



Boil Water Advisories as Risk Communication: Consistency between CDC Guidelines and Local News Media Articles

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ABSTRACT

The Safe Drinking Water Act Public Notification Rule requires that customers of public water systems (PWS) be informed of problems that may pose a risk to public health. Boil water advisories (BWA) are a form of communication intended to mitigate potential health risks. The Centers for Disease Control and Prevention (CDC) developed guidance for BWAs. We examined how local US news media incorporate the CDC's guidelines when reporting on BWAs. A content analysis of 1040 local news media articles shows these reports did not consistently incorporate CDC guidelines. Overall, 89% of the articles communicated enough information for readers to determine if they were included in the impacted area. Articles that included at least *some* of the CDC's instructions for boiling water were likely ($p < .001$) to include other risk information, such as the functions for which water should be boiled (e.g., drinking, brushing teeth) and that bottled water could be used as an alternative source. However, this information was included in only 47% of the articles evaluated. Results suggest public notifications often do not serve the public need for clear risk communication.

The American Society of Civil Engineers American Society of Civil Engineers (2017) has graded drinking water infrastructure of the United States (U.S.) as a "D+." ASCE estimates that there are over 240,000 water main breaks in the U.S. each year, or about 650 breaks per day. Additionally, between 1982 and 2015, the number of health-based violations to the Safe Drinking Water Act (SDWA) regulations has doubled (Allaire et al., 2018). It is unclear, however, if and how risks associated with these challenges are effectively communicated to the public. According to the Kaiser Family Foundation (2016), the public perceives contaminated drinking water among the nation's most serious health issues, trailing behind cancer and heroin abuse. The U.S. Environmental Protection Agency Environmental Protection Agency (2013) states,

The nation's drinking water utilities need 384.2 USD billion in infrastructure investments over the next 20 years for thousands of miles of pipe as well as thousands of treatment plants, storage tanks, and other key assets to ensure the public health, security, and economic well-being of our cities, towns, and communities. (p. i).

Unfortunately, there are many examples of water-related crises and risks in the U.S., resulting in widespread implications for communicating risk. The CDC's National Outbreak Reporting System includes 29 drinking water cases in 2017, associated with 225 illnesses, 73 hospitalizations, and 8 deaths (Centers for Disease Control and Prevention, 2018a). Communicating water-related risks to water consumers are among the principle ways harm may be mitigated.

Several highly publicized cases of water contamination have enhanced the prominence of water-related crises and risks. The

1993 *Cryptosporidium* contamination of the Milwaukee, Wisconsin water system involved over 400,000 people who were sickened by the water-borne parasite and is among the largest *Cryptosporidium* outbreaks in recent U.S. history (Gradus, 2014). Retrospective analysis identified changes in water quality (emerging risk) prior to the outbreak of disease. In May of 2000, the city of Walkerton, Ontario, Canada experienced an outbreak of *E. coli* and *Campylobacter* contamination resulting in the serious illness of 2,300 people (Hrudey et al., 2003). The outbreak was also attributed to poor monitoring, management, and maintenance of the city's water system. The more recent Flint, Michigan water crisis involved the contamination of the city's water supply with lead (Hanna-Attisha et al., 2016). If the first detectable spike in child blood lead levels in children was immediately communicated to the public, approximately 40% of the children in Flint would have been spared having elevated blood lead levels (greater than 5 µg/dl) (Zahran et al., 2017). The water in Flint was also associated with one of the largest recorded outbreaks of Legionnaires' disease (Zahran et al., 2018). At least 87 people were infected and 12 died from a bacterial form of waterborne pneumonia (Hersher, 2018; Zahran et al., 2018). In all of these examples, rapid and effective communication of emerging risks would have likely reduced harm to the public by encouraging boiling water before drinking or using alternative sources, such as bottled water.

The CDC and the EPA note that public water systems (PWS) serve over 286 million people. Just 8% of community water systems in the U.S. provide water to 82% of the U.S. population through large municipal water systems

(Centers for Disease Control and Prevention, 2014). Roughly half of the disease outbreaks in the U.S. and Canada are associated with small water systems, such as private and semi-private, public and semi-public, non-community, and micro-water systems (Pons et al., 2015). Five organisms are most commonly associated with disease outbreaks in water systems: *Giardia*, *Legionella*, *Shigella*, norovirus, and *Campylobacter* (Centers for Disease Control and Prevention, 2018b). When water systems become contaminated with these or other disease-causing organisms, warnings are issued. These warnings typically include boil water advisories (BWA), although precautionary BWAs are commonly issued when there is a potential of contamination. Warnings are risk messages about specific high consequence events that, when issued correctly can save lives, and reduce harm (Sellnow & Seeger, 2013).

The EPA's Public Notification (PN) Rule, 65 FR 25982, from May 4, 2000 requires that PWSs notify their customers of drinking water violations or situations that may pose a risk to public health (Environmental Protection Agency, 2019c). PWSs provide water for human consumption to 90% of the U.S. population (Environmental Protection Agency, 2019a). PWSs are regulated by the EPA and delegated to states and tribes (Environmental Protection Agency, 2019a). In contrast, households that rely on private drinking wells are not served by PWSs and are not regulated by the EPA, placing the responsibility of water safety on the homeowner (Environmental Protection Agency, 2019b). PWSs must notify their consumers (households, businesses, schools, etc.) any time a PWS violates a national primary drinking water regulation or has a situation posing a risk to public health. These notices must be provided directly to persons that consume the water, such as residents or exposed restaurant patrons. The PN rule specifies that BWAs include a description of the violation or situation, potential adverse health effects, identification of the population at-risk, efforts to correct the situation, sources of additional information, and any recommended actions the public should take. Among these actions are recommendations to boil water before human consumption (See Environmental Protection Agency, 2000 for a full list of required elements for PNs). The PN rule does not specify the channels or specific methods of notification, such as newspaper or radio, although the Environmental Protection Agency (2010) points explicitly to local media as important for disturbing public notification messages.

Communication about water contamination is generally framed as a form of risk communication (Covello, 2007; Environmental Protection Agency, 2010; Santos, 1990). In the event that water is contaminated or potentially contaminated with disease-causing organisms, measures like BWAs are issued to alert the public. BWAs are risk communication messages directed to a specific audience and intended to encourage specific precautionary measures (Eggertson, 2008). Public health and PWS officials generally issue these warnings when there is a potential increased risk to public health (Pontius, 1996). These risks include the identification of inadequate water treatment, violations of drinking water standards, the occurrence of water main breaks, low-pressure events, and/or natural disasters – such as floods or hurricanes that may inundate water treatment facilities.

In addition to requirements set by the U.S. EPA, PNs are governed by state agencies and industry conventions (Environmental Protection Agency, 2019c). Surprisingly, the specific events or circumstances that trigger a notification or BWA are not entirely clear, in part because different states use different criteria. Generally, a PN occurs in response to one of the three types of water system violations: (1) loss of pressure, (2) a positive microbial sample, and/or (3) a contamination event. The EPA classifies violations according to the severity and matches the timeline for PN. Tier 1 notices are for violations and situations with significant potential for serious adverse health effects as a result of short-term exposure. Notification must occur within 24 hours. Tier 2 notices are for less immediate violations with potential to have serious adverse health effects on human health and require notification within 30 days. Tier 3 notices are for all other forms of violations and situations and require notification within 1 year (Environmental Protection Agency, 2010, p. 6). The EPA specifically references broadcast media as recommended for tier 1 violations.

Tier 1 violations are those that are most likely to precipitate a BWA. These include exceeding the maximum contaminant or maximum residual disinfectant levels, violations of standard treatment techniques, violation of monitoring and testing procedures, or a waterborne disease outbreak among others (Environmental Protection Agency, 2010). In addition, drinking water distribution systems are pressurized, helping to inhibit the infiltration of untreated groundwater that may contaminate the system. In general, a significant drop in pressure would lead to a BWA; however, the minimum pressure threshold varies by state. In addition, routine testing may identify the presence of microbial pathogens, such as *E. coli*, requiring PN and a BWA. Finally, a contamination event, such as a flood, water main break, or extended power outage may evoke the need for a BWA (Environmental Protection Agency, 2019c).

The Centers for Disease Control and Prevention (2016), in collaboration with stakeholders including the EPA, the American Water Works Association (AWWA), the Association of State and Territorial Health Officials (ASTHO), developed the Drinking Water Advisory Communication Toolbox. This includes specific guidelines for BWAs and how these should be communicated to the public. These guidelines are part of a “protocol and practical toolbox, based upon research and identified practices, for communicating with stakeholders and the public about water advisories” (p. 1). These advisory standards are more comprehensive than the PN rules and were created to be consistent with the EPA's regulatory requirements. Although not statutory requirements, the CDC guidelines extend and operationalize the PN rules. According to the guidelines, specific information should be communicated to the public, such as how water should be boiled and stored, what risks may be mitigated by boiling water, identification of the affected water system and affected population, the cause(s) of the BWA, how the issue will be resolved, the timeframe for the resolution, and contact information. Providing the public with this information illustrates that BWAs are a form of risk communication designed to limit publics' exposure to harm and protect public

health and safety. However, it is unclear if dissemination of BWAs by local news media follows the CDC's guidelines. As news media are primary outlets for publics to receive information about current events, it is important to understand how they communicate BWAs and if the CDC's guidelines are followed.

This paper examines the types of information included in local news media reports of BWAs, with a focus on the consistency of these reports exhibiting the Centers for Disease Control and Prevention's (2016) recommendations for communicating BWAs. First, a review of literature surrounding risk communication, water advisories, and warnings is provided. Second, details about methods are discussed, followed by results. Finally, a discussion of results in relation to extant research, theory, and study limitations is presented.

Review of literature

Risk communication

Risk communication is a systematic, interactive, and science-based approach to communicating with diverse audiences and stakeholders in situations that are high-concern, high-stress, emotionally charged, and/or highly controversial (Covello, 2007; National Research Council, 1989). While risk communication is imperative for effective management of a water crisis, poor risk communication can undermine public trust and confidence, incite tensions, and create additional harm (Covello, 2007). Components of risk and crisis communication intersect at several points (Reynolds & Seeger, 2005). Most often, risk communication is associated with the pre-crisis stage while crisis-communication is associated with the crisis and post-crisis stages. Thus, crisis communication centers around "preparing for and reducing, limiting and responding to threats and harm" within the context of a given crisis (Sellnow & Seeger, 2013, p. 13). The scope of risk communication is personal in nature and aims to help individuals understand how they can reduce their exposure to risks (Sellnow et al., 2009). Heath (1995) explains that risk communication identifies, "risk estimates, whether they are appropriate, tolerable, and risk consequences," (p. 257). Risk-related warnings, advice, and protective actions and recommendations for mitigating risks are essential elements of effective risk communication (National Research Council, 1989; Verroen et al., 2013). Risk messages are generally disseminated via mainstream media (e.g., newspapers, radio, television) and increasingly via social media. These messages are designed to bolster individual self-efficacy (Seeger, 2006).

Effective risk communication is important to the development of self-efficacy among at-risk populations, which fosters capacity-building (Veil et al., 2008). Effective instructional risk messages may empower audiences to take appropriate measures for self-protection even in cases where they are not exposed to the potential risk (Mileti & Peek, 2000). In a general sense, messages of self-efficacy should be included in risk communication strategies. Self-efficacy bolsters an individual's belief that they have the capacity to execute recommended protective actions, such as boiling water (Seeger, 2006). However, the public's understanding of risk is strongly

influenced by past crisis and risk events, how they were managed, and the communication that surrounded these events (Seeger & Sellnow, 2016).

Boil water advisories as warnings

BWAs are risk messages designed to promote self-protective actions. They are part of a larger warning system, designed to, "detect impending disaster, give that information to people at risk, and enable those in danger to make decisions and take action," (Sorensen, 2000, p. 119; Harding & Anadu, 2000). Sellnow and Seeger (2013) describe a warning as a functional message or system of messages that inform an audience of a possible threat. Warnings are both informational and persuasive. They provide understanding about specific threats and induce protective actions. In most cases, warnings must also be timely in response to the identified risk(s). Specifically, water advisories that are delayed may not be effective in mitigating harm. Warnings must also reach affected or at-risk publics and communicate the five core purposes of warnings (Wogalter, 2006).

The communication of warnings serves five functions (Wogalter, 2006). First, warnings must convey safety information. Second, warnings should be designed to modify behavior. Third, warnings reduce or contain harm associated with an identified risk. Fourth, warnings are general reminders about hazards. Hazards describe a *type* of threat, such as a hurricane, tornado, etc., before its expected onset (Drabek, 2007). Finally, warnings may help protect agencies that are involved in responding to the identified risk.

Before issuing a warning, managers and officials must appraise the risk and ask, "what does the public need to know to protect themselves?" Crisis and risk communicators must balance uncertainty, risks and benefits, competing values, and different informational sources (Sellnow & Seeger, 2013; Ulmer et al., 2019). In some cases, these decisions may be postponed so that more information can be collected, or others can be consulted, such as state or federal agencies like the EPA. In the case of water contamination, state and federal guidelines specifying thresholds of unacceptable contamination indicate when public warnings must be issued and disseminated to the public (Mileti & Sorensen, 1990).

BWAs are public warnings that inform the public to boil their municipal-supplied water before consumption or use (Vedachalam et al., 2014). BWAs are issued by water systems, often in conjunction with local health departments. In addition to a BWA, "do not drink" and "do not contact" referents are other forms of water advisories although much less frequent (Centers for Disease Control and Prevention, 2016). Drinking water advisories are issued when there are reasons to believe that water quality is or may be compromised and are designed to protect public health (Vedachalam et al., 2014).

BWAs may be distributed through a variety of channels, such as flyers, posters, websites, radio, e-mail, social media, mass texting, and news releases. However, media preference and adherence to the recommended actions are likely to vary among the people based on their demographic characteristics (Day et al., 2019). Messages distributed through social media, such as Twitter, are perceived differently compared to

messages transmitted through legacy mass media (Sutton et al., 2015). It is important that these preferences are understood by crisis and risk communicators, so their strategic messaging reaches the intended audience(s) in a timely manner (e.g., Lachlan et al., 2007; Spence et al., 2006). In addition to the public, water systems may directly contact governmental agencies, hospitals, and healthcare facilities regarding BWAs (Centers for Disease Control and Prevention, 2016). In cases of Tier 1 violations, immediate and widespread distribution of BWAs are important elements for risk mitigation and protecting public health.

Public compliance with BWAs is contingent on risk communication (Vedachalam et al., 2016). Vedachalam et al. (2016) acknowledge the CDC's Drinking Water Advisory Communication Toolbox (Centers for Disease Control and Prevention, 2016) as helpful when managing a BWA. The Toolbox facilitates a comprehensive approach including resources for communicating pre-event, during an event and after an event. Though this toolbox may be readily available to PWS, it is unclear whether local water systems and news media engage with these best practices when publicly reporting BWAs. It is important to consider how local news media report BWAs because they are the primary sources for informing the public (Vedachalam et al., 2016). Additionally, local news media have the potential to frame publics' understanding of crises and risks as well as inform publics about protective actions (van der Meer, 2018). Therefore, the following research question (RQ) and sub-research questions were developed:

RQ1: How are CDC guidelines incorporated in U.S. local news media of BWAs?

RQ1a: How are the areas impacted by BWAs identified by U.S. local news media articles?

RQ1b: What information appears alongside CDC guidelines for boiling water in U.S. local news media articles about BWAs?

RQ1c: How are CDC guidelines about cause and resolution of BWAs communicated in U.S. local news media articles?

Methods

Data collection

This study examined coverage of BWAs to better understand the type of information that is reported by local news media during a BWA, and whether this information coincides with the Centers for Disease Control and Prevention's (2016) guidelines about communicating BWAs to the public. The sample for this study consisted of U.S. local news media articles reporting on BWAs. Articles were collected from a daily Google News Alert, which was established on September 27, 2018. The Google News Alert was programmed to capture news articles within the U.S., using the search terms "boil water advisory" and "boil water notice." Due to the platform's ability to monitor extensive news sources across the world in real-time, several studies have utilized Google News Alerts to sample news articles for research purposes (e.g., Klaiman et al., 2011; Ungar, 2008). Between September 27, 2018 and May 31, 2019, a total of 1139 alerts were received. Based on these alerts,

a total of 1122 articles were collected, as portable document format (PDF). Review of PDFs found 81 of the articles were not available or not applicable (e.g., not initial report of BWA) and 1 news article was from Canada, resulting in a final sample of $n = 1040$. The articles were gathered fall through spring, when freezing conditions increase the likelihood of water main breaks occurring and subsequent BWA notices (Kleiner & Rajani, 2002).

Coding scheme

The coding scheme (Appendix A) employed in this study was based on the CDC Advisory Press Release Template included in the Centers for Disease Control and Prevention's (2016) Drinking Water Advisory Communication Toolbox. The press release template suggests BWAs should include information pertaining to who is impacted by the BWA, the cause of the BWA, how to effectively sanitize water for consumption, and the functions that water should be boiled for (e.g., drinking, brushing teeth), among other information. In addition, the coding scheme assessed the articles' inclusion of a map to visualize the area(s) of impact as well as links to external sources where additional information about the BWA could be found. These two variables do not stem from the Centers for Disease Control and Prevention (2016) guidelines; however, they help readers gain a more comprehensive understanding of potential risks and the protective actions they may need to enact. Overall, media reports were coded for 13 content features.

Coding

Once the coding scheme was developed, two coders tested a sample of news media articles about BWAs that were outside of the study sample. Coders completed the test coding independently. Instances of disagreement were discussed until consensus was reached, and the coding scheme was refined for clarity before moving forward with coding the study sample. The same two coders each coded 55% of the total study sample. Inter-coder reliability scores were measured using Cohen's *kappa*, which are reported for each variable in Appendix B. Most variables ranged from $\kappa = .60-.98$, representing "moderate" to "almost perfect" agreement, according to Landis and Koch (1977). Inter-coder reliability for the variable measuring whether the affected population was clearly communicated was $\kappa = .32$, representing only "fair" inter-coder agreement (Landis & Koch, 1977). Though the *kappa* for this variable was low, the percent agreement was 96%. This finding suggests that a *kappa* paradox may have occurred. The low coefficient may have occurred due to *kappa*'s conservative assumptions and correction for a maximum level of chance (Krippendorff, 2011; Zhao et al., 2013). Inter-coder reliability was deemed sufficient based on the percent agreement for the affected population and the reported *kappa* coefficients. Therefore, all variables were included in the analysis. Data analysis was conducted using SPSS (version 25).

Results

Of the 1040 articles from U.S. local news, BWAs were coded from 38 states. Based on the date, city or county, and state identified in the news article, there were 919 unique events. Out of these events, 70% were associated with 1 news article, 26% had 2–3 news articles, and only 4% had 4–7 news articles. Reports contained between 0 and 12 elements of the 13 evaluated (Appendix A), with a mean of $5.5 \pm .06$ (standard error) elements in each.

RQ1 asked how Centers for Disease Control and Prevention (2016) guidelines are incorporated in U.S. news media coverage of BWAs. The majority of the news media articles about BWAs included the water system that was impacted (89%) and the affected population (92%). The cause of the BWA was included in most of the articles (91%); yet, a resolution, such as repairs to the water main break or microbial/bacterial testing, was only specified in 55.6% of the articles. When assessing the inclusion of the CDC's instructions for boiling water, half of the articles did not include any information about how the water should be boiled (50%). A small number of articles included the CDC's *complete* instructions for boiling water (3%). Just under half of the articles included *some* information about how to boil water but did not include all of the CDC's instructions (47%). For example, articles often indicated that water "should be brought to a vigorous, rolling boil for two minutes," but failed to include additional instructions as recommended by the CDC (e.g., Staff Report, 2019). Most news articles did *not* include a reference to bottled water as an alternative to boiled water (71%). However, the majority of news articles did specify the functions that water should be boiled for, such as for drinking cooking, brushing teeth, giving to pets, etc. (55%).

A large majority of the news articles lacked a quote from a water system spokesperson (85%). Quotes may lend credibility to a news report. Similarly, many articles did not include a timeframe for when the BWA would end (78%) and most articles did not include a timeframe for when the public could expect an update on the BWA (99%). Furthermore, only 8% of the articles included a map that specified the geographical areas impacted by the BWA and only 27% of the articles included additional contact information for the public (e.g., the phone number of the PWS spokesperson). Lastly, only 19% of the articles provided links to an external source that provided additional information about the BWA, such as a website or social media page.

To address how information about the impacted areas was communicated (RQ1a), a Pearson Chi-Square test was computed to examine the relationship between the reference to a specific water system and a clear reference to the affected population in the articles. A significant relationship with a *small* effect size was found between these variables: $\chi^2(1, n = 1040) = 46.104, p < .001, V = 0.211$ (Cohen, 1988). Simply put, there is a significant relationship between local news media articles' inclusion of the impacted water system and a clear reference to the affected population(s) when reporting on BWAs.

A series of Pearson Chi-Square tests were computed to determine what type of information appears alongside CDC guidelines for boiling water (RQ1b). A significant relationship with a *medium* effect size exists between the inclusion of some CDC guidelines for boiling water and a reference to bottled water: $\chi^2(1, n = 1038) = 135.074, p < .001, V = 0.361$ (Cohen, 1988). Articles that lacked guidelines for boiling water also lacked a reference to bottled water as a suitable source of clean water during a BWA. In contrast, articles that included partial or complete guidelines for boiling water were likely to reference bottled water as a suitable source of clean water during a BWA. Similarly, a significant relationship with a *large* effect size was found between the inclusion of some guidelines for boiling water and the inclusion of functions that water should be boiled for: $\chi^2(1, n = 1040) = 415.516, p < .001, V = 0.632$ (Cohen, 1988). Therefore, articles that did not have guidelines for boiling water also did not mention the functions for which water should be boiled (i.e. drinking, cooking, etc.). Articles that included partial or complete guidelines for boiling water were likely to specify the functions for which affected populations needed to boil their water. A significant relationship with a *small* effect size was also found between the inclusion of some guidelines for boiling water and the inclusion of contact information, such as a phone number or e-mail address, where readers could obtain more information about the BWA: $\chi^2(1, n = 1040) = 51.1378, p < .001, V = 0.222$ (Cohen, 1988). Finally, no significant relationship was found between the inclusion of guidelines for boiling water and the inclusion of links to external informational sources about the BWA.

Communication about cause and resolution of BWAs in accordance with the Centers for Disease Control and Prevention (2016) guidelines (RQ1c) was analyzed using a Pearson Chi-Square test. A significant relationship with a *small to medium* effect size was found between the inclusion of the cause for the BWA and the inclusion of a resolution to the BWA: $\chi^2(1, n = 1040) = 65.703, p < .001, V = 0.251$ (Cohen, 1988). This relationship suggests that news media articles that include the cause of a BWA are likely to include a resolution to the BWA, and articles that do not include the cause are not likely include a resolution.

Discussion and implications

The EPA's PN rule requires that customers of a PWS be notified if there is risk to public health (Environmental Protection Agency, 2019c). BWAs are principle tools for notification and for protecting public health and safety when water is contaminated or at-risk of contamination. Overall, the results of the analyses suggest inconsistency between the guideline and coverage of BWAs in local news media. BWAs may be functioning in many cases to meet the minimum agency requirements for public notification rather than providing the public information necessary to protect their health (Wogalter, 2006).

For example, articles overwhelmingly tend to include the cause of the water advisory and the water system that is impacted. However, only half of the articles included auxiliary information critical to the public understanding of the event

and the necessary response, such as information included in the CDC's toolkit. Additional key pieces of information, such as a reference to bottled water as an alternative source to boiled water, a quote from a water system spokesperson, a timeframe for when an update could be expected or the advisory would end, contact information to receive additional information about the BWA, external links, or a map of the impacted area, were included in less than half of the articles. Though there is variation in what information was consistently reported by local news media, results suggest that articles consistently report information about the affected water system and impacted population. This information allows readers to determine whether they are included in the area of impact during a BWA.

Articles that included *some* of the Centers for Disease Control and Prevention's (2016) guidelines for boiling water were likely to include information about bottled water as an alternative source to boiled water, the functions for which water needs to be boiled, and the inclusion of contact information where additional information about the BWA could be obtained. This finding suggests that articles which report some of the CDC's guidelines for boiling water are likely to incorporate more information recommended by the CDC's Drinking Water Advisory Communication Toolbox (Centers for Disease Control and Prevention, 2016). It is important to note that only 50% of the sampled news articles included at least *some* instructions for boiling water. The results of this research have various implications for risk communication.

BWAs are important forms of risk communication and media coverage is likely the primary way these messages reach the public. Given the incomplete information included in media coverage, it is likely that BWAs are not effectively communicating risks or mitigation strategies. As risk communication, aims to inform individuals about probabilities of harm that could occur in the future, the content of risk communication messages – like BWAs – must provide individuals with enough information to perceive and understand the risk (Sellnow et al., 2009). Most of the sampled news media articles provided information about the affected water system and affected population. However, articles that did not provide the Centers for Disease Control and Prevention's (2016) recommended instructions for boiling water also failed to specify the functions for which water needed to be boiled for (i.e. drinking, cooking, etc.). Most articles did not reference bottled water as a suitable, alternative source of clean water. The absence of this information is problematic. As Vedachalam et al. (2016) suggest, timeliness of information, content of the BWA, and number of outlets/sources reporting on the BWA have a significant impact on the public's response and compliance with the recommendations. Guidelines, such as those developed by the Centers for Disease Control and Prevention (2016) are important in facilitating effective communication through local news media.

News media are primary conduits for the public to seek and receive information, especially as related to health and health-risk information (McCool et al., 2011). These results suggest that most of the sampled news media articles about BWAs lacked essential information to help the public understand risk(s) associated with the BWAs. For instance, the inclusion

of the Centers for Disease Control and Prevention's (2016) full guidelines for boiling water and the inclusion of contact information (e.g., telephone number) for the public to seek-out additional details about BWAs were problematically low in the sampled articles. This finding may be correlated with journalists' lack of specialized training on health reporting and limited knowledge about health-related terminology (Keshvari et al., 2018). The gaps in reporting coverage may be a function of the information provided by PWS authorities.

Inaccurate, partial reporting about health risk(s) by news media can impede individuals' mitigation of risk, enactment of protective actions, and induce low-risk perception (Bomlitz & Brezis, 2008). Chan et al. (2018) suggest that, "changes in the volume of information in legacy media are followed by changes in protective behaviors," (p. 55). For example, when the cause of a BWA is not communicated, people are less likely to deduce the severity of the situation (Angulo et al., 1997). Similarly, when updates are not communicated throughout the course of a BWA, people may stop boiling water or forget to boil water (Laughland et al., 1993). BWAs in this study generally communicated the cause of the BWA but did not include when an update could be expected. This lack of communication surrounding BWAs by media has serious implications for individuals' enactment of protective actions.

News media influence the lay public's knowledge about health and their health behaviors (Brown & Walsh-Childers, 2002; Schwitzer, 2003; Stevens, 1998). When a protective action, like boiling water, is perceived by individuals as efficacious at reducing risk, messages that influence risk perceptions may also influence the enactment of protective behaviors (Chan et al., 2018; Rogers, 1983). However, journalists have acknowledged that their news stories can be laden with technical language and may not be written at an appropriate reading level for their audiences (Friedman et al., 2014). When reporting health and health-risk information, journalists have also acknowledged:

how limitations of their expertise, restricted access to information, and time constraints meant that they had to trust processes (peer review), institutions (universities), and experts (academic researchers) to inform them about, and ensure the accuracy of, information they intended to publish.. (Forsyth et al., 2012, p. 138)

It is important that media reports of health information and health risks are accurate, consistent, and promote core characteristics of risk communication, such as self-efficacy. At the local level, journalists, municipalities, and water authorities must understand the implications associated with news media's reporting about health risks, like BWAs, and the impact(s) that media can have on individuals' risk perception, enactment of protective actions, and health behaviors. An important implication for local journalists, municipalities, and water authorities to understand is the difference between identifying risk and communicating risk.

Communicating risk is inherently different from the identification of risk. *Identification* of risk signals that a risk is present in the environment but does not provide affected or at-risk publics with detailed information about the cause of the risk or protective actions. Thus, identifying risk does not function to create shared meaning and understanding about the

risk. *Communicating* risk provides individuals with detailed information about the risk, striving to create a shared sense of meaning. Further, communicating risk functions as a form of support and a resource that facilitates informed decision-making (Sellnow et al., 2009). As resiliency is a function of resources and support, *communicating* risk supports individual resiliency (Houston, 2015, 2018). Therefore, local news media articles that only identify the presence of a BWA fail to sufficiently communicate risk, which may negatively impact individual resilience. Local-level partnerships among government municipalities, journalists, and water authorities may be one way to support *communicating* risk, thereby promoting resilience. Such partnerships are a best practice of crisis communication (Seeger, 2006) and may be initiated and maintained through the cultivation of relationships between local municipalities' communication specialists, local journalists, and directors of local water authorities. Future research should investigate effective ways to develop and maintain strong partnerships among these entities.

Consistency in communicating health-risk information is important to help decrease public anxiety and promote adherence to protective actions (Rubin et al., 2009). When risk communicators disseminate inconsistent messages, the public may lose trust in that source(s) (Thomas, Friedman, Brandt, Spencer, & Tanner, 2016). News media framing could also complicate decision-making surrounding health risks due to its impact on an individual's psychological environment and risk perception (Reynolds, 2011). Application of the Centers for Disease Control and Prevention's (2016) guidelines for BWAs is one such way that consistency can be achieved among various risk communicators when responding to and communicating about local emergencies or risks, like BWAs. The Centers for Disease Control and Prevention's (2016) guidelines were developed to ensure compliance with the EPA's PN Rule and,

A technical workgroup of public health and drinking water agencies and drinking water system experts advised and guided the project. The project also engaged a broad cross-section of relevant stakeholders and technical experts including local government officials, emergency response professionals, and hazard communication experts. (p. 1)

Simply put, the guidelines are comprehensive and aligned with both risk communication principles and the EPA's PN Rule. Although PWS officials should follow these guidelines when working with local news media in issuing BWAs, it appears that many are not.

Future research

Although this study found that BWAs were issued frequently and that most did not follow all of the CDC's recommended guidelines, the study did not explore what might account for these deficiencies. It may be that PWS officials are simply not including all the recommended information in their notifications or it may be that local news media are electing not to include all the recommended information. Future inquiries should explore the specific processes and methods used to issue BWAs to help answer this question.

In addition, this study did not explore important questions about the effectiveness of BWA messages. Did the target audiences receive the BWA in a timely manner? Did they understand and act upon these messages? Did they follow the instructions and boil water according to the recommended guidelines? These questions are important in assessing the overall impact of BWAs. While warning messages allow PWS to meet the requirements of the EPA's PN Rule, it is not at all clear if they correlate to protecting the public health and safety for all affected populations.

Limitations

This study includes several limitations. Though Google News Alerts can expansively search the web for related news sources, it is possible that some BWAs were not included in our sample. Additionally, coded news articles were downloaded as PDFs within two weeks of a Google News Alert. This could have resulted in discrepancies between the initial news article and the PDF version coded. It is unclear if there are regional differences in how BWAs are communicated. The articles reviewed for this study were from 38 of 50 states, with slightly more than half (23) having 5 or more news articles. Finally, local news media are just one source where people seek and receive information about risks. Affected populations may also gather information about BWAs from social media, radio, and interpersonal networks, among other sources. However, local news media remain a primary source of information during crises (van der Meer, 2018).

Conclusion

Water-related risks are among the nation's most serious health issues (Kaiser Family Foundation, 2016). BWAs serve as an important form of risk communication to protect the public health and safety during potential water contamination events. Results from this study indicate that there is variation in what information is consistently reported by U.S. local news media when reporting on BWAs. The articles consistently reported information about the affected water system and impacted population, but only half of the articles included *some* instructions for boiling water as recommended by the Centers for Disease Control and Prevention (2016), functions water should be boiled for (e.g., drinking, brushing teeth), and a resolution for the BWAs. Results also highlight the importance of creating and maintaining local-level partnerships among government municipalities, journalists, and water authorities, which could support resilience. Furthermore, resilience is a function of resources and support. Risk communication is considered a resource and form of support; therefore, relevant and consistent risk communication can facilitate resilience. As may be evident, risk communication is essential to protect public health and safety during water-related risks, like BWAs. As water-related issues are projected to increase in severity and frequency over time, effective risk communication becomes increasingly important for conveying timely, accurate, and relevant information to affected publics.

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Appendix A

Coding Scheme

Code Number	Criteria	Definition	Example
1	Inclusion of Water System (Y/N)	Answer yes if the article references the water system or entire city system that is impacted by the water event by name, or if the article mentions that the water for an entire city is impacted. Answer no if the water system or city system is not referenced by name.	"The Startex-Jackson-Wellford-Duncan Water District is under a boil water advisory" OR "Rancho Viejo Water Utility No. 2 is under a boil water advisory" OR "Tryon Public Works ..." are all acceptable references to a water system.
2	Inclusion of Affected Population (Y/N)	The article clearly references the area impacted by the boil water advisory. This could be an entire city, neighborhood, subdivision, certain streets, or an area on a map. The coder should judge this variable by asking themselves: "If I were a resident in the area, would I be able to discern if I need to boil my water?"	"All residents of Walnut Cove, NC are urged to boil water for drinking and ... until further notice"
3	Cause of Advisory Included (Y/N)	The article clearly references the cause or event that led to the boil water advisory. This could be a water main break, contamination, turbidity, low water pressure, natural disaster, or another cause.	Leak in the system, water main break, presence of <i>e.coli</i> , elevated turbidity levels, power failure at the water plant, etc.
4	Guidelines for Boiling Water Included (Full, Partial, None)	The article provides guidelines for boiling water within that are more detailed than "affected populations are asked to boil water". Articles that just say to boil water without additional instruction would fall under the "none" category. Instructions should state that the affected population needs to bring water to a rolling boil (or heat the water until bubbles come to the top quickly) and continue boiling for one additional minute, then let the water cool and store in a clean, sanitized container.	1. Bring the clear water to a rolling boil for 1 minute 2. Let the boiled water cool. 3. Store the boiled water in containers with tight covers.
5	Includes a Reference to Bottled Water (Y/N)	Article includes a reference to the suitability of bottled water as a substitute for boiling water.	"Residents should use boiled or bottled water for all consumption purposes." clean sanitized containers
6	Includes Functions Water Should be Boiled For (Y/N)	Article includes the situations where water would need to be boiled. If the article lists different situations where water should be boiled or that water should be boiled for all consumption, the coder should answer yes.	Drinking, brushing teeth, washing fruits and vegetables, preparing food and baby formula, making ice, giving to pets.
7	Includes Resolution (Y/N)	Article includes the actions being taken to restore safe drinking water to the community. This could be repairs to a broken line or valve, water testing, filling an empty tank, or seeking to find what the problem is if not yet discerned.	Repairs to broken water main lines. Water testing. Repairs to broken water valves.
8	Includes a Quote from Water System Spokesperson (Y/N)	The article includes a verbal quote from a spokesperson affiliated with the water system. Paraphrasing can be counted as a yes if the article references a spokesperson (does not have to be by name) from the water system. Links to direct quotes from social media do not count as quotes from a spokesperson.	"Robert Bible, general manager of the authority, said a water line break occurred Tuesday afternoon by the Sheffield Heights station."
9	Includes Timeframe for End of Water Advisory (Y/N)	The article clearly references a timeframe for when the water advisory will end. The reference should include a time span or day/date for the BWA to end to be coded as a yes. Vague references such as "soon" are coded as no.	"24–48 hours", "We expect the advisory to be lifted by noon on Tuesday", etc.
10	Includes Timeframe for Next Update on Advisory (Y/N)	The article clearly includes a time when readers can expect an update on the boil water advisory. The reference should include a time span or day/date for the update.	"The city will provide an update when test results are in tomorrow morning"
11	Map Included (Y/N)	The article includes a map of the area impacted by the BWA.	Check the document for the inclusion of a map.
12	Contact Information Included (Y/N)	The article includes a phone number to a resource that can help the reader gain information related to the BWA.	"Anyone needing more information can call 270–236-2535"
13	Link(s) to Additional Sources Included (Y/N)	The article includes a link to an outside source such as a website, Twitter, or other social media page that has additional information regarding the BWA. If the link is not a hyperlink, but is a URL, it counts as a yes.	"This information will also be provided on Pennsylvania American Water's website at www.pennsylvaniaamwater.com , under the "Alerts Notifications" section."

Additional Rules:

- Original story coded, not the updates.
- Information in photos or other media that is visible within the article without clicking on links also coded.
- Headlines included in coding.
- All information available within the article without external searching coded.

Appendix B

Inter coder Reliability for All Coded Variables

Variable	Cohen's <i>kappa</i>
Inclusion of Water System	.60
Inclusion of Affected Population*	.32
Cause of Advisory	.85
Guidelines for Boiling Water	.88
Reference to Bottled Water	.88
Functions Water Should be Boiled For	.86
Inclusion of Resolution	.61
Quote from Water System Spokesperson	.72
Time Frame for End of Water Advisory	.79
Time Frame for Update on Water Advisory	.80
Inclusion of Map	.88
Inclusion of Contact Information	.98
Inclusion of Links to Additional Sources	.78

*Percent agreement for Inclusion of Affected Population was calculated due to the low *kappa* coefficient. Percent agreement for this variable is 96%.