

## **Consumer Response to Boil Water Notifications During Winter Storm Uri**

Ashleigh M. Day<sup>1</sup>, Khairul Islam<sup>2</sup>, Sydney O'Shay<sup>3</sup>, Kristin Taylor<sup>4</sup>, Shawn P. McElmurry<sup>5\*</sup>,  
Matthew W. Seeger<sup>2</sup>

<sup>1</sup> Department of Communication, University of Texas at Tyler, Tyler, Texas, 75799

<sup>2</sup> Department of Communication, Wayne State University, Detroit, Michigan, 48202

<sup>3</sup> Department of Languages, Philosophy, and Communication Studies, Utah State University, Logan, Utah 84322

<sup>4</sup> Department of Political Science, Wayne State University, Detroit, Michigan, 48202

<sup>5</sup> Department of Civil and Environmental Engineering, Wayne State University, Detroit, Michigan, 48202

\*Corresponding Author

### **Key Takeaways:**

1. Boil water notifications issued during Winter Storm Uri were typically followed
2. Cascading failure of interconnected systems (e.g. power and drinking water) inhibited some individuals from being able to follow boil water guidance
3. Of the people who boiled their water, over 92% reported boiling it for 2 or more minutes
4. Households with children present and higher income were more likely to follow boiling water recommendations.

### **Winter Storm Uri**

In February 2021, Winter Storm Uri moved across the southern United States (US) bringing cold temperatures, record-levels of snow, and damaging ice. For example, the Dallas-Fort Worth area, which typically experiences temperatures of 40°F to 60°F in mid-February, had

twelve consecutive days of temperatures below freezing, with the lowest temperature (-2°F) recorded for the area occurring on February 16, 2021 (National Weather Service, 2021).

Compounding the effects of the extreme cold, the storm also caused wide-spread power outages, affecting over 9.7 million people in the US and Mexico (HARC, 2021). In Texas, power outages were caused by widespread electrical grid failures, and this intensified the power-related risks to public health and safety.

Because of the power loss and freezing weather, nearly 15 million Texans experienced some disruption to their primary source of potable water (HARC, 2021). Due to the loss of power at water treatment plants and the rapid freeze/thaw cycle causing pipe leaks, boil water notifications (BWNs) were issued widely across Texas and Oklahoma. According to the Texas Commission for Environmental Quality (TCEQ), in the six weeks prior to Uri (February 12-16, 2021), there were approximately 39 BWNs per week in Texas. The week that Uri occurred, beginning on February 12, 2021, 2,055 BWNs were issued.

Although Uri dissipated after February 16, 2021, approximately 1.4 million Texans were still unable to depend on public drinking water systems for safe and reliable drinking water (Oxner and Garnham, 2021). More than 200,000 Texans were still without water on February 25, and snow, ice, and freezing temperatures persisted (HARC, 2021). BWNs were also being issued in Oklahoma, and other states. On February 18<sup>th</sup>, the Oklahoma Department of Environmental Quality recommended a “precautionary boil advisory to ensure that people have safe water” for the entire state for residents that experienced “extremely low or no water pressure” (OkDEQ, 2021).

### **Boil Water Notifications**

BWNs are cautioning messages intended to inform the public about potential or known risks in drinking water and to persuade at-risk individuals to take protective actions such as boiling tap water or using alternative sources of water (O’Shay et al., 2020). The US Environmental Protection Agency (EPA) and Centers for Disease Control and Prevention (CDC) provide guidance on what should be included in the messaging (Dearing, 2019). Disseminating these risk messages are critical to protecting the public (Bradway, et al. 2015), and some water systems collaborate with local or county health departments to disseminate these risk messages.

To protect public health during water emergencies, BWNs must be communicated effectively and efficiently to consumers. However, it is not always clear whether at-risk communities receive these messages in a timely fashion or the public follows recommendations. The challenges of timeliness and receptiveness to BWNs is further complicated during disasters and other events when consumers do not have regular means of communication and access to resources. For example during Uri, there were at least 216 communication outages reported in Oklahoma and Texas on February 18, 2021, affecting over 1 million users (FCC 2021), and many residents lost access to power—both electric and gas--that they would typically use to boil water (TCEQ, 2021).

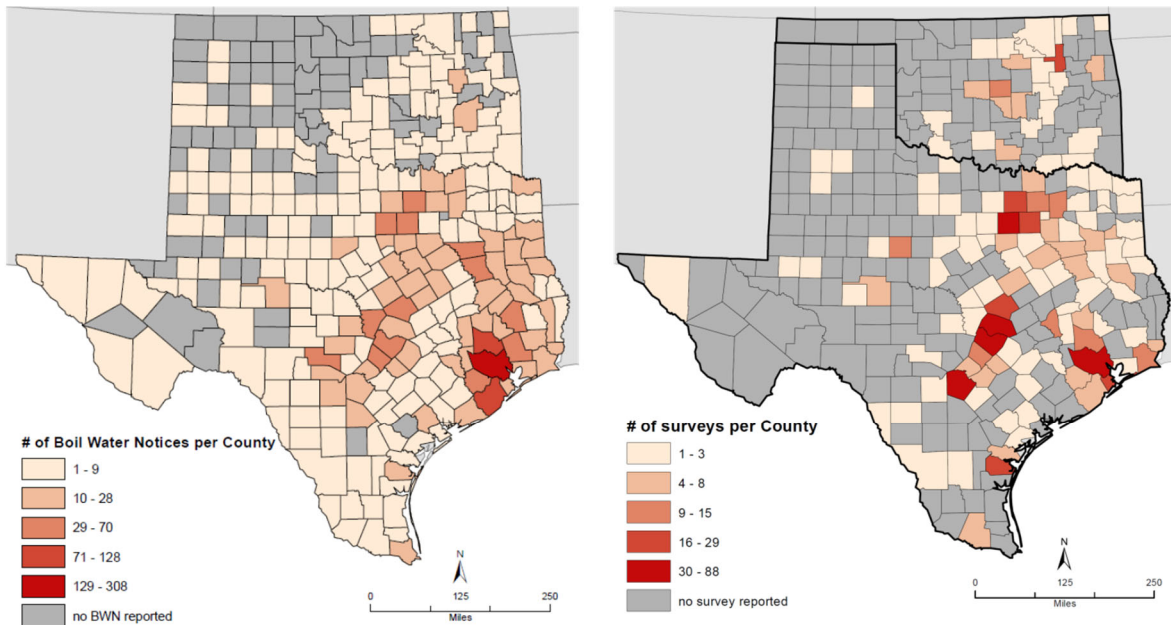
### **Water and Health Infrastructure Resilience, and Learning (WHIRL) Study**

To better understand how people respond to BWNs, a cross-sectional survey was conducted immediately following Winter Storm Uri as a part of the Water and Health Infrastructure Resilience, and Learning (WHIRL) project funded by the National Science Foundation. After approval from university Institutional Review Boards, we used a snowball

sampling technique to recruit participants and a targeted Facebook advertisement campaign to distribute a survey. Responses from adults (18+ years old) living in Texas and Oklahoma during the storm were collected March 2 through April 21, 2021 (Figure 1).

The survey took participants approximately 7 minutes (median response time) to complete. Almost all the survey respondents (99.9%) reported they were affected by the winter storm from February 14 to 26, 2021. Overall, there were a total of 893 participants; 775 from Texas, 101 from Oklahoma (including Indian reservations), and 17 other participants (did not identify, etc.). Survey participants tended to be female (86%), older (median age was 45-65 years), better educated (73.3% had a Bachelor’s degree), more affluent (median annual family income was \$75,000 to \$99,999), and more often White (87.4%) than residents of Texas and Oklahoma (Table 1).

### Boil Water Notifications in Texas (February 12 to April 21, 2021) and survey responses (March 9 to June 14, 2021)



*Note: The counties of 300 boil water notifications in Texas (10.8%) were not reliably identified and are therefore excluded from the map.*

(n=893)  
Created by Felice G. Sperone, Wayne State University

**Figure 1.**

<b>Characteristics of Survey Participants</b>	<b>Number of Participants (% sample)</b>	<b>Weighed Fraction of Texas and Oklahoma Residents</b>
<b>Gender (n = 776)</b>		
Male	87(11%)	49.6% <sup>a</sup>
Female	670 (86%)	50.4% <sup>a</sup>
Trans, Genderqueer, and Other	15 (1.5%)	NA
<b>Age (n = 775)</b>		
18-24 Years	51 (6.6%)	9.7% <sup>a</sup>
25-44 Years	322 (41.5%)	28.1% <sup>a</sup>
45-64 Years	310 (40.0%)	23.6% <sup>a</sup>
65-74 Years	79 (10.2%)	8% <sup>a</sup>
75 Years or over	13 (1.7%)	5.3% <sup>a</sup>
<b>Education (n = 775)</b>		
Less than High School	2 (0.3%)	14.9% <sup>a</sup>
High School Diploma	25 (3.2%)	26.0% <sup>a</sup>
Some College	180 (23.2%)	28.9% <sup>a</sup>
Bachelor’s Degree or Higher	568 (73.3%)	30.2% <sup>a</sup>
<b>Annual Family Income (n= 685)</b>		
Less than \$34,999	105 (15.3%)	27.4% <sup>a</sup>
\$35,000-\$49,999	81 (11.8%)	12.5% <sup>a</sup>
\$50,000-\$74,999	137 (20.0%)	18.0% <sup>a</sup>
\$75,000-\$99,999	131 (33.7%)	12.6% <sup>a</sup>
\$100,000 or more	231 (33.7%)	29.5% <sup>a</sup>
<b>Race* (n=761)</b>		
White	665 (87.4%)	66.0% <sup>b</sup>
Black	13 (1.7%)	17.6% <sup>b</sup>
Asian	14 (1.8%)	7.8% <sup>b</sup>
Mixed Race	50 (6.6%)	5.9% <sup>b</sup>
American Indian	19 (2.5%)	1.9% <sup>b</sup>

*\*Due to a survey error, the number of respondents that identified as Hispanic or Latino was not recorded*

<sup>1</sup> US Census (2019) ACS 1-Year Estimates Selected Population Profiles (Dataset: ACSPP1Y2019)

<sup>2</sup> US Census (2020) DEC Redistricting Data (PL 94-171) (Dataset: DECENNIALPL2020)

**Table 1.**

## **BWNs Were Overwhelmingly Followed**

The majority (83.2%) of the participants reported they received boil water or other water related notices. Thirteen percent reported they were unaffected by the BWNs and 3.6% of respondents indicated they were unsure about whether they were under a BWN. Survey respondents highlighted different forms of notices they received: 82.8% received specifically 'boil water advisory or notice,' 12.7% received a 'do not drink order,' and 4.6% received a 'do not use order.'

The majority (79.5%) of the participants who believed they were under a BWN reported that they boiled water before using it. This rate of boiling water is consistent with compliance rates (70% and 90%) reported in a randomized survey conducted via phone during boil water events in Oregon (Harding and Anadu, 2020); slightly higher than the median reported compliance rate (68%) found during a meta-analysis of 11 publications evaluating the response to boil water events (Vedachalam, et al., 2016); and slightly less than the 87.5% of survey respondents that refrained from drinking unboiled tap during a Boston boil water event (Galarce and Viswanath, 2012).

Survey results suggest that higher income individuals (Figure 2) and participants with children in their home were more likely to boil water. In the context of this study, this suggest that higher income individuals might be more likely comply with a BWN; although, how this observation holds up across a more diverse racial and ethnic population is not clear.

Given the relationship between employment and income, we wondered if employment status might be related to compliance with BWNs. A study by Rundblad et al. (2010) in the United Kingdom found that unemployed individuals are more likely to comply with BWNs than

employed individuals. As shown in Figure 2, higher income groups had greater employment than low income groups. Therefore, unemployment was inversely related to the BWN compliance. While it may be intuitive that greater employment is associated with greater income, these results appear to contradict the findings of Rundblad et al (2010).

When no child (under 18 years) resided in the home (n=392), the proportion of survey respondents that reported boiling water was 79.6%. When a child resided in the household (n=237), the proportion of survey respondents that reported boiling water increased to 87.3%. This increase was statistically significant based on a chi-square test ( $\chi^2_{(df=1, n=629)}=6.148$ ,  $\phi=0.099$ ,  $p=0.013$ ). These results suggest water providers should consider improving their messaging to lower income individuals who do not have children in the home.

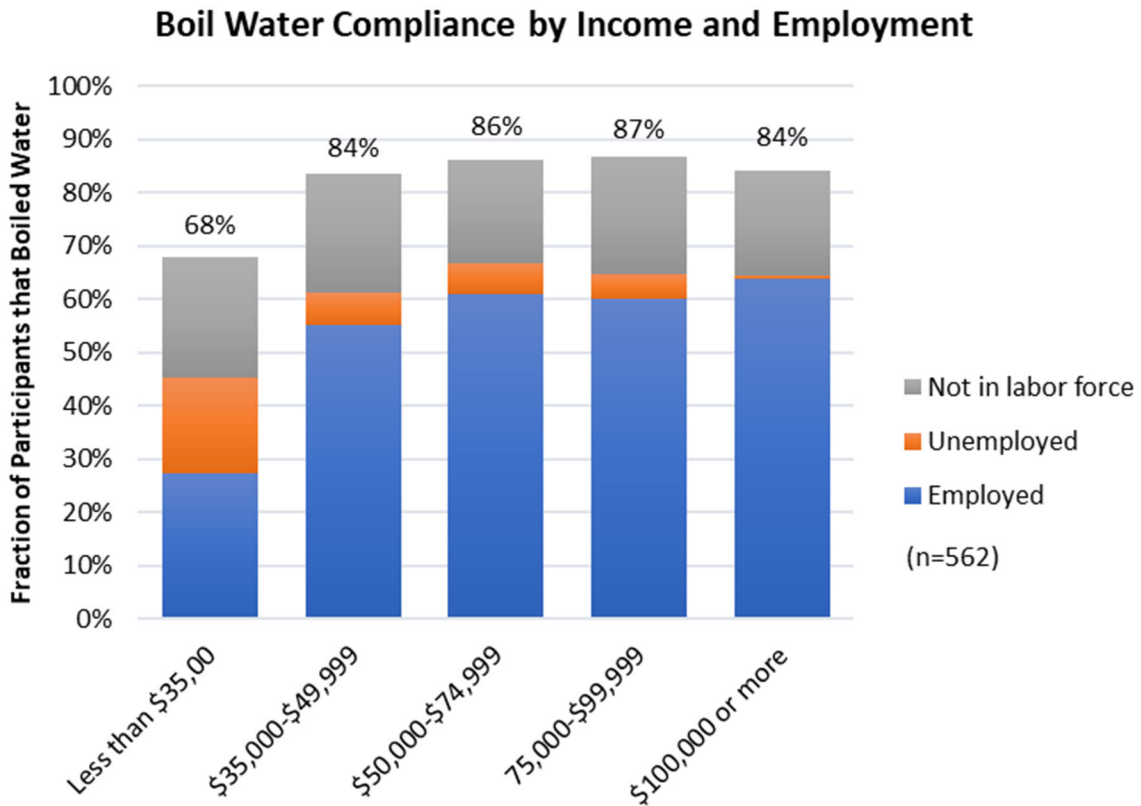


Figure 2.

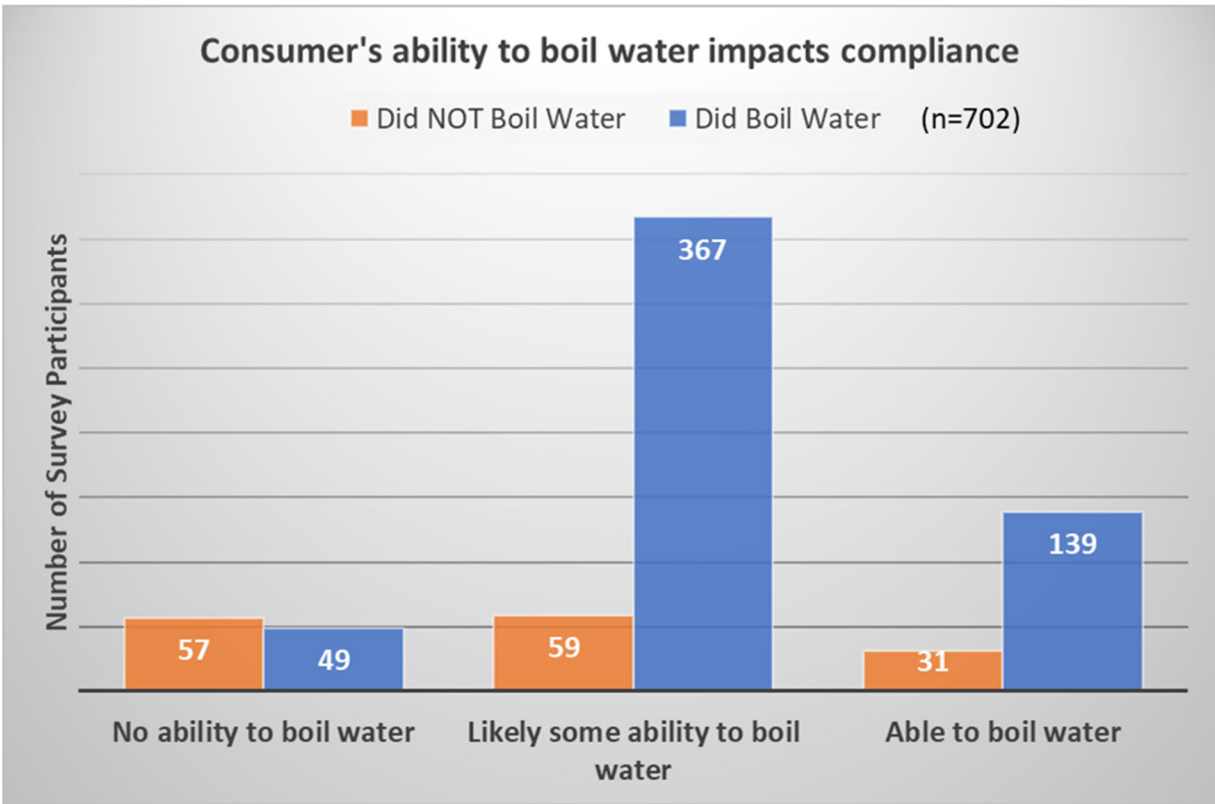
During Winter Storm Uri, slightly more than half of survey respondents (53.2%) reported they had no running water, 75% had low water pressure, 28% had discolored water, 21% had bad smell, and 31% had frozen water pipes. Over half, 58%, reported not having electricity or gas service, while 45% of respondents did have the electricity and gas service typically used to boil their water. Consumers who were told to boil their water and did not have the capacity to do so may have become frustrated and forced to turn to alternatives such as bottled or stored water.

To assess the effect of losing other services, respondents were grouped into three categories:

- 1) those that were able to boil water (they had both electricity and gas service)
- 2) those that had some ability to boil water (they had electricity and gas service, but not both)
- 3) they were not able to boil water (they had neither electricity and gas service, and reported having “no other way” to boil water).

As shown in Figure 3, compliance with BWNs was higher when consumers had at least some capacity to boil water. It is not surprising that, of respondents who report having at least some ability to boil water (n=596), 85% report boiling water. When residents did not have an immediate way to boil water, e.g., no gas or electric service (n=106), then boil water compliance decreased by nearly half, to 46.2%. The ability to boil water was a statistically significant effect based on a chi-square test ( $X^2_{(df=1, n=702)}=82.712$ ,  $\tau_b=0.343$ ,  $p<0.0005$ ).





**Figure 3.**

The survey results also indicate that respondents with a minor (e.g., child) in the home were more likely to boil water than respondents without a minor in the home. Having a child(ren) presents a unique set of challenges and considerations that may orient parents or guardians to be more risk aware, and more likely to comply with recommendations such as BWNs. This demographic may also create a specific set of needs that requires additional information during a BWN, such as how to safely make baby formula or if their child can safely take a shower during a BWN (see CDC, 2016). Simply, caretakers overseeing children likely need more tailored information during these events.

### Boil Water Paterns and Uses During Winter Storm Uri

Participants were asked how frequently they boiled water for drinking and how long water was boiled before using. A large majority (81%) of the respondents reported boiling water in a way that is close to compliant with the BWN notice; 15% boiled most of the time, 3% boiled some of the time, and less than 1% boiling water only to some extent. Additionally, one of the common questions consumers have about boiling water is how long should they boil water. Based on recommendations from the US CDC (2021), consumers should maintain a full boil for at least 1 minute. Of those that report boiling water, the survey results indicate that more than 92% of respondents boiled their water for 2 or more minutes (Figure 4), exceeding CDC guidance for populations living at elevations below 6,500 ft .

#### Length of Time Maintaining a Full Rolling Boil

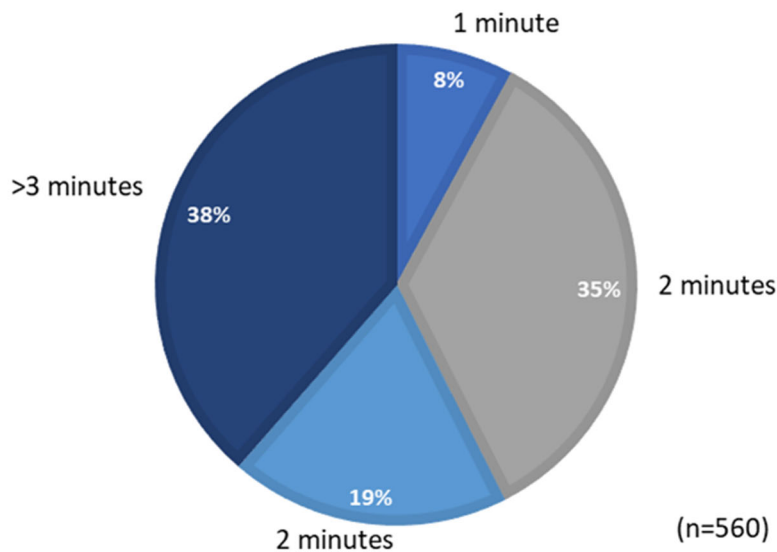
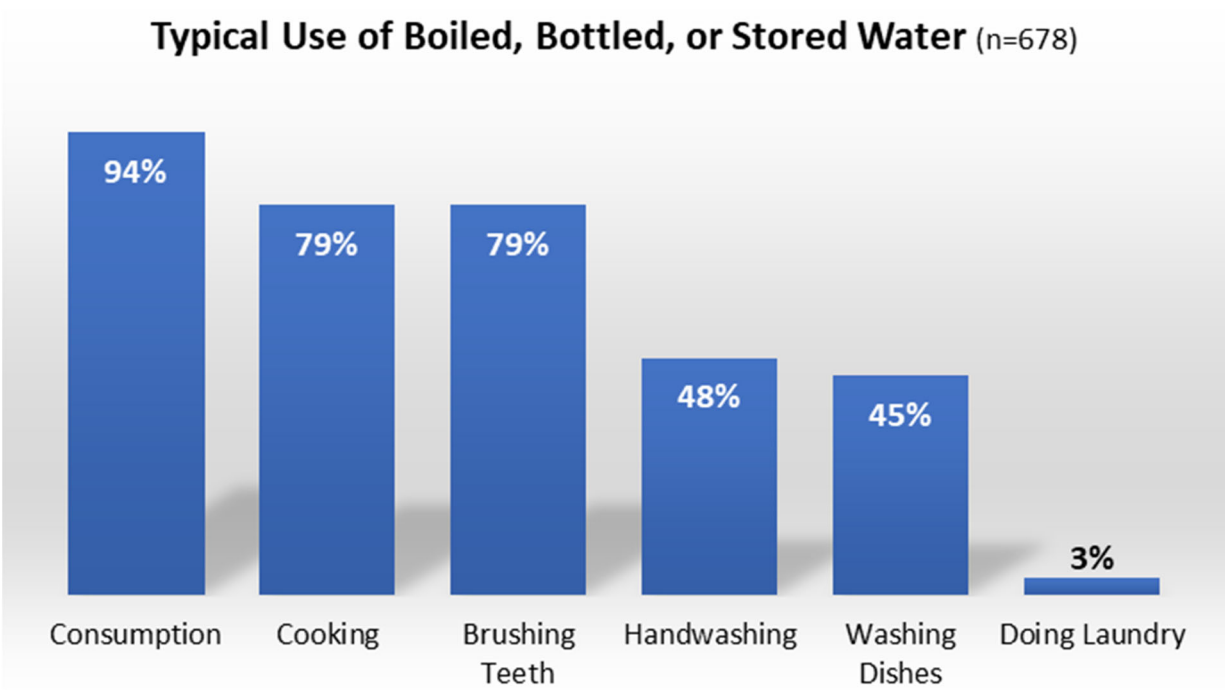


Figure 4.

During Winter Storm Uri, 85% of respondents reported using water from alternative sources including:

- purchased bottled water (81%)
- water collected from emergency distribution centers (13%)
- melted snow and ice water (27%)
- water stored prior to the storm (41%)
- water collected from lakes or other surface water sources (3%)

As shown in Figure 5, almost all the respondents said they used boiled or bottled water for drinking purposes (94%), cooking (79%) and brushing teeth (79%).



**Figure 5.**

In communicating BWNs to consumers, it is important to clearly highlight what uses require boiled water. According to the CDC (2016), during a BWN, boiled water (or bottled water) should be used for the following:

- any consumption purposes such as drinking, cooking, washing food preparation surfaces, washing fruits and vegetables
- brushing teeth
- to care for pets
- making baby formula
- washing baby bottles and nipples
- making ice

Communicating this information clearly, however, is even more complicated during an event like Winter Storm Uri when communication channels, especially wireless phone service, were disrupted; in addition, some consumers lost electricity/power, so they couldn't receive messaging via television, social media, etc. Winter Storm Uri shows that officials need to use multiple pathways to communicate BWNs during extreme weather events and anticipate that some of those channels might go down during an event.

### **Implications for BWNs**

Results of this study on BWNs in Texas and Oklahoma during Winter Storm Uri indicate the overwhelming majority of water consumers follow boil water recommendations. People with higher levels of income and children in the household are more likely to comply with

BWNs. Additionally, parents with young children - especially those with infants - may need guidance beyond what is required for other consumers.

The effectiveness of BWNs can be improved as the utility better understands the situation and its target audience, but this can be difficult during an emergency. When power and gas service are disrupted, consumers may not have the capacity to respond to BWNs. This limited capacity should be acknowledged when the BWNs are issued and in such cases, consumers should be directed to other sources of clean water.

Finally, we recommend that warnings about extreme weather and possible power disruptions preemptively include information about BWNs and storing water. For example, working with local weather reporters to include information about BWNs and storing water when discussing extreme weather events may help residents better prepare for the temporary loss of water services. In addition, general efforts during normal times are necessary to educate the public about what a BWN means and how it should be implemented to keep everyone safe during an emergency.

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