

Article

An Analysis of Household Perceptions of Water Costs across the United States: A Survey Based Approach

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Abstract: Research analyzing perceptions of water services has focused on water quality, water safety, and the propensity to consume water from different sources. It has not assessed perceptions of water costs. To address this knowledge gap, this study collected nationally representative survey data from households in the United States about water issues and incorporated these data into logistic regression models. In doing so, our study advances the water and public policy literature in three ways. One, it addresses the need for household resolution information about water issues given the absence of data at this scale in the United States. Two, it creates and utilizes one-of-a-kind survey data to understand the perceptions of household water bills and the drivers of these perceptions. Three, we assess the impact of proposed solutions to improve water affordability on household perceptions of water costs. Model results indicate low-income and households in underrepresented groups were more likely to perceive their water bills to be too high. The perception of water costs also varied geographically. From a policy perspective, model results indicate utilities can positively affect perceptions of water bills via the frequency of water billing and provision of payment assistance programs.

Keywords: water infrastructure; water services; water utilities; water bills; billing frequency; customer assistance programs (CAPS); affordability



Citation: Medwid, L.; Mack, E.A. An Analysis of Household Perceptions of Water Costs across the United States: A Survey Based Approach. *Water* **2022**, *14*, 247. <https://doi.org/10.3390/w14020247>

Academic Editor: Laura Bulgariu

Received: 6 December 2021

Accepted: 8 January 2022

Published: 15 January 2022

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1. Introduction

Approximately 68% of the world's population is projected to live in cities by 2050, representing a 13% increase in demand for water services in urban areas [1]. In addition to this rise in demand, water service providers face additional pressures related to institutional fragmentation, the inability to defray costs to replace deteriorating infrastructure, and increased capital costs to mitigate the impacts of climate change [2,3]. In the face of these challenges, urban water providers struggle to balance the rising costs of providing quality water service while simultaneously keeping the cost of service low for customers [2,4,5].

In the United States, there is some indication individuals feel their water bills are too high. Anecdotal evidence from news stories cite a lack of billing transparency and a complex mesh of reasons for rising water costs from city to city [6–9]. In San Diego, CA for example, residents are confused about the sudden spike in water bills and meter readings, which they say cannot be explained by rate increases alone [7]. In Bayonne, New Jersey, the city cut a deal to have its water managed by a Wall Street firm that guarantees a rate of return on their investment, which has contributed to rising water costs for residents [9]. These consumer concerns and the rising cost of providing water services mean it is important to understand consumer perceptions of the cost of water services. To this point in time, research has not assessed perceptions of water costs. Instead, research has focused on analyzing perceptions of other aspects of water services including: water quality [10,11], water safety [12–16], and the propensity to consume water from different sources (e.g., tap water or bottled water) [17,18]. A Canadian study found for example that 72% of respondents in Toronto were 'somewhat' or 'extremely' concerned about chemical pollutants in the water [17].

A study of the state of Georgia, found that approximately half of the respondents rated drinking water quality as very safe, safe, or fair [19]. In a study within the state of Florida, respondents who had experienced water quality issues previously were more likely to perceive that water quality problems were becoming worse [18]. The same study also found that participation in extension programs improved the perceptions of water quality.

Studies also find that people's perceptions of quality are based on superficial characteristics or organoleptic properties (e.g., taste, hardness, color, odor) that do not pose health risks to people compared to invisible quality issues related to microbial or chemical contamination [12–14]. For instance, hardness of tap water was found to be a main reason individuals avoid consumption of tap water, despite the fact that hardness does not pose any health risk [14]. Studies of bottled water consumption also find a divergence or paradox between product characteristics and consumption preferences [20] that is tied to the perceptions of taste [21,22] and perceptions of water safety [23]. Research also points to perceptions of water safety as a reason that vulnerable populations, such as low-income households, females and racial/ethnic minorities are more likely to purchase bottled water [19,22,24,25].

In terms of research that examines water costs directly, several studies have conducted research on water resource valuation, demand and willingness to pay [26,27]. Though the overall demand for water is inelastic [19], several trends have emerged in the literature. For instance, in Jordan and Elnagheeb's [19] study, Black Americans were willing to pay more for improvements in water quality than non-Black Americans. Willingness to pay was also found to increase with the level of education. Community engagement also affects public willingness to pay for watershed services as well as the level of public engagement in watershed management [28].

One of the largest disconnects between the perception of water costs and actual costs is access to clearly delineated water bills for household water consumers [26,29]. Interestingly, research indicates that the public's understanding of water rates is affected by the clarity of water bills [30]. Specifically, studies find that progressive price schedules are difficult to understand for consumers [30–32]. For example, a nation-wide study of the U.S. found that only 17% of utilities provided information about marginal prices and 78% provided no information other than the total amount required for payment [30]. More recent studies suggest this lack of clarity about water pricing may be linked to water consumption practices. For example, Binet et al. [33] investigated the perceived price of drinking-water when consumers are imperfectly informed about pricing schedules and found that households underestimate the price of water and consume more than what is economically rational. To this point in time, however, research on water and public policy has not yet evaluated the public's perception of the fairness of water costs.

To address this gap, this study designed and collected nationally representative survey data from over 9000 United States households about a variety of water issues, including the cost of water. These one-of-a-kind data were incorporated into logistic regression models to assess household perceptions of water bills and the characteristics of households who perceive their water bills to be too high. In doing so, our study advances the water and public policy literature by making several contributions. One, it addresses the need for household resolution information about water issues, given the lack of data at this scale in the United States. Two, it uses one of a kind survey data to understand the perceptions of household water bills and the drivers of these perceptions. Three, we assess the impact of proposed solutions to improve water affordability on household perceptions of water costs.

Model results indicate that low-income and racial/ethnic minority households were more likely to perceive their water bills to be too high. There are also geographic variations in household water perceptions that may reflect widespread affordability issues in particular parts of the country [34,35]. For example, respondents in the Detroit and Flint regions were the most likely to report their water bills are too high compared to other regions in the U.S. From a public policy perspective, model results suggest two ways that utilities and city governments can affect consumer perceptions of water prices. In particular, model results

indicated that billing frequency and participation in payment assistance programs affects consumers' perceptions of whether water bills are too high. Compared to those billed monthly, households billed quarterly are more likely to say their water bills are too high. Yet, when extended to annual or semiannual billing, this trend reverses, and households are more likely to report their water bills are about right. These results indicate that monthly or annual billing may be ideal billing frequency options for utility companies. Participants enrolled in payment assistance programs were also less likely to perceive water bills were too high. This suggests the development of customer assistance programs (CAPs) could improve perceptions of the cost of water services.

2. Materials and Methods

To provide a first glance at perceptions of residential water costs across the United States, this study uses data from the Survey of Water Innovation and Socioeconomic Status of Households (SWISSH). This survey was designed by the authors to address the lack of household data in the United States about water issues and administered to a panel of 9250 households by the Qualtrics survey firm [36]. The survey was administered to respondents at least 25 years of age in households across nine regions in the U.S. between December of 2017 and March of 2018. These regions represent geographically, as well as socioeconomically and demographically diverse locations. Rim weights that combine race/ethnicity and income into one probability weight for each respondent are available so that the data are representative of households in the nine regions in terms of race/ethnicity and income, as indicated by 2011–2015 American Community Survey data from the U.S. Census Bureau [36].

The survey covers a variety of water issues, one question in particular asks respondents about their views on the amount of money they spend on water. The text of this question reads as follows: "In your opinion, is the amount you pay for water fair or unfair?" Respondents were given five response options to this question: (1) "unfair, the price of water should be higher", (2) "unfair, the price of water should be lower", (3) "fair, the price of water is about right", (4) "don't know", or (5) "prefer not to answer". Survey responses were coded with a "1" if consumers perceived them to be unfair and too high. The other responses were coded as a "0" if respondents indicated that the amount they pay for water is fair and about right or unfair because they were too low. Responses of "do not know" or "preferred not to answer" were excluded from our analysis.

Logistic regression models were estimated in STATA 14 [37] using the 'logit' command and were weighted with the 'svy' command. Rim weights were used to ensure representative samples that align with the demographic composition of the U.S. Census' American Community Survey. The probability that households report their water bills are too high is as follows:

$$\Pr(y = 1 | x) = e^{x'\beta} / (1 + e^{x'\beta}) \quad (1)$$

where $y = 1$ indicates water bills are too high. Vector β consists of slope coefficients corresponding to the independent variables and an intercept. The overall predicted probability, Y^* is a ratio between the probability that households feel their water bills are either too high or not too high, as shown in Equation (2).

$$Y^* = \ln \left(\frac{P(\text{water cost too high})}{P(\text{water cost not too high})} \right) \quad (2)$$

The base category (denominator) is any response in which households did not consider their water bills too high including a response of fair/about right, or unfair because they believe the cost could be higher. Vector x in Equation (1) includes the exogenous variables chosen based on prior research associated with water quality and risk perceptions, willingness to pay for water, and awareness of environmental issues [9,26]. This body of work shows that demographic and socio-economic factors such as income, education, employment and race/ethnicity, are important to understanding perceptions of a range

of water issues [23]. Independent variables in this model therefore include: (1) water bill characteristics such as water billing frequency and whether the household is enrolled in a water bill payment assistance plan, (2) socioeconomic characteristics including age and income, (3) demographic characteristics, (4) regional variables, and (5) other control variables. For example, we elected to include controls in the model, such as whether respondents have health insurance, because these factors may place them at financial risk. Therefore, health insurance status may affect their perceptions of financial issues, including the cost of water services. The complete list and description of variables are found in Table 1.

Table 1. Variable Names and Descriptions.

Variable Name	Survey Question	Variable Description/Values
Perception	In your opinion, is the amount you pay for water fair or unfair?	Responses considered too high: - Unfair, the price of water should be lower Responses not considered too high: - Fair, the price of water is about right - Unfair, the price of water should be higher
Region	[Region based on zip code]	- Eastern Massachusetts (Boston–Worcester) - Front Range—Colorado (Denver–Fort Collins) - Mid-Atlantic (Washington, DC–Baltimore, Maryland) - Pacific Northwest—Oregon (Portland–Eugene) - Piedmont Atlantic (Atlanta, Georgia–Charlotte, North Carolina) - Southeastern Florida (Miami–Palm Bay–Melbourne) - Southeastern Michigan (Detroit–Flint) - Southern California (Los Angeles–San Bernardino) - Sun Corridor—Arizona (Phoenix–Tucson)
Wave	[N/A]	- Wave 1 - Wave 2 - Wave 3
Race	With which racial or ethnic group(s) do you identify yourself?	- Hispanic - Non-Hispanic African-American or Black - Non-Hispanic Asian or Asian-American - Middle Eastern, Native American or American Indian, Native Hawaiian or Pacific Islander, Other - White
Age	In what year were you born?	[Age was calculated according to the year the survey was administered]
Gender	Are you ...	- Female - Male
Education	What is the highest level of school you have completed?	- Did not finish high school - High school - Community college or vocational/technical school - 4-year college or graduate/professional degree
Health Insurance	Do you have health insurance? Which of these types of insurance do you have?	- Medicaid - Medicare - No health insurance - Private health insurance

Table 1. Cont.

Variable Name	Survey Question	Variable Description/Values
Assistance paying water bill	Do you participate in any program that helps you pay your water bill?	- No - Yes
Employment status	Which of the following best describes your current employment or labor force status?	- Full-time/part-time - Unemployed/disability/not working/not looking - Retired - Student/homemaker/other
Income	What was the total combined income before taxes of everyone in your household in [year]?	- Less than USD 50,000 - USD 50,000–USD 100,000 - More than USD 100,000
Household type	Do you live in . . .	- A single-family home/townhouse/patio home - A multi-family home/apartment building - A mobile home or trailer - Other
Frequency of water bill	How is the water bill paid in your household?	- Monthly to the service provider - Quarterly to the service provider - Annually to the service provider - Water bill is covered by our rent - Water bill is covered by HOA/condo association - Have a well and do not pay service provider - Other

Note: response options in bold indicate the reference category for each variable.

Odds ratios are used to estimate the relative increase or decrease in the perception that water bills are too high associated with each explanatory variable. These odds ratios should be interpreted relative to reference groups for each variable, which are highlighted in bold in Table 1. In general, indicators of high socioeconomic status were selected as the base comparison category including those who are non-Hispanic White, earners over USD 100,000, male, college graduate or higher, and full-time or part-time employment.

3. Results

A weighted tabulation and corresponding percentage of too high/other responses for select variables are presented in Table 2 which provides descriptive information about respondents. Tabulations and percentages were calculated for these variables because they are discrete and non-ordinal, and therefore, will be included as dummy variables in the regression analysis that follows. Most households (63.3%) reported that their water bills were about right or should be higher. Approximately 36.7% reported their water bills were too high. Several demographic and socio-economic factors impacted the perceptions of water bills. Females were more likely to indicate their water bills were too high, as were racial/ethnic minorities. Blacks, Hispanics, and respondents identifying as some other race (e.g., Native American, Native Hawaiian or Pacific Islander, or Middle Eastern) were more likely to indicate their water bills were too high. People with lower levels of educational attainment were also more likely to report that their water bills were too high. In particular, people without a high school education were the most likely to report that their water bills were too high. Relatedly, people with incomes under USD 50,000 reported feeling water bills were too high.

Table 2. Water Cost Perceptions and Household Demographic and Socio-Economic Characteristics.

Variable Category	Variable Option	Fair/Should Be Higher		Too High		Total
		#	%	#	%	#
TOO HIGH/OTHER		4147	63.3	2400	36.7	6611
RACE/ETHNICITY	White	2580	66.7	1291	33.3	3937
	Hispanic	791	59.6	537	40.4	1387
	NH Black	444	55.1	361	44.9	860
	NH Asian	270	62.2	165	37.8	497
	Other	63	56.9	47	43.1	167
GENDER	Male	1686	66.6	845	33.4	2598
	Female	2452	61.3	1550	38.7	4064
HIGHEST LEVEL OF EDUCATION	Bachelor’s or Graduate Degree	2548	67.0	1254	33.0	3870
	No High School	54	50.0	54	50.0	159
	High School	604	58.1	435	41.9	1097
	Community College	929	58.3	664	41.7	1652
INCOME LEVEL	<50 k	1162	54.0	989	46.0	2206
	50–100 k	1320	61.8	815	38.2	2198
	>100 k	1664	73.6	596	26.4	2334

Table 3 is similar in layout to Table 2 and presents additional information about other household characteristics including geographic location, employment status, and health insurance coverage according to water cost perception responses. The table also presents policy related information such as water bill frequency and respondents' enrollment in water payment programs. The table suggests there are regional differences in the percentage of respondents who felt their water bills were too high. The Pacific Northwest (40.9%), Southeast Michigan (51.9%), and Southern California (40.8%) were regions where the largest proportion of individuals reported their water bills were too high. Regions where most respondents said their water bills were about right or too low are in the Piedmont Atlantic (69.2%), the Mid-Atlantic (69.9%), and the Sun Corridor (67.1%). Some respondent and household characteristics had a much higher rate of reporting their water bills were too high. Some individuals reported their water bills were too high at a greater rate than the overall survey rate of 36.7% including those on Medicaid (49.0%), with no health insurance (46.5%), the unemployed (47.9%), and living in a mobile home/trailer (47.3%).

Table 4 presents the logistic regression results that help us understand which of the variables presented in Table 1 are explanatory variables of water bill perceptions, even after controlling for these factors simultaneously. Overall, income, geographic location, and race explained whether individuals considered their water bills to be too high. Compared to Whites, Black, Asian, and Hispanic individuals were more likely to perceive their water bill charges as too high: Hispanic respondents were 27.4% more likely to report water bills were too high, Black respondents were 43.8% more likely, and Asians were 32.1% more likely.

Income was also a strong indicator of whether respondents felt water bills were too high. Respondents in the lowest income bracket, making less than USD 50,000 per year were approximately 2.3 times more likely to report their water bills were too high compared to those making over USD 100,000 per year. Individuals in households making between USD 50,000 and USD 100,000 were approximately 75% more likely to report their water bills were too high compared to those making over USD 100,000.

There were also statistically significant geographic trends in water bill perceptions. Compared to the Piedmont Atlantic region, four regions were statistically more likely to have respondents that perceived their water bills to be too high. In Eastern Massachusetts, respondents were 45.2% more likely to report water bills were too high. In Southern California, respondents were 63.8% more likely to indicate that water bills were too high. In Southeast Michigan respondents were 2.59 times more likely to indicate they were billed

too much for water, while in the Pacific Northwest, respondents were 70% more likely to indicate their water bills were too high. From a water provider perspective, two significant variables are particularly interesting. Billing frequency and enrollment in a water payment assistance program were significant explanatory factors behind perceptions of water bills. Households on a quarterly schedule for water bill payments were 18% more likely to consider their water bills to be too high. However, respondents indicating they paid their water bills annually or had their water included in their homeowners' association (HOA) fees were approximately half as likely to indicate they perceived their water bills as too high. Households enrolled in a payment assistance program were about 26% less likely to perceive their water bills to be too high.

Table 3. Water Cost Perceptions and Other Household Characteristics.

Variable Category	Variable Option	Fair/Should Be Higher		Too High		Total
		#	%	#	%	#
TOO HIGH/OTHER		4147	63.3	2400	36.7	6611
REGION	Piedmont Atlantic	580	69.2	258	30.8	907
	Mid-Atlantic	488	69.9	210	30.1	768
	Eastern Massachusetts	404	65.2	216	34.8	684
	Southeast Florida	422	62.3	256	37.7	740
	Front Range	517	68.9	234	31.1	819
	Southern California	411	59.2	283	40.8	753
	Southeast Michigan	352	48.1	379	51.9	779
	Pacific Northwest	432	59.1	299	40.9	790
	Sun Corridor	542	67.1	266	32.9	875
WAVE	Wave 1	366	61.1	233	38.9	660
	Wave 2	1364	61.0	873	39.0	2298
	Wave 3	2417	65.1	1294	34.9	3777
HEALTH INSURANCE	Private Health Insurance	2503	64.9	1351	35.1	3919
	Medicaid	280	51.0	270	49.0	601
	Medicare	1015	66.9	502	33.1	1584
	None	217	53.5	188	46.5	458
WATER PAYMENT PROGRAM	Enrolled	165	61.3	104	38.7	330
	Not Enrolled	3970	63.4	2288	36.6	6321
EMPLOYMENT STATUS	Full time/Part time	2530	63.5	1453	36.5	4046
	Unemployed/Not Working/Looking	233	52.1	214	47.9	500
	Retired	1077	67.9	508	32.1	1653
	Student/Homemaker/Other	300	57.7	220	42.3	578
HOUSEHOLD TYPE	Single Family Home/Townhome	3467	63.7	1976	36.3	5506
	Multi-Family Home/Apartment	582	62.0	357	38.0	1001
	Mobile Home/Trailer	56	52.7	50	47.3	158
WATER BILLING FREQUENCY	Monthly	2799	63.3	1626	36.7	4489
	Quarterly	908	59.7	614	40.3	1582
	Annually/Semiannually	71	75.0	24	25.0	170
	Bimonthly	114	60.2	75	39.8	249
	HOA/Condo	108	79.6	28	20.4	215
	Have Well	115	95.5	5	4.5	215
	Other	32	53.6	28	46.4	114

Table 4. Logistic Regression Results: Odds Ratios for Factors affecting Perceptions of Water Bills.

Variable Category	Base Variable	Variable Option	Odds Ratio	Standard Error
REGION	Piedmont Atlantic	Mid-Atlantic	1.112	(0.147)
		Eastern Massachusetts	1.452 ***	(0.204)
		Southeast Florida	1.207	(0.155)
		Front Range	1.191	(0.149)
		Southern California	1.638 ***	(0.212)
		Southeast Michigan	2.588 ***	(0.330)
		Pacific Northwest	1.704 ***	(0.206)
		Sun Corridor	1.157	(0.143)
WAVE	Wave 1	Wave 2	1.104	(0.130)
		Wave 3	0.974	(0.111)
RACE/ETHNICITY	White	Hispanic	1.274 ***	(0.119)
		NH Black	1.438 ***	(0.136)
		NH Asian	1.321 ***	(0.128)
		NH Native American, Native Hawaiian, Middle Eastern, Other	1.233	(0.191)
GENDER	Male	Female	1.063	(0.069)
HIGHEST LEVEL OF EDUCATION	Bachelor's or Graduate Degree	No High School	0.719	(0.207)
		High School	1.006	(0.093)
		Community College	1.067	(0.081)
HEALTH INSURANCE	Private Health Insurance	Medicaid	1.131	(0.134)
		Medicare	0.826 **	(0.078)
		None	1.162	(0.157)
SOCIAL PROGRAM	Enrolled in Water Bill Payment Program	Note enrolled in water bill payment program	0.738 **	(0.114)
EMPLOYMENT STATUS	Full Time/Part Time	Unemployed/Disability/Not Working and Not Looking	1.121	(0.150)
		Retired	0.842 *	(0.085)
		Student/Homemaker/Other	1.213	(0.145)
INCOME LEVEL	>100 k	<50 k	2.343 ***	(0.217)
		50–100 k	1.745 ***	(0.131)
HOUSEHOLD TYPE	Single family home/townhome	Multi-Family Home/Apartment	0.943	(0.086)
		Mobile Home/Trailer	1.175	(0.314)
WATER BILLING FREQUENCY	Monthly	Quarterly	1.182 **	(0.100)
		Annually/Semiannually	0.504 **	(0.147)
		Bimonthly	1.107	(0.191)
		HOA/Condo	0.508 ***	(0.133)
		Have Well	0.089 ***	(0.039)
		Other	1.289	(0.368)
AGE	N/A	Age	1.009 ***	(0.003)
CONSTANT		Constant	0.148 ***	(0.032)

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. N = 6198 F-statistic = 9.305 ***.

Table 5 presents information from the U.S. Census Bureau and the Environmental Protection Agency's Environmental Quality Index (EQI) [38] for each of the regions to provide context to the regression results. These data correspond to the counties containing the city pairs of interest in each region, as listed earlier in Table 1. Social and demographic

information comes from the U.S. Census Bureau's American Community Survey 2015–2019 [39]. The EQI index presents a county-level ranking of overall environmental quality according to five categories: air, water, land, built, and sociodemographic environments across the U.S. [38]. Table 5 includes a measure of the total overall ranking, as well as the water subset of the EQI. Low rankings represent lower levels of degradation. The rankings are based on percentiles across U.S. counties as follows: lowest (0–5th percentile); very low (5th–20th percentile); low (20th–40th percentile); moderate (40th–60th percentile); high (60th–80th percentile); very high (80th–95th percentile); highest (95th–100 percentile). In Table 5, the regions are divided into two groups according to the previous regression results: regions where respondents were less likely to perceive their water bills to be too high and regions that were more likely to perceive their water bills to be too high.

The regions more likely to say their water bills are too high have on average, a higher percentage of individuals with a high school education or below (38.24% compared to 31.3%), a higher non-White population (43% compared to 30%), and higher population densities. Median household income and poverty levels were similar for both. Regions with a higher percentage of households more likely to say their water bills are too high are located in counties with a ranking of water quality problems ranging from high to highest (75% for regions more likely to report bills too high compared to 50% for those less likely). These regions also have higher levels of environmental degradation (37.5% compared to 30%). Therefore, respondents from regions that perceived their water bills to be too high are more likely to live in areas of lower water and lower environmental quality.

Table 6 presents tabulations of survey questions for respondents who felt their water bills were too high, which provide important contextual information about respondents' experiences with water and utilities (e.g., water and electricity). Based on the information presented in this table, the majority of households who perceive their water bills to be too high worry about the cost of water and are less likely to feel they can easily afford their water bills. Only 44.7% of these households reported they could easily afford their water bills and 81.2% say they worry about the cost of water. However, a lower percentage of these same respondents have had prior experience with utility affordability issues. Of the respondents who indicated their water bills were too high, just over a third had experienced prior restrictions on water use (32.8%) or had received a water (32.2%) or electric shutoff notification (36.3%); 23.3 percent and 20.5 percent had experienced a water or electric shutoff respectively.

Interestingly, these views and experiences do not appear to have impacted respondents' trust in public institutions at the time of the survey. Table 7 presents tabulations of survey questions about trust in public institutions, which may be a driver of water bill perceptions; households with low trust in institutions may be more likely to perceive water bills to be too high. The table indicates however, that the majority of respondents felt confident in institutions such as their local water utility (62%), flood control district (54.6%) and public health agencies (58.5%). A somewhat lower percentage of respondents felt confident about their city/town government (50.6%).

Table 5. Study Region Social, Economic, and Environmental Quality Characteristics.

State	County	% Non-White	% High School or Below	Median Income (USD)	% Unemployed	Median Household Value (USD)	% Poverty	Density	Water Quality Degradation Level *	Environment Quality Degradation Level *
Regions Less Likely to Report Water Bills Too High		0.30	31.30	USD 63,519	5.27	USD 287,238	6.41	1562.7	High–Highest: 5/10	High–Highest: 3/10
Sun Corridor-Arizona										
Arizona	Maricopa	0.22	31.18	USD 64,468	5.03	USD 260,200	6.41	470.6	Highest	High
Arizona	Pima	0.24	29.79	USD 53,379	6.96	USD 184,100	7.65	111.8	Highest	Moderate
Front Range-Colorado										
Colorado	Denver	0.24	25.28	USD 68,592	3.75	USD 390,600	6.31	4602.8	Moderate	Very Low
Colorado	Larimer	0.09	20.09	USD 71,881	4.65	USD 363,800	6.13	132.826	High	Moderate
Mid-Atlantic										
District of Columbia	District of Columbia	0.59	23.26	USD 86,420	6.91	USD 601,500	9.01	11330.3	Very Low	Very Low
Maryland	Baltimore	0.39	31.04	USD 76,866	4.79	USD 261,500	4.40	1383.8	Highest	Highest
Piedmont Atlantic										
Georgia	Fulton	0.55	22.78	USD 69,673	5.54	USD 313,300	6.86		Low	Low
North Carolina	Mecklenburg	0.46	24.47	USD 66,641	4.76	USD 238,000	5.03	2052.2	Very High	High
Southeastern Florida										
Florida	Brevard	0.18	31.32	USD 56,775	5.19	USD 196,400	4.90	576.8	Lowest	Low
Florida	Miami-Dade	0.25	43.19	USD 51,347	5.31	USD 289,600	6.64	1421.7	Lowest	Low

Table 5. Cont.

State	County	% Non-White	% High School or Below	Median Income (USD)	% Unemployed	Median Household Value (USD)	% Poverty	Density	Water Quality Degradation Level *	Environment Quality Degradation Level *
Regions More Likely to Report Water Bills Too High		0.43	38.24	USD 64,985	6.60	USD 457,382	6.93	2527.5	High–Highest: 6/8	High–Highest: 3/8
Eastern Massachusetts										
Massachusetts	Suffolk	0.45	32.85	USD 69,669	6.39	USD 496,500	8.95	13676.7	Very Low	Moderate
Massachusetts	Worcester	0.16	33.54	USD 74,679	5.00	USD 280,600	4.75	546.0	Very High	Highest
Southeastern Michigan										
Michigan	Genesee	0.25	36.75	USD 48,588	9.33	USD 111,100	8.36	640.3	Moderate	Low
Michigan	Wayne	0.47	38.67	USD 47,301	9.20	USD 113,000	10.43	2871.4	High	Very High
Pacific Northwest										
Oregon	Lane	0.13	26.95	USD 52,426	6.90	USD 263,200	8.30	81.9	Very High	Low
Oregon	Multnomah	0.22	22.02	USD 69,176	4.93	USD 386,200	6.34	1866.4	Very High	Low
Southern California										
California	Los Angeles	0.49	39.69	USD 68,044	6.09	USD 583,200	6.26	2484.3	Highest	Moderate
California	San Bernardino	0.39	43.20	USD 63,362	7.66	USD 328,200	7.01	107.1	Highest	High

Note: Data sources: U.S. Census Bureau 2015–2019 County Level Estimates [39] and the U.S. Environmental Protection Agency’s Environmental Quality Index [38].

Table 6. Contextual Survey Questions Related to Experiences with Water Services.

Question	Variable Option	Response Options	#	%
In the Past 12 Months Have You Had . . .	Water Use Restriction	Yes	443	32.8
		No	909	67.2
		Total	1353	100.0
	Water Shutoff Notification	Yes	180	32.2
		No	378	67.8
		Total	558	100.0
	Water Shutoff	Yes	94	23.3
		No	311	76.7
		Total	405	100.0
	Electric Shutoff Notification	Yes	248	36.3
		No	435	63.7
		Total	683	100.0
	Electric Shutoff	Yes	98	20.5
		No	381	79.5
		Total	480	100.0
Do you agree or disagree with the following statements?	Cost of Water has Increased	Disagree	127	5.3
		Neither agree nor disagree	439	18.4
		Agree	1822	76.3
		Total	2388	100.0
	Easily Afford my Water Bill	Disagree	635	26.5
		Neither agree nor disagree	689	28.8
		Agree	1068	44.7
		Total	2392	100.0
	Worried about Cost of Water	Disagree	149	6.2
		Neither agree nor disagree	301	12.6
		Agree	1939	81.2
		Total	2388	100.0
	I Conserve Water Due to Expense	Disagree	212	8.9
		Neither agree nor disagree	377	15.8
		Agree	1802	75.4
		Total	2392	100.0

Note: Affirmative responses (yes or agree) are presented in bold in this table.

Table 7. Survey Questions Related to Trust in Institutions.

Question	Variable Option	Response Options	#	%
As far as these institutions and their leaders are concerned, how confident are you in each of the following?	Your Local Water Utility	Not Confident	381	16.4
		Neutral	503	21.6
		Confident	1444	62.0
		Total	2329	100.0
	City/Town Government	Not Confident	537	23.0
		Neutral	614	26.3
		Confident	1181	50.6
		Total	2333	100.0
	Your Drainage/Flood Control District	Not Confident	337	15.8
		Neutral	635	29.7
		Confident	1167	54.6
		Total	2139	100.0
	Public Health Agencies	Not Confident	395	17.2
		Neutral	562	24.4
		Confident	1348	58.5
		Total	2305	100.0

4. Discussion

The United States is in an era of infrastructure replacement, which will require massive investments totaling an estimated USD 600 billion towards water infrastructure over the next two decades [3]. These investments, along with shutoffs in water service in several cities across the United States and the Flint water crisis, suggest that trust in water service and also the perceptions of water services are important to analyze at this juncture in history. Aside from consumer reactions to water costs, the perceptions of these costs are also important for water utilities to bear in mind since a sizable customer base that considers water bills to be too high may lead to the inability or unwillingness to pay for water services. It may also cause consumers to switch to alternate water sources, such as private wells or bottled water, which could erode the revenue streams of utilities [40]. Combined, these coping strategies may erode the long-term customer base of utilities and public engagement in local water policy decisions [41]. To this point in time, however, studies of water perceptions in the developed world have assessed dimensions of water services (e.g., quality and willingness to pay) other than perceptions of water costs. To address this research gap, the goal of this paper was to analyze the perceptions of households regarding the cost of water services and to assess the characteristics of households who felt their water bills were too high.

Not surprisingly, income was one of the more important factors in explaining water bill perceptions. Households making less than USD 50,000 were more likely to feel that their water bills were too high. Even after controlling for income, race was also a significant factor behind households' perceptions of water bills. Non-white, minority households were more likely to perceive that their water bills were too high. This finding is in line with recent research, which finds high water costs disproportionately affect communities of color [42,43]. Studies suggest that these high costs are a result of population decline in urban areas and postindustrial divestment [42]. It may also reflect the fact that Black and Hispanic neighborhoods are at higher risk for water shutoffs due to non-payment than predominantly White neighborhoods [29].

Another important finding of this study was variations in household perceptions across particular regions of the country. Households in four regions of the country (e.g., Eastern Massachusetts, Southern California, Southeast Michigan, and Pacific Northwest) were more likely to perceive water bills as being too high. This may reflect the higher cost of living in three of these areas of the country (Eastern Massachusetts, Southern California, Pacific Northwest). In Southeast Michigan, which includes the cities of Flint and Detroit, these results may reflect consumer awareness of shutoffs in Detroit and also rising water rates in these cities [34,35].

Model results also indicated that the frequency of billing affects perceptions of water bills. Respondents billed quarterly were more likely to consider their water bills to be too high compared to customers billed monthly or annually. Therefore, one recommendation based on these findings is for water companies to bill monthly, which prior work indicates helps household budget their money better [44]. Alternatively, companies could also bill households annually, allowing for customers to easily anticipate this one-time annual payment without focusing on water costs for the rest of the year. Another important result was that water payment programs reduced the likelihood that households perceived their water bills to be too high. This finding suggests that water providers should work to establish water assistance programs for customers in need. At present there is no federal framework guiding the implementation of customer assistance programs (CAPs) [45], which provides utilities with a good deal of flexibility in structuring these programs. Types of CAPs that may be offered range from water efficiency programs to bill discounts to lifeline rates [46]. Important considerations in CAP design that influence program cost include the program size and the type of assistance offered [46]. State laws governing utility regulation and the wording and interpretation of state statutes are also important considerations to keep in mind when designing programs because the legal barriers to CAPs do vary across states and utility type [8]. If a utility already has a CAP in place,

providers may want to develop outreach programs to communicate with customers and enhance their awareness of CAPS.

That said, it is important to acknowledge some limitations of the present study. One, the SWISSH survey contains several questions that ask about pollution in nearby water bodies and experiences with water pollution. These questions were not incorporated into the logit model because pollution is not related to the primary topic of this paper. In addition, as noted previously in the introduction to this paper, research on public perceptions of the quality of local water resources finds that perceptions of the quality of local water resources are based predominantly on organoleptic properties such as taste and turbidity, which are not based on measurable safety or water quality metrics [23,47]. Studies also show the perceived risk of local water resources is strongly associated with perceived (not necessarily measurable levels) of chemicals in water, external information, past health problems, and trust in water suppliers [47]. Two, the SWISSH survey does ask respondents to estimate the amount of their last water bill. We elected not to include this information in the models because prior research has indicated that biases in responses are likely to arise related to recall problems [48]. Studies have also found that consumers do not have an accurate understanding about how their water bills are calculated or how much they pay for water services [30]. There is also no nationwide data available in the United States about water rates to use in place of survey data. The American Water Works Association (AWWA) has a survey, but it is only for AWWA member utilities and is not representative of all utilities across the nation. The University of North Carolina also provides some rate data [49], but the coverage of these data is not national. It is also prohibitive from a time and financial perspective to collect rate data for the nation as a whole. Collecting this information would require collaboration with thousands of water providers. Harmonizing these data would also be quite complex because utilities use different pricing strategies for water in the United States, which contributes further to the infeasibility of creating a nationwide water rate database. A third limitation of this study is that it does not control for household water use, which could impact the amount of water bills and also perceptions of water bills. To control for this, water usage data would need to be acquired from individual utilities which may be infeasible because of privacy concerns for customers. It is also not feasible to acquire usage data with the same coverage as the SWISSH survey.

The limitations of this paper present several opportunities for future research that expand on the present study. One, future work could collect information about water costs, water use, and survey data about perceptions of water costs, based on those provided by the SWISSH survey, to understand the linkages between water cost, water use, and perceptions of water costs. Acquiring these data would also require the cooperation of a utility and would require them to solicit information from customers. There may be privacy risks to customers in acquiring these data, however. Thus, the feasibility of this research path is questionable. Two, future work could collect information about actual water costs from customer bills, and pair these data with survey data from customers about their estimated costs of water. This would be useful in understanding the extent customers are aware of the actual cost of their water use and their recall accuracy. Again, the privacy risk to customers and the time burden this may place on utilities may render this research path unfeasible. Third, the results of our study suggest that news coverage about water issues may explain geographic differences in household perceptions of water costs, particularly in Southeast Michigan, that includes the cities of Flint and Detroit, which has received a lot of national news coverage related to water shutoffs and water rate increases [34,35]. Future work could test the extent that news coverage creates bias in household perceptions of water costs by collecting times series information about water rates from individual providers, survey data about customer perceptions of water trends and news reports from the media about water issues. This type of survey design has fewer data privacy risks for individual consumers, but is risky because the data collection would be time intensive and require a knowledgeable team of personnel which could also be quite costly.

5. Conclusions

This study provided the first examination of household perceptions of water costs across nine geographically, demographically, and socioeconomically diverse regions of the United States. In doing so, our study advances the water and public policy literature in three ways. One, it collected one-of-a-kind survey data to address the need for household resolution information about water issues given the absence of data at this scale in the United States. Two, it incorporated these one-of-a-kind survey data into logistic regression models to understand the drivers of household perceptions of water costs. Three, we assessed the impact of proposed solutions to improve water affordability on household perceptions of water costs. Model results indicated low-income and households in under-represented groups, such as racial and ethnic minorities, were more likely to perceive their water bills to be too high. The perception of water costs also varied geographically. From a policy perspective, model results indicate utilities can positively affect perceptions of water bills via the frequency of water billing and provision of payment assistance programs. Utilities could also use the information from the survey and model results to focus outreach and communication activities to customers who feel their water bills are too high. As water utilities and city governments navigate the conflicting objectives of maintaining and upgrading water systems at prices that are affordable for a majority of water users, communication with customers will be key to maintaining good relationships during this period of change and adaptation.

Author Contributions: Conceptualization, L.M. and E.A.M.; methodology, L.M.; formal analysis, L.M.; resources, E.A.M.; data curation, L.M.; writing—original draft preparation, L.M. and E.A.M.; writing—review and editing, L.M. and E.A.M.; supervision, E.A.M.; project administration, E.A.M.; funding acquisition, E.A.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National Science Foundation Grant Number 1444758 and Supplement Number 1444758. The APC was funded by Michigan State University's Department of Geography, the Environment and Spatial Sciences and Laura Medwid.

Institutional Review Board Statement: The study was approved and deemed exempt in accordance with federal regulations by the Institutional Review Board (IRB) of Michigan State University (IRB# x16-579e 16 April 2016) for studies involving human subjects.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data for this study may be accessed via the Harvard Dataverse <https://doi.org/10.7910/DVN/0ETQ74> (accessed on 24 June 2021).

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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