not compromised. Others described their preference for sugar-sweetened beverages as an addiction, which made taste more important than health risk assessment (Block et al., 2013). Additional preferences may serve as barriers to increasing water intake including water temperature and availability of other options, such as sugar-sweetened beverages (Zoellner et al., 2012).

Tap Water Safety Perceptions in US Latinx Adults

Voluntary low TWI is exacerbated in Latinx adults and appears to be driven by tap water avoidance. There are many factors that could influence PWI source preferences (e.g., tap vs. bottled). Rural south-west Virginia adults identified availability of their preferred source of water as a barrier to increasing water intake (Zoellner et al., 2012). Contrarily, water intake was supported by availability and convenience of water (e.g., "Because it's handy. I always have at least one case of bottled water in the house.") (Zoellner et al., 2012). During focus group interviews, participants living in an under-resourced rural area in New Mexico reported that convenience was an important influence on PWI source choices, independent of access to safe tap water (Hess et al., 2019). Specifically, bottled water was described to be easily accessible and transportable, and it can be put in the freezer to accommodate palatability preferences (Hess et al., 2019). In a sample of parents of children in an urban/suburban pediatric emergency department, the odds of primarily relying on bottled water were significantly greater with beliefs that bottled water is more convenient (OR = 1.72, 95% CI = 1.16 – 2.54) than tap water (Gorelick et al., 2011). Furthermore, Latino parents (16.0%) were more likely to endorse a higher level of agreement with the statement "Bottled water is more convenient than tap water" compared to non-Latino white parents (10.6%) ($P < 0.001$) (Gorelick et al., 2011).

While bottled water is a costly alternative to tap water, income level has not influenced bottled water preference. Bottled water sales have increased in recent years by 34.40% from 2006-2015 (Rummo et al., 2020) and an additional 7.00% from 2016-2017 (Rodwan, 2018). Consequently, bottled water has become the most consumed packaged beverage in the US, with bottled water revenues reaching $18.5 billion in 2017 (Rodwan, 2018). Based on the 2015 national average price for bottled water ($0.32/L) and an estimated minimum amount of drinking and cooking water needed for survival (15 L/person/day), the average sample household relying entirely on bottled water (2.72 persons, $50,195 income) was estimated to spend $4,757 or 9.50% of their income on bottled water (Javidi & Pierce, 2018). Despite these costs, Latinx Milwaukee parents have reported bottled water expenditure comprising up to 12.00% of their household income (median spending: 1.00% of household income) (Gorelick et al., 2011). Moreover, 14.00% of Latinx parents reported having to sacrifice other purchases to afford bottled water (Gorelick et al., 2011). Greater reliance on bottled water despite added economic burden may be related to perceptions of unsafe tap water.

Racial and ethnic differences in PWI choices are widely believed to be related to tap water safety perceptions and beliefs (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018). While perceptions were not evaluated via NHANES, there is considerable evidence suggesting the Latinx community has a greater mistrust of tap water quality and safety. Perceptions of tap water safety in US adults have been evaluated via cross-sectional analyses of the 2010 HealthStyles Survey (HSS, n= 3,787) (Onufrak et al., 2012) and the nationally representative American Housing Survey (AHS) in 2013 (n = 126,424) (Pierce & Gonzalez, 2017) and 2015 (n = 39,085) (Javidi & Pierce, 2018). Perceptions of parents of children and/or adolescents in various healthcare settings have also been evaluated cross-sectionally in smaller, regional investigations (Table 2-3). Prevalence of mistrust was similar across samples, representing 13.0% of the HSS (Onufrak et al., 2012), 9.2% of the 2013 AHS (Pierce & Gonzalez, 2017), and 7.3% of the 2015 AHS (Javidi & Pierce, 2018). In both AHS samples, the prevalence of mistrust was greatest among Hispanic households (2013: 14.7%, 2015: 16.4%) and lowest among NH white households (2013: 5.2%, 2015: 5.1%) (Javidi & Pierce, 2018; Pierce & Gonzalez, 2017). 2015 Hispanic households were significantly less likely to trust the safety of their tap water compared to NH white households (OR = 0.406, S.E. = 0.0310, $P < 0.01$) (Javidi & Pierce, 2018). However, prevalence was most pronounced in NH black adults (19.9%) in the HSS sample compared to 16.0% of Hispanic parents and 10.8% of NH white parents ($P < 0.001$) (Onufrak et al., 2012). Perceptions were also assessed in a sample of US Hispanic adults (n = 1,000) via the 2015 *Estilos* survey. Prevalence of mistrust was greater in this sample, in which 33.8 ± 2.6% of respondents did not believe their home tap water was safe to drink and 40.6 ±

2.8% did not believe their community tap water was safe to drink (Park et al., 2019). Among HSS Hispanic adults, the odds of low PWI (≤ 1 time/d) were significantly greater for those who did not trust tap water safety compared to those who did trust the safety or felt neutral about it (OR = 1.9, 95% CI = 1.1 – 3.5) (Onufrak et al., 2012). The odds of low PWI were not different between perceptions of bottled water safety among Hispanic adults (Onufrak et al., 2012). PWI in the month prior to the *Estilos* survey was not related to any of the drinking water perceptions in Hispanic adults (Park et al., 2019).

Table 2-3. Investigational approaches to measuring plain water intake and perceptions.

Author, Year	n	Sample	Plain Water Intake Measurement	Perception Measurement
Park et al., 2019	1,000	US Hispanic adults (≥18 y)	***Estilos* Survey Fall 2015**: 1. During the past month, how often did you drink a glass or bottle of plain water? Include tap, water fountain, bottled, and unflavored sparkling water Response options: none, 1 – 6 times/wk, 1 time/d, 2 times/d, 3 times/d, ≥ 4 times/d	***Estilos* Survey Fall 2015**: 1. My tap water is safe to drink 2. Community tap water is safe to drink 3. Bottled water is safer than tap water 4. I would buy less bottled water if my tap water was safe Response options: strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, strongly agree
Javidi & Pierce, 2018	39,085	Sample of households nationally representative of US housing stock	**2015 American Housing Survey**: 1. Where do you get your water for drinking? **asked only if answered no to "In your opinion, is the water from this source for cooking and drinking?"* Response options: unfiltered tap water, filtered tap water, commercial bottled water, other	**2015 American Housing Survey**: 1. In your opinion, is the water from this source [housing unit] safe for cooking and drinking? Response options: Self-reported response recoded as binary variable – yes or no
Pierce & Gonzalez, 2017	126,424	Sample of households nationally representative of US housing stock	-	**2013 American Housing Survey**: 1. In your opinion, is the water from this source [housing unit] safe for cooking and drinking? Response option: Self-reported response recoded as binary variable – yes or no
van Erp et al., 2014	306	Adults (≥ 18 y) in Santa Clara County, California	**2011 Santa Clara County Dietary Practices Survey**:	**2011 Santa Clara County Dietary Practices Survey**: 1.Which do you think is safer, bottled water or Santa Clara

			1. Report the type of water consumed most often on a typical day Response options: format is not clear – responses categorized as primarily drinks tap water (unfiltered tap or filtered tap) or primarily drinks bottled plain water or seltzer (soda) water	County tap water or are they about the same? Response options: format is not clear – responses categorized as thinks bottled water is safer or does not think bottled water is safer
Onufrak et al., 2012	3,787	US respondents to ConsumerStyles survey (consumer mail survey) (≥ 18 y)	**2010 HealthStyles Survey**: 1. On a typical day, how many times do you drink a glass or bottle of plain water? count tap, bottled, and unflavored sparkling water. Response options: none, 1 time/d, 2 times/d, 3 times/d, 4 times/d, ≥ 5 times/d *Low intake = ≤ 1 time/d*	**2010 HealthStyles Survey**: 1. My local tap water is safe to drink 2. Bottled water is safer than tap water Response options: strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, strongly agree
Huerta-Saenz et al., 2012	208	Caretakers of children and adolescents in an academic community hospital in Pennsylvania	**14-Question Survey**[1,2,4]: 1. Preferred type of drinking water 2. Preferred type of water used for cooking Response options: filtered tap water, unfiltered tap water, bottled water, do not drink water	**14-Question Survey**[1,2,4]: 1. Taste of tap (filtered and unfiltered) and bottled water 2. Safety of tap (filtered and unfiltered) and bottled water 3. Clarity of tap (filtered and unfiltered) and bottled water 4. Purity of tap (filtered and unfiltered) and bottled water Response options: Rate items on a 5-pt Likert scale [5 highest]
Gorelick et al., 2011	632	Parents of children treated at an urban/suburban emergency department in Milwaukee, Wisconsin	-	**Questionnaire**[1,3,4]: (*11 belief statements, 4 statements about prior water use experiences, 7 statements about sources of information on tap and bottled water*) 1. Bottled water is cleaner than tap water 2. Bottled water is safer than tap water 3. Bottled water tastes better than tap water 4. Bottled water is more convenient than tap water 5. Bottled water has minerals and nutrients that tap water does not 6. My family may be protected from illness by choosing the best kind of drinking water Response options:

				Agreement for each statement rated on 5-point Likert scale [1, strongly agree; 5, strongly disagree]
Hobson et al., 2007	216	Parents of children attending an urban public health clinic in Utah	**15-Question Survey**[1,4]: 1. Do you drink tap water at home? 2. Do you give tap water at home to your children? 3. If your children drink tap at home, is it filtered? 4. Do your children drink bottled water at home? Response options: always, sometimes, never 5. What type of filter do you use? Response options: Water pitcher, faucet mounted, under sink [reverse osmosis or distillation], I don't know	**15-Question Survey**[1,4]: 1. If your child does not drink tap water at home, why not? Response options: I don't know how it tastes, I think tap water will make me sick, I was told not to drink tap, other

[1]Survey/questionnaire created by investigators; [2]Survey/questionnaire pilot-tested by investigators; [3]Survey/questionnaire created based on semi-structured interview; [4]Only some questions/statements from survey/questionnaire included in publication

Some studies have also assessed whether participants perceived bottled water to be safer than tap water. This belief was reported by 26.4% of HSS adults (Onufrak et al., 2012) and 26.0% of a sample of California adults (n = 306) via the 2011 Santa Clara County Dietary Practices Survey (SCCDPS) (van Erp et al., 2014). Prevalence was much higher among Hispanic respondents to the *Estilos* survey (64.7 $\pm$ 2.8%) (Park et al., 2019). Furthermore, 71.0% of the SCCDPS sample primarily consumed tap water (filtered or unfiltered) (van Erp et al., 2014). Accordingly, those who believed bottled water is safer were less likely to primarily consume tap water (OR = 0.28, 95% CI = 0.12 – 0.62, P = 0.002) (van Erp et al., 2014). Hispanic adults were significantly less likely to primarily consume tap water compared to NH white adults (OR = 0.33, 95% CI = 0.11 – 0.99, P = 0.48), only when the perception of safety was included in the model (van Erp et al., 2014). Additionally, adolescents and caretakers of children in academic community hospitals in Pennsylvania rated the safety of unfiltered tap water, filtered tap water, and bottled water as 3.0, 3.8, and 4.4 out of 5.0, respectively (P <0.01), with a higher number indicating a more positive perception of quality (Huerta-Saenz et al., 2012). Caretakers reported that infant formula was prepared exclusively with tap water (30.0%), exclusively with bottled water (51.0%), or with both (19.0%) (Huerta-Saenz et al., 2012). Among caretakers using tap water for formula preparation, boiled tap water was most prevalent (54.0%) compared to unfiltered tap water (39.0%) and filtered water (7.0%) (Huerta-Saenz et al., 2012). This suggests that most caretakers using tap water did not trust the safety of the tap water.

Findings from race/ethnicity comparisons are limited and inconsistent. The odds of thinking bottled water is safer than tap water were not significantly different between Hispanic and NH white adults (OR = 0.50, 95% CI = 0.11 – 2.27, $P = 0.366$) in the SCCDPS (van Erp et al., 2014). However, the prevalence in the HSS was greatest in NH black adults (40.00%) compared to 34.1% Hispanic parents and 21.8% of non-Hispanic white parents ($P < 0.001$) (Onufrak et al., 2012). This was also found among parents of children in a US urban/suburban pediatric emergency department (n = 632), in which Latino parents were more likely to endorse a higher level of agreement with the statement “bottled water is safer than tap water” (20.00% vs. 9.3%, $P < 0.001$) (Gorelick et al., 2011). In this sample, 44.8% of gave their children primarily or exclusively bottled water (Gorelick et al., 2011). Prevalence was significantly greater in Latino parents (~ 45%) than non-Latino white parents (~ 35%) ($P < 0.001$) (Gorelick et al., 2011). Those who believed bottled water is safer than tap water were significantly more likely to primarily give their children bottled water (OR = 2.44, 95% CI = 1.44 – 4.22) (Gorelick et al., 2011). Similarly, among parents of children in an urban public health center in Utah, 30.1% did not drink any tap water, and 41.20% reported never giving tap water to their child(ren) (Hobson et al., 2007). Of those children who did not drink tap, 59.6% exclusively consumed bottled water, while 35.6% exclusively consumed filtered water (Hobson et al., 2007). The odds of Latino parents consuming any tap water (OR = 0.26, 95% CI = 0.10 – 0.67) or giving their child(ren) tap water (OR = 0.32, 95% CI = 0.15 – 0.70) were significantly lower compared to non-Latino parents (Hobson et al., 2007).

While there are limited and inconsistent findings regarding PWI and perceptions in Latinx adults, PWI source choices (tap vs. bottled) do appear to be related to perceptions of tap and bottled water safety. These behaviors may also translate into PWI sources for children and adolescents. However, PWI has only been measured through one unvalidated survey question about the frequency of consumption (Onufrak et al., 2012; Park et al., 2019), through a question regarding the participant's primary source of PWI (Hobson et al., 2007; Huerta-Saenz et al., 2012; Javidi & Pierce, 2018; van Erp et al., 2014), or not at all (Gorelick et al., 2011; Pierce & Gonzalez, 2017) (Table 2-3). Future work is needed that evaluates PWI and hydration status using validated methods as well as perceptions to provide more insight into these associations. Among these investigations that have quantitatively assessed tap water safety perceptions, predictors of perceptions have not consistently or comprehensively been evaluated (Table 2-4). We have compiled their findings to describe the complex, interrelated determinants of tap water safety perceptions in Latinx adults in the United States. Perceptions of unsafe tap water can occur in both the presence and absence of water insecurity. The predictors discussed in the subsections after "*Water insecurity"* are described in a context of water security.

Table 2-4. Predictors included in investigations evaluating perceptions of tap water safety in US Latinx adults.

⊕ Included in investigation	Park et al., 2019	Javidi & Pierce, 2018	Pierce & Gonzalez, 2017 (Pierce & Gonzalez, 2017)	van Erp et al., 2014	Onufrak et al., 2012	Huerta-Saenz et al., 2012	Gorelick et al., 2011	Hobson et al., 2007
Geographic region	⊕				⊕			
Household and neighborhood characteristics		⊕	⊕					
Household income	⊕		⊕	⊕	⊕		⊕	⊕
Education level	⊕	⊕	⊕	⊕	⊕		⊕	
Sex	⊕	⊕		⊕	⊕			
Age	⊕			⊕	⊕	⊕		
Race/Ethnicity		⊕	⊕	⊕	⊕	⊕	⊕	⊕
US nativity		⊕	⊕	⊕			⊕	
Had a bad experience with tap water							⊕	
Organoleptic (sensory) factors						⊕	⊕	
Sources of information about water							⊕	⊕

Water insecurity

Current water insecurity is likely to impact tap water perceptions. Water security is largely out of US citizens' hands, as much of the responsibility lies in the private and public provision and regulation of water (e.g., laws and regulations, water testing, water treatment, reporting, infrastructural maintenance, agricultural practices, etc.) (Balazs & Ray, 2014; Katie Meehan et al., 2020). Numerous factors, including historical planning processes, redlining, reduced enforcement of water regulations and standards, and repeat water violations contribute to a greater risk of water insecurity in minority and low-income communities (Balazs & Ray, 2014).

Conflicting results have been observed regarding the association between geographic region and perceptions. This could be related to both rural and urban areas posing risks for water insecurity. Residents in rural areas are more dependent on wells, which have greater risks of water shortages and contamination (Katie Meehan et al., 2020). On the other hand, 73.0% of households without piped water in the US (2013 – 2017) were located in urban areas. Moreover, individuals of color, with low-income, with > 30.0% of their income allocated to rent or mortgages or living in mobile homes, were more likely to not have access to piped water (K. Meehan et al., 2020). Prevalence of tap and bottled water trust were different between regions among the HSS survey sample (Onufrak et al., 2012) but not among the *Estilos* survey sample (Park et al., 2019) (Table 2-5). The *Estilos* survey Hispanic sample had lower prevalence of tap water safety trust and greater prevalence of beliefs that bottled water is safer than tap water in all regions compared to the HSS sample. While differences in perceptions were not observed in the *Estilos* survey, agreement with the statement "I would buy less bottled water if I knew my local tap water was safe" was greatest among Hispanic adults in the South (Park et al., 2019).

Table 2-5. Prevalence of agreement with perceptions by geographic region among survey samples.

Survey	Perception	Geographic Region								
		New England	Middle Atlantic	South Atlantic	East South Central	West South Central	East North Central	West North Central	Mountain	Pacific
HSS (Onufrak et al., 2012)	"My local tap water is safe to drink"*	77.4%	64.2%	66.8%	68.7%	59.0%	70.9%	77.3%	71.0%	65.6%

	"Bottled water is safer than tap water"*	35.1%	22.9%	27.1%	25.0%	34.6%	27.2%	13.4%	24.1%	30.5%
		Northeast		South			Midwest		West	
Estilos (Park et al., 2019)	"My tap water at home is safe to drink"[1]	35.7 ± 5.9%		42.3 ± 5.6%			29.7 ± 7.8%		40.9 ± 4.4%	
	"Bottled water is safer than tap water"[1]	62.9 ± 6.4%		61.2 ± 5.5%			61.8 ± 8.5%		69.2 ± 4.0%	
	"I would buy less bottled water if I knew my local tap water was safe"[1]*	63.0 ± 6.0%		74.9 ± 4.70%			59.7 ± 8.7%		67.2 ± 4.1%	

Abbreviations: HSS, HealthStyles Survey
[1]Data are presented as mean ± standard error
*Significantly different prevalence by geographic region ($P < 0.05$)

Influences of the built environment on tap water perceptions in the US have only been evaluated using the 2013 and 2015 AHS (Javidi & Pierce, 2018; Pierce & Gonzalez, 2017). Greater overall housing unit quality, as rated by survey interviewers, was associated with increased odds of trusting tap water safety (2013: OR = 1.20, $P \leq 0.01$; 2015: OR = 1.069, $P < 0.01$) (Javidi & Pierce, 2018; Pierce & Gonzalez, 2017). However, inconsistent associations have been observed with more specific indicators of housing unit quality. The odds of trusting tap water safety were significantly lower with living in a mobile home park (2013: OR = 0.64, $P \leq 0.01$; 2015: OR = 0.738, $P < 0.01$) and living in public housing (2013: not included in model; 2015 OR = 0.764, $P < 0.05$) (Javidi & Pierce, 2018; Pierce & Gonzalez, 2017). Both types of housing units are at greater risk for inadequate regulation of water systems. Furthermore, small, private water systems (i.e., serve < 15 households) are less regulated than public water systems and often source water from wells, which are prone to contamination (Javidi & Pierce, 2018; Pierce & Gonzalez, 2017). Surprisingly, households with small water systems were more likely to trust their tap water (OR = 1.30, $P \leq 0.01$) (Pierce & Gonzalez, 2017) in 2013, while perceptions did not differ between households with private wells or publicly regulated systems in 2015 (Javidi & Pierce, 2018). Housing unit age (2013 AHS) also did not impact tap water safety perceptions (Pierce & Gonzalez, 2017). Houses built after 1986 were proposed to have better water quality due to an amendment to the Safe Drinking Water Act that restricted the use of plumbing materials containing lead (Pierce & Gonzalez, 2017; United States Environmental Protection Agency). Finally, favorable perceptions of neighborhood quality were also associated with greater odds of trusting tap water safety (2013: OR = 1.14, $P \leq 0.01$; 2015 OR = 1.149, $P < 0.01$) (Javidi & Pierce, 2018; Pierce & Gonzalez, 2017). Satisfaction with neighborhood conditions as well as access to and quality of public services could translate into satisfaction with locally sourced tap water. Household income may also serve as an indicator of the household drinking water system and built environment, as income could determine the reliability of water utilities, quality of housing units, and quality of plumbing infrastructure (Pierce & Gonzalez, 2017).

Latinx individuals who do not trust their tap water safety may be more likely to seek alternatives. Modifications to the household water system can be implemented via home water treatment devices (i.e., carbon, fiber, reverse osmosis, neutralizers, chemical feed-pumps, disinfection and softeners, and pitcher water filters). Among US Hispanic adults who did not trust their tap water, only 1.9% drank unfiltered tap water, compared to 22.1% who consumed filtered tap water and 73.8% who consumed bottled water (Javidi & Pierce, 2018). The risk of relying on unfiltered tap water (RR = 0.213, SE = 0.0798, $P < 0.01$) or filtered tap water (RR = 0.651, SE = 0.104, $P < 0.01$) over bottled water were significantly lower in Hispanic households compared to NH white households (Javidi & Pierce, 2018). Among 2007 – 2010 NHANES cohorts, 33.1 ± 1.7% of adults utilized a home water treatment device (Rosinger et al., 2018). Devices were utilized by 38.9 ± 2.4% NH white adults, 11.5 ± 1.4% of NH black adults, and 18.9 ± 1.3% Hispanic adults ($P < 0.001$) (Rosinger et al., 2018). While perceptions were not measured, adults without water treatment devices were less likely to consume any plain water (OR = 0.60, 95% CI = 0.51, 0.71) or tap water (OR = 0.55, 95% CI = 0.47, 0.64) but more likely to consume bottled water (OR = 1.21, 95% CI = 1.01, 1.44) compared to adults with water treatment devices (Rosinger et al., 2018). After adjustment for the use of water treatment device, Hispanic adults were more likely to consume plain water (OR = 1.24, 95% CI = 1.03, 1.52) (Rosinger et al., 2018). However, Hispanic adults were still less likely to consume tap water (OR = 0.61, 95% CI = 0.44, 0.83) and more likely to consume bottled water (OR = 1.89, 95% CI = 1.42, 2.52) compared to NH white adults (Rosinger et al., 2018). Surveys of municipal water consumers in Florida revealed that water filters were only believed to adequately address organoleptics (i.e., bad-smelling water), whereas bottled water was preferred for more serious concerns (i.e., safety, contamination, and health risk) (Triplett et al., 2019). Therefore, while filtered water may be trusted more than unfiltered water, filtered water still may not be perceived as safe.

Individual Characteristics

Tap water trust appears to be greater with increased household income and education level but does not appear to be related to sex or age. Tap water safety was trusted by fewer Hispanic women (35.8 ± 3.7%) than men (43.4 ± 4.5%) who completed the *Estilos* survey (P = 0.08) (Park et al., 2019). Similarly, among participants who completed the 2015 AHS, women were significantly less likely to perceive tap water as safe compared to men (OR = 0.762, P < 0.01) (Javidi & Pierce, 2018). However, sex differences were not observed in the HSS or SCCDPS (Onufrak et al., 2012; van Erp et al., 2014). No differences have been observed between age groups to date (Huerta-Saenz et al., 2012; Onufrak et al., 2012; Park et al., 2019; van Erp et al., 2014).

Based on the 2013 AHS, the odds of trusting tap water were not different for higher US household incomes per $1,000 increase (OR = 1.00, $P \leq 0.01$) (Pierce & Gonzalez, 2017). However, the prevalence of trusting tap water significantly increased with increased income level in both the HSS and *Estilos* survey samples (Table 2-6) (Onufrak et al., 2012; Park et al., 2019). However, the prevalence of believing bottled water is safer than tap water significantly decreased with increased income level in the HSS sample (Onufrak et al., 2012) but was not different among the *Estilos* survey Hispanic sample (Park et al., 2019). This is particularly concerning for low-income individuals who spend a considerable proportion of their income on bottled water. Finally, among parents of children in an urban public health center in Utah (80.5% Latino), plain water preference (bottled vs. tap) was not associated with household income (Hobson et al., 2007).

Even in the lowest income families (≤ $14,999), 32.9% of parents exclusively gave their children bottled water while 32.0% exclusively gave their children filtered tap water (Hobson et al., 2007).

Table 2-6. Prevalence of agreement with perceptions by household income level among survey samples.

Survey	Perception	Income Level			
		< $25,000	$25,000 – $59,999	≥ $60,000	
HSS (Onufrak et al., 2012)	"My local tap water is safe to drink"*	59.4%	68.8%	71.8%	
	"Bottled water is safer than tap water"*	34.3%	22.9%	24.8%	
		≤ $24,999	$25,000 – $44,999	$45,000 – $69,000	≥ $70,000
Estilos (Park et al., 2019)	"My tap water at home is safe to drink"[1]*	24.4 ± 3.0%	35.7 ± 5.6%	41.1 ± 7.2%	58.1 ± 6.3%
	"Bottled water is safer than tap water"[1]	63.6 ± 4.0%	65.5 ± 5.4%	60.1 ± 7.2%	68.2 ± 6.5%

Abbreviations: HSS, HealthStyles Survey
[1]Data are presented as mean ± standard error
*Significantly different prevalence by income level ($P < 0.05$)

Prevalence of trusting tap water among HSS adults was greatest in college graduates (Onufrak et al., 2012) (Table 2-7). This finding was supported by both AHS, in which US adults with at least a high school diploma were more likely to trust the safety of their tap water compared to those with less education (2013: OR = 1.448, S.E. = 0.108, $P < 0.01$ (Javidi & Pierce, 2018); 2015: OR = 1.15, $P \leq 0.01$ (Pierce & Gonzalez, 2017)). Among US Hispanic adults who completed the *Estilos* survey, tap water safety trust was more prevalent in adults some college education and with a college degree (Park et al., 2019). An inverse association has been observed between education and perceptions of bottled water safety. Among the HSS sample, the prevalence of believing bottled water is safer than tap water was lowest in college graduates (Onufrak et al., 2012). Similarly, California adults with at least some college education were less likely to think that bottled water was safer than tap water (OR = 0.32, 95% CI = 0.11 – 0.91, P = 0.033) compared to adults with a high school diploma or less (van Erp et al., 2014). However, among Hispanic adults who completed the *Estilos* survey, prevalence of beliefs that bottled water is safer than tap water was relatively high across all education levels (Park et al., 2019). Contrary to other samples, the greatest prevalence of this belief was observed in those with a college degree.

Table 2-7. Prevalence of agreement with perceptions by education level among survey samples.

Survey	Perception	Education Level			
		< High School Degree	High School Degree	Some College Education	College Degree
HSS (Onufrak et al., 2012)	"My local tap water is safe to drink"*	63.3%	65.5%	62.1%	77.5%
	"Bottled water is safer than tap water"*	40.0%	27.5%	29.5%	19.9%
Estilos (Park et al., 2019)	"My tap water at home is safe to drink"[1]*	27.3 ± 5.0%	37.2 ± 6.1%	53.3 ± 5.5%	52.1 ± 5.9%
	"Bottled water is safer than tap water"[1]*	61.8 ± 5.3%	64.5 ± 6.1%	55.1 ± 5.7%	78.2 ± 3.4%

Abbreviations: HSS, HealthStyles Survey
[1]Data are presented as mean ± standard error
*Significantly different prevalence by education level ($P < 0.05$)

Prior Experience with Poor Tap Water Quality

Latinx adults' perceptions of tap water in the US may be influenced by prior experience with poor water quality in their home countries. US citizens are more likely to trust tap water than non-US citizens (OR = 1.556, SE = 0.134, $P < 0.01$) (Javidi & Pierce, 2018). Similarly, 93.5% of native-born adults trust their tap water compared to 81.2% of foreign-born adults (Pierce & Gonzalez, 2017). Among foreign-born adults, 70.9% of adults born in Latin American countries trusted tap water safety compared to 86.4% of adults born in all other world regions (Pierce & Gonzalez, 2017). Among native-born race/ethnicity groups, Hispanic adults (of any race) had the lowest prevalence of trust (85.3%) (Pierce & Gonzalez, 2017). Compared to non-Latino white households, there were significantly lower odds of perceiving tap water as safe in foreign-born (OR = 0.22, $P \leq 0.01$) and Native-born (OR = 0.41, $P \leq 0.01$) Latino households (Pierce & Gonzalez, 2017). For each additional year lived in a home country before residing in the US, the odds of trusting tap water were lower (OR = 0.99, $P \leq 0.01$) (Pierce & Gonzalez, 2017). However, US nativity did not influence the odds of primarily consuming tap water (filtered or unfiltered) or of believing bottled water is safer than tap water in California adults (van Erp et al., 2014). Experiences of immigrants may also influence second-generation Latinx adults' perceptions (Pierce & Gonzalez, 2017). Mistrust of home tap water safety was most prevalent among Latinx adults unacculturated to the US/English culture (Park et al., 2019). Among those assimilated to US/English culture, 18.2 ± 4.5% mistrust while 60.6 ± 6.7% trust tap water safety. Alternatively, prevalence of mistrust and trust are similar among bicultural adults (38.6 ± 3.8% vs. 33.5 ± 3.5%) and adults unaccultured to US/English culture (39.6 ± 5.0% vs. 31.0 ± 5.2%). Acculturation was scored based on years in the US, language spoken at home, cultural self-identification, and use of Spanish language media (Park et al., 2019). Among parents of children in an urban/suburban pediatric emergency department, the prevalence of prior bad experiences with bottled or tap water was similar across Latino, non-Latino whites, and African American parents (Gorelick et al., 2011). However, the odds of primarily using bottled water (over tap) were significantly increased with having a bad experience with tap water (OR = 1.63, 95% CI = 1.06 – 2.46) and significantly decreased with primarily using tap water when younger (OR = 0.44, 95% CI = 0.23 – 0.83) (Gorelick et al., 2011). Having lived outside of the US at any time and level of education were not associated with primarily using bottled water.

Organoleptic (Sensory) Perceptions

Adolescents and caretakers have rated taste (4.5/5.0), clarity (4.8/5.0), and purity (4.2/5.0) highest in bottled water compared to filtered tap water (taste: 3.7/5.0, clarity: 4.6/5.0, purity: 3.5/5.0) and unfiltered tap water (taste: 3.0/5.0, clarity: 3.6/5.0, purity: 2.8/5.0) (P <0.01) (Huerta-Saenz et al., 2012). Ratings of purity and safety were correlated for filtered tap water (r = 0.83) and bottled water (r = 0.78) (Huerta-Saenz et al., 2012). Similarly, the odds of parents primarily relying on bottled water were significantly greater with beliefs that bottled water is cleaner (OR = 2.00, 95% CI = 1.14 – 3.51) and tastes better (OR = 2.76, 95% CI = 1.78 – 4.28) than tap water (Gorelick et al., 2011). Beliefs about minerals and nutrients in tap and bottled water were not associated with primarily using bottled water. Furthermore, Latino parents were significantly more likely than non-Latino white parents to believe bottled water is cleaner (23.7% vs. 11.6%, $P < 0.001$), tastes better (24.8% vs. 14.2%, $P < 0.001$), and has more minerals and nutrients (9.0% vs. 0.9%, $P < 0.001$) than tap water (Gorelick et al., 2011). Among another sample of parents, 30.6% of Latino parents and 25.6% of non-Latino parents avoided tap water because of taste (Hobson et al., 2007).

It appears that taste, odor, and appearance of water may be associated with health risk, even though organoleptics are not dependable indicators of health (Napier & Kodner, 2008). A previous study asked consumers to evaluate organoleptics of two blackcurrant juices and then to identify which juice they believed to be the most healthy (Luckow & Delahunty, 2004). Overall impressions (general sensory appeal) of each juice were highly correlated with flavor ratings and the frequency with which they would consume each juice (Luckow & Delahunty, 2004). Moreover, a majority of consumers believed that the juice they rated highest for “overall impression” was also the healthiest juice (Luckow & Delahunty, 2004). Thus, consumers may also associate organoleptics of water, particularly taste, with health and subsequently with safety. Furthermore, tap water consumers have been found to rate organoleptics (i.e., taste, odor, and color) as well as health and quality/hygiene of tap water to be significantly more preferable to that of bottled water (Debbeler et al., 2018). On the other hand, bottled water consumers rated bottled water as significantly more preferable than tap water for the same factors (Debbeler et al., 2018). Interestingly, blind taste-tests in the second sample of German students revealed that taste and health preferences diminished when they were blinded to water sources (Debbeler et al., 2018). Conversely, negative organoleptic perceptions may be interpreted as a health risk. Latino parents of young children residing in a rural California community participated in focus groups and qualitative interviews (Scherzer et al., 2010). They reported believing their tap water was not safe to drink because of taste (i.e., salty, strongly of chlorine), appearance (i.e., brown, yellow), and a smell that they associated with adverse health concerns (i.e., stomach aches, nausea, vomiting, skin irritations/lesions, hair loss) (Scherzer et al., 2010). They also believed that their children were at a greater risk since they were still developing (Scherzer et al., 2010). Similarly, participants living in an under-resourced rural area in New Mexico reported during focus groups that their community's water be unappealing, dirty, and unsafe (Hess et al., 2019). They also believed that chlorine or other minerals contributed to the bad taste of their tap water and were opposed to drinking it or bathing or cooking with it (Hess et al., 2019). Perceptions of water quality (i.e., bad taste, discoloration) contributed to perceptions that tap water was not safe (Hess et al., 2019).

Availability and Sources of Information

Few studies have assessed where individuals receive information about tap water. Among parents of children in an urban/suburban pediatric emergency department, the news, advertising, friends, and physicians were similarly prevalent sources of information about water across race/ethnicity groups (Gorelick et al., 2011). However, family as a source of information was more prevalent among Latino parents than non-Latino white parents ($P < 0.01$) (Gorelick et al., 2011). Additionally, environmental organizations were less common sources of information for Latino parents, though not significant ($P = 0.06$). Receiving information on tap water from an environmental organization was associated with greater odds of primarily relying on bottled water (over tap water) (OR = 1.74, 95% CI = 1.03 – 2.93) (Gorelick et al., 2011). Finally, avoiding tap water because someone told them not to drink it was not prevalent among Latino (8.1%) or non-Latino (4.7%) parents of children in an urban public health center in Utah (Hobson et al., 2007).

The United States Environmental Protection Agency (EPA) requires public water systems to inform citizens about the quality of their local water annually via consumer confidence reports (CCRs) (United States Environmental Protection Agency). However, these reports may not meet the readability standard for most of the national population (i.e., written at the 6^{th} – 7th-grade level) (Johnson, 2003; Roy et al., 2015). A nationally representative set of CCRs from 2011 – 2013 was determined to be written at the 11^{th} – 14th-grade level (Roy et al., 2015). The style was considered difficult, similar to that of academic and scientific publications (e.g., *Harvard Law* Review articles) and requiring high school or some college education for comprehension (Roy et al., 2015). Consequently, education level may impact perceptions through accessibility, understanding, and confidence in information on water safety and quality (Javidi & Pierce, 2018).

Bottled water advertisements and marketing may also contribute to water-related perceptions and behaviors (Doria, 2006; Pierce & Gonzalez, 2017). Bottled water marketing campaigns have commonly utilized labels such as pure, pristine, natural (Wilk, 2006) and healthy to promote positive associations with bottled water health, risk, and organoleptic perceptions (Doria, 2006). The influence of marketing tactics has been observed as college students' intention to purchase bottled water was related to bottled water's perceived benefits (e.g., convenience, taste, and health) (Xu & Lin, 2018). Bottled water marketing and advertising campaigns also have a history of targeting minorities (Javidi & Pierce, 2018). Furthermore, the odds of bottled water reliance in parents of children treated in an urban/suburban pediatric emergency department were significantly greater for those who believed their "family may be protected from illness by choosing the best kind of drinking water" (OR = 1.53, 95% CI = 1.01 – 2.32) (Gorelick et al., 2011). Latino and African American parents were more likely to strongly agree with that statement compared to NH white parents ($P = 0.007$) (Gorelick et al., 2011). Similarly, 42.2% of Latino parents of children cared for in an urban public health center reported avoiding tap water because it caused illness (Hobson et al., 2007). Latino parents were significantly more likely than non-Latino parents to avoid tap water due to fear of illness (OR = 5.63, 95% CI = 2.17 – 14.54) (Hobson et al., 2007). This is in contrast to testimony from the US Government Accountability Office concluding that while regulations for tap water by the EPA and bottled water by the US Food and Drug Administration are similar, the US Food and Drug Administration lacks the authority to enforce them (Huerta-Saenz et al., 2012; United States Government Accountability Office, 2009). Specifically, bottled water is not required to be tested in certified laboratories, and findings from testing, including violations of water quality standards, are not required to be reported (United States Government Accountability Office, 2009). Furthermore, bottled water labels are not required to include any information on compliance with regulations or contaminants present in their water and their potential health risks (United States Government Accountability Office, 2009). Positive perceptions of bottled water via marketing and advertising combined with a lack of information about bottled water safety may reinforce negative perceptions about tap water.

Latinx distrust in CCRs and trust in the bottled water industry could also be related to overall distrust in the government. Latino parents of young children residing in a rural California community, who were primarily low-income and of low education level, reported not trusting their tap water safety due to a history of municipal water quality problems in the community (Scherzer et al., 2010). These beliefs were even held by newer residents, who were warned by long-term residents, despite recent infrastructural improvements implemented by the government in addition to regular testing conducted by an institution independent of the government (Scherzer et al., 2010). While they reported not being aware of CCRs, they did believe independent water testing would convince them of tap water safety (Scherzer et al., 2010). Although there have been inconsistent findings regarding Latino adults' trust in the US government (Hero & Tolbert, 2004; Michelson, 2003), distrust in Mexican Americans has been observed to increase with acculturation into American culture as well as with experience with and/or observation of racism and discrimination (Michelson, 2003).

Conclusion

Adherence to NAM adequate intake recommendations for TWI have been low in recent years. TWI has been consistently lower in Latinx adults compared to NH white adults. The decision to drink water is complex and is influenced by a myriad of factors including context, environment, eating behaviors, geography, and beverage attributes. While overall PWI is similar between Latinx and NH white adults, Latinx adults are particularly averse to tap water. Thus, voluntary low TWI in Latinx adults appears to be driven by tap water avoidance. Tap water perceptions are complex and appear to be influenced by water insecurity, demographics, prior experiences, organoleptic (sensory) perceptions and availability and sources of information. Existing interventions designed to improve TWI primarily focus on improving access to water and/or educating individuals on the importance of hydration. However, this may not be sufficient in Latinx populations where water is not trusted. Furthermore, while overall PWI is similar across races and ethnicities, overall TWI is low and it's important for individuals to increase TWI through PWI and not through other beverages. Trust in tap water (in water secure contexts) could improve access to and convenience of water and improve the likelihood of choosing water over other beverages. Future work should comprehensively assess these factors in Latinx samples and include validated PWI, TWI, and hydration status measures. A greater understanding of these relationships could inform interventions to improve TWI and hydration status in Latinx adults.

CHAPTER 3

DETERMINANTS OF TAP WATER MISTRUST IN US LATINX ADULTS

Abstract

The purpose of this investigation was to characterize the various factors that predict the perception that tap water is not safe in Latinx adults residing in Phoenix, Arizona. Participants (n = 492, 28 ± 7 y, 37.4% female) completed an Adapted Survey of Water Issues in Arizona, which evaluates awareness, aptitudes, attitudes, and action toward water quality. They also completed household water security experience-based scales (i.e., water access, water quality and acceptability, and water distress) developed for low-income peri-urban and rural communities on the US-Mexico border. Binary logistic regression determined odds ratios (OR) with 95% confidence intervals (95% CI) for the odds of Latinx adults perceiving their tap water to be unsafe. Overall, 51.2% of Latinx adults perceived their tap water to be unsafe. The odds of mistrusting tap water were significantly greater for each additional favorable perception of bottled over tap water (OR = 1.94, 95% CI = 1.50, 2.50), each additional negative home tap water experience (OR = 1.32, 95% CI = 1.12, 1.56), each additional use of alternatives and/or modifications to home tap water (OR = 1.25, 95% CI = 1.04, 1.51), and decreased water quality and acceptability (OR = 1.21, 95% CI = 1.01, 1.45) ($P < 0.05$). The odds of mistrusting tap water were significantly lower for those whose primary source of drinking water is the public supply (municipal) (OR = 0.07, 95% CI = 0.01, 0.63) and for those with decreased water access (OR = 0.56, 95% CI = 0.48, 0.66) ($P < 0.05$). Overall, Latinx mistrust in tap water safety is very prevalent in Phoenix, AZ. Mistrust appears to be influenced by organoleptic perceptions and to lead to reliance on alternatives to the home drinking water system.

Introduction

Underhydration, dehydration, and low water intake have been linked to various adverse health outcomes including cardiovascular dysfunction, urinary tract infections, chronic diseases, and death (Clark et al., 2016; Enhorning et al., 2010; National Academy of Medicine, 2005; Sontrop et al., 2013). Latino and Hispanic (herein Latinx) adults have significantly lower total water intake (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018) and are 1.42 times more likely to be inadequately hydrated (Brooks et al., 2017) compared to non-Hispanic (NH) white adults. Moreover, Latinx adults tend to consume significantly high proportions of sugar-sweetened beverages (Rosinger et al., 2017), which can increase the risk for obesity, type 2 diabetes, and cardiovascular diseases (Huang et al., 2014; Malik & Hu, 2012).

The Centers for Disease Control and Prevention (CDC) recommend individuals to 'Rethink Your Drink' by replacing sugary drinks with water. Some tips offered by the CDC to increase water intake include improving the flavor of water by adding berries, lime, lemon, or cucumber, storing jugs or bottles of water in the fridge, and using a reusable water bottle that can be refilled while on the go (Centers for Disease Control and Prevention). These strategies may not be effective in Latinx adults as they are significantly more likely to perceive their tap water as unsafe compared to NH white adults (Javidi & Pierce, 2018; Onufrak et al., 2012; Pierce & Gonzalez, 2017) and bottled water serves as a costly alternative (Javidi & Pierce, 2018). Water insecurity is prevalent across the US and perceptions of unsafe tap water are likely valid for some individuals. In particular, minority and low-income communities are at a greater risk of water insecurity due to factors such as historical planning processes, redlining, reduced enforcement of water regulations and standards, and repeat water violations (Balazs & Ray, 2014). However, mistrust in tap water occurs despite access to safe water. Moreover, bottled water is not necessarily safer to consume than tap water. US Government Accountability Office testimony concluded that while the Environmental Protection Agency (EPA) and the US Food and Drug Administration have similar regulations for drinking water, the US Food and Drug Administration lacks the authority to enforce them (Huerta-Saenz et al., 2012; United States Government Accountability Office, 2009). In particular, there are no requirements for bottled water to be tested in certified laboratories or for test results (e.g., violations of water quality standards) to be reported (United States Government Accountability Office, 2009). There also are no requirements for bottled water labels to include information regarding regulation compliance, presence of contaminants, or potential health risks associated with contaminants (United States Government Accountability Office, 2009).

Tap water safety perceptions generally appear to be influenced by geography, household and neighborhood characteristics, demographics, prior experiences with tap water, organoleptic (sensory) perceptions, and availability and sources of information about water (Gorelick et al., 2011; Hobson et al., 2007; Huerta-Saenz et al., 2012; Javidi & Pierce, 2018; Onufrak et al., 2012; Park et al., 2019; Pierce & Gonzalez, 2017; van Erp et al., 2014). However, recent investigations have not consistently or comprehensively evaluated the same factors. Additionally, only one investigation (Park et al., 2019) included a sample comprised entirely of Latinx adults and many factors in the remaining investigations were not evaluated for differences by race or ethnicity. Therefore, the factors that have previously been identified to influence tap water safety perceptions may not all be relevant to Latinx adults, specifically.

A greater understanding of tap water aversion could enhance efforts to improve total water intake and plain water intake and reduce sugar-sweetened beverage intake in Latinx adults with access to safe tap water. Therefore, the purpose of this investigation was to *evaluate perceptions, knowledge, behaviors, and experiences related to drinking water in Latinx adults residing in Phoenix, Arizona*. Additionally, we aimed to characterize the degree to which various factors predict the perception that tap water is not safe. We also aimed to explore education level, annual income, and nativity status as potential moderators.

Methods

English- and Spanish-speaking male and female adults (18 - 65 y) who self-identify as Hispanic or Latinx (question: ‘What is your ethnicity?’; response options: ‘Hispanic or Latinx’, ‘Not Hispanic or Latinx’) in Phoenix, AZ (evaluated via self-reported zip code) were recruited for participation. The sample was selected using non-probability methods. Specifically, this investigation was advertised for through Facebook ads, printed flyers that were posted in university buildings, a university research participant registry, university banner ads, and word of mouth. Interested individuals completed an online survey (Qualtrics, Provo, UT, USA) to evaluate their eligibility. Participants were excluded if they satisfied at least one of the following criteria: 1) currently pregnant, 2) currently use diuretics, 3) do not have access to a desktop, laptop, tablet, or smartphone, or 4) do not have internet access. Individuals who satisfied all criteria were enrolled. All potential participants were informed of participation risks and benefits as well as their rights as a participant. Documented signed consent was obtained electronically from all participants.

Ultimately, 1,029 individuals consented to voluntary participation, enrolled, and completed the study online. Data from 537 participants were excluded due to multiple submissions by the same person (n = 63), straight-lined data (n = 471), or missing data (n = 3), resulting in n = 492 for the analysis. Multiple submissions by the same person were identified by use of the same email address and/or name. In some cases, multiple submissions were made by individuals with similar email addresses and/or variations of similar first and last names. Those participants were contacted to verify that they completed the survey on multiple occasions. Several survey questions were utilized to identify straight-lined data. For example, participants were asked to rank 11 items based on their level of importance to the individual. In many instances, items were ranked 1 – 11 in the order in which items were presented to the participant. Additionally, some questions asked participants to select 'yes' or 'no' to a list of several items, some of which were contradictory statements. Specifically, one question asked: 'Select 'yes' if you agree or 'no' if you disagree with each of the following statements about your home drinking water system'. Some individuals selected 'yes' for all eight items, which included: 'I often use bottled water for drinking purposes', 'I never buy bottled water', 'I am satisfied with my current drinking water (piped in house)', and 'I am not satisfied with my current drinking water (piped in house)'. Finally, participants were excluded from analysis if they were missing pertinent data. Specifically, nativity status was missing for one individual and age was missing for two individuals. Data collection occurred September 2021 – February 2022 in Phoenix, Arizona, USA.

This protocol was approved by the university's institutional review board and biosafety committee (protocol no. STUDY00014055), was registered at clinicaltrials.gov (NCT04997031), and was conducted in compliance with the Helsinki Declaration as revised in 1983.

Following enrollment, participants completed an online (Qualtrics, Provo, UT, USA) survey, which took an average of 37.14 minutes to finish. All responses were coded in Qualitrics before any participants completed the survey, which allowed researchers to download a coded version of the dataset. First, they completed an Adapted Survey of Water Issues in Arizona (Appendix D), which was adapted from previous national water survey needs assessments from the United States Department of Agriculture-Cooperative State Research, Education, and Extension Service Southwest States and Pacific Islands Regional Water Quality Program [subset of the National Water Quality Program] (Castro et al., 2011; Mahler et al., 2013). This survey evaluates participant awareness, aptitudes, attitudes, and action toward water quality (specifically feelings about the environment, environmental perspective, water safety and quality perceptions, water quality education, governance, and demographics). Adaptations to the survey were minimal. One question previously utilized in literature was added to evaluate prior experiences with tap water: 'What is your level of agreement with the following statement: I had a bad experience with tap water' (Gorelick et al., 2011). Response options included 'strongly disagree', 'disagree', 'neither agree nor disagree', 'agree', and 'strongly disagree'. The question 'What is your gender?' was updated to 'What is your biological sex?' due to differences in gender and biological sex. Finally, two questions were added to evaluate participant nativity status (born in the US vs. born outside of the US) and race.

Participants also completed household water security experience-based scales developed for low-income peri-urban and rural communities on the US-Mexico border (Jepson, 2014). The Idealized Guttman water scales include 1) Idealized Guttman scale for water access, 2) Idealized Guttman scale for water quality and acceptability, and 3) Idealized Guttman scale for water distress. The scale for water access was scored 0 – 7 and had good reliability (Cronbach's alpha = 0.83). Scores were classified as follows: 0 = adequate water access, 1 – 3 = marginal water access, 4 – 5 = low water access, and 6 – 7 = very low water access. The scale for water quality and acceptability was scored 0 – 6 and had good reliability (Cronbach's alpha = 0.79). Scores were classified as follows: 0 = acceptable water quality, 1 – 2 = marginal water quality acceptability, 3 – 4 = low water quality acceptability, and 5 – 6 = very low water quality acceptability. The scale for water distress was scored 0 – 6 and had good reliability (Cronbach's alpha = 0.85). Scores were classified as follows: 0 = low water distress, 1 – 2 = marginal water distress, 3 – 4 = high water distress, and 5 – 6 = very high water distress.

Outcome variable

The outcome variable for this analysis was the perception of tap water safety. Participants were asked: 'What is your level of agreement with the following statement: My tap water is safe to drink.' Response options included 'strongly disagree', 'disagree, agree', and 'strongly agree'. Responses were classified as a safe perception (agree and strongly agree) or an unsafe perception (disagree and strongly disagree) of tap water safety.

Exposure variables

Exposure variables included prior experience with poor water quality, organoleptic perceptions, sources of information about water, and the home drinking water system. Experience with poor water quality was evaluated with the question: 'What is your level of agreement with the following statement: I had a bad experience with tap water' (Gorelick et al., 2011). Response options included 'strongly disagree', 'disagree', 'neither agree nor disagree', 'agree', and 'strongly disagree'. Responses were classified as bad experience (agree and strongly agree) or no bad experience (neither agree nor disagree, disagree, and strongly disagree) with tap water. Organoleptic perceptions were evaluated by two questions. First, 'In your opinion, how do bottled water and tap water compare?'. Participants answered 'yes' or 'no' for the following items: 'bottled water tastes/smells better', 'bottled water is of higher quality', and 'bottled water is safer'. The three preceding items were utilized to create a continuous, composite variable ('Favorable perceptions of bottled water compared to tap water', 0 – 3), with each 'yes' response scored as 1 and each 'no' response scored as 0. The second question was: 'Which, if any of the following have you experienced with tap water in your home over the past year?'. Participants answered 'yes' or 'no' for the following items: 'hard water/mineral deposits', 'unpleasant taste', 'sediment', 'unpleasant smell', 'rusty color', and 'other contaminants'. The six preceding items were utilized to create a continuous, composite variable ('Negative home tap water experiences', 0 – 6), with each 'yes' response scored as 1 and each 'no' response scored as 0.

Participants were also asked: 'Have you ever received water quality information from the following sources?'. Participants responded 'yes' or 'no' for the following items: 'newspaper', 'television', 'environmental agencies (government)', 'environmental groups (citizens groups)', 'universities', 'consumer confidence reports', 'schools (elementary & secondary)', 'extension service', 'friends/family', and 'healthcare provider'. Items were reduced to clusters in meaningful ways: media (newspaper and television), government sources (environmental agencies, consumer confidence reports, and extension service), non-government sources (environmental groups, universities, and schools), friends/family, and healthcare provider. Finally, participants' home drinking water systems were evaluated by the three Idealized Guttman scales (Jepson, 2014) in addition to four questions: 1. 'In your opinion, what is the quality of groundwater (sources of well water) in your area?' 2. 'In your opinion, what is the quality of surface waters (rivers, streams, lakes, channels, and wetlands) in your area?' 3. 'Where do you primarily get your drinking water?' 4. 'Select 'yes' if you agree or 'no' if you disagree with each of the following statements about your home drinking water system.'. Response options for questions 1 and 2 included 'good or excellent', 'good, and improving', 'good, but deteriorating', 'fair', 'poor, but improving', 'poor', and 'no opinions/don't know'. Responses were classified as good quality (good or excellent, good and improving, good but deteriorating, fair, and no opinions/don't know) or bad quality (poor but improving and poor) of water. Response options for question 3 included 'public supply (municipal)', 'private supply (private well, river, pond, lake)', 'public supply (rural water district)', 'purchase bottled water', and 'I don't know'. The following items were included in question 4: 'I have water softener', 'I have a water treatment system (softener, etc.)', 'I purchase

≥ 1-gallon containers for drinking water’, ‘I often use bottled water for drinking purposes’, ‘I am not satisfied with my current drinking water (piped in house)’, and ‘my drinking water is separate from my water supply system’. The preceding items were utilized to create a continuous, composite variable (‘Use of alternatives and/or modifications to home tap water’, 0 – 6), with each ‘yes’ response scored as 1 and each ‘no’ response scored as 0. Reliability was acceptable (Cronbach’s alpha = 0.68). ‘I am not satisfied with my current drinking water (piped in house)’ was excluded from the composite variable to improve reliability (Cronbach’s alpha = 0.71).

Covariate Variables

Covariate variables included sex, age, highest level of education achieved, annual income, and United States nativity. Mutually exclusive categories were created for education level (high school graduate or less, some college, and college graduate or more) and annual income (< $25,000, $25,000 – $69,999, and ≥ $70,000).

Descriptive Variables

Participants were asked: ‘Have you ever changed your mind about an environmental issue as a result of …?’. Participants responded ‘yes’ or ‘no’ for the following items: ‘news coverage (TV, newspaper, etc.)’, ‘conversations with other people’, ‘public meetings’, ‘classes or presentations’, ‘speech by elected representative’, ‘firsthand observation’, and ‘financial considerations’. They were also asked: ‘In your opinion, who should be most responsible for protecting water quality in your community?’. Participants selected from ‘federal government’, ‘state government’, ‘county, city, or town’, ‘individual citizens’, ‘don’t know’, and ‘other’. Finally, participants were asked: ‘If you had the following kinds of learning opportunities available, which would you be most likely to take advantage of for water quality issues? (Check up to 3 items)’. Opportunities included: ‘read printed fact sheets, bulletins, or brochures’, ‘read a newspaper article or series, or watch TV coverage’, ‘visit a website’, ‘look at a demo or display’, watch a video of information’, ‘take part in a onetime volunteer activity to learn or do something (e.g., water monitoring)’, ‘attend a fair or festival’, ‘ask for a home, farm or workplace water assessment’, ‘get trained for a regular volunteer position (e.g., watershed steward, or water quality monitor)', 'attend a short course (weekend, evening)', and 'take a course for credit/certification'.

Statistical Analysis

Data analyses were completed using commercial software (IBM SPSS Statistics Version 27.0.0). Data are presented as odds ratio (OR), 95% confidence interval (95% CI), unless otherwise specified. A $P < 0.05$ was considered statistically significant for all analyses. Multicollinearity was assessed for predictor variables and interaction terms via bivariate correlation.

Binary logistic regression was utilized with tap water safety perceptions as the primary outcome variable (0 = perceived as safe, 1 = perceived as unsafe). Exposure variables were included as predictors based on relevance in the literature. Interactions between various predictors and nativity (i.e., prior bad experience with water, government information sources, and non-government sources), annual income (i.e., past year home tap water composite variable, home drinking water system composite variable, water access score, water quality and acceptability score, and water distress score), education level (i.e., media information sources, government information sources, non-government information sources, friends and family information source, and health care provider information source) were explored based on previous literature. All relevant variables were centered before evaluating interactions to account for multicollinearity. Interactions were individually added to the model and evaluated individually for statistically significant effects on the model via the likelihood ratio test. Predictors that did not have a statistically significant effect were removed from the model (Hosmer & Lemeshow, 2000). Individual odds ratios were determined for significant interactions.

Results

Demographic characteristics are presented in Table 3-1 and survey responses are presented in Table 3-2. The majority of individuals (28 ± 7 y) were male, educated (> 90% have at least some college education), and born in the United States. Overall, 51.2% of Latinx adults perceived their tap water to be unsafe. Perceptions of tap water safety were significantly different among education levels (χ^2 tests, $P < 0.05$). Specifically, the greatest proportions of adults with unsafe perceptions of tap water have some college education while the lowest prevalence of mistrust was observed in individuals with less and more than some college education. Household water insecurity was prevalent in the present sample. Less than 20% of adults have adequate water access, ~ 30% have acceptable water quality, and ~ 25% have low water distress. Contrarily, over 80% of the sample have positive perceptions of groundwater and surface water in their area.

Table 3-1. Sample demographics by the perception of tap water safety (n = 492).

	All		**Safe Perception of Tap Water**		**Unsafe Perception of Tap Water**		***P*-value[1]**
	n	**(%)**	**n**	**(%)**	**n**	**(%)**	
Sex							0.48
Male	308	(62.6)	154	(50.0)	154	(50.0)	
Female	184	(37.4)	86	(46.7)	98	(53.3)	
Race							0.09
Caucasian	93	(18.9)	56	(60.2)	37	(39.8)	
African American/African/Black/Caribbean	147	(29.9)	65	(44.2)	82	(55.8)	
Native American	43	(8.7)	21	(48.8)	22	(51.2)	
Other	209	(42.5)	98	(46.9)	111	(53.1)	
Education Level							**<0.001**
High school graduate or less	35	(7.1)	19	(54.3)	16	(45.7)	
Some college	142	(28.9)	50	(35.2)	92	(64.8)	
College graduate or more	315	(64.0)	171	(54.3)	144	(45.7)	
Annual Income							0.77
< $25,000	87	(17.7)	45	(51.7)	42	(48.3)	
$25,000-$69,999	310	(63.0)	151	(48.7)	159	(51.3)	
≥ $70,000	95	(19.3)	44	(46.3)	51	(53.7)	
Nativity							0.62
United States	452	(91.9)	222	(49.1)	230	(50.9)	
Other	40	(8.1)	18	(45.0)	22	(55.0)	

[1]χ^2 tests were used to assess differences across categories for each variable. Significant differences (P < 0.05) are formatted in **bold**.

Tap water safety perceptions significantly varied among many survey items (Table 3-2). Over half of the sample previously had a bad experience with tap water. However, about half of individuals with and without prior bad experiences mistrusted their tap water (χ^2 test, $P > 0.05$). The majority of the sample perceive bottled water to taste and smell better, have higher quality, and be safer than tap water and over 60% of individuals with each of these perceptions mistrust their tap water (χ^2 tests, $P < 0.001$). The majority (> 60%) of participants experienced hard water/mineral deposits and unpleasant taste in their home tap water in the previous year while the presence of other contaminants in home tap water was the least common experience. The perception of unsafe tap water was more prevalent for those experiencing hard water and mineral deposits, unpleasant taste, unpleasant smell, and other contaminants (χ^2 tests, $P < 0.05$).

Individuals in this sample most commonly changed their minds about an environmental issue as a result of news coverage whereas minds were least commonly changed by financial considerations. Moreover, water quality information is most commonly received via television and least commonly received via consumer confidence reports. Overall, sources of information did not differ widely between tap water perceptions. The only difference observed was that a higher proportion of individuals with unsafe perceptions receive water quality information from their healthcare provider (χ^2 tests, $P < 0.05$).

Half of the sample purchases bottled water as their primary source of drinking water. Tap water mistrust was less prevalent among those using public supplies (municipal and rural water district) and more prevalent among those using private supplies or purchasing bottled water for primary sources of drinking water (χ^2 tests, $P = 0.005$). Several differences were observed in regard to home drinking water systems. Specifically, tap water mistrust was more prevalent among those purchasing ≥ 1-gallon containers for drinking water, those who often bottled water for drinking purposes, dissatisfaction with home drinking water infrastructure, and obtaining drinking water separately from their home water supply system (χ^2 tests, $P < 0.05$). Tap water mistrust was more prevalent among those with adequate or low water access but less prevalent among those with very low water access (χ^2 test, $P < 0.001$).

Participants were asked to select the top three learning opportunities that they would take advantage of regarding water quality issues if they were available (Table 3-2). Overall, the top three opportunities of interest were to read a newspaper article or series or watch TV coverage, to read printed fact sheets, bulletins, or brochures, and to watch a video of information. However, greater proportions of individuals who trust their tap water comprised those who selected reading printed fact sheets, bulletins or brochures, reading a newspaper article or series or watching TV coverage, visiting a website, or attending a fair or festival (χ^2 test, P < 0.05). Contrarily, greater proportions of individuals who mistrust their tap water (> 60%) comprised those who selected wanting to take part in a onetime volunteer activity or to get trained for a regular volunteer position (χ^2 test, $P < 0.01$). Furthermore, beliefs about whether the environment receives the right amount of emphasis from local government and elected officials in Arizona (χ^2 test, $P = 0.002$) and about who should be most responsible for protecting water quality in the community (χ^2 test, $P < 0.001$) varied significantly by tap water safety perception. While 42.3% of the sample believes the environment receives the right amount of emphasis, 34.6% believe it does not. Moreover, 62.9% of individuals who believe the environment does not receive the right amount of emphasis also believe their tap water is not safe. The remaining individuals believe the environment receives too much emphasis (17.9%) or do not have an opinion/do not know (5.3%). The majority of the sample believe the county, city, or town (34.1%) or individual citizens (29.7%) should be most responsible for protecting water quality in their community. Interestingly, 63.1% of those who believe the county, city, or town are responsible and 38.4% of those who believe individual citizens are responsible, mistrust their tap water. The rest of the sample believe the state government (21.5%), federal government (12.8%), or “other” (0.6%) should be responsible. A small proportion (1.2%) do not know who should be responsible.

Table 3-2. Survey responses by tap water safety perceptions (n = 492).

	All (%)	Safe Perception of Tap Water (%)	Unsafe Perception of Tap Water (%)	*P*-Value[1]
Total sample	100.0	48.7	51.2	-
Prior bad experience with tap water				0.11
Yes	52.4	45.3	54.7	
No	47.6	52.6	47.4	
Perceptions of how bottled water compares to tap water:				
Bottled water tastes/smells better				**<0.001**
Yes	69.3	37.8	62.2	
No	30.7	73.5	26.5	
Bottled water is of higher quality				**<0.001**
Yes	75.4	39.1	60.9	
No	24.6	78.3	21.7	
Bottled water is safer				**<0.001**
Yes	73.8	38.3	61.7	
No	26.2	62.7	37.3	
Experiences with home tap water over the past year:				
Hard water/mineral deposits				**<0.001**
Yes	65.7	41.5	58.5	
No	34.3	62.7	37.3	
Unpleasant taste				**<0.001**
Yes	62.0	38.0	62.0	
No	38.0	66.3	33.7	
Sediment				0.59
Yes	49.6	47.5	52.5	
No	50.4	50.0	50.0	
Unpleasant smell				**0.008**
Yes	47.8	42.6	57.4	
No	52.2	54.5	45.5	
Rusty color				1.00
Yes	41.7	48.8	51.2	
No	58.3	48.8	51.2	
Other contaminants				**0.02**
Yes	35.6	41.7	58.3	
No	64.4	52.7	47.3	
Have changed their mind about an environmental issue as a result of:				
News coverage (TV, newspaper, etc.)				0.72
Yes	83.1	48.4	51.6	
No	16.9	50.6	49.4	
Conversations with other people				0.40
Yes	81.1	47.9	52.1	
No	18.9	52.7	47.3	
Public meetings				0.25
Yes	75.2	47.3	52.7	
No	24.8	53.3	46.7	
Classes or presentations				0.53
Yes	74.6	48.0	52.0	

	All (%)	Safe Perception of Tap Water (%)	Unsafe Perception of Tap Water (%)	*P*-Value[1]
No	25.4	51.2	48.8	
Speech by elected representative				0.78
Yes	66.5	49.2	50.8	
No	33.5	47.9	52.1	
Firsthand observation				0.20
Yes	79.9	47.3	52.7	
No	20.1	54.5	45.5	
Financial considerations				0.44
Yes	64.2	47.5	52.5	
No	35.8	51.1	48.9	
Have received water quality information from each of the following sources:				
Newspaper				0.06
Yes	80.3	50.9	49.1	
No	19.7	40.2	59.8	
Television				0.08
Yes	81.1	46.9	53.1	
No	18.9	57.0	43.0	
Environmental agencies (government)				0.47
Yes	74.4	49.7	50.3	
No	25.6	46.0	54.0	
Environmental groups (citizen groups)				0.40
Yes	71.7	47.6	52.4	
No	28.3	51.8	48.2	
Universities				0.38
Yes	72.8	50.0	50.0	
No	27.2	45.5	54.5	
Consumer confidence reports				0.10
Yes	58.3	51.9	48.1	
No	41.7	44.4	55.6	
Schools (elementary & secondary)				0.85
Yes	66.7	49.1	40.9	
No	33.3	48.2	51.8	
Extension service				0.09
Yes	60.8	51.8	48.2	
No	39.2	44.0	56.0	
Friends/family				0.69
Yes	76.6	48.3	51.7	
No	23.4	50.4	49.6	
Healthcare provider				**0.02**
Yes	70.3	45.4	54.6	
No	29.7	56.8	43.2	
Primary source of drinking water:				**0.005**
Public supply (municipal)	25.6	59.5	40.5	
Private supply (private well, river, pond, lake)	7.1	45.7	54.3	

	All (%)	Safe Perception of Tap Water (%)	Unsafe Perception of Tap Water (%)	*P*-Value[1]
Public supply (rural water district)	15.7	58.4	41.6	
Purchase bottled water	50.2	40.9	59.1	
I don't know	1.4	42.9	57.1	
Agreement with each of the following statements about their home drinking water system:				
I have water softener				0.45
Yes	69.5	47.7	52.4	
No	30.5	51.3	48.7	
I have a water treatment system (softener, etc.)				0.07
Yes	63.2	45.7	54.3	
No	36.8	54.1	45.9	
I purchase ≥ 1-gallon containers for drinking water				**0.01**
Yes	72.6	45.4	54.6	
No	27.4	57.8	42.2	
I often use bottled water for drinking purposes				**<0.001**
Yes	77.6	43.2	56.8	
No	22.4	68.2	31.8	
I am not satisfied with my current drinking water (piped in house)				**0.006**
Yes	55.5	43.2	56.8	
No	44.5	55.7	44.3	
My drinking water is separate from my water supply system				**<0.001**
Yes	65.0	40.0	60.0	
No	35.0	65.1	34.9	
Perception of groundwater (sources of well water) quality in their area:				0.63
Positive	88.2	48.4	51.6	
Negative	11.8	51.7	48.3	
Perception of surface water (rivers, streams, lakes, channels, and wetlands) quality in their area:				0.18
Positive	83.5	50.1	49.9	
Negative	16.5	42.0	58.0	
Water access classification:				**<0.001**
Adequate	18.9	19.4	80.6	
Marginal	38.6	49.5	50.5	
Low	18.1	42.7	57.3	
Very low	24.4	75.0	25.0	
Water quality classification:				0.39
Acceptable	29.9	50.3	49.7	
Marginal acceptability	12.8	49.2	50.8	
Low acceptability	28.5	42.8	57.1	
Very low acceptability	28.9	52.8	47.2	
Water distress classification:				**0.04**
Low	24.4	42.5	57.5	
Marginal	21.7	59.8	40.2	
High	22.6	44.1	55.9	
Very high	31.3	49.4	50.6	

	All (%)	Safe Perception of Tap Water (%)	Unsafe Perception of Tap Water (%)	*P*-Value[1]
Most likely to take advantage of each of the following learning opportunities for water quality issues[2]:				
Read printed fact sheets, bulletins, or brochures				**<0.001**
Yes	38.4	64.0	36.0	
No	61.6	39.3	60.7	
Read a newspaper article or series, or watch TV coverage				**0.005**
Yes	48.6	55.2	44.8	
No	51.4	42.7	57.3	
Visit a website				**0.03**
Yes	36.8	55.2	44.8	
No	63.2	45.0	55.0	
Look at a demo or display				0.21
Yes	26.2	53.5	46.5	
No	73.8	47.1	52.9	
Watch a video of information				0.10
Yes	37.0	44.0	56.0	
No	63.0	51.6	48.4	
Take part in a onetime volunteer activity to learn or do something (e.g., water monitoring)				**<0.001**
Yes	35.2	38.2	61.8	
No	64.8	54.5	45.5	
Attend a fair or festival				**0.002**
Yes	17.5	64.0	36.0	
No	82.5	45.6	54.4	
Ask for a home, farm, or workplace water assessment				0.47
Yes	21.5	51.9	48.1	
No	78.5	47.9	52.1	
Get trained for a regular volunteer position (e.g., watershed steward or water quality monitor)				**0.007**
Yes	23.6	37.9	62.1	
No	76.4	52.1	47.9	
Attend a short course (weekend, evening)				0.55
Yes	16.9	51.8	48.2	
No	83.1	48.2	51.8	
Take a course for credit/certification				0.13
Yes	14.2	57.1	42.9	
No	85.8	47.4	52.6	

[1]χ^2 tests were used to assess differences across categories for each variable. Significant differences ($P < 0.05$) are formatted in **bold**.
[2]Participants were instructed to select up to three learning opportunities.

Composite variables are presented in Table 3-3 and results from the binary logistic regression model are presented in Table 3-4. The odds of perceiving tap water to be unsafe were significantly greater for African American, African, Black, and Caribbean individuals compared to

Caucasian individuals (*P* < 0.05). Perceptions were not influenced by education, sex, age, annual income, or nativity. The odds of mistrust were also significantly greater for each additional score for favorable perceptions of bottled water compared to tap water, negative home tap water experiences, use of alternatives and/or modifications to home tap water and water quality and acceptability (*P* < 0.05). Conversely, the odds of mistrust were significantly lower for individuals whose primary source of drinking water is the public supply (municipal) as well as for each additional score for water access (*P* < 0.05). No sources of information had an influence of tap water safety perceptions. Finally, no significant interactions were observed between predictors and education level, annual income, or nativity status.

Table 3-3. Composite variables (n = 492).

	Number of Items	Cronbach's Alpha	Mean ± SD
Favorable perceptions of bottled water compared to tap water	3	0.81	2.18 ± 1.14
Negative home tap water experiences	6	0.82	3.02 ± 2.12
Use of alternatives and/or modifications to home tap water	5	0.71	3.48 ± 1.55
Water access	7	0.83	3.11 ± 2.43
Water quality and acceptability	6	0.79	2.96 ± 2.09
Water distress	6	0.85	2.89 ± 2.26

Abbreviation: SD, standard deviation

Table 3-4. Odds of an unsafe perception of tap water (n = 492).

Variable	Reference Category	Odds Ratio (95% CI)	*P*-Value
Female	Male	1.17 (0.72, 1.90)	0.52
Age (y)	-	1.00 (0.96, 1.03)	0.79
Race (of Latinx origin):			**0.02**
African American/African/Black/ Caribbean	Caucasian	3.28 (1.58, 6.80)	**0.001**
Native American	Caucasian	2.50 (0.96, 6.50)	0.06
Other	Caucasian	1.73 (0.87, 3.44)	0.12
Education Level:			**0.03**
Some college	College graduate or more	0.38 (0.14, 1.03)	0.06
High school graduate or less	College graduate or more	1.43 (0.84, 2.45)	0.19
Annual Income:			0.37
$25,000-$69,999	≥$70,000	1.85 (0.78, 4.41)	0.16
<$25,000	≥$70,000	1.27 (0.68, 2.39)	0.45
Born outside of the US	Born in the US	1.33 (0.50, 3.55)	0.57

Variable	Reference Category	Odds Ratio (95% CI)	*P*-Value
Prior bad experience with tap water	No prior bad experience with tap water	0.74 (0.43, 1.28)	0.28
Favorable perceptions of bottled water compared to tap water	-	1.94 (1.50, 2.50)	**<.001**
Negative home tap water experiences	-	1.32 (1.12, 1.56)	**<.001**
Use of alternatives and/or modifications to home tap water	-	1.25 (1.04, 1.51)	**0.02**
Have received water quality information from each of the following sources:			
Media	Not media	0.75 (0.30, 1.87)	0.54
Government	Not government	0.63 (0.28, 1.39)	0.25
Non-government	Not non-government	0.43 (0.17, 1.11)	0.08
Friends/family	Not friends/family	0.71 (0.40, 1.26)	0.24
Healthcare provider	Not healthcare provider	0.97 (0.50, 1.89)	0.93
Primary source of drinking water:			
Public supply (municipal)	Not public supply (municipal)	0.07 (0.01, 0.63)	**0.02**
Private supply (private well, river, pond, lake)	Not private supply	0.13 (0.01, 1.19)	0.07
Public supply (rural water district)	Not public supply (rural water district)	0.18 (0.02, 1.51)	0.11
Purchase bottled water	Not bottled water	0.15 (0.02, 1.21)	0.08
Positive perception of groundwater quality	Negative perception of groundwater quality	0.61 (0.27, 1.42)	0.25
Positive perception of surface waters quality	Negative perception of surface waters quality	1.87 (0.88, 3.97)	0.1
Water access score	-	0.56 (0.48, 0.66)	**<.001**
Water quality and acceptability score	-	1.21 (1.01, 1.45)	**0.04**
Water distress score	-	1.16 (0.98, 1.36)	0.09

Binary logistic regression was performed to determine odds ratios for the odds of perceiving tap water to be unsafe.
Abbreviations: 95%CI, 95% confidence interval; US, United States

Discussion

Mistrust in tap water in Latinx adults appears to be influenced by organoleptic perceptions and related to behavioral changes to the home drinking water system. Overall, 51.2% of Latinx adults in this Phoenix, Arizona sample perceive their tap water to be unsafe. Previous studies observed prevalence of mistrust from 14.7% to 33.8% in Latinx individuals (Javidi & Pierce, 2018; Onufrak et al., 2012; Park et al., 2019; Pierce & Gonzalez, 2017). It's not clear why the prevalence of mistrust is greater in the current sample, but it is unlikely that over half of the sample has access to unsafe water. The majority of drinking water in Phoenix, AZ is sourced from the Salt, Verde, and Colorado Rivers and regulated across five water treatment plants. Only ~2% of drinking water in Phoenix is sourced from groundwater wells, which are operated by the city (City of Phoenix Water Services Department, 2020). The City of Phoenix utilizes chlorine to disinfect all drinking water. This process can generate disinfection byproducts in water (i.e., total organic carbon, chlorine dioxide, chlorite, bromate, total trihalomethanes, and haloacetic acids). As of 2020, levels of chlorine and disinfection byproducts were all below the maximum contaminant levels as set by the EPA. Other substances detected in the water met the EPA's standards for maximum contaminant levels. Accordingly, municipal tap water available to individuals in this sample is likely safe for consumption. Participants appear to agree with this as 88.2% and 83.5% have positive perceptions about the quality of local groundwater (sources of well water) and surface waters (rivers, streams, lakes, channels, and wetlands). However, tap water quality can be affected by home infrastructure (e.g., premise plumbing). While tap water quality was not tested in participants' residences, the City of Phoenix tested for lead and copper in a small sample (n = 61) of residential water taps and the federal standards set by the EPA were met (City of Phoenix Water Services Department, 2020).

About half of Latinx adults in this sample purchase bottled water for their primary source of drinking water. The prevalence of tap water mistrust was greater in those purchasing bottled water but lower in those using the public supply (municipal and rural water district) as their primary source. Accordingly, the odds of mistrust were significantly lower in those who rely on the public supply (municipal). Those who mistrust their tap water appear to rely on alternatives or modifications to the home drinking water system. Specifically, there was significantly greater prevalence of mistrust among those who are not satisfied with their current drinking water (piped in house) and the odds of mistrust increased with each additional alternative and/or modification employed. Mistrust was significantly more prevalent in those who purchase ≥ 1-gallon containers for drinking water, who often use bottled water for drinking water purposes, and whose drinking water is separate from their water supply system. Thus, Latinx adults who mistrust their tap water are most likely to rely on alternatives to their home drinking water system rather than modifications (i.e., water softener or water treatment system). Hispanic households have previously been observed to be significantly less likely to rely on tap water (unfiltered and filtered) over bottled water compared to NH white households (Javidi & Pierce, 2018). Additionally, the use of home water treatment devices was significantly less prevalent among Hispanic adults compared to NH white adults (Rosinger et al., 2018). It's possible that filtered or treated water may not be perceived as safe, even if it is perceived more favorably than unfiltered or untreated water. Florida residents who consume municipal water believed that water filters could combat organoleptic concerns, such as unpleasant tasting water. However, they still preferred bottled water for what they considered to be more serious concerns (i.e., safety, contamination, and health risk) (Triplett et al., 2019). Similarly, tap water mistrust in the present sample was prevalent among perceptions that bottled water tastes and smells better (62.2%), is of higher quality (60.9%), and is safer (61.7%) than tap water. Moreover, the odds of mistrusting tap water were significantly greater with each favorable perception of bottled water compared to tap water. In comparison, previous investigations have observed 34.1% (Onufrak et al., 2012) and 64.7% (Park et al., 2019) of Hispanic adults to perceive bottled water to be safer than tap water. Adults who believe bottled water is safer than tap water are significantly less likely to primarily consume tap water (van Erp et al., 2014). Similarly, beliefs that bottled water is cleaner and tastes better than tap are both associated with significantly greater odds of primarily consuming bottled water (Gorelick et al., 2011).

The prevalence of tap water mistrust was not different across race categories in the present sample. NH Caucasian individuals commonly have the lowest prevalence of tap water mistrust among races in previous investigations. However, prevalence in this present sample was higher (39.8%) than previously reported (5.1 – 10.8%) (Javidi & Pierce, 2018; Onufrak et al., 2012; Pierce & Gonzalez, 2017). The difference in prevalence may be related to ethnicity as previous investigations only recruited NH Caucasian individuals while the present investigation only recruited Latinx Caucasian individuals. Moreover, after controlling for all other predictors in the model, Latinx African American, African, Black, and Caribbean adults were over three times more likely to mistrust their tap water compared to Latinx Caucasian adults. Tap water perceptions were not different between those born inside or outside of the US. This is in contrast to previous investigations in which the prevalence and odds of mistrusting tap water were greater in foreign-born individuals (Javidi & Pierce, 2018; Pierce & Gonzalez, 2017). Tap water mistrust in foreign-born Latinx adults was hypothesized to be related to experiences with poor water quality in their home countries. However, a significant interaction between nativity and prior experiences with tap water was not observed in the present investigation.

Mistrust in the present sample did not follow the patterns previously observed across education or income levels. Prevalence of mistrust was lowest in both the lowest and highest levels of education. While education level was a significant predictor of tap water mistrust, the odds of mistrust were not significantly different between having a college education or more and having some college education or having a high school education or less. In comparison, the prevalence of mistrust was lowest in the higher levels of education in previous investigations (Onufrak et al., 2012; Park et al., 2019). Moreover, the odds of trusting tap water safety were greater in US adults with at least a high school degree who completed the American Housing Survey in 2013 (OR = 1.448 (Pierce & Gonzalez, 2017)) and 2015 (OR = 1.15 (Javidi & Pierce, 2018)). The difference in our findings compared to previous findings is likely related to our sample being highly educated (> 90% have at least some college education). Additionally, the prevalence of mistrust has typically steadily declined with increased income in previous investigations (Onufrak et al., 2012; Park et al., 2019). A clear relationship between income and tap water mistrust was not observed in the present investigation. Furthermore, education level and income level were not observed to moderate any relationships between predictors and tap water mistrust.

Organoleptic characteristics of water have commonly been associated with safety perceptions. This is supported by our findings in which the odds of tap water mistrust increased with each additional negative home tap water experience. In particular, mistrust was more common among Latinx adults who have experienced hard water/mineral deposits, unpleasant taste, unpleasant smell, and other contaminants in their home tap water in the previous year. Prevalence of mistrust was not different among adults with and without sediment or rusty color in their home tap water. Additionally, the odds of mistrust were significantly greater for each additional water quality acceptability score, where a higher score indicates worse water quality and acceptability. While organoleptic characteristics of water are not dependable indicators of health risk (Napier & Kodner, 2008), it appears Latinx adults may associate undesirable perceptions with a lack of safety. The present findings are supported by previous focus groups and interviews in which Latinx adults reported believing their tap water was not safe due to unpleasant taste, discoloration, unpleasant smell, and presence of chlorine or other minerals that cause tap water to taste unpleasant (Hess et al., 2019; Scherzer et al., 2010).

While participants have changed their minds about environmental issues in response to various sources of information, differences in the prevalence of tap water mistrust were not observed for any source. However, newspapers, television, and friends and family were the most common sources of water quality information. Prevalence of mistrust was greater for those who receive water quality information from a health care provider (54.6%) compared to those who do not (43.2%). The news, advertising, and friends have previously been identified as prevalent information sources, with family being a significantly more common source for Latinx parents compared to NH white parents (Gorelick et al., 2011). Unsurprisingly, consumer confidence reports were the least common source of water quality information. While the EPA utilizes these reports to communicate with citizens about the quality of their local water, they do not meet national readability standards and are considered difficult to understand (Johnson, 2003; Roy et al., 2015). Receiving water quality information from government sources and non-government sources were not significant predictors of tap water mistrust. Latinx mistrust in tap water safety has been hypothesized to be related to distrust in the government (Scherzer et al., 2010). However, 68.4% of adults in this investigation believe some level of government (federal, state, or local) should be responsible for protecting water quality in the community. Mistrust was greatest in those who believe local government should be responsible and lowest in those who believe individual citizens should be responsible. Ultimately, education about water quality does not appear to be an effective way to address tap water mistrust in Latinx adults. Contrarily, favorable perceptions of and reliance on bottled water in this sample support previous beliefs that water-related perceptions and behaviors are influenced by bottled water advertisements and marketing (Doria, 2006; Pierce & Gonzalez, 2017). In particular, bottled water marketing campaigns appear to capitalize on perceived associations between organoleptic perceptions, health, and risk through utilizing labels such as pure, pristine, natural, and healthy (Doria, 2006; Wilk, 2006). Bottled water marketing and advertising campaigns also have a history of targeting minorities (Javidi & Pierce, 2018). Unfortunately, promotional campaigns for tap water currently do not exist.

Limitations

The sample was highly educated, with 92.9% of participants having completed at least some college, and was not evenly distributed across sexes (62.6% male). Participants were only recruited from Phoenix, AZ, so these results are not generalizable to other geographical areas. Furthermore, while participants with a wide range of ages (18 – 75 y) were recruited, 93.5% of the sample was < 40 y (median age of 26 y). As mentioned previously, the actual quality of participants' residential tap water was not tested. Accordingly, it is possible that some perceptions of mistrust in tap water safety are valid. Finally, there is unmeasured error associated with all forms of public opinion research. As is commonly the case with self-reported data, we were not able to verify the accuracy of responses. Specifically, we could not verify whether individuals were actually Latinx or residents of the greater Phoenix, AZ area.

Conclusion

Overall, Latinx mistrust in tap water safety is very prevalent in Phoenix, AZ, and appears to be related organoleptic perceptions of home tap water. Those who mistrust their tap water safety appear to rely on alternatives to their home drinking water system, such as purchasing bottled water and ≥ 1-gallon containers for drinking water. The majority of this sample perceives local sources of water positively and appears to trust their government to regulate municipal water. Accordingly, public policy and/or interventions differentiating quality and sensory characteristics (e.g., taste and smell) from safety seem warranted. Onetime or regular volunteer activities related to water may be effective means for reaching this population.

CHAPTER 4

TAP WATER PERCEPTIONS DO NOT INFLUENCE HYDRATION STATUS IN US LATINX ADULTS

Abstract

The purpose of this investigation was to evaluate the influence of tap water safety perceptions on plain water intake (PWI) and 24-h hydration status, after adjustment for predictors of tap water safety perceptions, in US Latinx adults. Latinx adults residing in Phoenix, Arizona (n = 55, age = 33 ± 14 y, 67.3% female, body mass index = 27.77 ± 6.60 $kg \cdot m^{2}$, and physical activity = 3,670 ± 4,799 $MET\text{-}minutes \cdot week^{1}$) completed data collection over one week. Predictors of tap water safety perceptions were evaluated via an Adapted Survey of Water Issues in Arizona and household water security experience-based scales. Online dietary recalls were completed on two weekdays and one weekend day via Automated Self-Administered 24-hour Dietary Assessment Tool to determine average PWI and total water intake (TWI). A 24-h urine sample was collected on one of the three dietary recall days and analyzed for urine osmolality (U_{Osm}). Independent t-tests were used to identify differences in baseline characteristics, hydration variables, and water intake variables between groups (safe vs. unsafe perception of tap water). Hierarchical linear regression was employed with 24-h U_{Osm} and PWI as primary outcomes. Overall, 52.7% of participants mistrust their tap water safety. There were no differences in TWI (trust = 2,589 ± 1,157 mL, mistrust = 2,759 ± 1,136 mL), PWI (trust = 1,247 ± 851 mL, mistrust = 1,455 ± 1,073 mL), or 24-h U_{Osm} (trust = 455 ± 236 $mosm \cdot kg^{-1}$, mistrust = 464 ± 235 $mosm \cdot kg^{-1}$) ($P > 0.05$). Participants who mistrust tap water consumed significantly more bottled water (751 ± 811 mL) than those who trust their tap water (376 ± 531 mL, $P < 0.05$). After adjustment for predictors of tap water safety perceptions, tap water safety perceptions did not significantly explain any of the variance in PWI or 24-h U_{Osm} ($P > 0.05$). In conclusion, perceptions of tap water safety do not appear to be related to PWI, TWI, or hydration status in Latinx adults. However, this is the first investigation to confirm that Latinx adults who mistrust their tap water consume more bottled water. Accordingly, tap water perceptions do not appear to be an important consideration for efforts designed to improve TWI or hydration status in Latinx adults.

Introduction

Underhydration, dehydration, and low water intake are consistently associated with adverse health outcomes. The National Academy of Medicine (NAM) has linked dehydration to numerous health outcomes, including cardiovascular dysfunction, urinary tract infections, several chronic diseases, and death (National Academy of Medicine, 2005). Greater prevalence of chronic kidney disease and diabetes has similarly been associated with low water intake (Clark et al., 2016; Enhorning et al., 2010; Sontrop et al., 2013). Contrarily, increased water intake has been associated with augmented cognitive performance in children (Fadda et al., 2012), less frequent urinary tract infections (Hooton et al., 2018), and enhanced glucose regulation (Enhorning et al., 2017). The NAM recommends adult men and women in the United States (US) to consume 3.7 L and 2.7 L per day, respectively, to maintain euhydration (National Academy of Medicine, 2005). Adherence to NAM total water intake (TWI) recommendations has been low in recent decades, ranging from 17.4 – 59.4% in adults > 18 y from 2005 to 2016 (Drewnowski et al., 2013; Vieux et al., 2020).

Latinx adults have consistently consumed significantly less TWI compared to non-Hispanic (NH) white adults in recent years (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018). In particular, Latinx adults were observed to consume 341 mL less of TWI and were 1.42 times more likely to be inadequately hydrated compared to NH white adults. (Brooks et al., 2017). Latinx adults who consumed any tap water were slightly less likely to be inadequately hydrated (odds ratio [OR] = 1.37; 95% CI = 1.18, 1.59) (Brooks et al., 2017). For the entire sample, 29.5% of individuals were inadequately hydrated, and the risk of inadequate hydration was lower for adults consuming any tap water (OR = 0.83; 95% CI = 0.70, 0.98) (Brooks et al., 2017). Although plain water intake (PWI) has not been different between NH white and Latinx adults, NH white adults consume more tap water while Latinx adults consume more bottled water (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018).

Individuals continuously lose water throughout the day (e.g., through sweating and urination), but their intake of water is episodic and deliberate. Individuals may voluntarily dehydrate when their fluid intake does not compensate for fluid losses, despite having access to water (Greenleaf & Sargent, 1965). Voluntary dehydration has historically been attributed to stressors that accentuate water losses (e.g., physical activity and environmental heat stress). However, it is apparent from National Health and Nutrition Examination Survey (NHANES) data that a similar phenomenon occurs in the absence of stressors or water deficits and allows for underhydration. The decision to drink water is complex and is influenced by a myriad of factors including context (Zoellner et al., 2012), environment (Sebastian et al., 2011; Zoellner et al., 2012), eating behaviors (Zoellner et al., 2012), geography (Goodman et al., 2013), and beverage attributes (Block et al., 2013; Zoellner et al., 2012).

In Latinx adults, the decision to drink water may also be influenced by their perceptions of tap water safety. The prevalence of tap water safety mistrust in Latinx adults is 14.7% to 33.8% and is commonly greater than the prevalence observed in non-Hispanic (NH) white adults (Javidi & Pierce, 2018; Onufrak et al., 2012; Park et al., 2019; Pierce & Gonzalez, 2017). While mistrust was associated with almost two times greater odds of low PWI ($\leq$ 1 time/d) in one sample of Latinx adults (Onufrak et al., 2012), no association was observed between perceptions and PWI over the previous month in another sample (Park et al., 2019). PWI source choices (tap vs. bottled) may also be related to perceptions of bottled water safety. Individuals who believe bottled water is safer than tap water are less likely (odds ratio, OR = 0.28) to primarily consume tap water. Furthermore, Latinx adults, specifically, were less likely than NH white adults to primarily consume tap water (OR = 0.33), only when the analysis was adjusted for safety perceptions (van Erp et al., 2014). Unavailability of an individual's preferred source of water has been identified as a barrier to increasing TWI, whereas availability and convenience of water are believed to support increasing TWI (Zoellner et al., 2012). Latinx adults have described bottled water as easily accessible and transportable (Hess et al., 2019) and are more likely than NH white adults to endorse a higher level of agreement with the belief that bottled water is more convenient than tap water (Gorelick et al., 2011). Moreover, primarily reliance on bottled water was 1.7 times more likely in adults who believe bottled water is more convenient than tap water (Gorelick et al., 2011).

Unfortunately, findings regarding PWI and water perceptions in Latinx adults are limited and inconsistent. Discrepancies are likely related to the measurement of PWI in recent studies evaluating tap and bottled water safety in US adults. PWI has only been measured through one unvalidated survey question about the frequency of consumption (Onufrak et al., 2012; Park et al., 2019), through a question regarding the participant's primary source of PWI (Hobson et al., 2007; Huerta-Saenz et al., 2012; Javidi & Pierce, 2018; van Erp et al., 2014), or not at all (Gorelick et al., 2011; Pierce & Gonzalez, 2017). Additionally, only one investigation (Park et al., 2019) included a sample comprised entirely of Latinx adults and no investigations included measurements of TWI or hydration status. Therefore, the purpose of this investigation was to *evaluate the influence of tap water safety perceptions on PWI and 24-h hydration status, after adjustment for predictors of tap water safety perceptions, in US Latinx adults*. PWI and TWI were assessed via the Automated Self-Administered 24-hour (ASA24®) Dietary Assessment Tool, developed by the National Cancer Institute (Subar et al., 2020). This validated method was adapted from the United States Department of Agriculture Automated Multiple-Pass Method, commonly used in the NHANES. Moreover, 24-h urine markers were utilized to evaluate hydration status, which are validated, are noninvasive, and encompass behavioral and neuroendocrine fluctuations across the day that are not captured in spot samples (Cheuvront et al., 2015).

Methods

English- and Spanish-speaking male and female adults (18 - 65 y) who self-identify as Hispanic or Latinx in Phoenix, AZ were recruited for participation. Participants were excluded if they satisfied at least one of the following criteria: 1) currently pregnant, 2) currently use diuretics, 3) do not have access to a desktop, laptop, tablet, or smartphone, or 4) do not have internet access. Individuals who satisfied all criteria were enrolled. All potential participants were informed of participation risks and benefits as well as their rights as a participant. Documented signed consent was obtained electronically from all participants. Fifty-five individuals from a larger investigation (Paper 2) consented to voluntary participation and participated in the current investigation. Data collection occurred September 2021 – February 2022 in Phoenix, Arizona, USA. This protocol was approved by the university's institutional review board and biosafety committee (protocol no. STUDY00014055), was registered at clinicaltrials.gov (NCT04997031), and was conducted in compliance with the Helsinki Declaration as revised in 1983.

Data collection occurred across a one-week period. As described previously in greater detail, participants initially completed an Adapted Survey of Water Issues in Arizona (Castro et al., 2011; Mahler et al., 2013) as well as household water security experience-based scales developed for low-income peri-urban and rural communities on the US-Mexico border (Jepson, 2014). Then, participants completed one 24-h urine sample and three 24-h dietary recalls via the Automated Self-Administered 24-hour (ASA24®) Dietary Assessment Tool, version (2020), developed by the National Cancer Institute, Bethesda, MD (Subar et al., 2020). Two dietary recalls were collected on weekdays, and one was completed on a weekend day. The days of the week that each participant completed his or her dietary recalls were randomly selected. Furthermore, 24-h urine sample collection aligned with one of the three dietary recall days. The International Physical Activity Questionnaire (long last seven days self-administered format; for use with young and middle-aged adults (15 – 69 years)) (Craig et al., 2003) was completed at the end of the week to determine physical activity levels across a 7-day period (MET-minutes·week^{1}). Ambient temperature (°F) was obtained from the National Weather Service Forecast Office Daily Climate Reports (National Weather Service Forecast Office) and an average ambient temperature was determined for the week of data collection for each participant.

Participants visited the lab for baseline data collection. Height and body mass measurements were collected (Seca 286, Seca GmbH & Co. KG, Hamburg, Germany), from which body mass index (BMI) was calculated (body mass (kg) / [height (m)]^2 (Centers for Disease Control and Prevention). Participants were provided with 24-h urine collection materials and instructed on the correct ways to collect 24-h urine samples. The collection started after the first-morning sample on the day of collection and ended with the first-morning sample on the following day. Hydration status was assessed through 24-h U_{Osm} via freezing point depression (A_2O® Advanced Automated Osmometer, Advanced Instruments, Norwood, MA, USA) and 24-h urine volume via digital scale (Taylor USA, Lifetime Brands, Inc., Oak Brook, IL, USA). Additionally, urinary osmotic excretion was calculated (urine volume (L) * urine osmolality ($mOsm \cdot kg^{-1}$), with the assumption that 1 L = 1 kg).

Dietary recalls were completed online via the ASA24® Dietary Assessment Tool, version (2020), developed by the National Cancer Institute, Bethesda, MD (Subar et al., 2020). Participants were required to complete recalls in one sitting (with breaks of no more than 30 minutes). ASA24® was available in both English and Spanish to accommodate participant preference and was accessible via desktop, laptop, tablet, or smartphone. PWI was determined from ASA24® dietary recalls. An average PWI was calculated from the three dietary recalls. Diet recalls were also used to determine the average total energy consumption as well as the average energy consumed by all beverages excluding plain water.

Statistical analyses

An a priori sample size of n = 57 was determined based on power = 0.80, $\alpha = 0.05$, 1 tested predictor, and 30 total predictors (Faul et al., 2007). At a minimum, this allows for detection of a partial R^2 of ~ 13% or more. No previous literature has statistically evaluated the association between tap water perceptions and plain water intake or hydration status. Thus, a medium effect size $f^2 = 0.15$ (Cohen, 1992) was utilized to evaluate the unique variance of plain water intake and hydration status explained by tap water safety perceptions.

Data analyses were completed using commercial software (IBM SPSS Statistics Version 27.0.0). Data are presented as mean ± standard deviation, unless otherwise specified. A $P < 0.05$ was considered statistically significant for all analyses. Independent samples t-tests were used to identify differences in baseline characteristics, hydration variables, and water intake variables between groups (safe vs. unsafe perception of tap water). Data were evaluated for normality and homoscedasticity. Multicollinearity was assessed for predictor variables and interaction terms via bivariate correlation.

Hierarchical linear regression was employed with 24-h U_{Osm} and PWI as primary outcomes. Model 1 included covariates of the outcome variables: physical activity level, average ambient temperature, BMI, sex, and age. Model 1 also included average TWI when 24-h U_{Osm} was the primary outcome. Model 2 included model 1 variables plus additional demographic variables: race, education level annual income, and nativity. Model 3 include variables from models 1 and 2 plus the perception of tap water safety. Finally, model 4 included all variables from previous models plus predictors that were previously identified to significantly predict unsafe perceptions of tap water safety (see Paper 2): favorable perceptions of bottled water compared to tap water, negative home tap water experiences, use of alternatives and/or modifications to home tap water, public supply (municipal) as the primary source of drinking water, water access score, and water quality and acceptability score. The residual variance in tap water safety perceptions was evaluated via partial R^2 of set 4. Models were evaluated by ANOVA and R^2 change, and predictors were evaluated by unstandardized coefficients (b).

Results

Sample demographics and characteristics are presented in Table 4-1. The majority of participants were female (67%), Caucasian (47%), college educated or more (64%) and born in the United States (67%). Age, body mass, height, BMI, and physical activity level were not different between groups ($P > 0.05$). Water intake and hydration status are presented in Table 4-2. On average, participants' 24-h urine osmolality was below 500 mosm·kg^{-1}. Average TWI was 2,841 ± 1,114 mL and 2,599 ± 1,157 mL for men and women, respectively. 22.2% of men and 27.8% of women met the NAM TWI guidelines. Ten (38.5%) participants who trust their tap water met the NAM TWI guidelines, compared to eight (27.6%) of participants who mistrust their tap water. Furthermore, 61.8% of participants were euhydrated (24-h U_{Osm} < 500 mosm·kg^{-1}), with similar observed between those who trust (65.4%) and mistrust (58.6%) their tap water. On average, TWI was 45.6 ± 20.5% PWI, 30.7 ± 16.5% water intake from other beverages, and 23.7 ± 9.8% water intake from foods. Among individuals who trust their tap water, 30.8% consumed no bottled water and 15.4% consumed no tap water (0 mL). In contrast, among individuals who mistrust their tap water, 20.7% consumed no bottled water, 31.0% consumed no tap water, and 3.4% consumed no plain water (0 mL). Energy consumed from beverages was 13.3 ± 7.8% of total energy. No differences were observed in any markers of hydration status between tap water safety perceptions (*P* > 0.05). The only difference observed regarding water intake was that individuals who mistrust their tap water consumed significantly more bottled water compared to those who trust their tap water (mean difference = 375 mL, 95% CI = -1, 750 mL, $t_{[53]}$ = 2.002, *P* = 0.050).

Table 4-1. Sample demographics and characteristics (n = 55).

	Safe Perception of Tap Water	**Unsafe Perception of Tap Water**	**All**
Total (n)	26	29	55
Sex (n)			
Male	10	8	18
Female	16	21	37
Race (of Latinx origin) (n)			
Caucasian	15	11	26
Other[1]	11	18	29
Education Level (n)			
High school graduate or less	3	0	3
Some college	8	9	17
College graduate or more	15	20	35
Annual Income (n)			
<$25,000	7	9	16
$25,000-$69,999	16	14	30
≥$70,000	3	6	9
Nativity (n)			
United States	16	21	37
Other	10	8	18
Age (y)	33 ± 15	33 ± 13	33 ± 14
Body mass (kg)	77.40 ± 16.12	79.56 ± 23.80	78.54 ± 20.38
Height (m)	1.692 ± 0.112	1.665 ± 0.101	1.678 ± 0.106
Body mass index ($kg \cdot m^{-2}$)	26.92 ± 4.45	28.54 ± 8.06	27.77 ± 6.60
Physical activity (MET-minutes·week[1])	4,435 ± 6,327	2,984 ± 2,768	3,670 ± 4,799

Data are presented as sample size (n) or mean ± standard deviation.
[1]"Other" does not include Asian, Pacific Islander, or Native American.

Table 4-2. Water intake and hydration status (n = 55).

	Safe Perception of Tap Water	**Unsafe Perception of Tap Water**	**All**

24-h Urine volume (mL)	1,626 ± 926	1,562 ± 755	1,592 ± 833
24-h Urine osmolality (mosm·kg^{-1})	455 ± 236	464 ± 235	460 ± 234
24-4h Urinary osmotic excretion (mosm)	611 ± 285	612 ± 222	611 ± 251
Average total water intake (mL)	2,589 ± 1,157	2,759 ± 1,136	2,678 ± 1,139
Average plain water intake (mL)	1,247 ± 851	1,455 ± 1,073	1,357 ± 971
Average tap water intake (mL)	871 ± 709	705 ± 927	783 ± 827
Average bottled water intake (mL)	376 ± 531	751 ± 811*	574 ± 712
Average water intake from other beverages (mL)	775 ± 430	702 ± 333	736 ± 380
Average water intake from food (mL)	567 ± 279	602 ± 297	585 ± 287
Average energy intake (kcal)	1,972 ± 921	1,932 ± 616	1,951 ± 768
Average energy intake from beverages (kcal)	268 ± 193	232 ± 135	249 ± 164

Data are presented as mean ± standard deviation.
*Significant difference between individuals with safe and unsafe perceptions of tap water (*P* = 0.05).

Results from the hierarchical linear regression models are presented in Table 4-3 for 24-h urine osmolality and Table 4-4 for plain water intake. Model 1 predicted a significant amount of the variance in 24-h urine osmolality ($F_{6,48}$ = 2.610, *P* = 0.03; R^2 = 0.246). Models 2 (ΔR^2 = 0.038, $\Delta F_{4,44}$ = 0.588, *P* = 0.67), 3 (ΔR^2 = 0.003, $\Delta F_{1,43}$ = 0.168, *P* = 0.68), and 4 (ΔR^2 = 0.157, $\Delta F_{6,37}$ = 1.748, *P* = 0.14) did not significantly explain additional variance in 24-h urine osmolality. No models significantly explained plain water intake (Model 1, $F_{5,49}$ = 1.317, *P* = 0.27; R^2 = 0.118; Model 2, ΔR^2 = 0.095, $\Delta F_{4,45}$ = 1.360, *P* = 0.26; Model 3, ΔR^2 = 0.000, $\Delta F_{1,44}$ = 0.009, *P* = 0.93; Model 4, ΔR^2 = 0.024, $\Delta F_{6,38}$ = 0.196, *P* = 0.98).

Table 4-3. Hierarchical linear regression models for 24-h urine osmolality (mosm·kg^{-1}) (n = 55).

Variable	Model 1$^{+,\#}$	Model 2	Model 3	Model 4
Sex	-123.26 (-250.72, 4.21)	-129.34 (-261.52, 2.84)	-132.30 (-266.47, 2.07)	-152.22 (-288.09, -16.35)*
Age (y)	-1.09 (-5.58, 3.41)	-2.51 (-8.43, 3.41)	-2.46 (-8.45, 3.53)	-1.67 (-7.70, 4.36)

Variable	Model 1[+,#]	Model 2	Model 3	Model 4
Body mass index ($kg \cdot m^2$)	0.83 (-8.55, 10.22)	0.50 (-9.84, 10.84)	0.20 (-10.34, 10.75)	1.34 (-8.87, 11.55)
Physical activity (MET-min/wk)	0.00 (-0.01, 0.01)	0.00 (-0.02, 0.02)	0.00 (-0.02, 0.02)	0.00 (-0.01, 0.02)
Average temperature (°F)	1.33 (-14.64, 17.30)	0.81 (-15.86, 17.49)	1.13 (-15.79, 18.04)	7.66 (-9.82, 25.14)
Average total water intake (mL)	-0.10 (-0.15, -0.04)**	-0.11 (-0.17, -0.05)**	-0.11 (-0.17, -0.05)**	-0.11 (-0.17, -0.05)***
Race (of Latinx origin)		63.03 (-59.24, 185.29)	56.58 (-70.95, 184.10)	89.73 (-38.52, 217.99)
Education level		3.18 (-127.27, 133.62)	7.70 (-125.95, 141.35)	14.94 (-119.47, 149.36)
Annual income		-58.27 (-179.22, 62.68)	-59.45 (-181.78, 62.88)	-125.08 (-257.52, 7.37)
Nativity		-30.32 (-176.72, 116.08)	-29.457 (-177.42, 118.50)	-4.28 (-152.26, 143.71)
Unsafe tap water perception			26.34 (-103.23, 155.90)	-13.53 (-158.50, 131.44)
Favorable perceptions of bottled water compared to tap water				60.41 (-10.32, 131.14)
Negative home tap water experiences				-41.36 (-97.67, 14.96)
Use of alternatives and/or modifications to home tap water				10.83 (-45.31, 66.96)
Primary drinking water source: public supply (municipal)				-107.33 (-258.86, 44.20)
Water access score				-2.55 (-62.43, 57.34)
Water quality and acceptability score				-0.61 (-48.83, 47.61)

Data are presented as beta coefficient (95% confidence interval)
+Model ANOVA significantly significant ($P < 0.05$)
#Model R2 change significantly significant ($P < 0.05$)
**Significant beta coefficient ($P < 0.01$)
***Significant beta coefficient ($P < 0.001$)

Table 4-4. Hierarchical linear regression models for plain water intake (mL) (n = 55).

Variable	Model 1	Model 2	Model 3	Model 4
Sex	-105.29 (-667.80, 457.22)	-173.69 (-734.03, 386.65)	-176.42 (-746.44, 393.59)	-177.49 (-821.62, 466.64)

Variable	Model 1	Model 2	Model 3	Model 4
Age (y)	-15.78 (-35.53, 4.01)	-19.93 (-44.47, 4.60)	-19.88 (-44.73, 4.98)	-18.36 (-46.11, 9.39)
Body mass index (kg·m^2)	37.56 (-2.90, 78.03)	34.46 (-9.06, 77.97)	34.16 (-10.34, 78.65)	36.74 (-11.23, 84.71)
Physical activity (MET-min/wk)	-0.02 (-0.08, 0.04)	0.01 (-0.05, 0.07)	0.01 (-0.06, 0.08)	0.01 (-0.07, 0.08)
Average temperature (°F)	-30.81 (-101.52, 39.90)	42.21 (-113.35, 28.94)	-41.89 (-114.20, 30.42)	-32.57 (-116.18, 51.04)
Race (of Latinx origin)		126.70 (-399.49, 652.89)	120.37 (-429.25, 669.99)	176.52 (-439.23, 792.28)
Education level		-374.72 (-928.59, 179.15)	-370.18 ('939.07, 198.72)	-284.15 (-922.10, 353.80)
Annual income		-129.51 (-632.39, 373.37)	-130.56 (-639.89, 378.78)	-119.55 (-734.67, 495.57)
Nativity		-382.24 (-1,008.97, 244.48)	-381.33 (-1,015.77, 253.11)	-429.94 (-1,138.25, 278.37)
Unsafe tap water perception			25.95 (-532.87, 584.76)	-82.99 (-779.34, 613.37)
Favorable perceptions of bottled water compared to tap water				94.25 (-245.16, 433.66)
Negative home tap water experiences				40.13 (-230.34, 310.60)
Use of alternatives and/or modifications to home tap water				-86.61 (-354.81, 181.58)
Primary drinking water source: public supply (municipal)				-186.41 (-902.22, 529.40)
Water access score				-73.96 (-361.61, 213.69)
Water quality and acceptability score				-57.09 (-288.69, 174.50)

Data are presented as beta coefficient (95% confidence interval)

Discussion

To the authors' knowledge, this is the first investigation to evaluate perceptions of tap water safety, total water intake, and hydration status in Latinx adults. Differences in perceptions of tap water safety were not associated with differences in any markers of hydration status. The only difference observed regarding water consumption was that individuals who mistrust tap water consumed significantly more bottled water (~ 12 fluid ounces) compared to those who trust tap water.

While adherence to NAM TWI guidelines was low (men, 22.2%; women, 27.8%), the participants in this sample were well-hydrated (24-h U_{Osm} < 500 mosm·kg^{-1}) (Perrier et al., 2015). Previous NHANES data have revealed that Latinx adults (710 – 758 mL/d) consumed significantly more bottled water compared to NH white adults (345 – 437 mL/d) (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018). Differences in bottled water intake were proposed to be related to the greater prevalence of tap water mistrust in Latinx adults. The present study is the first to confirm this association between tap water safety perceptions and bottled water intake in Latinx adults. It has also been hypothesized that individuals who mistrust their tap water would consequently consume less plain water intake overall, which was not observed in the present study. Previously, mistrust in Latinx adults was associated with greater odds of low PWI (≤ 1 time/d) (Onufrak et al., 2012) but was not associated with PWI in the previous month (Park et al., 2019). Furthermore, the present findings reflect previous NHANES findings in which PWI was not different between NH white and Latinx adults, despite significantly greater bottled water intake in Latinx adults (345 – 437 mL/d) (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018). Differences in TWI between NH white and Latinx adults are likely attributable to differences in consumption of other beverages, such as sugar-sweetened beverages.

Despite high prevalence of tap water mistrust in US Latinx adults, tap water perceptions do not appear to be a barrier to water consumption or adequate hydration. The lack of findings is likely related to 38.2% of participants being inadequately hydrated (24-h U_{Osm} ≥ 500 mosm·kg^{-1}). Previously, 29.5% of US Latinx adults were identified as inadequately hydrated based on the cut-off of U_{Osm} ≥ 800 mosm·kg^{-1} (Brooks et al., 2017). Using that criterion, only 7.3% of the present sample would be considered inadequately hydrated. It is possible that findings could be different in a sample with hydration status that more accurately reflects the hydration status of Latinx adults across the US. Interestingly, PWI and TWI in the present study were lower than what is typically reported in Latinx adults in NHANES (Brooks et al., 2017; Drewnowski et al., 2013; Rosinger et al., 2018). It is likely that water consumption in the present study was underreported in dietary recalls, which appears to be supported by the participants' hydration status. Twenty-four-hour dietary recalls have previously been observed to capture fewer drinking occasions compared to a 7-day fluid diary (Bardosono et al., 2015). This may be related to beverage consumption behaviors, as beverage consumption typically occurs continuously over the course of a day (Barraj et al., 2009) and 70% of beverage consumption is estimated to occur outside of meals (Gandy, 2012). However, the ASA24 incorporates methodology to prompt individuals to report consumption outside of meals (e.g., participants were asked specifically about consumption during gaps between meals and snacks). Furthermore, participants in the present study completed three dietary recalls in an attempt to accurately capture their fluid intake. Finally, previous studies have only explained up to 14% of the variance in hydration status (spot urine osmolality) and stratified water intake (Muñoz & Wininger, 2019). Evidently, our current understanding of hydration status and water intake is superficial. Identification and inclusion of important predictors may enhance our ability to evaluate the relationships between water intake, hydration status, and tap water perceptions.

Limitations

The statistical analysis was powered a-priori for 57 participants, and we only recruited 55. Additionally, this sample was very well hydrated. It is possible that individuals who already value hydration were more likely to be recruited for this study. It is also possible that the topic of this research influenced participants' water consumption behaviors during data collection. Participants were only recruited from Phoenix, AZ, so these results are not generalizable to other geographical areas. Additionally, this sample was not evenly distributed across sex, education level, or income level. Finally, all dietary data was self-reported by participants, which is prone to inaccuracies. Participants completed three dietary recalls, one of which was on a weekend day, in an attempt to more accurately capture typical dietary consumption.

Conclusion

Perceptions of tap water safety do not appear to be related to PWI, TWI, or hydration status in Latinx adults. However, this is the first investigation to confirm that Latinx adults who mistrust their tap water consume more bottled water. Accordingly, tap water perceptions do not appear to be an important consideration for efforts designed to improve TWI or hydration status in Latinx adults. Additional investigation is needed in larger samples and samples from different geographic areas in the US to further explore the relationship between tap water perceptions and hydration status.

CHAPTER 5

CONCLUSION

Overall, Latinx mistrust in tap water safety is very prevalent in Phoenix, AZ, and appears to be related organoleptic perceptions of home tap water. Those who mistrust their tap water safety appear to rely on alternatives to their home drinking water system, such as purchasing bottled water and ≥ 1-gallon containers for drinking water. The majority of this sample perceives local sources of water positively and appears to trust their government to regulate municipal water. Accordingly, public policy and/or interventions differentiating quality and sensory characteristics (e.g., taste and smell) from safety seem warranted. Onetime or regular volunteer activities related to water may be effective means for reaching this population. Futhermore, perceptions of tap water safety do not appear to be related to PWI, TWI, or hydration status in Latinx adults. However, this is the first investigation to confirm that Latinx adults who mistrust their tap water consume more bottled water. Accordingly, tap water perceptions do not appear to be an important consideration for efforts designed to improve TWI or hydration status in Latinx adults. Additional investigation is needed in larger samples and samples from different geographic areas in the US to further explore the relationship between tap water perceptions and hydration status.

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APPENDIX A

IRB APPROVAL

APPROVAL: EXPEDITED REVIEW

Stavros Kavouras
Nutrition
(602) 496-2547
Stavros.Kavouras@asu.edu

Dear Stavros Kavouras:

On 6/1/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Tap Water Intake and Perceptions in US Latinx Adults
Investigator:	Stavros Kavouras
IRB ID:	STUDY00014055
Category of review:	
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• 2021-05-06 TWIPLA Flyer.pdf, Category: Recruitment Materials; • 2021-06-01 Participant Instructions.pdf, Category: Participant materials (specific directions for them); • 2021-06-01 TWIPLA IRB_Bioscience-Protocol.docx, Category: IRB Protocol; • 2021-06-01 TWIPLA Phase One Consent Form.doc.pdf, Category: Consent Form; • 2021-06-01 TWIPLA Phase Two Consent Form.pdf, Category: Consent Form; • Adapted National Integrated Water Quality Program Needs Assessment Survey 2.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • COVID19 Prescreening Questions.pdf, Category: Screening forms; • Idealized Guttman Water Scales.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

	• IPAQ_English_self-admin_long.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • IPAQ_Spanish(USA)_self-admin_long.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Screening Questions.pdf, Category: Screening forms; • TWIPLA Phase One Recruitment via Social Media.pdf, Category: Recruitment Materials; • TWIPLA Phase Two Recruitment via Email.pdf, Category: Recruitment Materials;

The IRB approved the protocol from 6/1/2021 to 5/31/2022 inclusive. Three weeks before 5/31/2022 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 5/31/2022 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the “Documents” tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Abigail Colburn
Abigail Colburn
Stavros Kavouras

APPENDIX B

PHASE ONE CONSENT FORM

Tap water intake and perceptions in US Latinx adults

I am a graduate student under the direction of Dr. Stavros Kavouras in the College of Health Solutions at Arizona State University. I am conducting a research study to evaluate perceptions of and experiences with drinking water in Latino and Hispanic adults living in Phoenix, AZ.

I am inviting your participation, which will involve the completion of three surveys. These surveys will address participation eligibility (11 questions)*, water quality in Arizona (40 questions), and household water experiences (19 questions). *The 11-question survey addressing participation eligibility will assess your eligibility for the current phase of this study as well as for a future phase. Collectively, these surveys will take approximately 30 minutes to complete. You have the right not to answer any question, and to stop participation at any time.

Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty. You must be 18 – 65 y to participate in the study.

Although there is no direct benefit to you, your participation in this study will benefit researchers by learning more about Latino and Hispanic adults' relationships with drinking water. There are no foreseeable risks or discomforts to your participation.

Your responses will be confidential and your data will be coded by a number instead of your name. This code will be used during data entry and in all computer programs for analysis. The results of this study may be used in reports, presentations, or publications but your name will not be used.

If you meet eligibility criteria and agree to take part in this research study, we will pay you $10 in the form of an e-gift card for your time and effort upon completion of the surveys. If you agree to participate in this study, then consent does not waive any of your legal rights. However, no funds have been set aside to compensate you in the event of injury. Upon compensation for this study, information may need to be reported to the IRS for tax purposes if other funds from Arizona State University total > $600.

If you have any questions concerning the research study, please contact the research team at: 602-496-2547, Stavros.kavouras@asu.edu to talk to the Principal Investigator Dr. Stavros Kavouras or at abigail.colburn@asu.edu to talk to Abigail Colburn. If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788.

By signing below you are agreeing to be part of the study.

Name:

Signature: Date:

APPENDIX C

PHASE TWO CONSENT FORM

Title of research study: Tap water intake and perceptions in US Latinx adults

Investigator: Stavros A. Kavouras, Ph.D., Assistant Dean and Professor of Nutrition, College of Health Solutions, Arizona State University

Why am I being invited to take part in a research study?

We invite you to take part in a research study because you are an adult aged 18 – 65 y, you self-identify as Hispanic or Latinx, and you expressed interest in participating during an earlier component of this study.

Why is this research being done?

The purpose of this study is to evaluate intake of all foods and beverages over a one-week period.

How long will the research last?

We expect that individuals will spend 30 minutes on one occasion and one hour per day on three additional occasions across a one-week period participating in the proposed activities.

How many people will be studied?

We expect about 62 people will participate in this research study.

What happens if I say yes, I want to be in this research?

It is up to you to decide whether or not to participate. You will be asked to provide data on four separate occasions across a one-week period. You will be asked to wear a mask when you visit the Hydration Science Lab at Arizona State University in the Wexford Laboratory. Members of the research team will be available to answer questions or concerns about data collection procedures for the duration of the study.

<u>Baseline (duration: approximately 30 min)</u>

You will visit the lab and height and weight measurements will be recorded. You will also be provided with materials for future data collection.

<u>Remaining three occasions (duration: approximately 1 h each)</u>

You will be asked to provide data on two weekdays and one weekend day. On each occasion you will be asked to complete an online 24-h dietary recall in which you report all foods and beverages consumed in the previous 24-h period, including time of consumption, description of food/beverage, and approximate size/volume of food/beverage.

On one of these occasions, you will be asked to collect your urine over a 24-h period in a provided container. The urine collection will start after the first morning void and end with the first morning sample the following day. You will be asked to bring your 24-h urine sample to the lab that same day by noon.

On the third occasion, you will also be asked to complete a questionnaire about your physical activity habits.

What happens if I say yes, but I change my mind later?

You can leave the research at any time it will not be held against you.

If you decide to leave the research, contact the investigator so that the investigator can make any schedule changes. If you stop being in the research, already collected data may not be removed from the study database. If you agree, this data will be handled the same as research data. This data may be used for analysis in the research study. You will not be expected to give a reason for your withdrawal.

Will being in this study help me in any way?

We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits include receiving feedback on your nutritional habits.

What happens to the information collected for the research?

Efforts will be made to limit the use and disclosure of your personal information, including research study and medical records, to people who have a need to review this information. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of this organization. All information will be kept private to the extent allowed by University Policy, State and Federal law. Your data will be coded by a number instead your name. This code will be used during data entry and in all computer programs for analysis. All data will be locked and stored in the Hydration Science Laboratory of the College of Health Solution. You will not be identified by name in any publication or presentation. Federal law provides additional protections of your related health information. These are described in an attached document.

Your urine samples will be stored at Arizona State University freezers for at up to 1 year and they might be analyzed in the future for exploration in the area of diet and diseases. Only scientists involved in the research study will have access to the laboratory.

What else do I need to know?

Continued failure to complete scheduled data collection may warrant termination of your participation in this study. The research team will notify you if we have determined that you should not continue in the study.

If you agree to take part in this research study, we will pay you up to $100 in the form of an e-gift card for your time and effort upon completion of the entire study. You will be compensated $25 for completion of each timepoint after baseline and an additional $25 as a completion bonus once you have completed the entire study. If you agree to participate in this study, then consent does not waive any of your legal rights. However, no funds have been set aside to compensate you in the event of injury. Upon compensation for this study, information may need to be reported to the IRS for tax purposes if other funds from Arizona State University total > $600.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team at 602-496-2547, Stavros.kavouras@asu.edu to talk to the Principal Investigator Dr. Stavros Kavouras or at abigail.colburn@asu.edu to talk to Abigail Colburn.

This research has been reviewed and approved by the Bioscience IRB ("IRB"). You may talk to them at (480) 965-6788 or research.integrity@asu.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.

You cannot reach the research team.
You want to talk to someone besides the research team.
You have questions about your rights as a research participant.
You want to get information or provide input about this research.

Signature Block for Capable Adult

Your signature documents your permission to take part in this research.

____ ____________________

Signature of participant Date

____

Printed name of participant

____ ____________________

Signature of person obtaining consent Date

____

Printed name of person obtaining consent

APPENDIX D

ADAPTED SURVEY OF WATER ISSUES IN ARIZONA

HOW DO YOU FEEL ABOUT THE ENVIRONMENT?

How important are each of the following water issues to you? (Select **one** answer per question)

Issue	Not important	Somewhat important	No opinion	Very Important	Extremely important
1. Clean drinking water	○	○	○	○	○
2. Clean groundwater	○	○	○	○	○
3. Water for household/private sector	○	○	○	○	○
4. Clean rivers	○	○	○	○	○
5. Protection of aquatic organisms	○	○	○	○	○
6. Water for agriculture	○	○	○	○	○
7. Watershed restoration	○	○	○	○	○
8. Destruction of wetlands (riparian areas)	○	○	○	○	○
9. Water for commerce/industry	○	○	○	○	○
10. Water for power generation	○	○	○	○	○
11. Water for recreation	○	○	○	○	○

DRINKING WATER ISSUES

12. Where do you primarily get your drinking water? (Select **one** answer)
- ○ Private supply (private well, river, pond, lake)
- ○ Public supply – municipal
- ○ Public supply – rural water district
- ○ Purchase bottled water
- ○ I don't know

13. Please <u>**select all**</u> of the boxes that apply to your home drinking water system.
- ☐ I have water softener
- ☐ I have a water treatment system (softener, etc.)
- ☐ I purchase ≥1-gallon containers of drinking water
- ☐ I often use bottled water for drinking purposes
- ☐ I never buy bottled water
- ☐ I am satisfied with my current drinking water (piped in house)

- ☐ I am not satisfied with my current drinking water (piped in house)
- ☐ My drinking water is separate from my water supply system

14. What is your level of agreement with the following statement: My tap water is safe to drink
- o Strongly disagree
- o Disagree
- o Agree
- o Strongly agree

15. Do you have your home drinking water tested?
- o Yes
- o No

16. In your opinion, how do bottled and tap water compare? (check **<u>all</u>** that apply)
- ☐ No difference
- ☐ Bottled water tastes/smells better
- ☐ Bottled water is of higher quality
- ☐ Bottled water is safer
- ☐ Tap water is safer
- ☐ Tap water tastes/smells better
- ☐ Tap water is of higher quality

17. Which, if any, of the following have you experienced with the tap water in your home over the past year? (check **<u>all</u>** that apply)
- ☐ No problems experienced
- ☐ Hard water / mineral deposits
- ☐ Unpleasant taste
- ☐ Sediment
- ☐ Unpleasant smell
- ☐ Rusty color
- ☐ Other contaminants

18. In your opinion, what is the quality of groundwater (sources of well water) in your area? (Select **one** answer)
- o Good or excellent
- o Good, and improving
- o Good, but deteriorating
- o Fair
- o Poor, but improving
- o Poor
- o No opinions / don’t know

19. In your opinion, what is the quality of surface waters (rivers, streams, lakes, channels, and wetlands) where you live? (Select **one** answer)
- o Good or excellent

- ○ Good, and improving
- ○ Good, but deteriorating
- ○ Fair
- ○ Poor, but improving
- ○ Poor
- ○ No opinions / don't know

20. Do you regard water **quantity** (having enough water) as a problem in the area where you live? (Select **one** answer)

- ○ No
- ○ Probably not
- ○ I don't know
- ○ Probably
- ○ Definitely

20. Rank the following water uses from most important (1) to least important (11) to you. (Use each number only once)

Item	Rank
Clean Drinking water	
Household water supply	
Clean groundwater	
Clean rivers, streams, lakes	
Water for agriculture	
Watershed restoration	
Aquatic organism protection	
Water for power generation	
Water for industry	
Wetlands/riparian areas	
Water for recreation	

21. How would you rate your awareness of the following factors that affect water quality?

Pollutant	Unaware	Somewhat aware	Aware
a. Agricultural water management	○	○	○
b. Animal waste management	○	○	○
c. Drinking water and human health	○	○	○
d. Environmental restoration	○	○	○
e. Nutrient and pesticide management	○	○	○
f. Pollution prevention and assessment	○	○	○
g. Watershed management	○	○	○
h. Water policy and economics	○	○	○

22. Do you know of or suspect that any of the following pollutants affect water quality in your area?

Pollutant	Not a problem	Don't know	Suspect	Know
a. High bacteria	○	○	○	○

b. Fertilizers/nitrates	○	○	○	○
c. Heavy metals	○	○	○	○
d. Minerals	○	○	○	○
e. Pesticides	○	○	○	○

23. Which of the following are most responsible for the existing pollution problems in rivers and lakes in your state? (Check **3** answers)

- ☐ Ag-crop production
- ☐ Ag-Livestock
- ☐ Erosion, wildfires
- ☐ Forestry
- ☐ Industry
- ☐ Military bases
- ☐ Mining
- ☐ Rangeland management
- ☐ Roads/construction
- ☐ Septic systems
- ☐ Wastes from urban areas
- ☐ Wild animals

24. Do you know what a watershed is?

- ○ Yes
- ○ No

25. What is your level of agreement with the following statement: I had a bad experience with tap water.

- ○ Strongly disagree
- ○ Disagree
- ○ Neither agree nor disagree
- ○ Agree
- ○ Strongly agree

GOVERNANCE

26. In your opinion, does the environment receive the right amount of emphasis from local government and elected officials in your state?

- ○ No, not enough emphasis
- ○ Yes, about right
- ○ No, too much emphasis
- ○ No opinion / don't know

27. In your opinion, who should be most responsible for protecting water quality in your community?

- ○ Federal government
- ○ State government
- ○ County, city, or town
- ○ Individual citizens
- ○ Don't know
- ○ Other

YOUR ENVRIONMENTAL PERSPECTIVE

28. Have you ever changed your mind about an environmental issue as a result of…

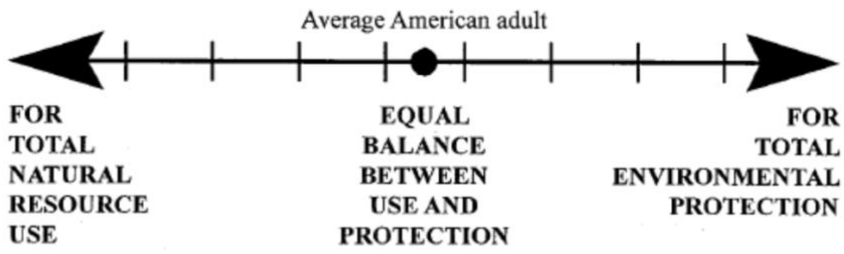
	Yes	No
a. News coverage (TV, newspaper, etc.)	○	○
b. Conversations with other people	○	○
c. Public meetings	○	○
d. Classes or presentations	○	○
e. Speech by elected representative	○	○
f. Firsthand observation	○	○
g. Financial considerations	○	○

29. Have you or someone in your household done any of the following as part of an individual or community effort to conserve water or preserve water quality? (Check **all** that apply)

- ☐ Bought or installed water saving device
- ☐ Changed how you use water in your house
- ☐ Chosen to dispose at approved facility
- ☐ Changed how yard is landscaped
- ☐ Changed how you deal with motor oil
- ☐ Changed how you wash your vehicle
- ☐ Other

WATER QUALITY EDUCATION

30. Please rate yourself on how you see yourself on environmental issues. Give a number, on a scale of 1 to 10, where 1 = total use of natural resources, 5 = balance between resource use and environmental protection, and 10 = total environmental protection.



31. Have you received water quality information from the following sources?

	Yes	No
a. Newspaper	○	○
b. Television	○	○
c. Environmental agencies (government)	○	○
d. Environmental groups (citizen groups)	○	○
e. Universities	○	○
f. Consumer Confidence Reports	○	○
g. Schools (elementary & secondary)	○	○
h. Extension Service	○	○
i. Friends/family	○	○
j. Healthcare provider	○	○

32. Would you like to learn more about any of the following water quality issue areas? (Check **all** that interest you)

- ☐ Drinking Water and Human Health
- ☐ Watershed Management
- ☐ Environmental Restoration
- ☐ Water Conservation
- ☐ Pollution Assessment and Prevention
- ☐ Nutrients & Pesticide Management
- ☐ Water Policy and Economics
- ☐ Agricultural Water Management
- ☐ Animal Manure and Waste Management

33. If you had the following kinds of learning opportunities available, which would you be most likely to take advantage of for water quality issues? (Check up to 3 items)

- ☐ Read printed fact sheets, bulletins, or brochures
- ☐ Read a newspaper article or series, or watch TV coverage
- ☐ Visit a website
- ☐ Look at a demo or display
- ☐ Watch a video of information
- ☐ Take part in a onetime volunteer activity to learn or do something (e.g., water monitoring)
- ☐ Attend a fair or festival
- ☐ Ask for a home, farm or workplace water assessment

- ☐ Get trained for a regular volunteer position (e.g., watershed steward, or water quality monitor)
- ☐ Attend a short course (weekend, evening)
- ☐ Take a course for credit/certification

DEMOGRAPHICS

34. What is your gender?
- ○ Male
- ○ Female
- ○ Other

35. What is your age?
- ○ <30
- ○ 30-39
- ○ 40-49
- ○ 50-59
- ○ 60-69
- ○ 70-79
- ○ 80+

36. What is your highest level of education?
- ○ Less than high school
- ○ High school graduate
- ○ Some college
- ○ College graduate
- ○ Post graduate course work

37. What is your community size?
- ○ >100,000
- ○ 25,000 to 99,999
- ○ 7,000 to 24,999
- ○ 3,500 to 6,999
- ○ <3,500

38. What is your zip code?

39. How long have you lived in Arizona?
- ○ Your entire life
- ○ >10 years
- ○ <10 years

40. What is your annual income?

- <$25,000
- $25,000-$44,999
- $45,000-$69,999
- ≥$70,000

41. What is your race?
- White
- Black
- Asian
- More than one race

42. What is your ethnicity?
- Hispanic or Latinx
- not Hispanic or Latinx