Exploring the Role of Trust in Drinking Water Systems in Western Virginia

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ACADEMIC ABSTRACT

As the impacts of global change drivers and anthropogenic influences increase, the lakes and reservoirs that communities rely on for their drinking water are threatened by more frequent, severe, and unpredictable disturbances. This study was a part of an interdisciplinary effort to understand and increase resilience in water systems to improve managers adaptive capacity to cope with these disturbances. A key element of social resilience is trust, which can improve the speed and effectiveness of management actions and can spillover into community wellbeing and behavioral outcomes, including acceptance or rejection of tap water. Using a four-stage drop off pick up method, I surveyed 611 residents in Roanoke, Virginia to examine the role of trust in drinking water systems between a community and their utility. I first focused on factors that related to a person's trust in their water utility. I examined the relationship between four determinants of trust ecology, the salience of a trusting behavior, and trust, as well as and the effects of information provision about new water security technologies on trust. I then assessed trust's role in characterizing drinking water behavior (i.e. water source usage) alongside factors of risk, water quality evaluations, and salience. I found that trust can be high in low salience situations and information provision had no effect on trust, suggesting that people might take their water security for granted when it is not at the forefront of their thoughts. Calculated beliefs about a utility's capability were only linked to increasing trust when those beliefs were negative,

suggesting that people might have a threshold where their utility is capable enough to trust. Even in the absence of the information to form affinitive judgments, value and goodwill-based judgments were important to community trust. Lastly, understanding behaviors might provide indicators for managers about the state of community perceptions of their water since trust, risk perceptions, and evaluations of tap water's taste, smell, and appearance varied based on an individual's water source choice. These findings demonstrate the complexity and importance of community's trust in their water managers. This study of, and continued research into, trust can help us further our understanding of, and the tools to build, the resilient water systems needed to preserve water security and community health.

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GENERAL AUDIENCE ABSTRACT

The raw water sources that utilities use to treat drinking water are typically lakes and reservoirs. This means that the safety of public drinking water is reliant on the stability of the surface water sources that water utilities use. Because of extreme weather, warming temperatures, and human land use, disturbances to surface lakes and reservoirs are becoming more frequent, severe, and unpredictable. A key goal of water-quality researchers is to learn how to develop systems that are more capable of adapting to these disturbances. Trust is an asset to water systems ability to handle disturbance. If people trust their water utility, they offer less resistance to new management plans and worry less about their water. To better understand trust in water utilities, I conducted a survey on residents in Roanoke Virginia. Trust in an institution is a function of an individual's calculation that their water utility can deliver safe drinking water (rational determinants), their feelings of value affinity or goodwill to their utility (affinitive determinants), their natural inclination to trust (dispositional determinants), and their belief that the water utility is regulated by a larger system of procedures (systems determinants). Trust also varies based on salience of a trusting behavior, which, in this case, was the degree to which citizens are aware of and think about their drinking water safety and supply. I assessed how these four judgments and salience relate to trust, and if providing information about new technology designed to keep water safe could increase trust. I then looked how trust interacted with other factors of risk, water

quality evaluations, and people's awareness of their drinking water to characterize the perceptions of people who drink from different water sources. I found that when people have had consistent outcomes for their water security, they don't think about their water much but still have high trust that it to be safe. Providing people with information about water safety technology did not impact their trust. All four determinants had different relationships with trust. Levels of trust plateaued after neutral levels of capability beliefs and moderate levels of value and goodwill judgements were reached while broader system beliefs maintained a strong positive relationship with trust and disposition maintained a weak positive relationship with trust. Affinitive, rational, and procedural determinants were important to trust. People were more likely to drink tap water if they had higher trust in their utility, lower risk perceptions, and more favorable tap water quality evaluations. Salience, though important to trust formation, played less of a role in characterizing drinking water behavior. Overall my findings show that several factors interact together to form trust, and that trust, once formed, plays an important role in characterizing different drinking water behaviors. This study and future attempts to learn about trust can help us understand how to build water system's adaptive capabilities and preserve community health through disturbances.

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Thesis Introduction

Problem Statement

The aquatic resources that many people depend on as a source for their drinking water are increasingly degraded by anthropogenic climate and land-use change (Dunn et al., 2012; Garrote, 2017; Pouget et al., 2012). Algae blooms and hypoxic conditions that introduce dangerous cyanotoxins into water sources or increased metal concentrations causing taste, odor, or appearance issues in water are examples of the types of disturbances that are becoming more frequent and less predictable in water systems (Ho & Michalak, 2015; Olsen & Shindler, 2010). s these events become more common, they threaten the security of public drinking water, and relatedly, community health.

Disturbances introduce health risks to drinking water but treating disturbed water to make it potable and fulfill federal quality regulations takes time. This delay in treatment can force utilities to shut off the water supply to communities. For instance, when Lake Erie's water was contaminated by a harmful cyanobacterial bloom in 2014, the water utility in Toledo, Ohio was forced to shut off delivery to half of a million residents to prevent exposure to toxins the cyanobacteria produce (Fitzsimmons, 2014; D. R. Smith et al., 2015; Wilson, 2014). Environmental factors including rising temperatures, increased fertilizer runoff into water sources, and a reduction in native phytoplankton due to invasive muscle predation enabled this bloom (D. R. Smith et al., 2015; Steffen et al., 2014). Many environmental changes, like the disturbances that affect surface water, are not caused by one factor, but a compilation over time

(Chapin et al., 2009). Disturbance events like this harmful algal bloom are expected to increase in frequency, severity, and range (Ho & Michalak, 2015). As such, changing climate and land-use drivers that continually affect water in surface sources threaten water safety and access for communities.

Resilience-based water management presents a promising strategy to respond to the uncertainty of water system disturbances (Carpenter et al., 2001; Cumming et al., 2005; Folke, 2016; Holling, 1973). Resilience, or "The ability of a system to maintain its structure and patterns of behavior in the face of disturbance," (Holling, 1986: p296) enables systems to rapidly and dynamically adapt to changing conditions (Carpenter et al., 2001; Desjardins et al., 2015; Folke, 2016). In Toledo, management responded to the algal bloom after the cyanobacteria had already grown in the water and attempted to return the lake's conditions to the state it was in before the bloom occurred. This reactionary management strategy is poorly situated to manage rapid change as it extends recovery time and is slow to adapt (Chapin, 2009; Pouget et al., 2012; Skinner, 2017). A resilience-based management strategy, on the other hand, is flexible, focusing on maintaining essential functions of a system, not keeping the system in the same state of stability (Folke, 2016; Folke et al., 2009). Because of its ability to embrace change, resilient systems react faster to disturbances (Longstaff & Yang, 2008), making them well equipped to respond to the challenges water systems face.

The Smart and Connected Communities (SCC) project is an interdisciplinary attempt to build resilience in water systems and understand how communities can adapt their water systems to contend with disturbance events. Using a watershed in Roanoke, VA, members of the SCC team developed technology that uses an integrated sensor network to collect real-time data on water conditions and forecast water quality changes in a drinking reservoir. Sensors reduce the need for manual water testing, which can be extremely time-consuming and result in feedback delays. Additionally, near-term iterative forecasting allows utilities to predict future changes in water conditions, enabling managers to detect issues faster and reducing the delay between problem occurrence and treatment (Clark et al., 2001; Dietze et al., 2018). Forecasting allows utilities to prepare for disturbances before they occur, ensuring the continued supply of safe drinking water to a community. This enhanced ability to produce secure drinking water can strengthen community resilience by improving public feelings of trust in their water utilities (Gray et al., 2012; Langridge et al., 2006; J. W. Smith et al., 2013). In this way, the SCC project aims to improve ecological resilience by increasing the ability of managers to detect and respond to changes and community resilience through spillovers into social trust.

The success of resilience-based water management efforts, like forecasting, are often reliant on public acceptance and trust in management institutions (Aldrich, 2012; Lachapelle & McCool, 2012; Venkatesh et al., 2003). Trust is the core concept of my thesis and is defined as the psychological state when one actor, the trustor, accepts vulnerability based on the expectation that another entity, the trustee, will perform an action or behavior (Mayer et al., 1995). Public trust in water managers to deliver safe drinking water can enhance resilience by encouraging cooperation between citizens and managers, increasing the speed with which managers can enact plans (Davenport et al., 2007; Song et al., 2019) Trust also increases public approval of managers and support for management plans, which reduces resistance to management shifts (Lachapelle & McCool, 2012). Public support is typically a key determinant in the success or failure of new projects (Dolnicar et al., 2011). For example, Ross et al. (2014) examined the trust citizens had in their utility shortly before a vote on whether to implement a novel water recycling plant and found that the higher an individual's trust in water managers was, the more likely they were to accept the new plan. Over the past decade, trust in tap water has declined, particularly in light of events like the water shutdowns of Flint, Michigan and Toledo, Ohio (AP-GfK Poll, 2016). This trend threatens to both reduce the benefits trust brings managers and communities and degrade the resilience of water systems.

Trust plays a role in community relationships with water managers, but it can also influence individual behaviors like the acceptance and use of tap water as a drinking source. Public drinking water is not the only option for a drinking water source. Some of the most common alternatives to tap water are bottled water or filtered water from a sink, refrigerator, or pitcher. An individual's drinking behavior varies based on the degree to which they drink from tap water or these alternatives. Tap water consumption has been declining in recent decades (Doria, 2006; Huerta-Saenz et al., 2012), indicating a shift away from water utilities' key product. This shift is not only an issue for utilities; it is also a burden for community members, for whom alternate water sources likely carry an increased financial cost compared to tap and, in the case of bottled water, environmental cost (Parag & Timmons Roberts, 2009). While trust in water utilities has been linked to positive attitudes about tap water and greater acceptance of tap water, mistrust has been linked to a rejection of tap water as a personal water source (Doria, 2006, 2010). As such, social trust in water utilities not only benefits community and management interactions but can affect an individuals' at-home behavior.

Research Objectives

In light of increased disturbances to water systems, driven by a plethora of climate and anthropogenic land-use factors, understanding the dynamics of resilient systems is critical. My research informs community resilience through a lens of social trust. In Chapter 1, I examine determinants of trust and, whether it can be bolstered by information about resilience-based technology as part of the Smart and Connected Communities project effort to increase resilience in water systems (Figure 1). Following Stern & Baird's (2015) trust ecology framework, I also explore the relationships between judgments of the utility, the broader system that regulates the utility, and the trustor's general disposition and overall trust. Trust has most often been studied in situations where people have high issue salience, or a high degree of awareness and mental associations with an issue (Higgins & Kruglanski, 1996). With no history of contamination incidents or water shutdowns, my research is novel in its focus on a context that the public tends to take for granted. By studying trust and its related factors, I hope to increase knowledge and tools that can contribute to building social resilience in water systems.

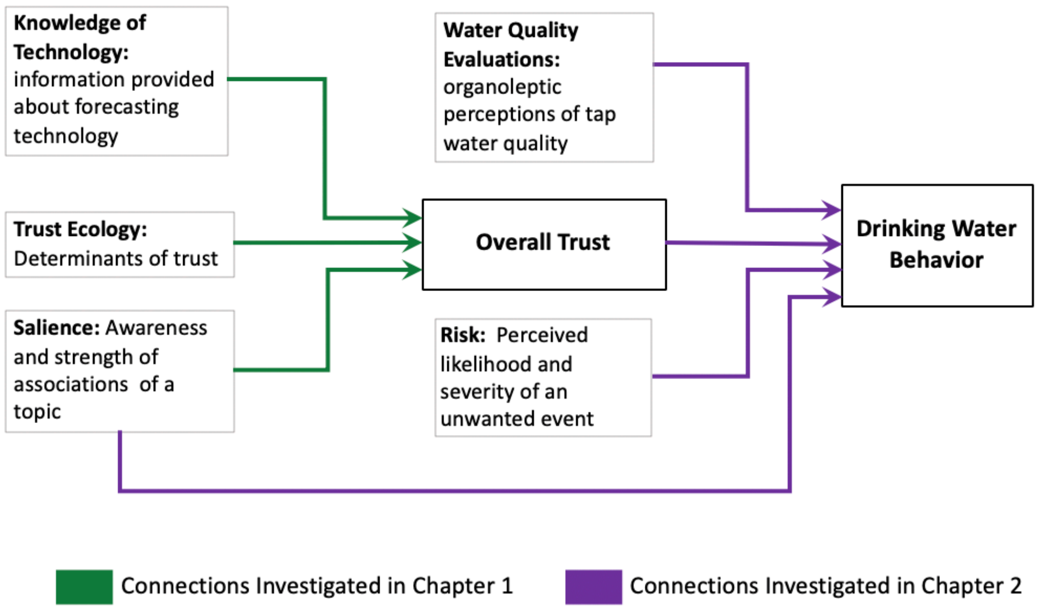

Figure 1: My conceptual framework examines the factors that influence overall trust, as examined in Chapter 1, and the factors that influence drinking water behavior, as examined in Chapter 2. It posits that overall trust in a water utility is a function of knowledge about advances in resilience-based management efforts, judgments about the utility that form determinants of trust ecology, and individual's salience of their home water quality. It further posits that evaluations about tap water quality, overall trust in the water utility, risk perceptions about tap water safety, and salience of home water quality influence an individual's at home drinking water behavior. Connections examined in Chapter 1 are represented with green arrows while connections examined in Chapter 2 are depicted with purple arrows.

Trust in water utilities can influence attitudes about tap water quality and decisions to drink the tap water utilities provide (Doria, 2006, 2010). In Chapter 2, I examined the role trust plays in people's water source choice behavior, specifically the choice to use and frequency of use of sink filters, appliance filters, and bottled water. Trust is not the only factor that has been linked to drinking water source behavior. Factors of risk, salience, and water quality evaluations (taste, smell, and appearance) have also been related to acceptance or rejection of drinking water sources (Doria, 2006; Saylor et al., 2011). I examined trust alongside these factors to characterize people's drinking water source choice behavior and the role trust plays in informing water drinking behavior.

The two chapters of my thesis explore the path of trust in drinking water, from its formation and potential alteration in Chapter 1 to its effect on community behavior in Chapter 2. I do this by first determining if trust can be altered by increased awareness of water utilities' enhanced ability to predict changes in reservoirs, as was made possible by the Smart and Connected Communities project. I further examine trust's formation, specifically how contextual factors like salience could moderate the judgments an individual used to form their trust. Lastly, I explore how trust, once formed, relates to behavioral outcomes, specifically personal water source choice. The ultimate goal of this examination of trust in water utilities is to further our understanding of, and the tools to build, resilience in water systems.

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Chapter 1:

GOOD ENOUGH TO TRUST: EXPLORING TRUST IN WATER UTILITIES IN LOW SALIENCE SYSTEMS IN WESTERN VIRGINIA

ABSTRACT

Over the past decade, global change drivers are increasing the frequency and severity of security threats to drinking water systems that rely on surface reservoirs and lakes for raw water. Managers are working to build resilient water systems to adapt to these disturbances. A critical component of social resilience is citizen trust in their water utilities to provide safe drinking water. This study examined the factors that might relate to trust's formation and if trust levels could be altered by providing information about technology designed to protect water resources. Trust in an institution is a function of an individual's calculation tin their water utility's capability and track record (rational determinants), their feeling that their utility shares values or has goodwill for them (affinitive determinants), their personal inclination to trust (dispositional determinants), and their belief that the water utility is transparent and follows regulations from a broader system (procedural determinants). Trust also varies based on the salience of a trusting behavior, or the degree to which citizens take the supply of safe drinking water for granted rather than paying attention to it. We used a four-stage drop off pick up method to survey 611 residents in Roanoke, Virginia to examine the relationship between determinants of trust and overall trust in local water utilities, as well as the role of salience. We embedded one of three vignettes in each survey that provided different amounts of information about new water security technology

as an experimental condition to assess the effect of information provision. We found that residents had low salience about their tap water and high trust, indicating that residents might take their water security for granted. Resident's trust did not change based on the information provided to them about new technology. Trust increased slightly as dispositional beliefs increased and strongly as procedural beliefs increased. The same could be said for rational and affinitive beliefs, though their relationships with trust plateaued at a neutral level of belief for rational and moderate belief for affinitive, suggesting the two have thresholds where residents believe their utility is good enough to trust. Despite the different relationships, these determinants best explained trust when considered together. Considering salience factors improved our regression model, suggesting that salience is an important contextual element that helps explain the complexity of trust. Our findings indicate that managers in low salience situations looking to increase trust in their institutions would fair best by focusing on perceptions of the regulations and transparency governing their institution, feelings of goodwill or value alignment with their customers, and addressing any negative beliefs about their utilities' capabilities.

INTRODUCTION

Global deterioration of water quality as a result of anthropogenic climate and land-use change poses a considerable threat to water security (S. M. Dunn et al., 2012; Garrote, 2017; Pouget et al., 2012). These large-scale drivers are introducing increasingly frequent and unpredictable disturbances such as algal blooms, hypoxia, changing metal concentrations, and eutrophication that impact the water quality of the lakes and reservoirs (Olsen & Shindler, 2010). Many communities depend on these surface water sources for their drinking water. At a minimum, disturbance events can affect the water treatment process, resulting in foul odors or tastes in drinking water. In more extreme cases, disturbances can cause toxin release that directly threatens human health (Falconer, 1999; Moore et al., 2008). Water utilities are required to stop water delivery when events degrade its quality below the health standards set by the federal government to minimize human health risks (*Safe Drinking Water Act of 1974 (Title XIV of Public Health Service Act)*, 1996). For instance, when Lake Erie's water was contaminated by a cyanobacterial bloom in 2014, the water utility in Toledo, Ohio curtailed delivery to half of a million residents (Fitzsimmons, 2014; Michigan Sea Grant, 2020; US EPA, 2018). As anthropogenic influence drives changes in the water quality of lakes and reservoirs, challenges to the security and availability of drinking water like that in Toledo continue to occur.

Resilience-based management offers promising strategies to respond to the types of challenges water systems face (Carpenter et al., 2001; Cumming et al., 2005; Folke, 2016; Holling, 1973). Rather than responding to events like the Toledo algae bloom after they arise to return each component of a system to its previous states of stability, resilience-based management embraces change as an essential part of a system and attempts to adapt with it to maintain essential functions (Folke et al., 2009; Folke, 2016). Because of its focus on flexibility and learning, resilient systems are well equipped to handle change, regaining function after disturbances with shorter delays (Longstaff & Yang, 2008). This quality makes resilient strategies well suited to address the disturbance events with which drinking-water systems contend.

Forecasting technology contributes to the resilience-based management of drinking water systems from both biological and social standpoints. Near-term iterative forecasting creates predictions of future ecosystem conditions, reducing the lag between detection and treatment of problems (Dietze et al., 2018; Thomas et al., 2020). Improving disturbance detection increases opportunities for water treatment facilities to adapt to those disturbances and ensure the continued supply of safe drinking water. If managers in Toledo were able to detect the algal bloom before it happened, they might have been able to better limit damage to water quality or prevent the bloom from happening at all. This enhanced ability to detect and adapt can spillover into community resilience by affecting feelings of public trust in their water utilities and, subsequently, community member's feelings of security with their water systems (Langridge et al., 2006; Gray et al., 2012; Leahy & Anderson, 2008).

Trust is essential for resilience-based management efforts to be successful. Trust is an asset that can improve the speed and effectiveness of management actions, allowing the public to focus their attention on other aspects of community wellbeing (Zellner et al., 2011; Nelson et al., 2017; Song et al., 2019), especially in emergencies (Longstaff & Yang, 2008). Trust helps get citizens to get on board with management shifts and encourages cooperation (Davenport et al., 2007; Ross, 2014). Conversely, distrust can delay effective management by decreasing public receptiveness to communication, cooperation, or adoption of new programs (Gray et al., 2012; Leahy & Anderson, 2008; Stern & Baird, 2015). As such, the success of novel technologies and management efforts that can enhance resilience in water systems and, by continuation, protect the security of water resources, often depends on social trust in water management institutions.

Evaluations of trust in institutions like water utilities are likely moderated by salience, or the degree to which water security is at the forefront of people's minds (Gray et al., 2012; Higgins & Kruglanski, 1996). While there is high salience for water catastrophes such as those in Flint, Michigan and Toledo, Ohio (APGfK Poll, 2016), often, people are less aware of their tap water if they live in areas that have never or rarely experienced significant water quality issues (Attari et al., 2017; Quisto et al., 2017). When the salience of water quality is low, the decision to trust one's water utility may reflect a heuristic rather than a conscious deliberation (Möllering, 2006).

Given that the success of resilience-based water management efforts like forecasting is related to public acceptance and trust in water utilities (Aldrich, 2012; Lachapelle & McCool, 2012; Venkatesh et al., 2003), we examined the relationship between the adoption of forecasting technology by a water utility and the level of trust a community has in that water utility to continually deliver safe drinking water. We expected that increased knowledge about efforts to enhance water security would be positively related to trust; however, we expected this relationship to be moderated by the degree to which people consciously pay attention to their water quality. Additionally, we explored how people's emotional and evidence-based judgments of the utility and broader water system, as well as their tendency toward a trusting disposition, related to their level of trust (Stern and Coleman 2015).

Using a sample of residents from a small city in southwest Virginia, we examined community trust in a water utility that is developing and testing technology to forecast disturbance events such as algal blooms. We hypothesized a positive relationship between knowledge about the new forecasting technology and trust. However, we recognized that the water utility's history of providing consistently safe drinking water since its inception in 2004 could moderate the impact of this information. Consequently, our research question centers around determinants of social trust when the salience of drinking water quality as an "issue" is low. Under these circumstances, we expected trust to be high, less related to information about new technology or emotional connections with the utility, and more strongly related to judgments about the system in place to protect drinking water (e.g., water quality standards and regulations) as well as judgments about the water utility's capacity to supply safe drinking water.

CONCEPTUAL FRAMEWORK:

Our study's conceptual framework involved three broad factors: salience, trust ecology (evidence-based, emotional, procedural, and personality-based), and knowledge about forecasting technology (Figure 1). Our framework integrates Stewart's (2009) weather salience framework with Stern & Baird's (2015) trust ecology framework.

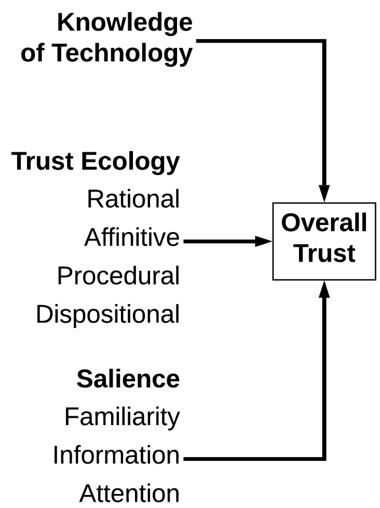

Figure 1: Our conceptual framework posits that overall trust in a water utility is a function of knowledge about advances in resilience-based management efforts, judgments about the utility and personal propensity to trust, and individual's salience of their home water quality. Trust ecology is based on judgments about the utility in the form of rational, affinitive, and procedural determinants, and personal propensity to trust in the form of dispositional determinants. Salience is conceptualized based on three factors: familiarity with water utility, information known about water quality, and attention paid to changes in water quality.

Salience

Salience refers to the psychological significance that people place on an issue (Wlezien, 2005). Salient thoughts are at the forefront of one's mind and easier to retrieve or access cognitively, while low salience thoughts are harder to access (Taylor & Fiske, 1978; Higgins & Kruglanski, 1996) Evaluating the salience of an issue to an individual or community can provide insight into how they will judge or respond to it (Dannevig & Hovelsrud, 2016).

Salience has been linked to trust perceptions (Schwartzt & Brand, 1983; Doria et al., 2009; Siegrist & Cvetkovich, 2000), but the nature of that relationship varies in different situations. For example, in an experimental study on the effects of sexual assault thoughts on women's relationships with themselves and others, Schwarzt & Brand (1983) prompted some women to think about violent crimes while other women received no prompt. In a questionnaire administered after the prompt, women who were told to think about crimes reported lower trust in others than the women who received no information. These results suggested that heightening salience can decrease trust. However, high salience may also be associated with higher trust in government institutions while low salience is related to diminished trust. For example, Hetherington & Husser (2011) showed that when media attention focused on issues like defense spending or welfare and thus heightened their salience, trust in governmental institutions, and related support for these policies increased.

Low salience can also impact trust levels. Low salience can result in a more blind form of trust, where an individual takes it for granted that the entity they are trusting will follow through on their commitments because the alternative is not at the forefront of their mind (Möllering, 2005). This taken-for-granted brand of trust could be an asset to resilience-based management, allowing institutions to take faster action while freeing citizens to focus their attention on other aspects of community wellbeing. However, taken-for-grantedness is not a guaranteed outcome of low salience situations (Aldrich, 2012; Möllering, 2008), and there is a need to better understand how salience and trust interact under low salience situations.

We employ Stewart's (2009) salience framework for weather forecasting in our efforts. The framework includes an event's noticeability, impact on emotion, duration and frequency, power on people's daily lives, and psychological attachment to a topic. Each of these categories consists of multiple subdimensions. For example, noticeability of an event included attention paid to weather and weather information, current knowledge of weather events, or direct observation of weather. While Stewart's (2009) framework was designed specifically for weather systems, aspects of it are adaptable to drinking water systems. As opposed to weather, which is experienced daily, our system focuses on an issue that tends to be periodic and punctuated, only rising to importance when issues occur. Consequently, we focus on familiarity, knowledge, and attention as the key components of salience for drinking water systems.

Water systems are typically low salience issues. Social awareness of water quality is not widespread, and the water treatment process itself is not well understood by the general public (Attari et al., 2017; Quisto et al., 2017). While salience for failures of public trust and recent catastrophes such as those in Flint, Michigan and Toledo, Ohio is high (APGfK Poll, 2016), most people do not have similar levels of salience for their drinking water. People tend to have some knowledge about drinking water systems, but it is largely incomplete (Attari, 2014). Most underestimate the amount of water they use, which can lead to underestimations of the impact water has on their lives (Attari et al., 2017). This low salience found in most water systems has implications for the way people trust their water utility. The population we sampled has not received any serious warnings in the past decade about the quality of their tap water that would require them to change their drinking habits. Because of this, ***we expected that our community would have low familiarity, knowledge, and attention to their drinking water (H1).***

Trust

Trust is a psychological state that occurs when an individual (the trustor) consciously accepts vulnerability to another entity (the trustee) based on the expectation that the trustee will perform a certain action or behavior (Mayer et al., 1995). Trust is a key element in the effectiveness of natural resource management efforts (Gray et al., 2012; Leahy & Anderson, 2008; Stern & Baird, 2015). In the context of water systems, the trustor is the resident accessing drinking water, the trustee is the water utility, and the trusting behavior is the provision of safe drinking water. A trusting resident will be more comfortable accepting the arrangement that the water utility will deliver safe drinking water to their tap than would a non-trusting resident.

A key but unexplored component in the measurement of trust is the willingness of the trustor to accept that they are vulnerable to the trustee. This inherent uncertainty of whether or not the trustee will deliver upon the trustor's expectations exists in every trusting relationship (Möllering, 2008). Without the trustor accepting some level of vulnerability, trust could not exist. According to this conceptualization, willingness to trust and willingness to accept vulnerability both represent trust. Our focus in this research is on the degree to which residents are both comfortable accepting vulnerability and the degree to which the report that they trust their water utility to deliver safe drinking water.

There are a variety of scholarly interpretations of the underlying dimensions of trust. Some conceptualize trust as having multiple dimensions that are too statistically similar to differentiate, while others argue that these dimensions can not only be distinguished but can have different relationships with trust (Poortinga & Pidgeon, 2003; Smith et al., 2013; Stern & Coleman, 2015; Vaske et al., 2007). Stern and Coleman (2015) and Stern and Baird (2015) synthesized much of this literature for natural resource research in the trust ecology framework. They posit that trust is formed based on relationship and evidence-based evaluations of the trustee, the trustor's disposition, and the systems in place that increase or reduce the trustor's vulnerability (Stern & Coleman 2015; Stern & Baird 2015).

The trust ecology framework recognizes four trust determinants: affinitive, rational, dispositional, and procedural. The affinitive determinant is based on the trustor's emotional evaluations of a trustee. It can occur when a trustor believes a trustee genuinely cares about them, shares values with them, has a likable charisma, or for other emotional factors that ingratiate a trustee to a trustor. As opposed to the emotional nature of affinitive determinants, rational determinants involve a calculated evaluation of a trustee's ability to affect a positive outcome for the trustor, sometimes based on their track record of prior performance or other knowledge of a trustee's capability (Stern & Coleman, 2015). The rational determinant is positively related to trust when the trustor believes the benefits of trusting outweighs the cost.

The two other determinants of trust focus on a broader system in place to reduce the trustor vulnerability and the characteristics of the trustor. Procedural determinants are based on the trustor's perceptions of the larger system that regulates the trustee, rather than their perceptions of the trustee. It occurs when a trustor believes a system is fair, transparent, or has strong enough structure and regulation to appropriately control a trustee's behavior (Stern & Coleman, 2015). Dispositional determinants are based on a trustor's personal predisposition to be trusting, either in general or in a specific context. For instance, an individual could be more or less inclined to trust authority figures or could be generally trusting of others (Stern & Coleman, 2015). These characteristics can vary depending on the context of the situation in which trust is employed. When a trustor does not have sufficient interaction with the trustee to form affinitive or rational judgments, they tend to rely on procedural determinants (Song et al., 2019b).

The trust ecology framework has been conceptualized and applied to natural resource research in a variety of manners. Some studies use the framework as a means of interpreting results rather than directly measuring the concepts (Davis et al., 2017). Other research focuses only on parts of the trust ecology framework (Temby et al., 2017). Still others have conceptualized the determinants as measurements of trust itself (Lutter et al. 2018). Most research comprehensively employing the trust ecology framework focus on inter-organizational governance networks where salience is high for the stakeholders involved. Perry et al. (2017) examined coastal residents' attitudes about new marine reserve managers, specifically how feelings of shared values with managers impacted trust in reserves. They found that increases in these affinitive determinant indicators were related to higher levels of trust. Lima et al. (2019) studied trust ecology determinants between the members of multiple U.S. and Mexico based organizations collaborating and participating in a fishery management network in the Gulf of Mexico. They found that organization members had low procedural beliefs about the broader network system and, that when there was little communication between organizations, rational determinants were most important to bringing about organizational change. Song et al. (2019) focused on a fishery management network in the Great Lakes region and found that rational and procedural determinants were important to mutual goal alignment between organizations, while affinitive determinants were critical to effective communication and decision making. Studies that considered dispositional determinants found weak or no relationships with trust and suggested that dispositional determinants may form a baseline for trust (Lima et al., 2019; Song et al., 2019).

We expect that an increase in any of the four determinants would be related to higher trust in citizen's water utility. However, consistent with prior research, we believed that dispositional determinants provide a baseline evaluation and have a positive relationship with trust. In a low-salience context where trust may be "taken for granted" and interactions that inform affinitive determinants are limited, ***we anticipated that procedural and rational determinants will be more strongly related to an individual's overall trust in their water utility than affinitive or dispositional determinants.***

Knowledge and technology adoption

Although our research focuses on technology adoption, it differs markedly from previous studies. Theories like the technology acceptance model focus on factors that are directly related to an individual's adoption (Davis et al. 1989), such as perceived usefulness and perceived ease of use, which are both related to trust (Pavlou 2003). Trust also has been found to account for variance in attitudes and intention to use technology (Gefen et al., 2003; Egea & González, 2011). Our focus differs in two ways from this body of literature. First, we examine an individual's trust in an institution that is adopting new technology. Second, we focus on trust as an outcome of adoption rather than as an input. For these reasons, we look at the link between knowledge of a water utility's efforts to improve their capacity to provide safe drinking water to the public and trust in the water utility to do so.

Knowledge of institutions has been linked to trust in those institutions. Trust judgments change as a trustor gains more experience with a trustee (Mayer et al., 1995). Scholars have used this as a rationale to posit that increased knowledge of a trustee will impact trust and reliance on certain trust determinants. In the medical field, researchers have linked knowledge provision with elements of affinitive and procedural determinants, proposing that providing more information to patients about payment structure increases trust in insurers by demonstrating transparency and an honest value system (Hall et al., 2002). In Scherer et al.'s (2016) study on people's support for a hepatitis vaccine, the authors provided survey respondents with three information conditions: one that provided basic CDC vaccine information, another that added a summary of scientific findings to the CDC information, and a third that added thorough scientific documentation of the vaccine to CDC findings. They found that in their first two conditions, the respondent's perceptions of trust in the vaccine increased, indicating that trust can be positively impacted by the provision of simple and scientifically-based information. Siegrist & Cvetkovich (2000) found that when individuals are informed about natural resource hazards, they rely on rational judgments to determine situational risk while uninformed individuals rely more on affinitive trust.

Based on the link between technology perceptions and trust, and our expectations about the low salience of our system, we expected that increased knowledge of new technology designed to help managers maintain water safety would be related to higher trust levels, especially if that knowledge focused on the usefulness of the new technology to protect water security. This aligns with our expectations about the importance of rational determinants for trust in low-salience conditions because knowledge about new technology gives individuals more information and transparency about their water utilities actions and capabilities.

In sum, our framework explores how trust in an institution is related to that institution's efforts to increase its capacity to provide consistently safe drinking water in the face of changing environmental conditions. Although trust has been widely explored in a natural resource context, previous research has not examined salience's role in contextualizing that trust. We propose that salience of an issue is a key scope condition that specifies the parameters under which determinants should influence trust (Foschi 1997). Specifically, water systems are often characterized as a low-salience issue, which reduces the degree to which individuals are motivated to reflect on all forms of information about the trustee before making a judgment. In this case, we expect the trustor to focus on evidence-based information and the system in place to protect the trustor rather than on emotional and value-based connections or their disposition.

MATERIALS AND METHODS

Study area

The greater Roanoke area, in western Virginia, includes the city of Roanoke and three surrounding counties: Franklin, Botetourt, and Roanoke. It is home to roughly 283,000 individuals and characterized by urban and suburban neighborhoods (U.S. Census Bureau, 2017b). The greater Roanoke area is populated by mostly white (81%) residents with a median income between $41,483 within the city of Roanoke to $64,733 within Botetourt County. The majority (89%) of residents have a high school education or higher (U.S. Census Bureau, 2017c).

Save for one adjacent city that supplies its water to residents, all municipal water for the area comes from a single water utility. Since its inception in 2004, this utility has not experienced water safety problems severe enough to necessitate warning residents about water quality. Of the 130,000 households in the greater Roanoke area, approximately 48% receive drinking water from the utility. The utility's main water sources include two surface water reservoirs and one underground spring.

Sampling & Data collection

Because our study was centered on threats to lakes and reservoirs that are sources for drinking water, we limited our population to residents whose households received tap water from the water utility's two surface water reservoirs. We formed our sampling frame using publicly available data. We cross-referenced entries with the water utility to ensure the sampling frame included only households who received water from the target reservoirs. We randomly selected 800 residents from this list to form our sample and collected data through a survey. Eight people were removed due to invalid addresses, leaving a final sample of 792. A response rate of 40% (n = 385) would provide ±5% sampling error for 95% confidence intervals (Dillman et al., 2014).

We employed a four-stage drop-off pick-up method based on Trentelman et al. (2016) for our survey distribution. We selected the drop-off pick-up approach because we anticipated that the lack of major water quality issues in the region over the past two decades would result in low salience of the topic and suppress participation in a mail survey. Drop-off pick-up methods emphasize social exchange and typically yield a 60-70% response rate, which is substantially higher than mail or phone survey modes (Jackson-Smith et al., 2016; Steele et al., 2001; Trentelman et al., 2016).

We began the data collection effort by sending letters to each resident in our sample one-week before the first in-person visit. This letter informed them of the study and our upcoming visit. Each house then received up to three in-person visits: the first to invite the resident to participate and drop off the survey, and, if the resident agreed, up to two follow-up visits as needed to retrieve it. Each member of the research team followed a script adapted from Dillman et al. (2014) and Trentelman et al. (2016) to enhance the uniformity of our interactions with residents. We visited addresses two days apart to give the resident enough time to complete the survey. If the resident had not completed the survey by the research team's third and final visit, we provided that resident with a postage-paid envelope allowing them to mail back the survey at their convenience. If a resident was not home when researchers visited, researchers made up to two additional attempts per visit to make contact on a different date and time. Each time we failed to contact a resident in these attempts to retrieve a questionnaire, researchers left a note on the participant's door saying, "Sorry we missed you, we will be back on [insert date]." If despite these efforts, we were not able to contact a resident to pick up their survey, we left a note on their doorstep explaining our retrieval attempts and provided a packet with a spare survey, cover letter, and a postage-paid envelope for the resident to return the survey in at their convenience. If we were unable to contact a resident for the initial visit after three attempts, we left a similar packet by their door with a longer note containing introductory details about the project and an invitation to participate.

We scheduled visits between 4 pm and 8 pm on weekdays and between 10 am and 4 pm on weekends to maximize the likelihood that residents would be home. We began collecting data in September 2019 and suspended collection in November due to daylight savings time and safety concerns about working after dark. We intended to complete data collection in March 2020, however, our ability to continue data collection was precluded by the COVID-19 pandemic. This reduced our sample of 792 to 611. While the sample selection was random, we distributed our survey based on geographic convenience, so 181 addresses we did not get to survey were all clustered to the northeast of Roanoke city. We caution against the generalization of results to all residents on municipal water in the greater Roanoke area due to systematic differences in socio-economic status across neighborhoods.

We performed a nonresponse bias check to examine the degree to which our sample represented the population (See Supporting information Table S1). Because race has been associated with water quality issues (Doria, 2010; Fragkou 2016), we conducted a test on the equality of proportions comparing the proportion of respondents in each race category in our sample to 2017 data from the U.S. Bureau of Census (2017a).

Measurement

The survey instrument focused on resident's trust in their water utility to supply safe drinking water to their homes, the salience of in-home water quality, beliefs about and use of tap water in the home, and demographic information. To test for the effects of information provision, each survey had one of three vignettes with different types of information embedded in the middle of the question items. Because we were concerned about a lack of variation in responses due to low salience, namely high levels of trust, we conducted considerable pretesting of our dependent variable measure, trust, using a pilot study (n = 20) in Roanoke and online samples from popular crowdsourcing market Amazon Turk (Chandler & Shapiro, 2016). We pretested the entire instrument (n = 60) on students at Virginia Tech before implementing the survey.

Salience

Our indicators of salience were adapted from Stewart's (2009) framework for weather forecasting systems and focused on attention to the issue, impact on daily activities, emotional impact, and familiarity with one's tap water system. We measured attention using four questions asking how often respondents noticed changes in their water in general and in terms of taste, smell, appearance, and in general (1 = *Never* to 5 = *Extremely often*). We asked residents to respond to two questions about their knowledge about water quality and its delivery. The first question asked respondents to indicate the amount of information they could provide to a friend or family about their neighborhood's water quality (1= *No information* to 5 = *A great deal of information*). The second question asked residents how familiar they were with what their water utility did to provide tap water to their homes. (1= *Not familiar* to 5 = *Extremely familiar*).

Trust

We focused on two factors that could influence one's trust in their water utility: the provision of information about technology that maintains water security, and social-psychological determinants of trust (Stern & Coleman 2015).

For both factors, the dependent variable of interest was trust, which was comprised of two items based on Mayer et al.'s (1995) and Stern and Coleman's (2015) conceptualizations of trust as a willingness to accept vulnerability. We considered the resident the trustor, the water utility as the trustee, and delivery safe drinking water the trusting behavior.

We first asked residents the extent to which they "trusted [their] local water utility to provide drinking water to [their] home that is safe to drink." Second, we assessed the mechanism of vulnerability by which trust occurs by asking the extent to which they were "comfortable with [their] local water utility controlling the quality of water delivered to [their] home." We assessed both using 9-points scales from 1 = *Do not trust at all* to 9 = *Completely trust* and 1 = *Not comfortable at all* to 9 = *Completely comfortable*, respectively. We avoided a *strongly disagree* to *strongly agree* scale because disagreement on the scale could reflect a lack of trust to some and distrust for others. Distrust is a separate concept and not the focus of our study (Stern & Coleman, 2015).

Trust and information provision about technology adoption

To address the question of how new technology could relate to social trust, we adopted an experimental design with three groups each receiving a different type of information about the efforts of their water utility to provide safe drinking water to them (Table 1). The first group received no information and served as a control. We provided the information-only group with generic information about their utility's water delivery system. This generic information treatment controls for the fact that simply receiving any information can lead to an effect. It allowed us to isolate the potential effect of the technology-specific treatment group who received information about new forecasting technology that would allow their utility to better predict and adapt to changes in the water quality of the reservoirs.

The information-only and technology-specific treatments were embedded as the final paragraphs in a larger vignette that provided information on the name of their water utility and a brief description of the issue of reservoirs, algal blooms, and potential impacts on drinking water. After reading the description, respondents in both treatments were asked if they had heard of the information provided. This served as an attention check. Respondents in the control condition did not receive information or attention check questions.

Table 1. Information treatments used to assess the role of new water treatment technology on trust. Treatments are presented with the exact formatting used in the survey. We used bold and italic formatting to highlight key phrases we wanted our readers to retain.

Condition	Information provided
Control	No information provided
Information-only	Your water utility is using five surface reservoirs and one spring to ***store water*** until it is ready to be treated. This system uses pipes to ***distribute*** water to customers' homes. This is intended to allow the water utility to maintain and distribute water throughout their operation. The goal of this system is to help managers ***deliver*** safe drinking water to your home.
Technology-specific	Your water utility is using ***newly developed technology*** to help them predict changes in reservoir water. This system uses water quality sensors and ***computer forecasting*** to alert the water utility when conditions will change in the future. This is intended to allow the water utility to cope with changes early on by adding additional treatments, or by obtaining water from other reservoirs. The goal of this technology is to help managers detect and respond to changes in reservoirs ***more quickly*** and deliver safe drinking water to your home.

Trust Determinants

We used concepts from the trust ecology framework to develop question items for trust determinants (Stern & Coleman 2015; Stern & Baird 2015). We operationalize rational determinants as a function of an individual's calculated belief that their water utility has delivered and remains capable of delivering safe drinking water to their home. Affinitive determinants are a function of an individual's feelings of connection, goodwill, and value alignment with their utility. Dispositional determinants are based on general tendencies to be trusting and procedural determinants are based on an individual's belief that their water utility is regulated by larger governmental systems that ensure the delivery of safe water. Respondents rated their level of agreement for four rational determinant indicators, four affinitive determinant indicators, four procedural determinant indicators, and one dispositional determinant indicator. Rational, affinitive, and dispositional items were all measured on a 7-point Likert-type scale from 1 = *Strongly disagree* to 7 = *Strongly agree*. Because the procedural determinants statements were designed to examine respondents' belief in the existence of systems that prevent their utility from delivering unsafe water, we used a 5-point scale from 1 = *Definitely not true* to 5 = *Definitely* *true* for procedural items. Our one dispositional determinant indicator asked respondents to indicate the degree to which they "generally trust others", which is a validated indicator of generalized trust (Yamagishi et al., 1994, 2015).

Data Analysis

Salience

We used Cronbach's alpha and exploratory factor analysis to assess the dimensionality of attention (4 items) and combined them into a single index (Cronbach's alpha = 0.87). We examined means and distributions to assess the degree of salience for tap water.

Indicators of trust

We compared the two indicators that assessed overall trust in and vulnerability to the water utility to determine the degree to which the trust item and the vulnerability item captured trust as conceptualized by Stern & Coleman (2015). We compared distributions visually by examining histograms and quantile-quantile plots, and statistically by testing standard deviations. We also assessed the central tendency using a t-test to examine differences between the means. We used Pearson's correlation to examine the strength of the two items' relationship with each other to determine if they could be combined.

Trust and technology

To understand if the residents' overall trust varied based on their knowledge of new technology, we performed a one-way ANOVA to test differences in means using overall trust as our dependent variable and treatment as our grouping variable.

Trust, determinants of trust & salience

We used exploratory factor analysis to assess the dimensionality of the four determinants: rational, affinitive, procedural, and dispositional. We used Cronbach's alpha to assess internal consistency. We examine the linearity of the relationship between each determinant and overall trust using locally weighted regression and smoothing lines over scatterplots (See Supporting information Fig S1). Because the rational and affinitive determinants exhibited non-linear relationships, we selected the best-fitting model using Akaike's information criterion (AIC) to identify the appropriate polynomial terms to include (Anderson et al. 2000).

We employed two ordinary least squares regression models to examine the relationship between overall trust, trust determinants, and salience. Our first model examined the relationship between overall trust and rational, affinitive, procedural, and dispositional determinants. Our second model explored the potential moderating role of salience on overall trust. Given the variation in salience in our sample, we explored how increases in salience relate to overall trust.

We conducted a commonality analysis of both models to better understand variance attribution for each of our concepts (Nimon 2008; Sorice 2011). This uses semi-partial correlations to partition the explained variance of overall trust for each variable into its unique contribution and its shared contribution (i.e., common to all possible combinations of variables).

RESULTS

We contacted 538 residents out of the 611 addresses attempted between September and November 2019 for a 75% contact rate. Of those, 114 declined to participate, 57 failed to complete their survey after agreeing to do so, and 7 were deemed ineligible due to language barriers or illness. A total of 352 residents returned completed surveys for an 89% cooperation rate and a 59% response rate (AAPOR 2016). According to a test of proportions, the race and gender demographics we measured in our sample did not differ significantly from the population's 2017 census measured demographics (U.S. Census Bureau, 2017) (See Supporting information Table S1).

Salience

As expected, drinking water quality was not a salient issue (H1). The means and medians for our three indicators indicated low levels of knowledge and attention (Table 2). Most respondents (83%) reported that they *never* or *rarely* noticed changes in their water. Further, most (65%) were *not* or only *slightly* familiar with what their water utility did to provide tap water to their home, and only 7% *very* or *extremely* familiar. Knowledge about the general water quality in their neighborhood was also low with 60% indicating that they could provide no information or a little information and only 10% indicating they could provide *a lot* or *a great deal* of information.

Table 2: Salience descriptive statistics

Salience item variable	Obs.	Mean	Median	St. Dev.	Minimum	Maximum
Attention	348	1.68	1	0.74	1= Never	4 = Often
Familiarity	341	2.07	1	1.01	1 = Not Familiar	5 = Ext. Familiar
Information Known	343	2.35	2	0.98	1 = No Information	5 = A Great Deal

Trust

Although trust had a slightly higher mean than vulnerability, statistically the two indicators were not different from each other (t (344) =1.87, p = 0.06). In addition to a 0.92 correlation between the two items, a quantile-quantile plot (Figure 2a) and a comparison of distributions (Figure 2b) indicated that the distribution for trust and vulnerability are similar in spread and shape. Both variables have the same median (md = 8). Based on this, we combined trust and vulnerability into a single item we labeled "overall trust," using the mean score for each respondent. Overall trust in the water utility to deliver safe drinking water was generally high (Mean = 6.3, SD = 1.9, md = 7). We used this overall trust measure as this as our dependent variable throughout the analysis.

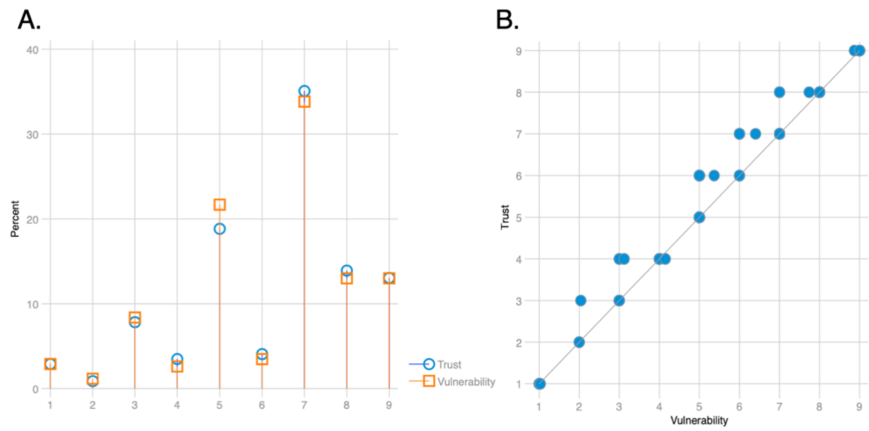

Figure 2 Visual inspection of trust and vulnerability indicators using a histogram (A) and a q-q plot (B) suggest a similar distribution across indicators.

Trust and technology adoption

The returned surveys were fairly evenly distributed between our conditions: 29% in the control condition (n=104), 33% in the general-information condition (n=118), and 36% in the technology-information condition (n=128). The medians and distributions for the overall trust variable were similar across the three treatment conditions (Figure 3). Overall trust means did not vary with the information given information ($F_{(2, 343)} = 0.21$, $p = 0.81$). This finding held for the non-parametric Kruskal-Wallis test that accounts for the non-normal distributions of overall trust ($H_{(2)} = 0.42$, $p = 0.81$). In sum, overall trust in the water utility was not related to the provision of information about efforts to improve water security.

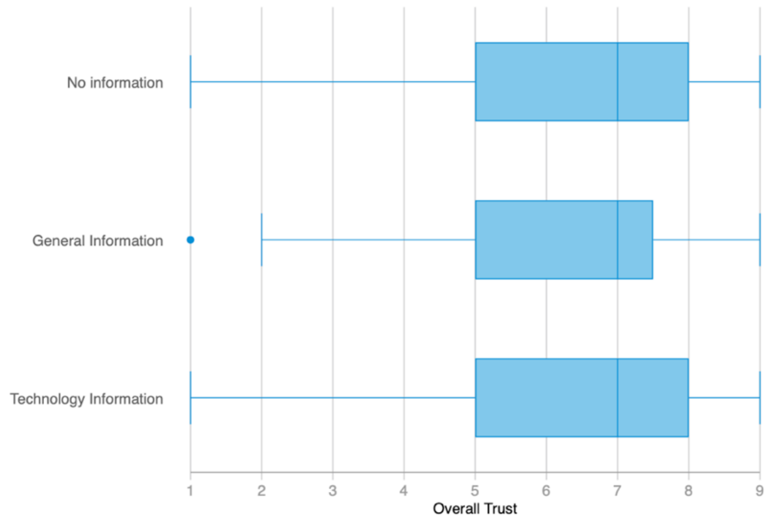

Figure 3: Distribution of responses across treatments suggest similar levels of trust across conditions. Boxes indicate 25% and 75% percentile confidence intervals, middle lines in the boxes indicate medians, and bracket lines indicate range.

Determinants of trust

Given that overall trust did not differ across treatments, conducted a regression to understand additional factors of trust determinants and salience that could explain trust's variance. We included the knowledge treatments in our models to statistically control for potential variation related to respondents reading different vignettes. Based on correlations and exploratory factor analysis, the four items we used to measure rational, affinitive, and procedural determinants and salience attention could all be combined to form one indicator per concept. The AIC model selection procedure indicated that third-degree polynomial for the rational determinant and a second-degree polynomial for the affinitive determinant provided the best fit to the data. All four trust determinants were significantly related overall trust level ($F_{(9, 318)} = 23.70$, $p < 0.01$, $R^2 = 0.40$, $R^2_{adjusted} = 0.38$; Figure 4).

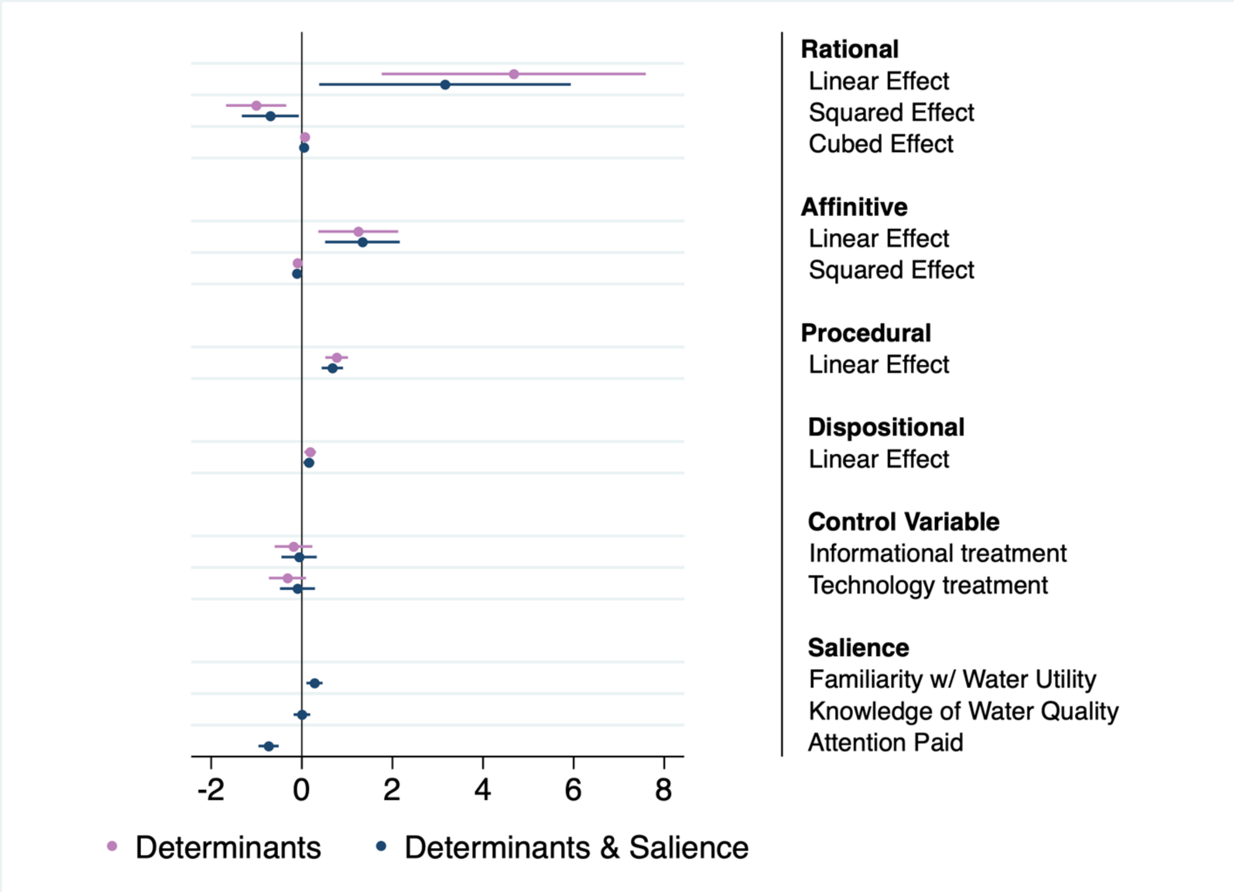

Figure 4: Coefficient plot for regression model of trust determinants only (pink) and a regression model that includes salience (blue). Dots indicate coefficient values and emergent lines indicate 95% confidence intervals. Lines that cross the zero-coefficient line are representative of non-significant variables.

The fitted regression line of the rational determinant reflects a sharp increase in trust as evidence-based beliefs about the water utility delivering safe drinking water change from *strongly disagree* to *slightly disagree* (Figure 5A). As the rational determinant increases from *neutral* to *strongly agree*, the expected level of overall trust decreases slightly (about 0.5 of a trust level). The affinitive determinant is also nonlinear; as emotion-based beliefs about value similarity and utilities goodwill increases from *strongly disagree* to *slightly or moderately agree,* the expected level of overall trust increases gradually before leveling off (Figure 5B). As the belief that a system exists to protect the resident (procedural determinants) increases by one level, expected overall trust increases by 0.77 (Figure 5C). Finally, personal disposition was also positively related to overall trust; for every one-level increase in trusting disposition, overall trust increased by 0.18 (Figure 5D).

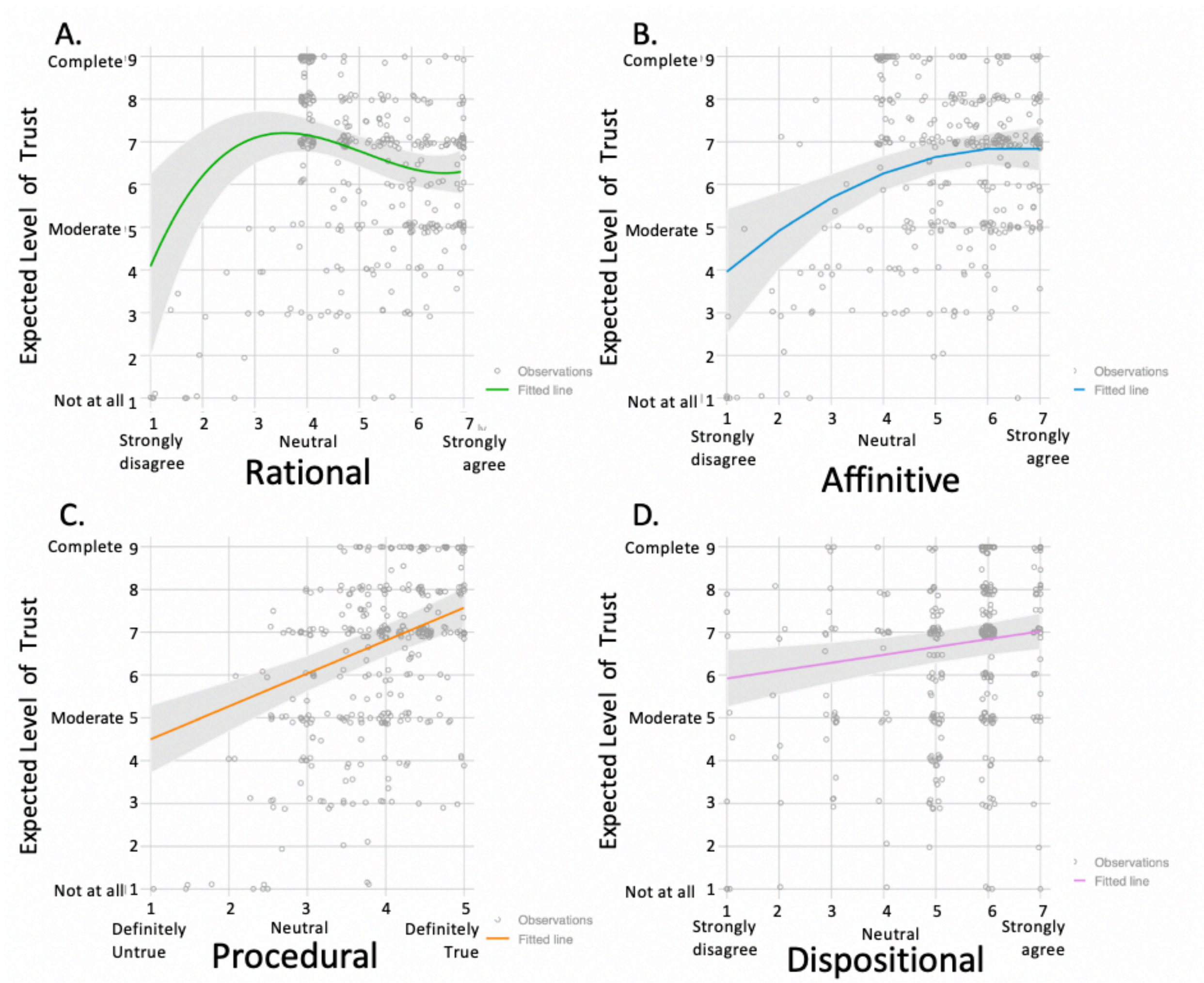

Figure 5: Relationship between rational (A), affinitive (B), procedural (C), and dispositional (D) determinants of trust and expected overall trust holding other determinants constant at their averages. Because the data are ordinal-treated-as-interval and overlapping data would be hard to visualize, random noise was added to the scatterplot to perturb the location of markers and provide greater information about the number of observations at each point. Hollow dots represent data points and the surrounding gray area represents confidence intervals.

The commonality analysis indicates that, although determinants individually contribute to explaining variance, over half (59%) of the total variance explained by the model is shared by multiple determinants (Table 3). Individually, the procedural determinants contributed the most to explaining variation in overall trust (7%), more than twice as much as the rational and affinitive determinants.

Table 3: Commonality analysis showing the unique variance explained by the determinants of trust

Determinant	R^2 Contribution
Unique to Rational	0.02
Unique to Rational Squared	0.01
Unique to Rational Cubed	0.01
Common to Rational, Rational Squared, and Rational Cubed	-0.01
Unique to Affinitive	0.01
Unique to Affinitive Squared	0.01
Common to Affinitive and Affinitive Squared	0.01
Unique to Procedural	0.07
Unique to Dispositional	0.01
All other Common Variance	0.24

Trust determinants controlling for salience

When we added indicators of salience to the trust determinant model, the fit improved (ΔAIC = -42.98) and the R^2 increased significantly from 0.40 to 0.48 ($\Delta R^2 = +0.08$, $F(3, 315) = 16.91$ $p < 0.01$) All trust determinants remained statistically significant, although the coefficients for rational, procedural, and dispositional determinants were somewhat dampened (Figure 4). Familiarity with the water utility was positively related to trust ($b = 0.28$, $t = 3.06$, $p < 0.01$) while attention paid to changes in water quality was negatively related to trust ($b = -0.73$, $t = -6.46$ $p < 0.01$). The ability to inform others about one's water quality was not related to overall trust (*b* = -0.00, *t* = 0.02 *p* = 0.98). In sum, the more familiar residents are with what their water utility does to provide tap water to their home, the higher the trust; however, paying attention to water quality and noticing unacceptable changes in it decreases trust (Figure 4).

In the commonality analysis for the model that included both trust determinants and salience, common variance accounts for 66% of the total variance explained (Table 4). The affinitive and dispositional determinants remain relatively unchanged from the model examining trust determinants alone, but the inclusion of salience dampened the extent to which rational and procedural determinants contributed to explaining overall trust. The level of attention residents pay to changes in water quality uniquely accounts for 7% of the variance described in the model, making it the strongest unique contributor. Salience factors alone, or in combination with each other, contribute 0.08 of the variance explained by the model, indicating that the remaining variance can be attributed to trust determinants or the variance shared between trust determinants and salience.

Table 4: Commonality analysis showing the unique variance explained by the determinants of trust and salience.

Determinant	R^2 Contribution
Unique to Rational	0.01
Unique to Rational Squared	-0.01
Unique to Rational Cubed	0.01
Common to Rational, Rational Squared, and Rational Cubed	-0.02
Unique to Affinitive	0.02
Unique to Affinitive Squared	0.01
Common to Affinitive and Affinitive Squared	0.00
Unique to Procedural	0.05
Unique to Dispositional	0.01
Unique to Familiarity	0.01
Unique to Information	0.00

Unique to Attention	0.07
Common to Familiarity, Information, and Attention	0.00
All other Common Variance	0.32

DISCUSSION

Water utilities are tasked with the critical job of safeguarding the production of drinking water. People tend to pay little attention to and lack knowledge about water systems, especially for those that have consistently provided acceptable tap water that meets safety standards (Attari et al., 2017; Quisto et al., 2017). The nature of trust in these low salience conditions has not been explored. Our primary objective in this study was to characterize trust in drinking water systems by examining how information about new technology designed to improve a utility's capability to produce safe drinking water was related to trust, and by exploring how judgments of the water utility itself related to trust. We found support for the hypothesis that the salience of water issues moderates the relationships between judgments of the water utility and trust in it to provide safe drinking water. However, providing information about the new technology used to improve water security did not increase trust.

Our findings matched our expectations that people would largely have low salience about their drinking water and high trust in the water utility: the majority of our sample *moderately* to *mostly* trust their utility to deliver safe drinking water to their homes. High trust under low salience could be explained by the concept of cognitive frames, a memory tool that helps people mentally organize information about their world (Lewicki & Brinsfield, 2011). Lewicki & Brinsfield (2011) proposed that judgments of trust could be deliberative at first, but then become a cognitive frame a trustor uses for future interactions with a trustee. That frame will stay stable until a new experience forces a trustor to reconsider their initial deliberation. This idea is similar to Mollering's (2008) theory that in stable, low salience contexts, trust can be "taken for granted," where individuals continue to trust with little question. This reflects a decrease in attention to an issue as expectations for consistent outcomes of the relationship increase based on acceptable performance. Thus, trust ecology may take different forms over time as salience changes, and efforts to inform users about enhanced water security may be effective at some points but not others. Future research could investigate this mechanism more directly through longitudinal studies.

Information provision

Information provision about efforts in place to ensure or enhance continued delivery of important goods and services is an alluring mechanism to enhance trust in the public, particularly in 'knowledge deficit' situations where individuals have little to no starting knowledge about said efforts. Indeed, research focusing on water utilities calls for better communication to increase trust (Vedachalam & Kirchoff, 2020; Weisner et al., 2020). Information provision in general has been effective in the past at increasing trust. For example, in a national survey about trust and acceptance of vaccines, Scherer et al. (2016) found that when they provided participants with simple and scientifically-based information on the vaccine, their perceptions of trust in the vaccine increased.

Our finding of no relationship between information and trust conflict with Scherer et al.'s (2016) results. We offered two explanations for the lack of effect of the information treatments in our study could be explained by two potential reasons. Our information provision might have had a greater impact if consumers were choosing the technology themselves. In an evaluation of over one hundred studies that used the technology acceptance, most of them commonly related to a consumer's direct acceptance of a certain technology out of an array of choices, such as choice of email engine or internet provider (Lee et al., 2003). In one example, Achterberg (2014) found that providing information about new hydrogen-based fuel technology and sustainability increased the support survey respondents reported for that technology. In this instance, respondents were asked about their attitudes about a new technology directly. In contrast, our study involved trust in a third party based on their acceptance of technology; the respondent was not choosing the technology themselves. Our information might also have had a greater effect if it addressed an existing concern that users had with their water. Van Vugt (2009) identified information as one of the four essential components to crafting successful environmental interventions; however, simple information is most effective when people are already aware of a behavior or an issue and are contemplating changing it. In systems characterized by high trust and low salience, information provision alone is not sufficient to alter judgments.

Ours is not the first study to investigate the effectiveness of information provision at changing attitudes, and while information provision has been effective in some circumstances, ours is also not the first to demonstrate a negligible effect. For example, Frewer (2003) found that providing people with information about genetically modified food did not alter their attitudes about that food. In another instance, Cox & Lease (2007) investigated negative consumer attitudes toward the adoption of new technology by prawn farmers that favored more environmentally friendly prawn farming strategies. Similar to our finding that increasing information about novel technologies did not alter trust levels, Cox & Lease (2007) found that providing information about prawn farming technology to consumers did not change existing negative attitudes about prawn farmers using novel technologies for their food. Looking at previous studies, information provision alone is rarely effective. Based on the mixed effectiveness of information provision efforts, the conditions in which information provision is applied could enable it to be more or less effective at shifting attitudes.

Information provision may be helpful for certain levels of salience or pre-existing trust. For instance, in Achterberg's (2014) study, the authors found that the levels of support that people with already-high trust had in hydrogen technology could be increased by the provision of positive information about the technology and reduced by negative information; however, the support levels of those with already-low trust levels did not change. Notably, Achterberg (2014) tested their respondents' knowledge of hydrogen technology before their information intervention and found that over half of the respondents correctly answered questions, indicating a moderate level of salience. In another instance, Diamond et al. (2020) found that when people received scientific information about climate change and genetically modified food, their beliefs shifted to be more in line with the scientific consensus, particularly if that information conflicted with their prior beliefs. They further found that in one of their two sample countries, the level of trust moderated this information provision effect. Salience may be one condition that could help explain variation in the information-trust relationship. When there is high salience of an issue and high trust, as indicated in Achterberg (2014), information can have an effect. On the other hand, in our study with low salience and high trust, information provision had no effect. We propose that the concept of salience could moderate the information-trust relationship and may be useful in future research to understand the conditions under which information influences trust judgments.

Trust ecology

Beyond examining information provision's relationship with trust, we also sought to understand the relationship between trust and the four classes of determinants characterized by Stern & Baird's (2015) trust ecology framework. We expected that procedural and rational determinants would be stronger contributors to overall trust than affinitive or dispositional determinants. In particular, we expected the affinitive determinant to have little to no effect because: 1) positive affinitive judgments can be costly to the trustee because they require time and energy to create (Song 2019); and, 2) The extent of interactions between a water utility and their customers are typically transactional (e.g., fix an issue) and procedural (e.g., paying a bill). This, combined with the low salience we saw in our population, led us to expect that our sample would rely more heavily on evidence-based and system-level judgments, which rely on calculations and information about utilities that are readily available to respondents.

Supporting our predictions, the procedural determinant exhibited the strongest unique contribution to overall trust variance, almost doubling the contribution of the next nearest variable. Counter to our expectations, the affinitive determinant contributed equally to trust as the rational determinant (see Table 2). Previous research has highlighted how important perceptions of shared values, goodwill, and emotional connections are to building effective relationships and overall trust. For example, Perry et al. (2017) determined that trust in marine reserves increased as people felt they shared values with the institution administering the reserves. However, in this case, trustors had information and experiences with trustees to form affinitive judgments. Stern & Coleman (2015) describe how affinitive judgments can be formed based on cognitive evaluation or subconscious judgments of a trustee's character. The latter can be an indicator of reliance on an affect heuristic, or automatic feeling-based associations with a topic (Slovic et al., 2007). Our findings suggest even when information to reinforce emotional or value-based connections may be largely absent, affinitive determinants still have a strong relationship with overall trust, perhaps because of the use of an affect-based heuristic. These findings highlight the importance of efforts of water utilities to demonstrate care and goodwill toward customers.

Procedural determinants may be an important component of trust in low salience situations. Unlike rational and affinitive determinants, procedural determinants are not dependent on evaluations of the trustee *per se* (Stern & Coleman, 2015). When there is little contact or communication between a trustor and trustee, as seen with water systems, information about utilities needed to form rational and affinitive judgments are limited. However, in these same situations, the information needed about broader systems that trustors rely on to form procedural judgments is not necessarily limited. In place of judging an institution, trust may be enhanced by considering the safeguards in place to protect the trustee and broader governmental regulations.

In addition to sharing a similar unique variance contribution as rational determinants, both affinitive and rational determinants had nonlinear relationships with overall trust. Specifically, rational determinants plateau around a neutral level of agreement, with a slight oscillating between moderate to strong levels of agreement. Affinitive trust has a more sustained positive relationship with trust, plateauing at a slight to moderate level of agreement. These patterns are reminiscent of satisficing theory, which posits that decisions can be made that either maximize optimum outcomes or satisfy a threshold of criteria (Simon, 1956). Satisficing effects (e.g. Caplin et al., 2011; Schwartz et al., 2002) could extend to trust judgments, specifically related to rational and affinitive determinants. This suggests that gains in trust, while strongly positive at lower levels of determinant values, can be limited once individuals believe the utility performs up to a certain standard that encapsulates their interests. Based on the point of the plateau for rational and affinitive determinants, building calculated perceptions of capability may only increase overall trust when those beliefs are below a moderate threshold while building relationships, shared value perceptions, and increasing perceptions of security with regulations and procedures could increase overall trust at higher levels of affinitive and procedural beliefs.

The nonlinear relationships may indicate that the concept of distrust may be relevant to this issue. Our scale focused on a range of trust from a complete lack of trust to complete trust. While a lack of trust may capture distrust, it also captures situations where insufficient information is available for an individual to form a trust assessment. Distrust is specific to judgments where a trustor believes a trustee will negatively affect them (Stern & Coleman, 2015). In such cases, a trustor rejects vulnerability rather than accepting it (Möllering, 2008). Thus, another avenue of research on trust in low salience contexts could consider the role of distrust as well as the role of lack of trust in understanding trust as a concept.

Conclusion:

Our primary objective in this study was to explore the context in which trust occurs in drinking water systems and examine if that trust could be increased. Overall, our information provision was not related to trust levels. One factor that could have contributed to this is the low salience of water systems to our respondents. Our research highlighted that salience is a key variable that characterizes the system in which trust judgments form. Taking salience variables into account improved the ability to explain overall trust in the water utility. The importance of salience is not addressed in most prior research because studies of trust tend to focus on salient issues, such as the impacts of protected area tourism on communities (e.g., Stern 2008), outreach evaluations for conservation program participants (Lutter et al., 2018), or coastal residents' attitudes towards management agencies when they were directly impacted by the agencies marine reserves (Perry et al., 2017). Our findings suggest that incorporating salience as an explicit scope condition in future research can enhance theory and understanding of the factors that influence trust judgments.

Our examination of trust ecology revealed that, while trust determinants are inextricably interwoven with overall trust, their differences are also important to understanding the context of trust's formation. Sixty percent of the common variance in our model was shared between trust determinants, demonstrating the power these determinants have when considered together. It is this nature of trust determinants that caused some prior researchers to consider trust a uni-dimensional concept (e.g. Smith et al., 2013). Despite this, some trust determinants were better at explaining of trust than others, supporting Stern & Baird's (2015) proposition that certain determinants will matter more than others under different conditions.

Our data collection efforts were limited by the restrictions presented by the COVID-19 pandemic. We employed a random sample selection, yet our in-person data collection was geographically based. Consequently, several neighborhoods remained unsampled when COVID-19 disrupted our data collection efforts. Given that demographic factors are often geographically autocorrelated, perceptions of trust and salience may have differed there. The omission of this data limits the degree to which we can generalize our sample to the population in the greater Roanoke area. We addressed this by focusing our efforts on the theoretical implications of our data rather than the generalizability of our sample to its population.

As global change threatens the security of water systems, resilience-based management is becoming an attractive strategy to preserve water systems and prevent delays. In a resilient system, managers would have adaptive strategies and technologies to handle disturbances to water sources. Community support for managers would enable them to act with less resistance and free residents from concern about their drinking water security. Trust is an important component for building this social resilience of a system. Trust may or may not come from a water utility's effort to communicate progress in enhancing water security and efforts to increase trust should not exclusively focus on providing information to the public. Concomitant investments in goodwill and value-based connections are valuable because they recognize the importance of affinitive connections and the high interconnectedness of trust determinants. Building more resilient water systems and related social trust in water institutions is an essential step to addressing the myriad of unpredictable and severe disturbances that threaten water resources. Understanding trust and the context in which trust is formed can help us build these necessary systems and better protect our resources.

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CHAPTER 2:

DON'T BOTTLE IT UP – HOW PERCEPTIONS OF TRUST, RISK, TAP WATER QUALITY, AND SALIENCE CHARACTERIZE DRINKING WATER CHOICES

ABSTRACT

As the impacts of global change and anthropogenic influences increase, managers' ability to ensure the security of drinking water is integral to community health. Relationships between water utilities and the communities they serve water can be influential to the success of management efforts. Community trust and risk perceptions are important to these relationships, but they also spill over into individual behavior like drinking water source choice.

To better understand how factors of trust, risk, salience, and tap water quality evaluations characterize patterns of drinking water behavior, I conducted a drop off-pick up survey of 600 residents within a watershed in Roanoke, Virginia. I found that examining patterns of water source frequency of use made for a more realistic depiction of drinking water behavior than categorizing people as bottled water or tap water drinkers. Despite that, I found that the majority of my sample drank from exclusively one water source, with 24% drinking only bottled water, 22% drinking exclusively from an appliance filter, and 18% drinking tap water. Tap water drinkers had the most perceptual differences from bottled people who drank exclusively from an appliance filter. Perceptions of trust, risk, tap water evaluations, and, to some extent, salience differed between the drinking water groups. I found that it was less important to behavioral

outcomes if a respondent believes their water is safe and more important if they believe it is safer than bottled water sources. Overall, my findings suggest that managers can gauge the relationships between themselves and their community in terms of trust, risk, and water quality evaluations by looking at that community's drinking water behaviors. Similarly, managers looking to increase tap water consumption as opposed to alternate sources will have the most impact by focusing on citizen's perceptions of trust, comparative safety, and quality of tap water.

INTRODUCTION

Relationships between community members and their water managers are an integral component to the success of water utilities efforts as well as community wellbeing. Communities with supportive relationships with their managers might offer less resistance to managers' actions, thus enabling managers to expedite their reaction to disturbances (Bondelind et al., 2019). Public trust in water managers is one critical factor often studied in relation to water issues, both in terms of management support and personal behavior. Trust can encourage citizens' cooperation with managers and support for management plans, increasing the speed and effectiveness of those plans enaction and reducing backlash to management shifts (Davenport et al., 2007; Lachapelle and McCool 2012; Song et al., 2019). For instance, Ross et al. (2014) examined public trust in citizens the week before they were to vote on a contentious water recycling plan and found that citizens with higher trust in their water managers were more accepting of the proposed plan.

Trust's effects spill over into personal behaviors like acceptance or rejection of tap water as a drinking source (Doria, 2010). There are several alternatives to tap water that a person could choose to drink from in their home. Utilities filter water as a part of their treatment process, but some individuals choose to apply additional household filters to their water from a sink attachment, refrigerator, or pitcher. An individual's drinking behavior can be characterized by the degree to which they drink directly from the tap, bottled, or home filtered water sources. Trust in water utilities has been cited as a significant factor in people's attitudes about tap water quality and acceptance of the tap water utilities provide (Doria, 2006, 2010).

Trust is not the only factor that has been linked to drinking water source behavior. Factors of risk, salience, and water quality evaluations (taste, smell, and appearance) have also been related to acceptance or rejection of drinking water sources. The degree of risk people perceive for their drinking water is a function of their beliefs in the possibility that they could lose access to safe water or suffer adverse health effects from drinking their water. Some studies identify risk as a key component in the decision to purchase bottled water as opposed to tap (Jakus et al., 2009; Saylor et al., 2011), while others found that people's perceived risk only had a slight impact on water source choice (Lavellois et al., 1999; Doria et al., 2005). Leveque & Burns (2017) surveyed resident's perceptions and drinking water behaviors in West Virginia and found that those who perceived higher risk associated with their tap water were more likely to drink bottled water compared to tap, but not home filtered water compared to tap. They further found that changes in organoleptic perceptions, or sensory perceptions of taste, smell, and appearance, of tap water affected resident's decision to drink from both bottled and household filtered sources. Less favorable organoleptic perceptions of tap water are commonly linked to the decision to drink from alternative water source choices (Doria, 2006). Taste in particular has been linked to decisions to drink from bottled water sources as opposed to tap (Kenat, 2017; Doria et al., 2005; Lavellois et al., 1999). Finally, in my previous chapter, I outlined the importance of salience, the degree to which or the degree to which a topic is easily brought to mindor has strong associations to a person (Gray et al., 2012; Higgins & Kruglanski, 1996). I found that the trust level varies based on the salience of the issue. Little prior research exists on the relationship between salience and an individual's choice of their drinking water source; however, elements of salience, such as familiarity with drinking water and information gained from friends, have been linked as both causes and results of trust and behavior (Doria et al., 2009).

The purpose of this study was to examine drinking water behavior and perceptions of trust, risk, salience, and water quality evaluations in a community in southwest Virginia to better understand the role these factors play in determining drinking water source choice. My study's conceptual framework of drinking water behavior integrates conceptualizations of risk from Saylor (2011) and Debbler et al. (2018), Stewart's (2009) weather salience framework, and Mayer et al.'s (1995) conceptualization of trust (Figure 6).

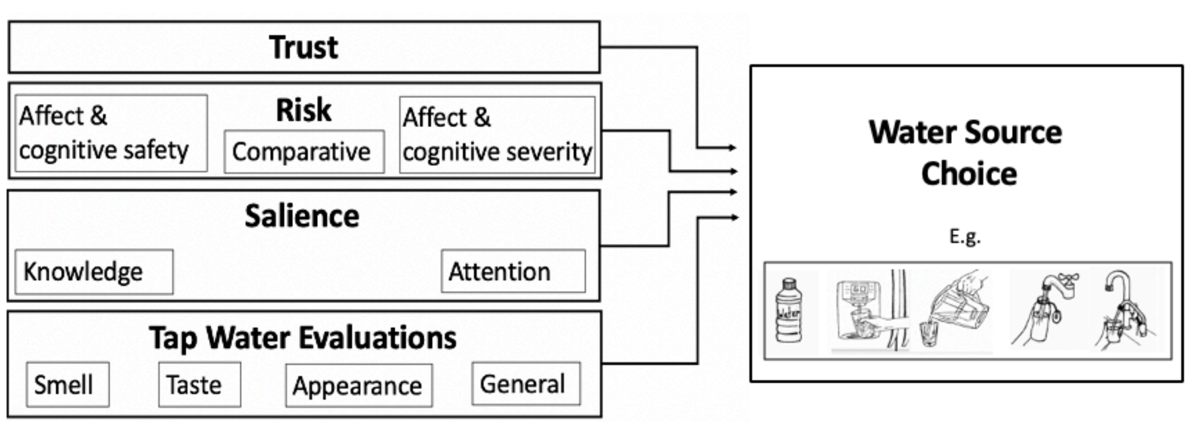


Figure 6: My conceptual framework posits that the water source(s) an individual chooses to drink from is a function of their trust in the utility to deliver safe drinking water to them, salience of their home water quality, risk judgments of water safety, alone and compared to bottled, emotional concern, and severity of consequence should their water become unsafe, and organoleptic judgments of their tap water quality

CONCEPTUAL FRAMEWORK

Trust:

Trust is conceptualized as the psychological state when one actor, the trustor, accepts vulnerability based on the expectation that another entity, the trustee, will perform a certain action or behavior (Mayer et al., 1995). Previous research into technology acceptance has linked trust in organizations with both attitudes and intentions to use that organization's technology (Pavlou 2003; Egea & González, 2011). For example, Gefen et al. (2003) found that the more trust students had in an online vendor, the stronger intentions they had to purchase from that vendor in the future. Applied to water systems, this would mean the intention to drink tap water from a given utility would be dependent on an individual's trust in that utility to deliver safe drinking water to them. Although residents cannot choose what utility supplies their tap water, they can choose which water source to drink.

Trust has been linked as an influential factor in individuals drinking water behavior (Doria, 2006). Saylor (2011) interviewed and surveyed students at Purdue University to determine the factors behind their decision to accept or reject tap water. The authors found that students who trusted their local water utility to deliver safe drinking water were more likely to drink from tap water sources while those who lacked trust in their government and university were more likely to drink bottled water. These results were supported by McSpirit and Reid (2011) who surveyed residents in West Virginia and found that increased trust related to residents' decisions to drink from tap water sources.

Risk Perceptions:

Alongside trust, risk perceptions have also been established as a driving factor of acceptance (Ross et al., 2014; Doria, 2006). Risk is conceptualized as a function of the perceived likelihood of an unwanted event occurring and the severity of consequence should that unwanted event occur (Cox, 2008). Risk perceptions are a frequent object of study in natural resource management, where institutions are charged with protecting the public from hazards like poor water quality (Poortinga & Pidgeon, 2005). In a study of university students, Saylor (2011) found that, in addition to trust, the perceived health risk associated with tap water were significant barriers to tap water drinking. Similarly, Hu et al. (2011) conducted a national survey about people's decisions to drink from a tap or bottled water source and found that people who had safety concerns with their tap water were more likely to reject it as a drinking source. Triplett et al. (2019) conducted a similar survey of households in Jackson, FL which included household filtered water as a drinking choice. The authors found that, as a resident's perceptions of safety, contamination, and sickness increased, they consumed more bottled water compared to tap, but not more household filtered water.

Risk has been conceptualized in drinking water studies most frequently as a cognitive indicator in surveys, asking how safe people believe their water is to drink (Bratanova et al., 2013; Doria, 2009). Debbler et al. (2018) added to this by including a measure of affect-based risk.

While cognitive risk measures assess probability beliefs, affect risk measures assess worry, concern, or other emotional components associated with an unwanted events' occurrence. By examining both cognitive and affect measures, researchers can get a more complete picture of risk perceptions. Additionally, Saylor (2011) found that when people's perceived risk of bottled water was lower than their perceived risk of tap, they were less likely to accept tap water, introducing the concept of comparative risk to the water risk framework. This is supported by earlier research. Here I conceptualize risk as a function of both cognitive and affective perceptions of water safety, cognitive and affective perceptions of severity should one's drinking water be compromised, and comparative risk of bottled and tap water.

Salience:

Both risk and trust perceptions are moderated by salience, or the degree to which drinking water topics are readily brought to mind or have strong associations for an individual (Gray et al., 2012; Higgins & Kruglanski, 1996). In Chapter 1, I studied the role of salience and other determinants in the formation of trust in water utilities to deliver safe drinking water to the public. I found that residents had low salience about drinking water quality issues and had a high baseline trust in the utility. I also demonstrated how trust varied based on salience: higher familiarity with what a utility did to treat water increased trust; but, higher attention to changes in water quality was associated with decreased trust. Anadu & Harding (2000) came to similar conclusions when looking at elements of salience and risk perceptions of drinking water. They surveyed four communities in Oregon with differing levels of water contamination and found that, in cases where a problem was present, increased awareness of that problem over longer durations was related to increased risk perceptions. Since salience plays an important role in the formation of attitudes like risk and trust, I expect that it may also be an important contextual factor for an individual's behavior.

This study adapts Stewart's (2009) salience framework for weather forecasting in its conceptualization of the salience of drinking water. Stewart's (2009) framework includes broad factors of weather's noticeability, emotional impact, event frequency, and an individual's weather-based knowledge. Unlike water quality which should only change if issues occur, weather conditions shift daily. I included items from Stewart's (2009) framework that adapted to drinking water including attention to changes in water quality and information known about water quality.

Organoleptic evaluations:

A final commonly cited factor of water use behavior are organoleptic factors of taste, smell, and appearance. Doria (2009) used structural equation modeling of a survey of residents in the UK and Portugal to identify organoleptic factors as the main determinants of whether an individual considered their tap water to be good or bad quality. Their models further showed that organoleptic factors influenced people's risk perceptions, trust, and their decision to drink tap water. Huerta-Saenz et al. (2011) demonstrated the importance of these factors by surveying parents and children at an inner-city clinic about their water perceptions to explore drinking water preferences between household filter, bottle, and tap water drinking. They examined taste and appearance factors as well as demographic variables and found that not only did bottled water have higher average organoleptic ratings, but those ratings drove preferences for drinking behavior in favor of bottled water consumption. In their survey of household drinking water source choice, Triplett et al. (2019) found that organoleptic perceptions were important in distinguishing between tap and household filtered water drinkers, even when risk factors of safety, contamination, and sickness concerns were not important distinguishers between those groups. It is unclear whether organoleptic evaluations are a reflection of objective preference, familiarity with a water source, or, in part, an artifact of other traits and perceptions (Doria, 2006; Huerta Saenz et al., 2011; Harmon, 2018).

The majority of prior literature into drinking water choice behavior focuses on the specific public preference for bottled water over tap or vice versa. Since bottled water has a substantially higher carbon cost to produce and dispose of (Cole et al., 2011; GAO, 2009; Gleick & Cooley, 2009), and a higher economic cost for consumers (Güngör-Demirci et al., 2016), it is natural that this dichotomy of tap or bottled water has been the focus of previous studies. However, focusing on the dichotomy does not acknowledge the complex patterns of use that characterize how people consume water in their homes. While some studies included home filtered water, such as in Huerta Saenz et al. (2011) or Leveque & Burns (2017), and some assess the difference between exclusive and preferred tap or bottled water use, as in Delpha et al. (2020), water use is still often determined by asking about primary water source choice, rather than assessing patterns in use frequency.

To better understand this complexity and the patterns that characterize how people consume water in their homes, I examined the frequency of and patterns of use of four water source choices in a population in Roanoke, VA. I looked at factors of risk, salience, trust, and water evaluations to get a more comprehensive view of which factors were related to patterns of water consumption in the home. I hypothesized that:

H1: Those with higher trust in their water utility to provide safe drinking water to them will be more likely to drink their tap water in their home as opposed to drinking from other sources.

H2: Those with greater risk perceptions associated with their tap water will be less likely to drink their tap water in their home as opposed to drinking from other sources.

H3: Salience will be an important factor in determining water source choice, but the degree to which it supports acceptance or rejection of tap water will depend on the mechanism.

H3a: Those who know more information about their tap water sources will be more likely to drink from tap water sources in their home as opposed to drinking from other sources.

H3b: Those who notice changes to water quality more frequently will be less likely to drink from tap water sources in their home as opposed to drinking from other sources.

H4: Those with more positive organoleptic water quality evaluations will be more likely to drink from tap water sources in their home as opposed to drinking from other sources.

In addition to testing these four hypotheses, I aim to understand if and how factors of trust, risk, salience, and tap water evaluations drive water source choice behavior. Previous research has highlighted the importance of these factors to water source choice, however, as far as I know, this is the first study to examine them combined and the patterns of in-home water drinking behavior they form. I explored which of these concepts contributes the most to understanding patterns of drinking water sources in one's home.

MATERIALS AND METHODS:

Study Area:

The city of Roanoke is an urban and suburban area in western Virginia. Since 2004, one water utility has provided public water for Roanoke city and its neighboring Botetourt and Roanoke counties. This greater Roanoke area is home to roughly 227,000 people, the majority of whom are white (78%) lower middle class (median income from $41,483 in Roanoke City to $64,733 in Botetourt County) citizens (U.S. Census Bureau, 2017). Since the water utilities' formation, it has had a record of safe and timely drinking water delivery, without a single incident of severe water quality problems by the utilities' or governments' standards.

Because my study focused on resident's choice to drink from the municipal tap or non-municipal tap sources, I excluded addresses that received their water from private wells. Approximately 50% of households in the area are customers of the local utility. I randomly selected 800 publicly available addresses and cross-listed them with the utility to ensure I were only selecting residents who received water from their utilities' surface reservoirs. I intended to survey residents in each of these households but needed to exclude eight of them due to invalid addresses, leaving us with a final sample of 792. If I received 385 survey responses from this sample, that would provide my study with a representative sample of the population with ±5% sampling error and 95% confidence intervals (Dillman et al., 2014).

Distribution:

I distributed my survey using a four-stage drop off pick up method adapted from Trentelman et al. (2016). Because of the increased social exchange and personal repour created from in-person interactions, the drop off pick up method typically garners a 60 to 70% response rate. This is far higher than mail surveys, which average 30%, or phone surveys, which average 15% (Dillman et al., 2014; Steele et al., 2001; Trentelman et al., 2016). I predicted that the lack of water quality issues in the Roanoke area would lower resident's interest in survey participation. I employed the drop-off pick-up method to offset that effect and heighten the survey response.

I sent introduction letters to each resident informing them of my study and imminent visit. One week after the letters sent, my research team visited their home in-person to provide them with information about the study and invite them to participate. To ensure each resident received equal information, my research team adhered to a script I developed based on guidelines from Dillman et al. (2014) and Trentelman et al. (2016). If the resident agreed to participate, my team left the survey with them to complete at their convenience and made up to two follow up visits as needed to their house to pick up the survey. Residents were each given a doorknob bag so they could leave their completed surveys outside for us to pick up two days later. I waited two days before visiting residents again to give them ample time to complete the survey.

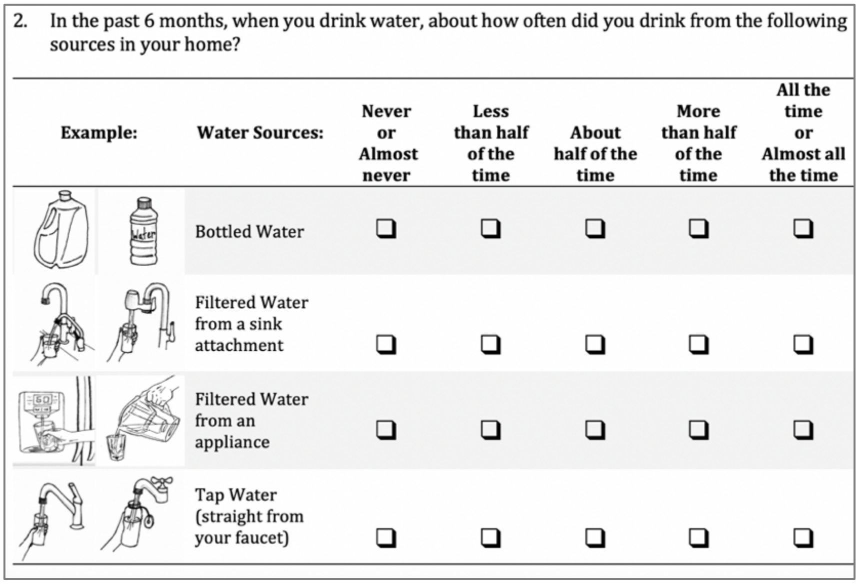
If a resident was not home when researchers arrived at their door and a survey was not left outside for pick up, researchers considered that a failed visit and scheduled another attempt to contact a resident two days later. I made up to three attempts per visit to contact a resident. If the failed attempt was made during an introductory visit, researchers left and returned another day. After three failed attempts at an introductory visit, research teams left a packet by the resident's door with a note explaining our attempts at contact and introducing the study, a cover letter requesting participation, the survey itself, and a postage-paid envelope to return the survey to us. If a failed attempt was made on a pick-up visit, then researchers left a note on the participant's door saying, "sorry I missed you, I will be back on [insert date]." We left the note to establish the research team's reliability because participants had been told what date to expect the team's return. If, after three attempts team members still had not contacted a resident for a survey pick up, they left a note on the doorstep explaining that we attempted to collect the survey, a packet with a spare survey, and providing a postage-paid envelope for the resident to return the survey in. Researchers left the same package with residents who had not completed their survey after our third visit.

I scheduled visits between 4 pm and 8 pm on weekdays and between 10 am and 4 pm on weekends to maximize the likelihood that residents would be home from work. I followed recommendations from route finding software (Optimoroute) to optimize my drive time. I began with the homes closest to my team's base location west of Roanoke and moved further east week by week. I started data collection in September but halted operations in November when the sun set at 6:00 and working in the dark presented safety concerns to my team. I intended to start data collection again after daylight savings time in the spring but were prevented from doing so due to COVID-19 regulations. This reduced my sample from 792 to 611. The remaining 181 addresses were located to the northeast of Roanoke and occupied some of the more urban areas of my population.

Measurement:

The questionnaire assessed resident's patterns of drinking water behavior, their salience of water topics, perceived risk, tap water quality evaluations, trust in the water utility. The survey also measured demographic factors adapted from the 2010 US Census that were used to conduct a response bias check. I conducted a pilot study (n = 20) in Roanoke to assess the variability of three key trust and behavior questions and pretested the entire questionnaire (n = 60) before printing the surveys.

To determine water source choice, I asked how often residents drank from bottled water, tap water, appliance filter, and sink filter sources in their home in the past six months on a five-point scale (1 = *never*, 2 = *less than half of the time,* 3 = *half of the time*, 4 = *more than half of the time*, 5 = *almost always*). Respondents marked an answer for each of the four potential water source choices (Figure 8).



2. In the past 6 months, when you drink water, about how often did you drink from the following sources in your home?

Example:	Water Sources:	Never or Almost never	Less than half of the time	About half of the time	More than half of the time	All the time or Almost all the time
	Bottled Water	❑	❑	❑	❑	❑
	Filtered Water from a sink attachment	❑	❑	❑	❑	❑
	Filtered Water from an appliance	❑	❑	❑	❑	❑
	Tap Water (straight from your faucet)	❑	❑	❑	❑	❑

Figure 7: Water source choice survey item

I measured trust with two items based on the conceptualization of trust as a willingness to accept vulnerability (Stern & Coleman, 2015; Chapter 1). The first question asked residents the extent to which they "trusted [their] local water utility to provide drinking water to [their] home that is safe to drink." The second asked their degree of comfort "with [their] local water utility controlling the quality of water delivered to [their] home." This second item was intended to measure vulnerability as a proxy indicator of trust. Both items were measured on a 9-point scale from 1 = *Do not trust at all* or *Not comfortable at all* to 9 = *Completely trust* or *Completely comfortable*.

I adapted Stewart's (2009) salience framework for weather forecasting systems to form my tap water salience questions. I included two measures of salience: attention to the issue and information known about one's tap water system. I measured attention using four questions; the first three asked how often respondents noticed unacceptable changes in their tap water in terms of taste, smell, and appearance in the past six months (1 = *Never* to 5 = *Extremely often*), and the fourth asked how often they noticed unacceptable changes in their tap water in general (1 = *Never* to 4 = *Often*). As all residents receive water from the same utility, the degree to which they notice these changes should reflect their attention rather than changes in the water quality itself. I measured knowledge of water topics with one question asking residents to indicate the amount of information they could provide to a friend or family about their neighborhood's water quality (1= *No information* to 5 = *A great deal of information*).

I measured risk based on the perceived likelihood of tap water safety issues and emotional concern of tap water safety issues, perceived safety of tap water compared to bottled water, and severity of impact should an event occur. I labeled these variables cognitive safety, affective safety, comparative risk, cognitive severity, and affective severity. To assess the likelihood of safety issues, I asked respondents to rate how safe they believed their water was from 1= *completely unsafe to drink* to 5 = *completely safe to drink*. For emotional concern, I asked how concerned they were about their tap water safety (1= *extremely concerned* to 5 = *no concern*). I measured comparative risk by asking respondents to rank how safe tap water was compared to bottled water on a 5-point Likert-type scale from 1=*More safe* to 5 = *Less safe*. Lastly, to identify perceived severity, respondents indicated how they would react emotionally (worry and anger) and behaviorally (inconvenience and daily routine change) if they found themselves unable to access their home's tap water. I measured these items on a 5-point Likert-type scale from 1 = *Not at all* to 5 = *A great deal*.

My tap water quality evaluations were all measured on a 5-point Likert type scale of acceptability. Respondents rated how acceptable their water was in terms of taste, smell, appearance, safety, and in general (1 = *Not acceptable* to 5 = *Completely acceptable)*.

Analysis:

I determined patterns of behavior by performing a hierarchical cluster analysis to partition my sample into smaller, mutually exclusive groups based on the water source choice item (Everitt, 2001). Hierarchical cluster analysis presents these groups in a dendrogram with increasing options of clusters into which a population could be split. I used Ward's minimum variance method, which groups items into clusters based on the similarities and differences between each data point (Ward, 1963). To determine the potential optimum cluster solution to use in my subsequent analysis, I used a Calinski/ Harabasz test and a Duda/Hart test, which allowed me to identify the solution with the lowest ratio of within and between cluster variance and lowest pseudo t squared (Calinski and Harabasz, 1974; Duda, Hart, and Stork, 2001). The clusters served as my dependent variable in subsequent analysis.

For my predictor variables with multiple indicators, I used Cronbach's alpha and factor analysis to determine internal consistency. I performed one-way ANOVAs for each predictor variable to see how they individually related to water source choice. I used a Bonferroni test for each ANOVA to explore differences between groups and characterize my clusters based on differences in risk, trust, salience, and water quality evaluation perceptions in addition to a resident's drinking water behavior.

I used a classification tree model to explore how variations in these factors shaped group membership. Classification and regression trees divide data into a hierarchical regression tree for continuous variables or a classification tree for discrete variables. In my case, the dependent variable is membership in a cluster. As these groups are nominal data, I used a classification tree. The classification tree is composed of splits, which are the variables and variable thresholds that divide data, and nodes, which provide the proportion of membership for each cluster (Brieman et al., 2017). The goal of the tree is to use predictor variables as a splitting criterion to divide the clusters in ways that minimize the heterogeneity of group membership. I used JMP software to create my classification tree (JMP Pro®, Version <15>). The program determines splits by selecting the variables with the highest G^2 likelihood ratio chi-square and LogWorth statistic, a negative log of a p-value. Because classification tree models are susceptible to overfitting, I used 5-fold cross-validation. I used JMP's default settings to produce the tree. JMP selects the model after it runs ten consecutive models that fail to produce a pseudo-r squared value .005 higher than the selected tree.

RESULTS:

Response:

I visited 611 addresses out of the initial 792 because the COVID 19 pandemic restricted my actions during my planned spring sampling timeframe. I achieved a contact rate of 75%, communicating with 538 residents between September and November 2019. Of those 538 residents, 89% cooperated with us. I received 352 surveys for a 59% response rate (AAPOR

2016). Of the remaining 178 residents who I contacted, but from whom I did not receive surveys, 114 residents refused to participate, 7 were determined ineligible to participate, and 57 agreed to participate but failed to return a survey. I tested the race, income, and gender demographic variables in my sample to see if they matched population demographics measured in the 2017 census. Based on a test of proportions, my sample matched their population (Supporting information table S1).

Descriptive Statistics:

Looking at different water source behaviors, drinking bottled water had the highest frequency of use and drinking from a sink filter the lowest (Table 5). All groups had moderate to low means and low medians, indicating that a substantial portion of my sample chose to drink from a mixture of two or more sources rather than from one source alone.

Table 5: Descriptive Statistics for dependent variables

Water Source	Obs.	Mean	Median	St. Dev.	Minimum	Maximum
Bottled	339	2.84	1	1.55	1= Never or almost never	5=All the time or Almost all the time
Sink Filter	312	1.38	1	1.03	1= Never or almost never	5=All the time or Almost all the time
Appliance Filter	331	2.44	1	1.65	1= Never or almost never	5=All the time or Almost all the time
Tap	337	2.32	1	1.50	1= Never or almost never	5=All the time or Almost all the time

Most respondents had relatively high trust in their water utility. 61% reported that they *mostly* or *completely* trusted their utility to deliver safe drinking water to them (Table 6). The majority of my sample had low risk perceptions about the safety of their water, but moderate risk perceptions about the severity of the consequences they'd experience should access to that secure water be compromised. Most people (82%) reported that their tap water was *completely* or *somewhat* safe and 77% of people reported they were *not* or only *slightly* concerned about their tap water quality. However, if hypothetically they were unable to use their water, most people (50%) reported that would inconvenience them and change their daily routine *a great deal* and 40% reported that it would worry and anger them *a great deal* or *a lot*. The majority of my sample reported that they consider bottled water equally as safe as tap water (45%). At the same time, drinking water was a low salience topic for the majority of respondents. Most respondents (63%) reported that they *never* noticed changes in their tap water and that they only knew *little* to *no* information about the quality of water in their neighborhood (61%). Lastly, people generally had favorable impressions of their tap water quality. 53% of people ranked their tap's smell, odor, taste, and general characteristics as *very* or *extremely* acceptable.

Table 6: Descriptive Statistics for predictor variables

Variable	Obs.	Mean	Median	St. Dev.	Minimum	Maximum
Trust	345	6.34	7	1.97	1=No trust	9=Complete trust
Risk: Cognitive Safety	340	1.71	1	0.89	1=Completely safe	4=Completely unsafe
Risk: Affective Safety	344	1.87	1	1.09	1=Not concerned	5=Extreme Concern
Risk: Cognitive Severity	339	3.25	5	1.40	1=None	5=A great deal
Risk: Affective Severity	326	3.23	4	1.28	1=None	5=A great deal
Risk: Comparative	339	3.52	3	0.98	1=Bottled much less safe than tap	5=Bottled much more safe than tap
Salience: Attention	348	1.68	1	0.74	1= Never	4 = Often
Salience: Information Known	343	2.35	2	0.98	1 = None	5 = A great deal
Tap Water Quality Evaluations	348	3.70	4	0.93	1=Not acceptable	5=Extremely acceptable

In-home drinking water behavioral choice patterns:

Based on a Calinski/ Harabasz test (F=206.33) and a Duda/Hart test (Je(2)/Je(1)=0.66, T=11.75), I chose a six cluster solution for water source choice behavior groups, which was the solution with the best fit (Supplemental Information Table S3; Supplemental Information Figure S2;). I labeled the six clusters based on the means for drinking frequency of bottled, sink filter, tap, and appliance filter water (Figure 8).

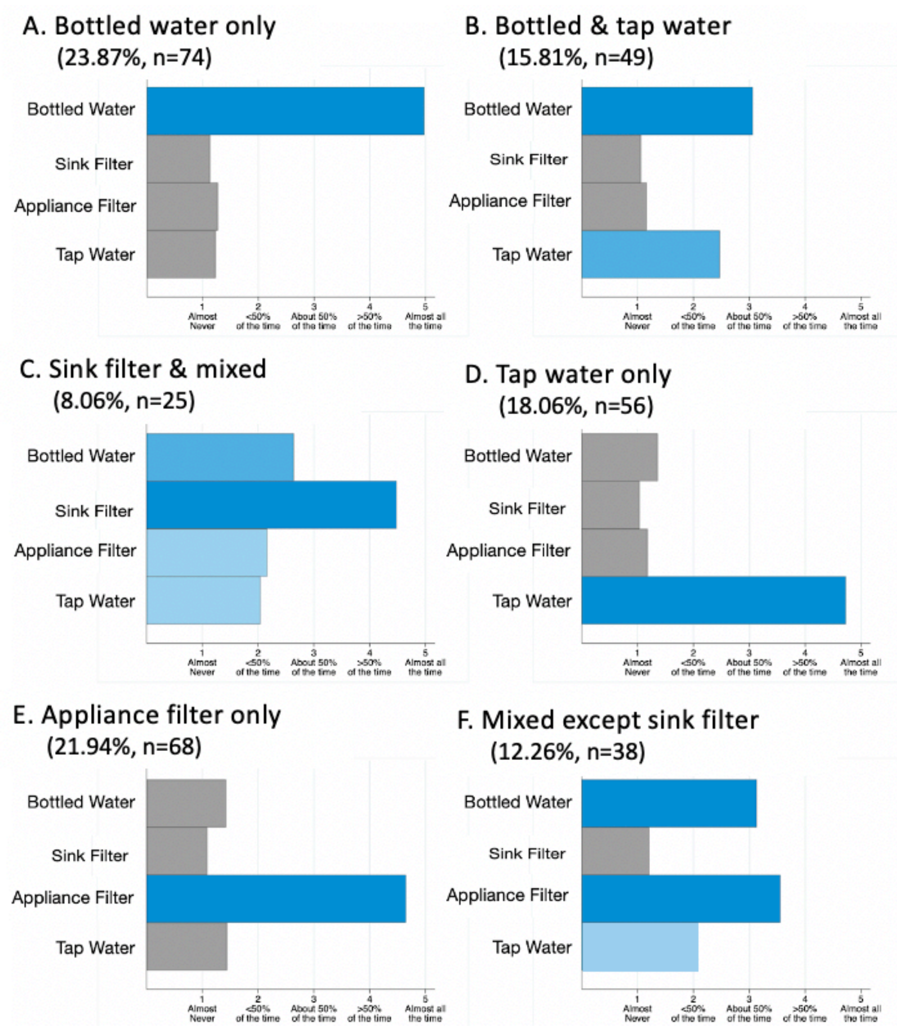


Figure 8: Means of frequency of water source use for each cluster in my six-cluster solution. Each cluster is named according to their patterns of water use. A) Bottled water only cluster, B) Bottled and tap cluster, C) Sink Filter and mixed cluster, D) Tap water only cluster, E) Appliance filter only cluster, and F) Mixed except sink filter cluster. Dark blue bars represent water source usage at or above *50% of the time*. Medium blue bars represent water usage between *<50% of the time* and *50% of the time*. Light blue bars represent water usage at or slightly below *<50% of the time.* Grey bars represent water usage at or around *almost never.*

I refer to groups with use patterns focusing predominantly on one water source as "exclusive." The plurality of the sample (23.87%) was in the bottled water only group. The next most common group was appliance filter only, containing 21.94% of the sample. The tap water only group was the third most populated group with 18.06% of the sample. The remaining groups with the lowest group membership were characterized by a mix of two or more water source choice behaviors. These included those who drank half from the tap and half from bottled water sources (15.81%), those who drank from all four sources, but mostly drank from sink filters (8.06%), and those who drank from a mix of bottled, appliance filter, and tap sources, but did not drink from sink filters (12.26%). The lower means in these mixed groups compared to the exclusive source groups indicated that residents more commonly prefer to drink from one water source than a variety of sources. Despite the survey instructions to select a response for each water source, 42 respondents did not indicate a frequency of use for one or more water source options and were thus left unclassified.

Comparing groups

The means and distributions for the six clusters differed across almost all of my trust, salience, risk, and tap water evaluation variables (for full ANOVA results, see supporting information Table S4). The exception was information known about water quality, which was similar across the six clusters (F (5, 298) = 1.85, p = 0.103). Comparative risk and tap water evaluations had the most mean differences between groups, while salience variables and affective risk in terms of safety had the lowest number of differences (Figure 9).

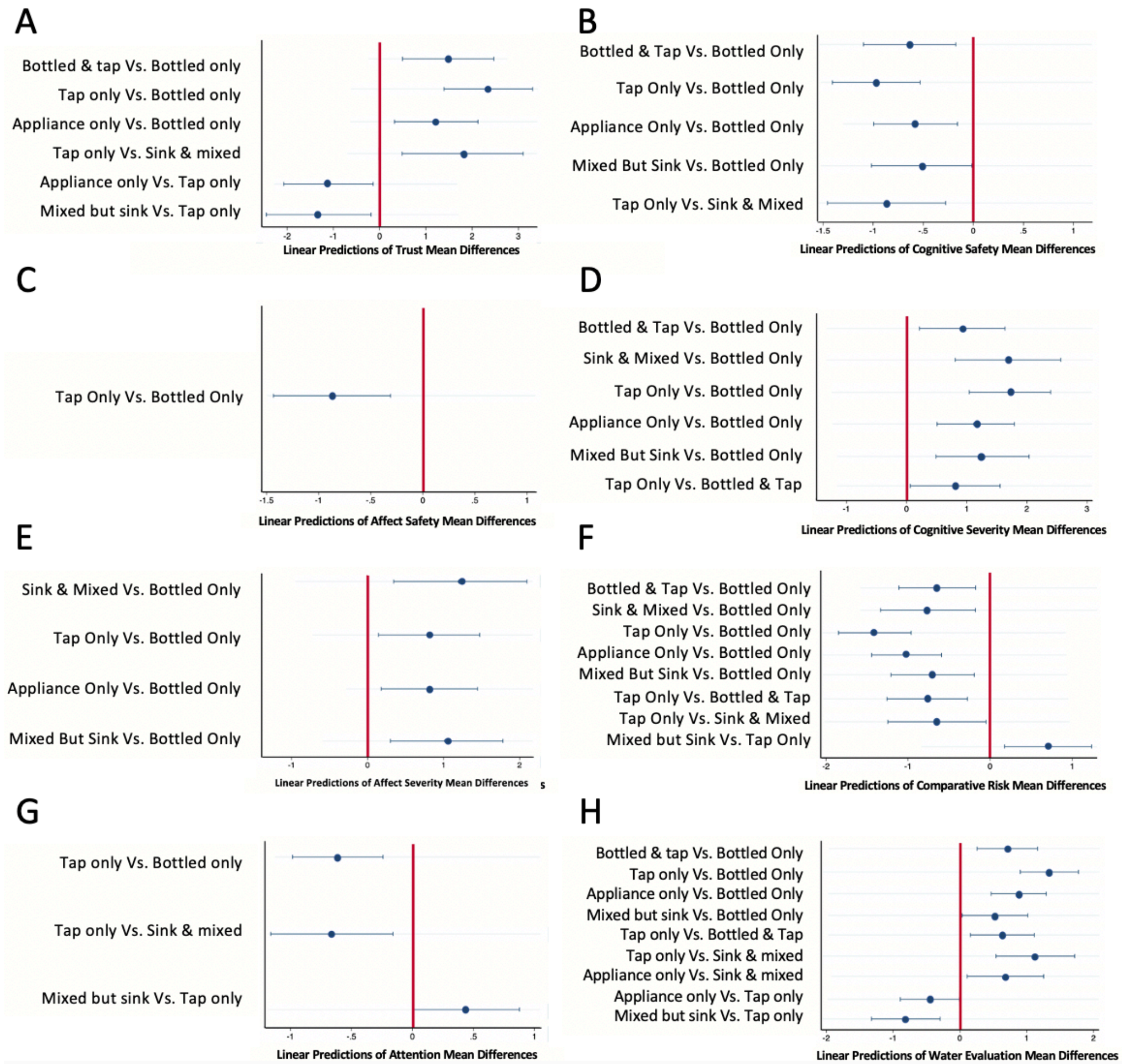


Figure 9: Post hoc pairwise comparisons of adjusted linear predictions of mean differences between clusters for each predictor variable. Predictions were calculated using a Bonferroni test with 95% confidence intervals. Only significant differences are displayed. Plots are presented for A. Trust, B. Risk: Cognitive Safety, C. Risk: Affect Safety, D. Risk: Cognitive Severity, E. Risk: Affect Severity, F. Comparative Risk, G. Salience: Attention, H. Tap Water Quality Evaluations. Salience: information is not pictured because none of its pairs were significant.

H1: Those with higher trust in their water utility to provide safe drinking water to them will be more likely to drink their tap water in their home as opposed to drinking from other sources.

The results of the pairwise comparisons mostly support my hypothesis that higher trust is related to increased decisions to drink from the tap. People in the tap water only group trusted their utility more to deliver safe drinking water to them than those in other groups except the bottled & tap group, which was not significantly different (Figure 9A). People who drank tap water exclusively *mostly* trusted their utility to deliver safe drinking water to them (Mean (m) = 7.55). Exclusive tap water drinker's trust was much higher than exclusive bottled water drinkers (m=5.22) or sink filter & mixed water source drinkers (m=5.75), moderately higher than mixed except for sink filters drinkers (m=6.25), and slightly higher than appliance filter drinkers (m=6.45). Notably, there was not a difference in trust between those who drank tap water all of the time and those who drank tap water half of the time and bottled water the other half.

H2: Those with greater risk perceptions associated with their tap water will be less likely to drink their tap water in their home as opposed to drinking from other sources.

The paired comparison tests partially supported my second hypothesis about risk. Although no pairs of comparisons contradicted my hypothesis, tap water groups had lower risk perceptions than only some of the other behavioral groups, not all of them. People who drank tap water exclusively were, on average, *not* concerned about the safety of that tap water (m=1.43). They were less concerned than bottled water drinkers (m=2.30) who were *slightly* concerned about tap water. However, none of the other behavioral groups differed in concern level from tap water drinkers. (Figure 9C). Similarly, people who drank tap water exclusively would be more worried or angry if they lost access to drinking water (m=3.38), than exclusive bottled water drinkers (m=2.58; Figure 9E). The remaining mean differences for the affective severity variable all related to exclusive bottled water drinkers, not exclusive tap water drinkers. Exclusive bottled water drinkers were less likely to be worried or angry about losing access to their tap water compared to sink filter and mixed drinkers (m=3.80), mixed without sink filter drinkers (m=3.62) and appliance filter drinkers (m=3.38).

Exclusive tap water drinkers believed more strongly that their tap water was safe to drink (m=1.21) than exclusive bottled water drinkers (m=2.18) or sink filter & mixed water drinkers (m=2.08) believed (Figure 9B). These findings are reminiscent of the trust item pairwise comparison results in which tap water drinkers had the most differentiated means from bottled water only and sink filter & mixed groups. The remaining mean differences for cognitive safety occurred between exclusive bottled water drinkers and other groups. Exclusive bottled water drinkers believed their water was less safe than every other group besides sink filter & mixed, which was not significant.

People who drank tap water exclusively were more likely to think that not having access to their home water would directly impact their lives (m=3.94) than people who drank bottled water only (m=2.22) or both bottled & tap water (m=3.13; Figure 9D). Compared to every other group, people who drank bottled water were less likely to think that losing access to tap water would directly impact their lives.

The comparative risk item had the highest number of pairs with mean differences out of all five risk indicators (Figure 9F). People who drank tap water believed that bottled water was less safe compared to tap (m=2.88) than people who drank from bottled water exclusively (m=4.28), bottled & tap (m=3.64), sink filter & mixed water sources (m=3.52), and from mixed water sources excepting a sink filter (m=3.58), but there was no difference between the tap water only group and the appliance filter only group.

Overall, tap water groups had lower risk perceptions than several non-tap water groups, but not all. More differences were in cognitive and comparative risk measures than in affective risk measures. The mean differences that did exist between groups involved either the bottled water only group, the tap water only group, or both. Exclusive bottled water drinkers and exclusive tap water drinkers had the largest and most consistent differences. Exclusive tap water and appliance filter groups did not show different means across any of the risk indicators.

H3: Salience will be an important factor in determining water source choice, but the degree to which it supports acceptance or rejection of tap water will depend on the mechanism.

- <u>*H3a:*</u> *Those who know more information about their tap water sources will be more likely to drink from tap water sources in their home as opposed to drinking from other sources.*
- <u>*H3b:*</u> *Those with who notice changes to water quality more frequently will be less likely to drink from tap water sources in their home as opposed to drinking from other sources.*

The ANOVA pairwise comparison results from the information measure did not support my hypothesis as there were no mean differences between pairs of groups (*H3a*). The data partially supported my hypothesis about the degree to which someone notices changes in their tap water quality (*H3b*; Figure 9G). Exclusive tap water drinkers noticed changes in their tap water (m=1.31) less frequently than exclusive bottled water drinkers (m=1.92), sink filter & mixed water source drinkers(m=1.98), and mixed water source excepting sink filter drinkers (m=1.75). Similar to findings from the trust and risk items, the appliance filter group and bottled & tap group did not have a different mean from the tap water group.

H4: Those with more positive organoleptic water quality evaluations will be more likely to drink from tap water sources in their home as opposed to drinking from other sources.

The water evaluation ANOVA pairwise comparison results supported my fourth hypothesis. Exclusive tap water drinkers had more favorable perceptions of their tap water quality (m=4.35) than every other behavioral group (Figure 9H). This difference was particularly pronounced with exclusive bottled water drinkers (m=3.01) or sink & mixed water source drinkers (m=3.28), and least pronounced when looking at appliance filter drinkers (m=3.91).

Overall, the ANOVA results mostly supported my hypothesis that tap water drinkers would have lower risk perceptions, higher trust, and higher water quality perceptions than other groups. Cognitive and comparative risk items demonstrated more support for the hypothesis than affective risk items, which had fewer mean differences between pairs of groups. Exclusive tap water drinkers had the lowest number of differences with exclusive appliance water drinkers, suggesting a similarity between those groups. Exclusive tap water drinkers showed the strongest differences when compared to exclusive bottled water drinkers and sink & mixed water source drinkers.

Variable importance in cluster membership

The classification tree I chose to explore how factors of trust, risk, salience, and water quality evaluations explained group membership partitioned group members into four terminal nodes using three splitting criteria (Figure 10). The 5-fold K-fold cross-validation identified this tree as the one that best explained the partitioning of group members without overfitting the data. The best fit tree had a pseudo r-squared of 11.4% and a misclassification rate of 0.63. The tree splits were associated with the comparative risk, water quality evaluation, and trust items.

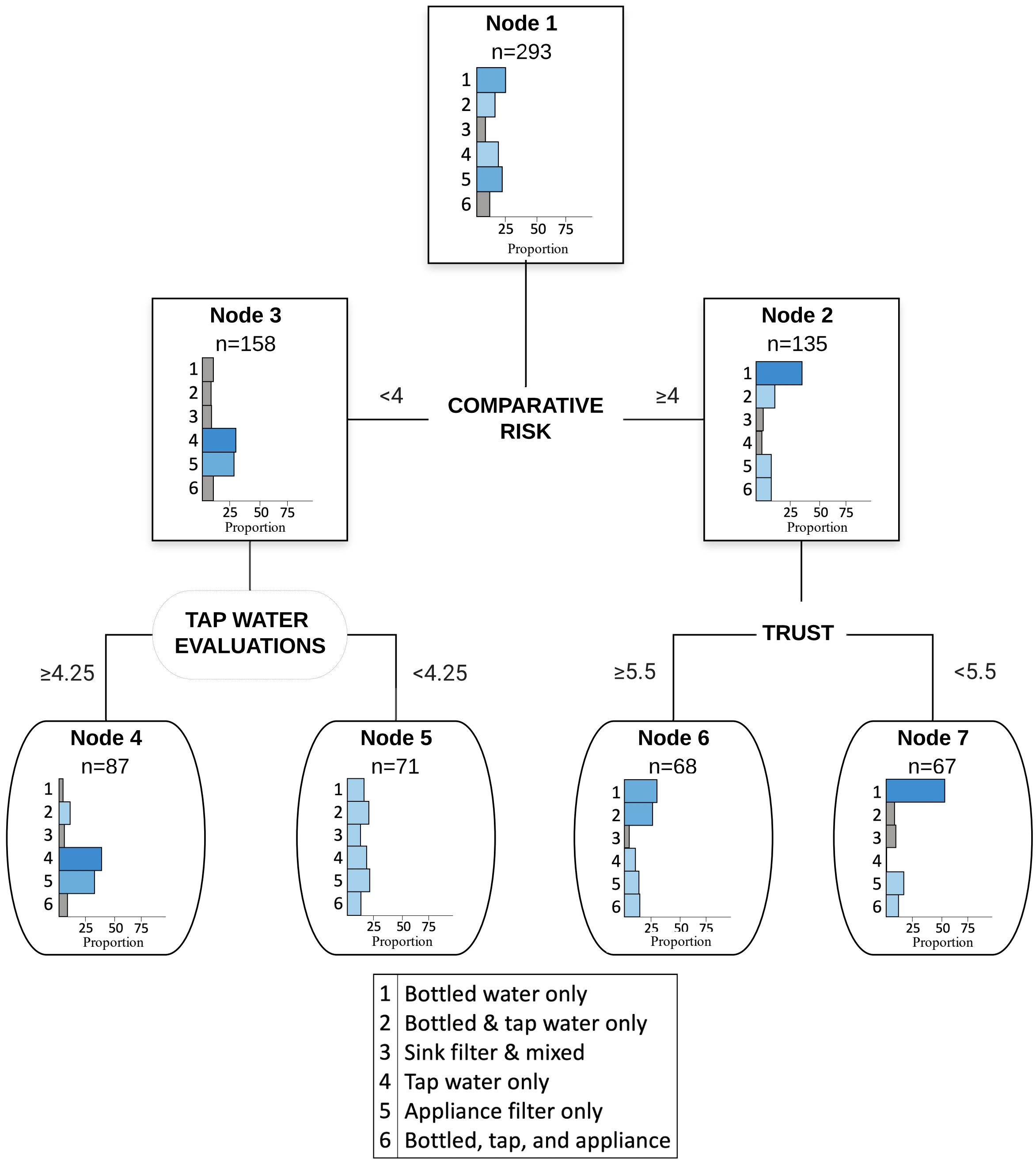


Figure 10: Classification tree diagram of how the variables of trust, risk, salience, and water quality evaluations explain the classification of my sample into clusters of drinking water behavior. Nodes display the results of a split including the number of sample participants who fall under that node, and the probability of membership in each cluster by terminal node. Rows are colored dark blue when probability exceeds 40%, medium blue when probability exceeds 20%, and light blue when probability exceeds 10%. Terminal nodes are drawn in ovals. Nodes that have further splits branching off of them are indicated by squares.

The comparative risk item was the primary splitting variable in my classification tree, accounting for three times more discrepancy in the model than the other two splitting variables did (proportion = 0.61; Supplemental information Figure S5). This result indicates that the most important variable to classify people's drinking water source choice was their beliefs about tap waters relative safety compared to bottled water. If people believed bottled water was *somewhat* or *much* safer than tap water, they were more likely to be in the bottled water only group (probability (prob) = 0.42), less likely to be in the tap water only group (prob =0.05), and less likely to be in the appliance filter only group (prob = 0.12; Figure 10 Node 2). If however, they believed that bottled water was equal or less safe than tap water, then they were less likely to be in the bottled water only group (prob=0.09) and more likely to be in the tap water only group (prob=0.30) or in the appliance filter only group (prob=0.28; Figure 10 Node 3). For that node of mostly tap and appliance drinkers, the next most significant variable was tap water evaluations, which accounted for almost one-fifth of the model's classification power (proportion = 0.18). If people believed their tap water was at least as safe as bottled and also believed their tap water quality was *extremely* acceptable in terms of taste, odor, smell, and in general, then the probability of them being in the tap water only group (prob = 0.40) or the appliance filter only group (prob = 0.33) increased further (Figure 10 Node 4). If, however, they believed their tap water was at least as safe as bottled and thought less highly of their water quality, then they were almost equally likely to be in any of the six groups (Figure 10 Node 5).

If respondents believed bottled water was *somewhat* or *much* safer than tap, their degree of trust in their water utility was the next most important variable for categorization (proportion of classification power = 0.19). People who believed bottled water was safer than tap and had *moderate* or lower trust in their utility had the highest likelihood of being in the bottled water only group (prob=0.55; Figure 10 Node 7). If those same people who believed bottled water was safer than tap had *moderate* or higher trust in their utility, then they were more likely to belong to the bottled & tap water (prob=0.26) group or the bottled only group (prob=0.31; Figure 10 Node 6).

DISCUSSION

Water utilities' goal is to ensure the water they provide is good quality and safe for drinking, and they devote substantial energy to accomplish that. At the same time, a growing number of people are opting to drink from alternate sources to their tap (Doria, 2006; Olson, 1999). Bottled water consumption, for instance, rose 3.6% in 2019 alone ((IBWA), 2019). This places a burden on community members who invest in alternate water sources to tap, which are often more expensive or time-consuming to maintain. Bottled water costs 200 times more per gallon than tap water (Güngör-Demirci et al., 2016) Excepting filters that are built into appliances like refrigerators, household filters also represent an additional cost for residents. The trend away from tap water is also problematic for utilities as their customer base opts out of drinking their main product. My study characterized patterns of drinking water behavior to understand people's drinking water source decisions and related perceptions. I considered trust perceptions alongside other factors that have been related to water source choice behavior in prior research, including risk, tap water evaluations, and salience. I hypothesized that increased trust, more favorable water quality evaluations, and decreased perceptions of risk and salience would be associated with a stronger propensity to drink tap water as opposed to sink filtered, appliance filtered, or bottled water. I examined these factors together to determine trust's importance in driving water drinking behavior.

Broad patterns between groups

I characterized water drinking behavior through a combination of groups of people (behavioral groups) who relied on one water source exclusively and groups of people who mixed their water sources. Much of the previous literature examining drinking water source choice compared bottled water drinkers to tap water drinkers (e.g., Saylor et al., 2011; Doria 2009). Looking at patterns of behavior based on usage allowed me to go more in-depth into categorizing that behavior. This depiction recognizes that people may rely on multiple sources of drinking water in the home. Indeed, only 42% of my sample drank exclusively bottled or exclusively tap water, and the percent of people in the appliance filter only group was greater than those in the tap water only group (Figure 8). While some researchers added exclusive household filter water drinkers to their study scope (e.g., Huerta Saenz et al., 2011; Leveque & Burns, 2017), I am unaware of studies that examine the people who prefer to mix their water sources or differentiate between household filter types. These mixed groups were important in my data, accounting for 36% of my respondent's water source choice behavior.

Some of the behavioral groups in my study shared similar perceptions of trust, risk, salience, and water evaluations, while others were more disparate. Exclusive tap water drinkers had the strongest differences with exclusive bottled water drinkers and people who drank mostly from a sink filter but also a mix of other sources (Figure 9). The strong difference in perceptions for trust, risk, salience, and water quality evaluations between exclusive tap and exclusive bottled water drinkers (Figure 9) is reminiscent of previous studies that demonstrated similar contrasting beliefs between tap and bottled groups (e.g., Saylor et al., 2011; Hu et al., 2011). The strong difference between the sink & mixed group and the tap water only group could be indicative of the financial investment needed to obtain a sink filter. Although appliance filters often need replacing, they often have a low initial cost or are incorporated into other necessary household items like refrigerators. Sink filters, on the other hand, are often more expensive and can require time to install. Out of the five non-exclusive tap water groups, the exclusive bottled and sink filter & mixed sources require the highest financial and time investment. Perhaps lower trust, lower perceptions of tap water quality, and higher risk beliefs about their water might compel people to invest in a sink filter or bottled water.

Differences in perceptions of risk, trust, salience, and water quality perceptions depend on the type of household filter individuals employ. Members of the appliance filter only group were one of the most similar groups to tap water. Exclusive appliance filter water drinkers differed from exclusive tap water drinkers in terms of their tap water quality evaluations and trust, not risk, or salience. Previous research that investigates household filtered water does not distinguish between home filter type. For example, Huerta Saenz et al. (2011) examined water preferences among minority children and young adults by asking them to evaluate the water quality of plain tap water, household filtered tap water, and bottled water. Leveque & Burns (2017) employed similar methods when they characterized their sample's drinking water behavior by asking them to report how often they drank from their tap, home filter, or bottled water sources. The authors found that individuals who reported higher risk perceptions of tap water were more likely to drink bottled water, but not more likely to drink household filtered water. Based on my findings, it is possible that these studies might have been able to determine more differences between their tap and household filtered water groups had they distinguished between types of home filters employed.

Trust, risk, salience, and water evaluation specific differences

Trust

I found partial support for my hypotheses that higher trust would be associated with an increased propensity to drink tap water as opposed to sink filtered, appliance filtered, or bottled water. Higher trust levels led to an increased choice of an exclusive tap water source for every group except for the mixed tap & bottled water group. This result is reminiscent of previous studies that emphasized the distinction in trust between those who drank from tap water sources and those who drank bottled water (Doria, 2006; McSpirit & Reid, 2011; Saylor, 2011). I found similar trust perceptions between those who drank tap water exclusively and those who drank tap water half of the time and bottled the other half.

Perhaps people drink bottled water exclusively because of their negative perceptions about tap water, while those who drink bottled water only half of the time do so for other reasons, like convenience. Ward et al, (2009) interviewed university students to understand beliefs about the health of bottled water and bottled water use at the University of Birmingham. They found that, while those who drank bottled water had a range of health beliefs about that water, the most motivating factor in buying bottled water was convenience. Similarly, Saylor et al. (2011) found that convenience was a barrier to drinking tap water in their survey of students at Purdue University. My classification tree also demonstrated the similarity between tap water only groups and half bottled half tap group (Figure 10). It distinguished between those who were most likely to be in exclusive bottled water group and those who were equally likely to be in either the bottled & tap group or the exclusive bottled water group based on trust. Individuals with lower levels of trust were less likely to include tap water as one of their drinking sources. This split was the only point where trust level helped determine group membership, indicating that, while trust levels might distinguish between groups, trust only contributes to classifying group membership to determine the degree to which respondents will rely entirely on bottled water.

Risk

I found partial support for my hypothesis that tap water drinkers would have decreased risk perceptions compared to other groups. This partial support is similar to previous research, which has had conflicting results regarding the relevance of risk items to distinguish between drinking water behavior. Some previous research has noted the importance of risk beliefs in acceptance or rejection of water sources (e.g., Hu et al., 2011; Triplett et al., 2019), yet others have found that risk measures such as health beliefs were unimportant to determining which water source an individual will choose (Ward et al., 2009). One possible reason for these mixed results could be because some studies measure cognitive risk while others add measures of affect or comparative risk (e.g. Debbeler et al., 2018; Hu et al., 2011; Saylor et al., 2011).

There was slightly more support for my risk hypothesis from cognitive measures of risk than affect-based measures of risk. This distinction was particularly prominent when focusing on differences between bottled water drinkers and other groups rather than on tap. It may be easier for an individual to envision the impact of a risk-based on objective likelihoods rather than affective emotions. Finucane et al. (2000) examined people's reliance on affective heuristics, or emotional associations, to inform risk/benefit perceptions rather than cognitive deliberations. They found that when people have less opportunity to deliberate about a decision or feel more removed from it, they rely less on affective heuristics. My respondents were asked about a hypothetical risk situation and given ample time to consider their response. Following Finucane et al.'s (2000) logic, these conditions could have dampened respondent's ability to project affective judgments and reduced variability of response to affect-based risk items. However, these dampened responses may not be reflective of how a respondent would feel when faced with a loss of water access or contaminated drinking water.

Salience

Out of the four variables I examined, salience had the most negligible impact on behavioral group differences and classification. Respondents' salience perceptions did not support the hypothesis that increased knowledge about water quality would impact tap water usage and only partially supported the hypothesis that increased attention to tap water changes would be related to decreased tap water usage. In Chapter 1, I surveyed respondents to determine the role salience played in trust formation. Considering salience variables improved my understanding of trust.

Salience acted as an important contextual variable for trust determinants. Unlike salience, trust perceptions were relevant to behavioral group classification. Based on this, and my findings in Chapter 1, I propose that salience may indirectly relate to behavioral choice through the formation of trust, which is more proximately related to behavioral choice.

Water quality evaluations

My findings fully supported my hypothesis that higher tap water quality evaluations in terms of taste, smell, and appearance would be associated with an individual's choice to drink from tap water sources instead of alternates. These results are similar to previous literature that cites organoleptic properties as a crucial determinant of tap water drinking (Doria, 2006; Huerta Saenz et al., 2011; Trippet, 2019). Despite the significant difference in means across groups, my classification tree revealed that water quality evaluations were only relevant to classifying group membership if a respondent believed their tap water was equally as safe as bottled water if not safer. Thus, water quality beliefs are less important to consider when distinguishing between bottled water groups and more important to consider when distinguishing between people who do not often drink from bottled water sources (i.e. tap water, mixed water sources, and home filtered water sources).

Limitations

Despite ample differences between groups means, my classification tree was not particularly powerful at explaining discrepancy amongst my groups (See Supplemental Information Figure

S7). While it does provide me with information about how to classify group members, it is best at classifying the difference between the bottled water group and tap water and slightly modified tap water (appliance filter only) groups. The primary variable that distinguished between behavioral group classification was the comparative risk item. The relationships between trust and group classification and water evaluations and group classification were subsequent to comparative risk. Comparative risk, introduced by Saylor (2011), does not touch on all aspects of risk but instead asks respondents to contrast relative safety of tap water relative to bottled water. Besides the application of comparative risk in water literature (e.g., Saylor, 2011), comparative risk has a lack of theoretical basis. As a result, it is difficult to speculate about why this variable performed better than other risk indicators. It could be that this model only distinguishes well between bottled water and tap and modified tap water because the primary splitting variable, comparative risk, only asks respondents to distinguish between bottled water and tap. Despite its limited scope, this one comparative risk item was important in my study. Future research might benefit from expanding avenues of relative risk to compare other water sources besides just bottled and tap, or compared these sources based on other measures besides just cognitive safety.

The lack of power in my model (Figure 10; Supplemental Information Figure S7) shines a light on the advantages and drawbacks of looking at water sources choice as a function of patterns of drinking water behavior, rather than as a dichotomy between tap and bottled water drinkers. Considering all of these patterns of behavior allowed my model to more realistically mirror the scope of drinking water source choice practiced by my respondents. However, considering all of these groups opened my model to increased variability and decreased distinguishing power. The model itself was better at distinguishing between exclusive choice groups than it was at distinguishing between mixed choice groups.

My study was also limited by its small sample size. Small samples can reduce the statistical visibility of slight trends, particularly when a given variable has a low range, as seen with the salience items. My sample was also smaller than intended because I had to halt survey distribution efforts after the first 611 addresses due to the restrictions of the COVID-19 pandemic. My team paused survey distribution in November when it got dark in the early evening, but we were unable to resume activity in the spring because of the pandemic. Since we distributed surveys based on locational convenience, the remaining 182 addresses we did not reach were all in the northeast section of Roanoke County. This limits the generalizability of my sample and prevents me from making broad claims about the representativeness of my data to the population in the Greater Roanoke Area.

Conclusions

My findings show that those looking to encourage others to drink from their tap would have the most impact by focusing on cognitive safety perceptions of tap water health compared to bottled water, rather than on perceptions of tap water safety itself. I also demonstrated the significance of considering different household filter types when distinguishing between differing perceptions related to drinking water behavior. Appliance filter drinkers had similar perceptions to tap water drinkers, while those who drank mostly from a sink filter were more similar to bottled water drinkers. Future research looking to characterize drinking water behavior could incorporate this distinction into question items to get a fuller scope of the impact of different drinking water behaviors. Adding measures of comparative risk between other groups, household filtered water, and tap water, for example, could also be beneficial for future research. Lastly, while trust plays a role in categorizing perceptions between drinking water behavioral choices, its power lies primarily in distinguishing between those who drink exclusively bottled water and those who drink bottled water half of the time and tap the other half. My results suggest that efforts to increase trust in water utilities might be more effective at decreasing bottled water use than they would be at increasing exclusive tap water use.

Trust is often studied in natural resource management because of its positive relationship with management support, effective communication, and technology acceptance. When communities have higher trust in managers, those managers can enact faster and more effective plans (Davenport et al., 2007; Lachapelle & McCool, 2012; Song et al., 2019). As degrading conditions and disturbance events threaten resources, these links are particularly relevant to water systems. The effects of trust are not limited to management support. Trust is also related to personal behavior in the form of drinking water source choice. People who trust more are less likely to rely as heavily on bottled water as a drinking source (Doria, 2006). To better understand the role trust plays in drinking water source choice, I attempted to characterize this behavior in terms of trust perceptions and other factors linked to drinking water behavior, including risk, salience, and water quality evaluations. Besides trust, factors of risk and tap water quality evaluations also differ between preferences for different drinking water source choices, particularly people's belief about their tap water quality and the comparative health risks of tap and bottled water. Based on my findings, one could intuit information about a community's trust in their utility and related social resilience by examining the water sources people in those communities choose to use. For example, a manager looking at a community who drinks mostly bottled water could hypothesize that those community members might have decreased trust or increased risk perceptions compared to a similar community who drinks more tap or appliance filtered water. Information about how these perceptual factors interact with behavior can help us understand individual's decision making when it comes to their drinking water.

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Thesis Conclusion

The surface water bodies many communities rely upon as a source for their drinking water are being affected by increasingly frequent, severe, and unpredictable (Dunn et al., 2012; Garrote, 2017; Pouget et al., 2012). Because of its emphasis on adaption to changing conditions, resilience-based management is an alluring strategy to minimize these delays and the safety hazards of contaminated drinking water (Carpenter et al., 2001; Cumming et al., 2005; Folke, 2016; Holling, 1973). My research was part of an interdisciplinary effort from the Smart and Connected Communities (SCC) project to understand and increase the resilience and adaptive capacity of water systems. By collecting real-time aquatic condition data and forecasting future water changes, the SCC project provides tools to adapt to changing conditions with the goal of building more resilience of water systems.

My research followed the role of one critical social component of resilience in drinking water systems: trust. Trust contributes to resilient systems by enabling managers to make faster, more effective actions with constituent support. I surveyed municipal water users in and around Roanoke, Virginia, to examine the pathways by which trust is formed and subsequently informs behavior. My work contributed to the SCC project's objectives by determining how information about newly developed technology affected social trust in water utilities. In addition to this specific objective, my work provided theoretical contributions to trust research and implications for applied water management.

Summary of Findings

In Chapter 1, I focused on characterizing the formation of trust in drinking water systems, exploring the roles of trust determinants, conceptualized by Stern & Coleman, (2015), and salience, conceptualized by Stewart (2009). Specifically, I examined the relationships between the judgments people make about their utility, systems that regulate their utility, and their general disposition and overall trust while considering the contextual element of salience. I further examined how increasing knowledge about SCC technology might impact overall trust. As trust ecology has often been studied in high salience situations, my research into trust for the expected low salience issue of drinking water in a historically safe system offers a novel contribution to trust literature.

Residents of the Greater Roanoke Area did indeed have low awareness and knowledge about their drinking water systems. In those low salience conditions, residents also had generally high trust in their water, indicating a potential taken-for-granted mechanism where, once residents reached certain thresholds of beliefs about their utility, they trusted their water to be safe with little deliberation. While information provision is sometimes useful in affecting trust (e.g. Scherer et al., 2016) the level of trust did not change when I provided respondents with information about the SCC project's efforts to enhance managers' ability to deliver safe drinking water to the public.

By understanding the role of salience, I was able to better characterize the relationships between rational, affinitive, procedural, and dispositional determinants and trust. These determinants displayed varying relationships with trust, from sharp positive relationships between procedural determinants and trust to nonlinear plateauing relationships between affinitive determinants and trust. Despite these differences, determinants had the most power to explain that trust when examined together.

In Chapter 2, I furthered my examination of trust in water systems by shifting my focus from trust's formation to trust's role as a factor in explaining drinking water behavior. Residents in our study and across the country have a variety of drinking water source options besides municipal tap water they could drink from, including filtering water using an appliance or sink attachment or purchasing bottled water. Because these sources are more expensive than tap water and typically require some amount of time commitment to obtain (Güngör-Demirci et al., 2016; Olson, 1999), use of these non-tap sources places additional burdens on community members. Consumer reliance on non-tap sources are also a challenge for water utilities as it indicates a lack of support for their key product.

Previous research connected trust to water source choice and drinking behavior along with other factors of risk, salience, and tap water quality evaluations (e.g. Doria, 2006; Saylor et al., 2011). I identified groups of water drinking behaviors based on patterns of water source choice use. These six groups included those who drank exclusively from one water source and those who drank from a mixture of sources. I then examined factors of trust, risk, salience, and tap water quality to understand how these perceptual factors characterized different behavioral outcomes and differentiate between those who drink directly from their tap water and those who prefer alternative sources. Residents who drink exclusively from their tap typically had higher trust in their utility, more favorable perceptions of their tap water in terms of taste, smell, and appearance and decreased perceptions of tap water risk. I did not find a strong connection between the level of salience about tap water and behavioral outcome.

Together, my two chapters lay a foundation for characterizing the role of trust in drinking water systems. Overall, for stable and safe drinking water systems it is reasonable to expect that residents might have high trust in their utility. In these circumstances, residents are likely to have strong beliefs about the systems in place to regulate their water utility and moderate trusting dispositions. They may only need to know that the utility is performing in ways that are good enough to trust. Despite not having a clear mechanism to build emotional or value-based relationships with their utility, residents had strong associations between affinitive connections and trust. Similar to rational beliefs, a moderate agreement threshold of affinitive beliefs appeared to be good enough to support sustained trust. Despite the tendency towards high trust in low salience drinking water situations, there is variability in trust levels. Residents with higher trust in their utilities are more likely to drink water directly from their tap all or half of the time as opposed to from alternative sources.

Theoretical Contribution

My chapters contribute to current trust theory, first and foremost, by demonstrating the role of salience in understanding trust ecology. My study was novel in its examination of salience as a key contextual element of trust and trust's relationships with determinants. The high trust I found in a low salience situation suggests that trust judgments can rely on heuristics rather than conscious deliberation. This contributes to the literature by suggesting that, to best understand trust's formation and relationships with determinants, one needs to consider the salience an individual has about the topic in which they are applying their trust. While the role of salience was significant in characterizing trust's formation, it did not extend to explaining the differences between behavioral groups. Trust, risk, and water quality evaluations were all better at distinguishing between behavioral groups than salience was. It is possible that salience sets the context for trust to occur but does not directly relate to indirectly relate to behavioral choice.

Comparative risk, adapted from Saylor et al. (2011), was a particularly useful in distinguishing drinking water behavior. My comparative risk item was limited to safety comparisons between bottled and tap water and it helped to classify these groups. The importance of comparative risk at distinguishing between groups suggests that further gains in understanding behavior might be made by expanding the relative risk comparisons to other water sources to tap.

My research confirms the validity of trust ecology concepts and measures. I confirmed the definition of trust as a willingness to accept vulnerability with two highly correlated question items asking respondents to rate their trust in their utility to deliver safe drinking water to them and their comfort with their utility controlling their water quality (correlation = 0.92). While previous research employs a format, "I trust X to do Y," I am unaware of previous research that has explicitly investigate trust as accepting vulnerability. I found similar success in the relatedness of my battery of measures for procedural, rational, and affinitive determinants, confirming the theoretical integrity of these concepts.

The method I used to identify drinking water behaviors was, as far as I am aware, novel to the water source choice field. Most studies examine the dichotomy of bottled water drinkers or tap water drinkers, occasionally examining filtered water drinkers or the difference between those who exclusively drink from a source versus those who drink mostly from a source (e.g. Delpla et al., 2020; Huerta-Saenz et al., 2012; Triplett et al., 2019).Instead of using such clear-cut categorization methods, my approach attempted to be a more realistic reflection of respondent's decisions by incorporating the reality that people often have complex behavioral patterns. Using this method, I was able to draw connections between the similar perceptions of those who drink tap water and those who drink appliance filtered water. I also identified the strong difference between those who drink tap water and those who drink mostly from a sink filter or entirely from bottled water sources. This technique demonstrated that those who drank from tap water sources had the most disparate perceptions of trust, risk, salience, and water quality evaluations from those who drank bottled water. Studies that focus on these two groups might see stronger differences in perceptions of trust, risk, salience, and water quality evaluations than studies that consider a mix of sources and usage patterns.

My research in Chapter 1, relied on theoretical frameworks of trust ecology (Stern & Baird, 2016) and salience (Stewart, 2009) they explained trust relatively well (R squared = 0.46). In Chapter 2 I relied more heavily on applied research to inform my conceptual map of water drinking behavior. My classification tree in Chapter 2 did not explain much of the distinguishing power between drinking water behavior groups (Pseudo R squared = 0.11). While Chapter 2's model provides valuable information to explain distinguishing characteristics between groups of behavior, there is also a large amount of information left unexplained. Incorporating and developing a theoretical background for drinking water behaviors could be useful for future research in this field.

Practical Implications

The goal of my research on trust was to not only to understand trust theoretically but also to use that theory to develop the tools and knowledge base to build resilience capabilities of drinking water systems. Trust is beneficial to resilience, often improving and quickening management capabilities by increasing community support for managers and reducing the backlash against management actions (Davenport et al., 2007; Lachapelle & McCool, 2012). Because of this, it is natural for managers to seek out ways to increase community trust. My work did not identify mechanisms to increase trust. Indeed, I found that efforts to provide information about new technology designed to safeguard water in “knowledge deficit” situations did not alter levels of trust. Instead, my study provided insight into what trust looks like in low salience situations.

To create a resilient system, it is important to acknowledge the importance of procedural beliefs on trust. Beliefs about the strength of regulations and structures that govern a utility are important to overall trust. Before designing interventions to attempt to increase trust, it could be beneficial to check and see if procedural system beliefs are strong for an area. Similarly, affinitive and rational beliefs are also important considerations up to a point. Residents needed slightly positive rational beliefs and moderately positive affinitive beliefs to show strong trust in their utility.

My work demonstrated that all four determinants have greater power to explain trust when examined together. Because they are difficult to disentangle, efforts to study or increase one determinant rather than focusing on all of them will likely be limited. That being said, there were differences between the relationships of each determinant and overall trust. My study demonstrated that, to foster a system with high trust between a community and their utility, it is important to acknowledge the importance of procedural beliefs on trust. Beliefs about the strength of regulations and structures that govern a utility are important to overall trust. Similarly, affinitive and rational beliefs are also important considerations up to a point. Residents needed slightly positive rational beliefs and moderately positive affinitive beliefs to show strong trust in their utility.

Based on my findings, those looking to increase trust in low salience situations might benefit from checking to see if procedural systems are strong for an area. It would also be beneficial to check if people believe an institution is capable of delivering a product to them, and if people have moderately positive beliefs about their affinitive relationships with that same institution. Additionally, water utilities might be able to get a sense of the degree of trust community members have in them to begin with based on the water they drink. Those who drink bottled water or water from a sink filter would likely have lower trust in their utility than those who drink tap or appliance filtered water.

Limitations

There are several limitations to this study, the largest of which is a function of the necessary data collection halt due to the COVID 19 pandemic. While my survey sample was random, my in-person distribution efforts were location-based, focusing on geographically clustered addresses to optimize the time my team spent delivering and retrieving surveys. I halted operations after daylight savings time in the Fall of 2019 due to safety and approachability concerns associated with conducting house visits in the dark. COVID-19 restrictions prevented me from starting data collection back up in Spring 2020, leaving me with 181 geographically clustered addresses in my original sample that my team never visited (Figure 11). This group of unsurveyed addresses may share perceptions or demographics that I did not access in my surveyed sample. This limits the generalizability of my findings. Rather than focusing on the representativeness of my sample to the population in the greater Roanoke area, I focus on drawing theoretical conclusions about concepts I measured.

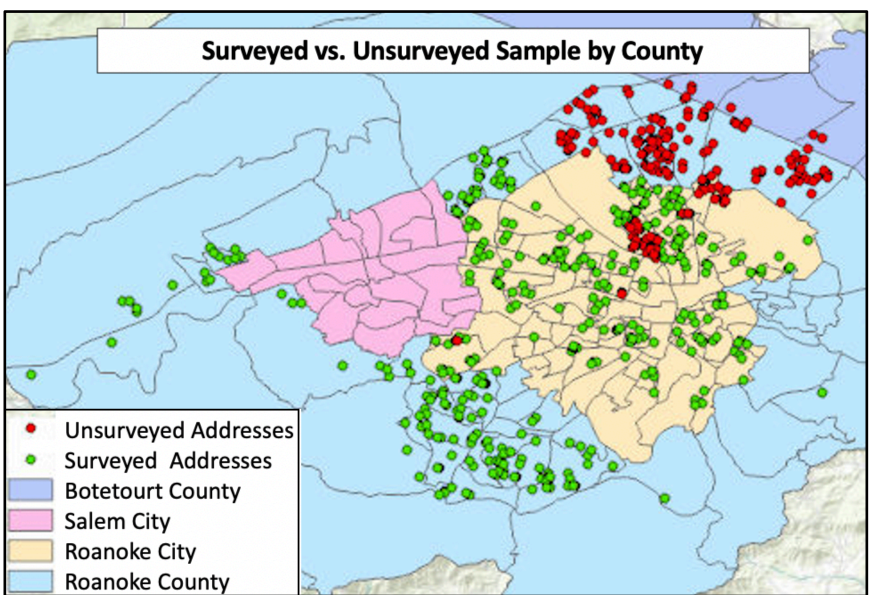

Figure 11: Map of addresses included in my study sample. The green dots represent addresses my research team delivered surveys to while the red dots represent addresses we did not have the chance to visit.

The concepts I measured also have limitations to them. For example, my study only distinctly measured the difference between trust and lack of trust rather than including an item of distrust. While a lack of trust is the mere absence of belief that a trustor will perform a given behavior, distrust is the belief that a trustee will harm a trustor. Because my questionnaire did not measure distrust, I can only focus on the degree to which people feel they trust their water utility. A further limitation to this study is that I may have under-sampled people with distrusting dispositions. It is possible that distrusting individuals would be less likely to participate in a voluntary survey for an institution like Virginia Tech. As a result, my findings may not reflect the people who don't trust their utility to the same degree as it does to people who do trust. This issue of under-sampling is inherent to all voluntary surveys as well as many other social science methods.

My study is also limited in the scope of what I measured. For example, the comparative risk item turned out to be important in distinguishing between patterns of drinking water behavior, yet it primarily distinguished between groups that drank bottled water and groups that drank tap or modified tap water. These limitations present opportunities for future research to expand upon my findings. Future research should consider adding measures of distrust to better understand trust theory in drinking water contexts and should consider adding comparative items that focus on different groups besides tap and bottled water to better understand the role of this risk item.

Conclusion

Trusting relationships between communities and utilities is important to the health of those communities and the ability of institutions to effectively manage water resources and provide safe drinking water to the public. This research focused on the formation of community members trust in their utility to provide safe drinking water to them and the subsequent role of trust as a mechanism to distinguish between different patterns of drinking water behavior. My thesis demonstrates how salience contextualizes relationships between trust ecology concepts (rational judgments, affinitive connections, trustor disposition, and regulatory systems beliefs) and overall trust. Trust's formation is based on these trust ecology and salience concepts. Further, trust, once formed, is an important distinguishing factor in an individual's drinking water behavior. Salience, however, does not play a strong role in distinguishing between behavioral outcomes. Its role lies primarily in the formation of trust. Other factors of risk and water quality evaluations were more important in distinguishing between patterns of drinking water behavior. In addition to the theoretical contributions, this research into the role of trust in drinking water systems provides, this line of inquiry can help us better understand how to build the resilient water systems needed to protect community health from future disturbances that threaten water security.

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Appendix A: Shared Chapter 1 and 2 Supplemental Materials

Table S1: Nonresponse bias check for sample and population data by census block group based on 2017 data. There were insufficient observations for Native Americans/Native Alaskans and Native Hawaiians in our sample to perform a test of proportions.

Var	Population Total	Population Percent	Sample Total	Sample Percent	Mean Difference	St. Err. Difference	z	p
Black	19985	18.74%	47	13.43%	-0.05	0.05	-0.93	0.351
White	77781	72.93%	259	74.00%	0.01	0.03	0.39	0.699
Asian	4066	3.81%	12	3.43%	-0.00	0.05	-0.07	0.945
Hispanic	4514	4.23%	9	2.57%	-0.02	0.05	-0.25	0.805
Female	55560	52.10%	178	50.86%	-0.00	0.04	-0.06	0.949

Appendix B: Chapter 1 Supplemental Materials

Table S2: Correlation tests between the items that I combined to create my variables.

Item	Observation	Item Test Correlation	Item Rest Correlation	Average Interitem Covariance	Alpha
Rational Items				1.35	0.81
Capability	341	0.77	0.59	1.46	0.78
Delivery Record - Past	338	0.83	0.69	1.30	0.74
Delivery - Future	339	0.80	0.60	1.35	0.79
Skill	339	0.82	0.67	1.30	0.75
Affinitive Items				1.65	0.85
Utility cares about water	341	0.74	0.54	1.93	0.87
Best interests at heart	338	0.84	0.70	1.59	0.80
Shared values	335	0.88	0.78	1.52	0.77
Utility cares about resident	340	0.86	0.74	1.56	0.79
Procedural items				0.43	0.75
Listen to concerns	344	0.80	0.60	0.38	0.67
Obey laws	346	0.67	0.48	0.53	0.73
Has government constraints	345	0.81	0.59	0.36	0.67
Has procedures in place	345	0.75	0.53	0.44	0.70
Dispositional items				0.66	0.58
I find it hard to trust	338	0.76	0.42	0.47	0.45
Most people are honest	337	0.59	0.27	0.82	0.57
I'm careful with others	335	0.63	0.32	0.73	0.54
I generally trust	340	0.68	0.43	0.62	0.45
Salience attention items				0.54	0.86
Notice changes in smell	347	0.87	0.72	0.59	0.83
Notice changes in appearance	345	0.87	0.72	0.59	0.82
Notice changes in taste	343	0.92	0.79	0.45	0.77

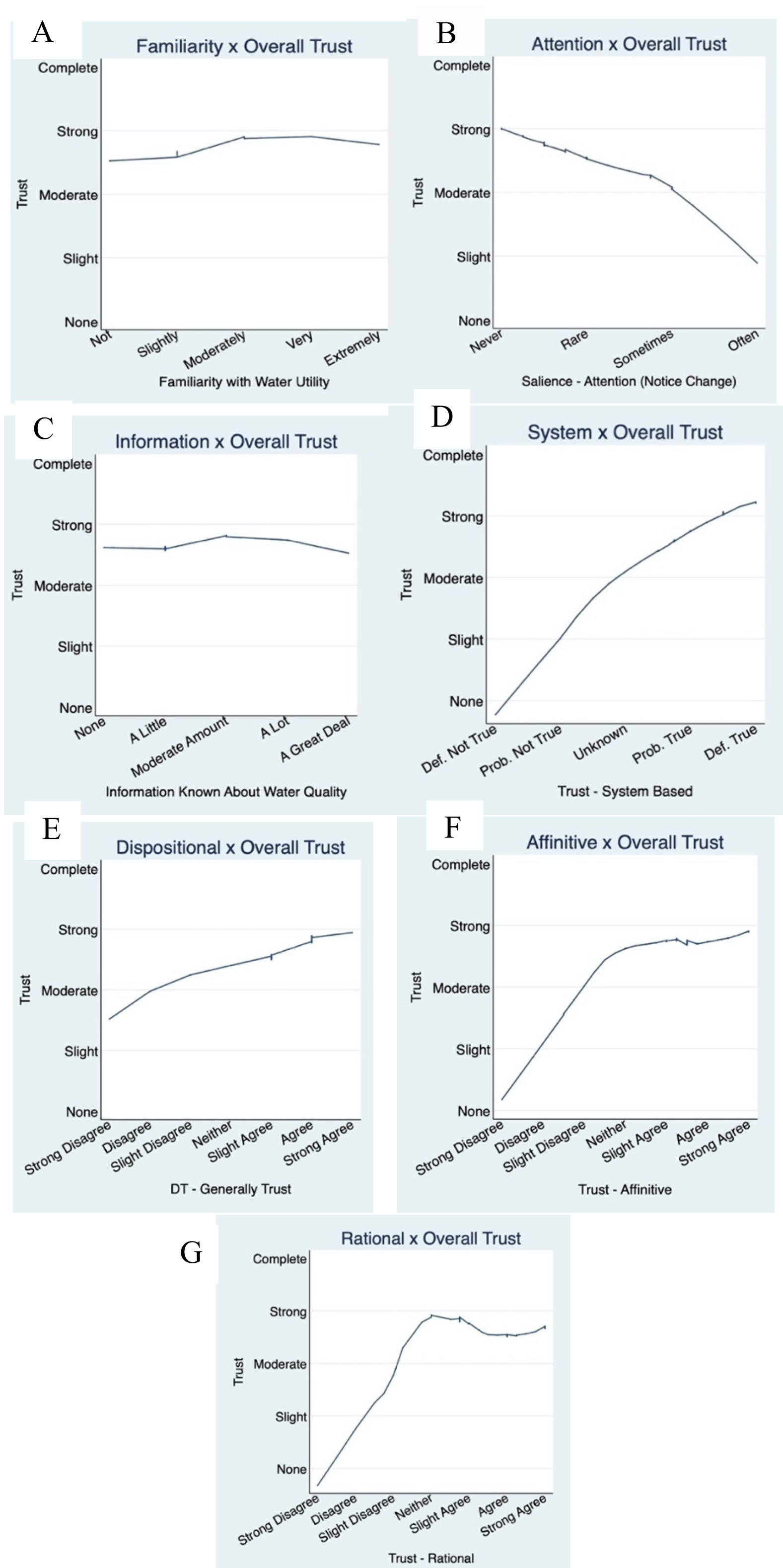


Figure S1: locally weighted regression and smoothing lines over scatterplots for salience variables: familiarity (A), attention (B), information (C), and determinants of trust: procedural (D), dispositional (E), affinitive (F), and rational (G) to examine the linearity of the relationship between each variable and overall trust.

Appendix C: Chapter 2 Supplemental Materials

Table S3: Calinski/ Harabasz test and a Duda/Hart test for my K means cluster analysis on water source choice behavior. Based on these tests, a 6-cluster solution was deemed appropriate

		Duda/Hart	
Cluster Number	Calinski/Harabasz pseudo-F	Je(2)/Je(1)	Pseudo T-squared
Looking For:	Highest Value	Highest Value	Lowest Value
2	130.89	0.5627	156.96
3	187.33	0.6134	92.02
4	206.72	0.4888	126.55
5	205.55	0.661	53.33
6	206.33	0.6618	11.75
7	198.52	0.5626	27.99
8	199.06	0.4086	11.58
9	200.62	0.6157	29.34
10	199.49	0.5658	17.65
11	193.84	0.3445	7.61
12	190.09	0.47	25.93
13	188.51	0.6866	30.13
14	189.12	0.5265	11.69
15	188.29	0.6404	40.43

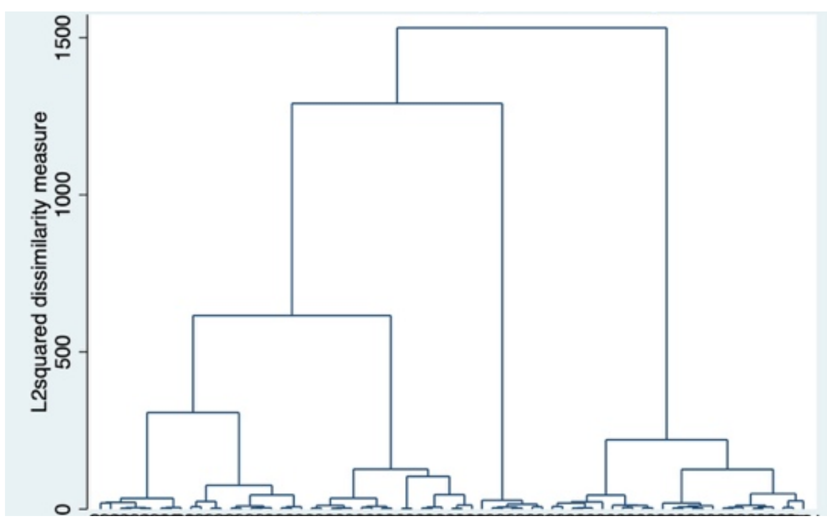


Figure S2: Dendrogram for the hierarchical cluster analysis. Based on my tests, a six-cluster solution was deemed appropriate

Table S4: Oneway ANOVA results comparing drinking water behavior cluster means for each independent variable. * Indicates a p<0.05 significance ** Indicates a p <.01 significance

	Cluster 1 Bottled Only		**Cluster 2 Bottled & Tap**		**Cluster 3 Sink Only**		**Cluster 4 Tap Only**		**Cluster 5 Appliance Only**		**Cluster 6 Mixed**		**Degrees of Freedom**	**F**	**n**	**Eta^2**	**Bartlett Chi^2(5)**
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median					
Trust	5.22	5.0	6.69	7.0	5.75	6.0	7.56	7.5	6.45	7.0	0.25	7.0	5,295	11.52**	301	0.161	21.66*
Salience: Attention	1.92	2.0	1.61	1.2	1.98	1.8	1.31	1.0	1.59	1.5	1.75	1.8	5,303	6.12**	309	0.092	20.61*
Salience: Information	2.32	2.0	2.32	2.0	2.88	3.0	2.43	2.0	2.24	2.0	2.27	2.0	5,298	1.85	304	0.030	5.96
Risk: Cognitive Safety	2.18	2.0	1.55	1.0	2.08	2.0	1.21	1.0	1.61	1.0	1.67	1.0	5,300	10.26**	306	0.148	33.51*
Risk: Affective Safety	2.31	2.0	1.81	2.0	1.84	1.0	1.43	1.0	1.84	1.0	1.78	1.0	5,299	4.4**	305	0.069	7.33
Risk: Cognitive Severity	2.22	2.0	3.14	3.5	3.90	4.5	3.95	4.5	3.37	3.5	3.49	4.0	5,296	14.12**	302	0.193	0.79
Risk: Affective Severity	2.58	2.5	3.11	3.2	3.80	4.5	3.38	3.5	3.38	3.5	3.62	3.5	5,284	6.03**	290	0.096	2.63
Risk: Comparative	4.28	4.0	3.64	4.0	3.52	3.0	2.87	3.0	3.26	3.0	3.58	4.0	5,294	19.71**	300	0.251	7.95
Tap Water Evaluations	3.06	3.0	3.76	4.0	3.26	3.8	4.38	4.2	3.93	4.2	3.58	3.8	3,303	20.31**	309	0.240	23.61*

Table S5: Post hoc pairwise comparisons of mean differences between pairs of clusters for each independent variable. I used a Bonferroni test with 95% confidence intervals to calculate differences for each possible pair. A * beside the ∆m value indicates a significant difference at the p<0.05 level.

Variable	Pairs	∆m	Std. Err.	95% Confidence Interval	
Trust					
	Bottled & tap vs Bottled only	1.472*	0.333	0.485	2.458
	Sink filter & mixed vs Bottled only	0.528	0.424	-0.727	1.783
	Tap only vs Bottled only	2.332*	0.322	1.379	3.286
	Appliance filter only vs Bottled only	1.226*	0.304	0.326	2.127
	Mixed except sink vs Bottled only	1.028	0.361	-0.040	2.096
	Sink filter & mixed vs Bottled & tap	-0.944	0.448	-2.271	0.383
	Tap only vs Bottled & tap	0.861	0.354	-0.185	1.907
	Appliance filter only vs Bottled & tap	-0.245	0.337	-1.243	0.752
	Mixed except sink vs Bottled & tap	-0.444	0.389	-1.595	0.707
	Tap only vs Sink filter & mixed	1.805*	0.440	0.502	3.107
	Appliance filter only vs Sink filter & mixed	0.699	0.427	-0.566	1.963
	Mixed except sink vs Sink filter & mixed	0.500	0.469	-0.888	1.888
	Appliance filter only vs Tap only	-1.106*	0.326	-2.072	-0.140
	Mixed except sink vs Tap only	-1.305*	0.380	-2.428	-0.181
	Mixed except sink vs Appliance filter only	-0.199	0.364	-1.277	0.880
Risk: Cognitive Safety					
	Bottled & tap vs Bottled only	-0.630*	0.155	-1.090	-0.170
	Sink filter & mixed vs Bottled only	-0.103	0.192	-0.672	0.465
	Tap only vs Bottled only	-0.969*	0.148	-1.406	-0.532
	Appliance filter only vs Bottled only	-0.577*	0.141	-0.995	-0.159
	Mixed except sink vs Bottled only	-0.516*	0.169	-1.017	-0.016

Sink filter & mixed vs Bottled & tap	0.527	0.204	-0.078	1.132
Tap only vs Bottled & tap	-0.339	0.163	-0.822	0.145
Appliance filter only vs Bottled & tap	0.053	0.158	-0.414	0.519
Mixed except sink vs Bottled & tap	0.113	0.183	-0.428	0.655
Tap only vs Sink filter & mixed	-0.866*	0.199	-1.454	-0.278
Appliance filter only vs Sink filter & mixed	-0.474	0.194	-1.048	0.100
Mixed except sink vs Sink filter & mixed	-0.413	0.215	-1.050	0.223
Appliance filter only vs Tap only	0.392	0.150	-0.052	0.836
Mixed except sink vs Tap only	0.452	0.176	-0.070	0.975
Mixed except sink vs Appliance filter only	0.061	0.171	-0.446	0.567
Risk: Affect Safety				
Bottled & tap vs Bottled only	-0.497	0.200	-1.090	0.096
Sink filter & mixed vs Bottled only	-0.466	0.248	-1.199	0.268
Tap only vs Bottled only	-0.877*	0.190	-1.440	-0.314
Appliance filter only vs Bottled only	-0.467	0.181	-1.002	0.067
Mixed except sink vs Bottled only	-0.522	0.216	-1.161	0.118
Sink filter & mixed vs Bottled & tap	0.031	0.264	-0.751	0.814
Tap only vs Bottled & tap	-0.380	0.211	-1.005	0.245
Appliance filter only vs Bottled & tap	0.030	0.203	-0.570	0.629
Mixed except sink vs Bottled & tap	-0.025	0.235	-0.719	0.670
Tap only vs Sink filter & mixed	-0.411	0.257	-1.172	0.349
Appliance filter only vs Sink filter & mixed	-0.002	0.250	-0.741	0.737
Mixed except sink vs Sink filter & mixed	-0.056	0.277	-0.874	0.762
Appliance filter only vs Tap only	0.410	0.193	-0.161	0.980
Mixed except sink vs Tap only	0.355	0.226	-0.314	1.025
Mixed except sink vs Appliance filter only	-0.054	0.218	-0.700	0.591
Risk: Cognitive Severity				
Bottled & tap vs Bottled only	0.917*	0.241	0.204	1.630
Sink filter & mixed vs Bottled only	1.679*	0.298	0.798	2.559
Tap only vs Bottled only	1.725*	0.229	1.047	2.403
Appliance filter only vs Bottled only	1.146*	0.218	0.503	1.790
Mixed except sink vs Bottled only	1.265*	0.262	0.489	2.040
Sink filter & mixed vs Bottled & tap	0.762	0.316	-0.174	1.697
Tap only vs Bottled & tap	0.808*	0.253	0.060	1.556
Appliance filter only vs Bottled & tap	0.229	0.242	-0.488	0.946
Mixed except sink vs Bottled & tap	0.348	0.283	-0.489	1.185
Tap only vs Sink filter & mixed	0.046	0.307	-0.863	0.956
Appliance filter only vs Sink filter & mixed	-0.532	0.299	-1.417	0.352
Mixed except sink vs Sink filter & mixed	-0.414	0.333	-1.398	0.570
Appliance filter only vs Tap only	-0.579	0.231	-1.261	0.103

Mixed except sink vs Tap only	-0.460	0.273	-1.268	0.347
Mixed except sink vs Appliance filter only	0.118	0.263	-0.661	0.898
Risk: Affect Severity				
Bottled & tap vs Bottled only	0.539	0.234	-0.154	1.232
Sink filter & mixed vs Bottled only	1.223*	0.296	0.348	2.099
Tap only vs Bottled only	0.806*	0.225	0.141	1.471
Appliance filter only vs Bottled only	0.808*	0.214	0.173	1.443
Mixed except sink vs Bottled only	1.041*	0.250	0.299	1.782
Sink filter & mixed vs Bottled & tap	0.685	0.313	-0.242	1.612
Tap only vs Bottled & tap	0.267	0.247	-0.464	0.999
Appliance filter only vs Bottled & tap	0.269	0.238	-0.435	0.973
Mixed except sink vs Bottled & tap	0.502	0.271	-0.300	1.304
Tap only vs Sink filter & mixed	-0.418	0.306	-1.324	0.489
Appliance filter only vs Sink filter & mixed	-0.415	0.299	-1.300	0.469
Mixed except sink vs Sink filter & mixed	-0.183	0.326	-1.147	0.781
Appliance filter only vs Tap only	0.002	0.229	-0.674	0.679
Mixed except sink vs Tap only	0.235	0.263	-0.543	1.012
Mixed except sink vs Appliance filter only	0.233	0.254	-0.519	0.985
Comparative Risk				
Bottled & tap vs Bottled only	-0.643*	0.158	-1.110	-0.177
Sink filter & mixed vs Bottled only	-0.762*	0.195	-1.339	-0.184
Tap only vs Bottled only	-1.407*	0.150	-1.850	-0.963
Appliance filter only vs Bottled only	-1.020*	0.144	-1.446	-0.594
Mixed except sink vs Bottled only	-0.698*	0.172	-1.206	-0.190
Sink filter & mixed vs Bottled & tap	-0.118	0.208	-0.733	0.496
Tap only vs Bottled & tap	-0.763*	0.166	-1.254	-0.272
Appliance filter only vs Bottled & tap	-0.377	0.161	-0.852	0.099
Mixed except sink vs Bottled & tap	-0.055	0.186	-0.605	0.495
Tap only vs Sink filter & mixed	-0.645*	0.202	-1.242	-0.048
Appliance filter only vs Sink filter & mixed	-0.258	0.197	-0.843	0.326
Mixed except sink vs Sink filter & mixed	0.063	0.218	-0.583	0.710
Appliance filter only vs Tap only	0.387	0.153	-0.066	0.839
Mixed except sink vs Tap only	0.708*	0.179	0.178	1.239
Mixed except sink vs Appliance filter only	0.322	0.174	-0.194	0.838
Salience: Attention				
Bottled & tap vs Bottled only	-0.320	0.130	-0.705	0.065
Sink filter & mixed vs Bottled only	0.053	0.163	-0.430	0.536
Tap only vs Bottled only	-0.614*	0.125	-0.985	-0.244
Appliance filter only vs Bottled only	-0.333	0.119	-0.684	0.019
Mixed except sink vs Bottled only	-0.177	0.141	-0.594	0.240

Sink filter & mixed vs Bottled & tap	0.373	0.173	-0.140	0.885
Tap only vs Bottled & tap	-0.295	0.138	-0.703	0.113
Appliance filter only vs Bottled & tap	-0.013	0.132	-0.404	0.378
Mixed except sink vs Bottled & tap	0.143	0.152	-0.308	0.594
Tap only vs Sink filter & mixed	-0.668*	0.170	-1.169	-0.166
Appliance filter only vs Sink filter & mixed	-0.386	0.165	-0.873	0.102
Mixed except sink vs Sink filter & mixed	-0.230	0.181	-0.767	0.307
Appliance filter only vs Tap only	0.282	0.127	-0.094	0.658
Mixed except sink vs Tap only	0.438	0.148	-0.001	0.876
Mixed except sink vs Appliance filter only	0.156	0.143	-0.267	0.578
Salience: Information				
Bottled & tap vs Bottled only	-0.005	0.181	-0.540	0.530
Sink filter & mixed vs Bottled only	0.556	0.224	-0.106	1.218
Tap only vs Bottled only	0.105	0.172	-0.404	0.613
Appliance filter only vs Bottled only	-0.089	0.163	-0.572	0.394
Mixed except sink vs Bottled only	-0.054	0.195	-0.631	0.523
Sink filter & mixed vs Bottled & tap	0.561	0.238	-0.144	1.265
Tap only vs Bottled & tap	0.109	0.190	-0.454	0.672
Appliance filter only vs Bottled & tap	-0.084	0.182	-0.624	0.456
Mixed except sink vs Bottled & tap	-0.049	0.211	-0.674	0.577
Tap only vs Sink filter & mixed	-0.451	0.231	-1.136	0.233
Appliance filter only vs Sink filter & mixed	-0.645	0.225	-1.310	0.021
Mixed except sink vs Sink filter & mixed	-0.610	0.249	-1.347	0.127
Appliance filter only vs Tap only	-0.193	0.174	-0.707	0.320
Mixed except sink vs Tap only	-0.158	0.204	-0.761	0.445
Mixed except sink vs Appliance filter only	0.035	0.196	-0.546	0.616
Tap Water Evaluations				
Bottled & tap vs Bottled only	0.723*	0.149	0.281	1.165
Sink filter & mixed vs Bottled only	0.268	0.187	-0.286	0.823
Tap only vs Bottled only	1.342*	0.144	0.917	1.767
Appliance filter only vs Bottled only	0.907*	0.136	0.504	1.310
Mixed except sink vs Bottled only	0.559*	0.162	0.081	1.038
Sink filter & mixed vs Bottled & tap	-0.455	0.199	-1.042	0.133
Tap only vs Bottled & tap	0.619*	0.158	0.151	1.087
Appliance filter only vs Bottled & tap	0.184	0.151	-0.264	0.632
Mixed except sink vs Bottled & tap	-0.164	0.175	-0.681	0.353
Tap only vs Sink filter & mixed	1.074*	0.194	0.498	1.649
Appliance filter only vs Sink filter & mixed	0.638*	0.189	0.079	1.198
Mixed except sink vs Sink filter & mixed	0.291	0.208	-0.325	0.907
Appliance filter only vs Tap only	-0.435*	0.146	-0.867	-0.004

Mixed except sink vs Tap only	-0.783*	0.170	-1.285	-0.280
Mixed except sink vs Appliance filter only	-0.347	0.164	-0.832	0.137

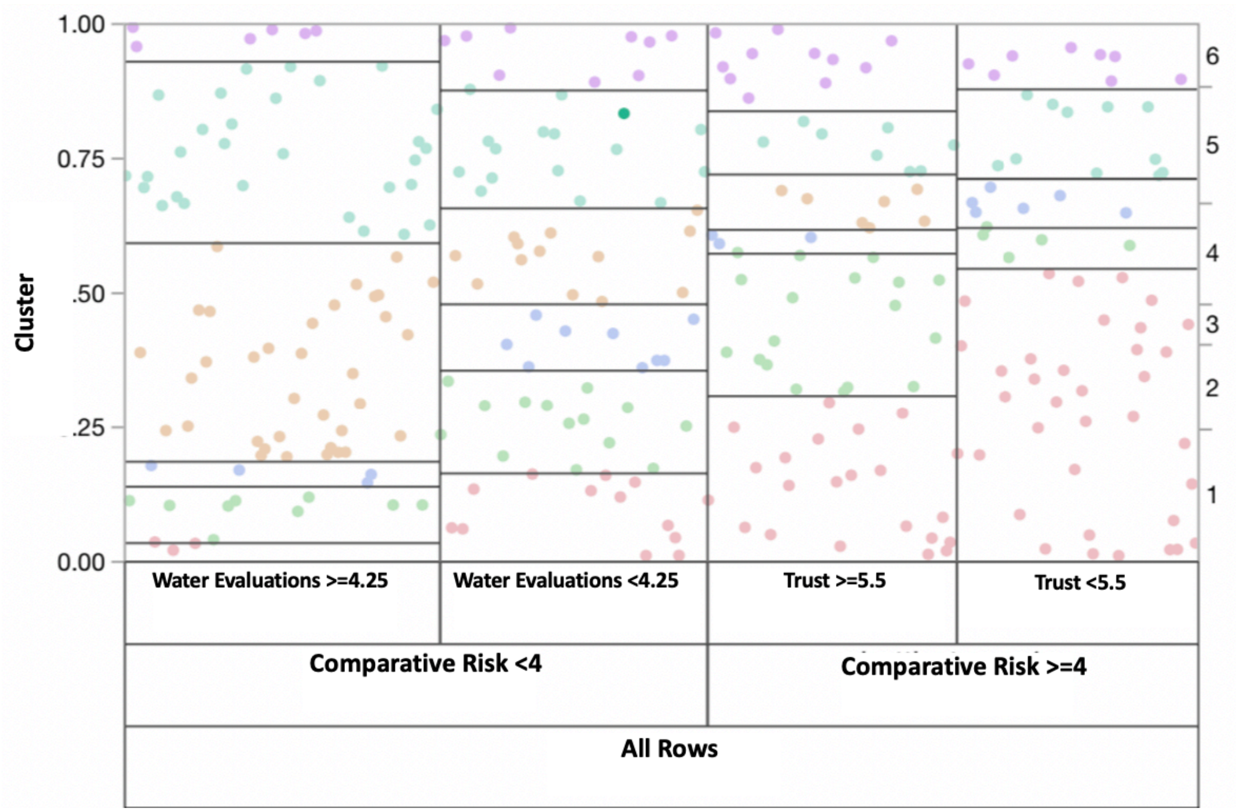


Figure S3: JMP output - The partition plot of the classification tree

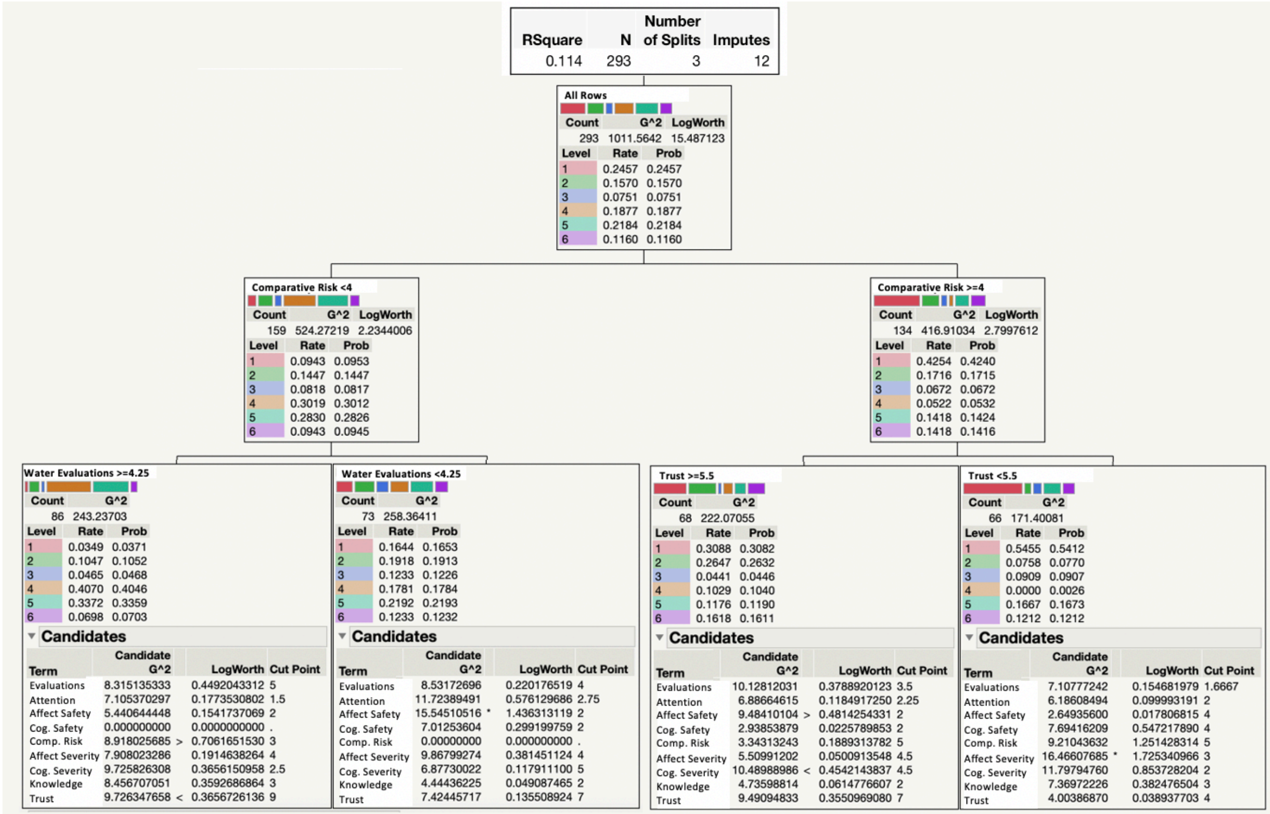


Figure S4: Full results for the classification tree diagram of how the variables of trust, risk, salience, and water quality evaluations explain classification of my sample into clusters of drinking water behavior. G^2 are analogous to sum of squares in a regression and LogWorth values are negative log p values

Term	Number of Splits	G^2	Portion
bottlevtap	1	70.8210712	0.6054
otrust	1	23.3756372	0.1998
wateval	1	22.7934856	0.1948
salaimpct	0	0	0.0000
rconcern	0	0	0.0000
saldimpct	0	0	0.0000
salatten	0	0	0.0000
rsafe	0	0	0.0000
info	0	0	0.0000

Figure S5: JMP output – column contribution table displaying the portion of discrepancy in the model for each variable

Cross-validation			
k-fold		-2LogLike	RSquare
5	Folded	938.526914	0.0722
	Overall	895.072489	0.1142

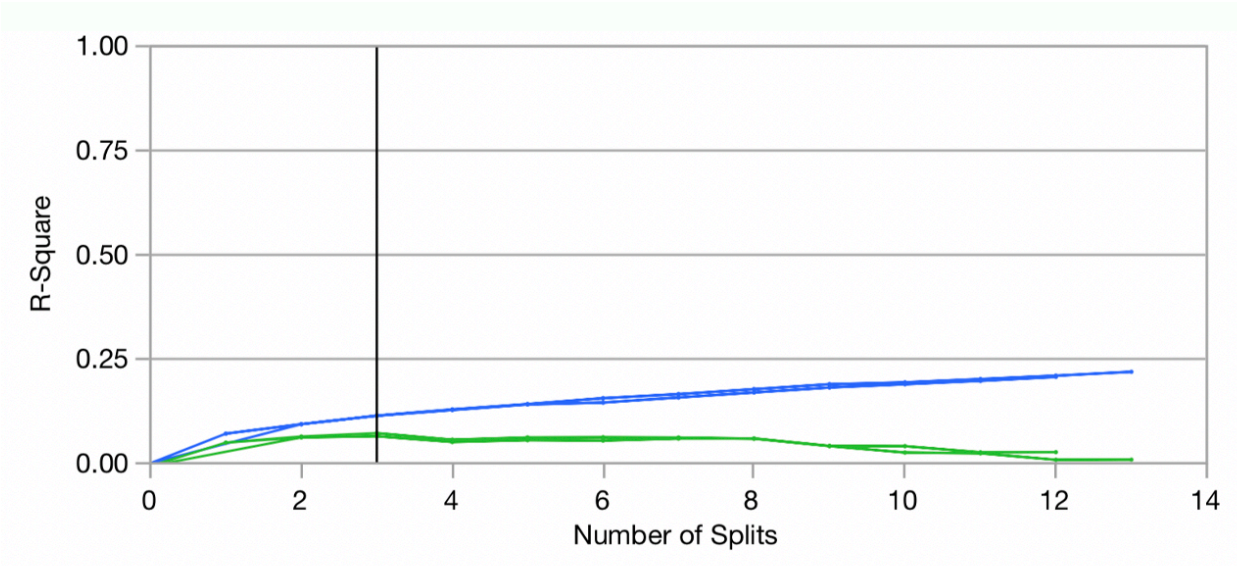


Figure S6: JMP cross validation output. The blue line represents blue line is r squared for data the model was trained on, green line is points that were held out to do validation

Measure	Training	Definition
Entropy RSquare	0.1136	1-Loglike(model)/Loglike(0)
Generalized RSquare	0.3351	(1-(L(0)/L(model))^(2/n))/(1-L(0)^(2/n))
Mean -Log p	1.5301	∑ -Log(ρ[j])/n
RASE	0.7562	√ ∑(y[j]-ρ[j])²/n
Mean Abs Dev	0.7428	∑ |y[j]-ρ[j]|/n
Misclassification Rate	0.6314	∑ (ρ[j]≠ρMax)/n
N	293	n

Figure S7: JMP Fit details output for the classification tree

Appendix D. Survey Materials

Cover Letter

Dear [First Name],

Thank you for agreeing to help me with this research study about how residents like you think about your drinking water here in the greater Roanoke area. People in the area have a wide range of opinions on the water that comes out of their faucets. Each of these viewpoints is valuable to my project and I'd like to hear what you have to say. I obtained your address from the records of people who drink city water in the Roanoke Area. I hope that, as a resident here, you will consider helping me out by sharing your perceptions.

I've designed a questionnaire that takes about 10 to 15 minutes to complete. You can complete the survey at your own convenience, can skip any question you prefer not to answer, and you may withdraw from the study at any time. The questionnaire has a unique identification number to protect your confidentiality. There are no known risks associated with this project and your participation is completely voluntary.

By sharing your opinions, you will help us and your community identify the factors that influence trust in institutions that supply drinking water, and this can ultimately help us better understand how residents like you think about water resources in the Roanoke Valley.

Please fill out the attached questionnaire as best you can. A member from our research team at Virginia Tech will return to your address to pick up the survey in the next day or two. You don't need to be around when we come back—feel free to use the attached bag to hang the survey from your doorknob for a member from our team to pick up. If you prefer not to participate, please call, email, or leave a blank questionnaire hanging from your doorknob instead and we will remove your name from our list.

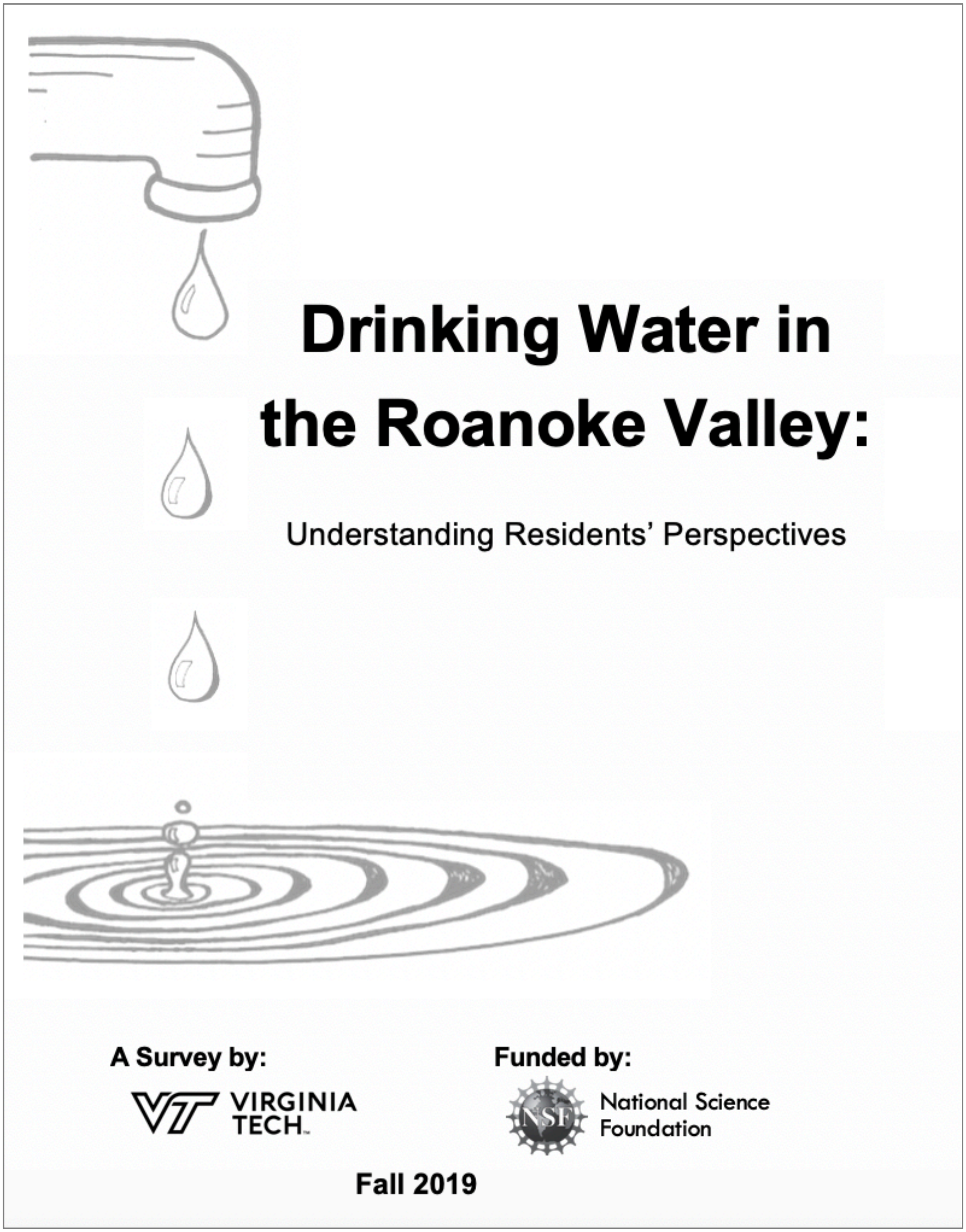
If you have any questions about this project, feel free to contact me, Madeline Grupper, at maddyag@vt.edu or (201) 749-1744 at any time. You may also be in touch with my advisor, Michael Sorice at (540) 231-8303 or msorice@vt.edu. Finally, this research has been reviewed and approved by the Virginia Tech Institutional Review Board (IRB). You may communicate with them at (540) 231-3732 or irb@vt.edu if: you have questions about your rights as a research subject, your questions or concerns are not being answered by the research team, you cannot reach the research team, or you want to talk to someone beside the research team.

Thank you for your time and help.

Sincerely,

Madeline Grupper
Graduate Student – Virginia Tech
Forest Resources and Environmental Conservation

Full Survey



Drinking Water in the Roanoke Valley:

Understanding Residents' Perspectives

A Survey by:

VIRGINIA TECH

Funded by:

National Science Foundation

Fall 2019

We're interested in your perceptions of your tap water in the Roanoke Valley. This is part of a project that will help us understand how people think about their drinking water and suggest how water quality can be improved.

TAP WATER is the plain water that comes directly out of your sink's faucet. You may alter your tap water before you drink it by using a filter. That's okay. However, when we ask about tap water, we are referring to your water before it is filtered.

Tap water in your HOME

This survey asks about the water you drink when you are at home—where you reside. If you live in more than one location, please answer based on the address where you received this survey. Please do not consider drinking water conditions at work or at other people's homes.

If you have any questions or concerns, please contact project director Madeline Grupper at maddyag@vt.edu or (540) 231-8303, or Mike Sorice at the same phone number or msorice@vt.edu.

Thank you for your help!

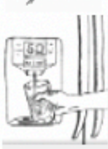
Begin Survey →

SECTION A: WE INVITE YOU TO TELL US ABOUT THE WATER YOU DRINK.

1. In a typical day, how many times do you drink a glass or bottle of water (8 to 12 ounces)?
In your estimate include plain tap water, filtered tap water, water from a drinking fountain, water from a water cooler, bottled water, and spring water.

- ❑ Never (0 times)
- ❑ 1 time per day
- ❑ 2 times per day
- ❑ 3 times per day
- ❑ 4 times per day
- ❑ 5 or more times per day

2. Over the past six months, about how often did you drink water from the following sources in your home?

		Water source:	Never or Almost never	Less than half of the time	About half of the time	More than half of the time	All the time or Almost all the time
		Bottled water	❑	❑	❑	❑	❑
		Filtered water from a sink attachment	❑	❑	❑	❑	❑
		Filtered water from an appliance	❑	❑	❑	❑	❑
		Tap water (straight from your faucet)	❑	❑	❑	❑	❑

3. In a typical day, how many times do you drink sweetened drinks like sodas, fruit drinks, sports or energy drinks, or other sugar-sweetened drinks?

- ❑ Never (0 times)
- ❑ 1 time per day
- ❑ 2 times per day
- ❑ 3 times per day
- ❑ 4 times per day
- ❑ 5 or more times per day

SECTION B: PLEASE TELL US ABOUT THE QUALITY OF TAP WATER IN YOUR HOME.

The questions below ask for your opinions of the water that comes directly out of your faucet (tap water). If you filter your tap water before drinking it, please provide your opinion on the water before it is filtered.

4. How acceptable do you typically feel your home's tap water is for drinking in terms of the following characteristics?

	Not acceptable	Slightly acceptable	Moderately acceptable	Very acceptable	Extremely acceptable
Safety	❑	❑	❑	❑	❑
Taste................................	❑	❑	❑	❑	❑
Appearance (color or clarity)................	❑	❑	❑	❑	❑
Smell................................	❑	❑	❑	❑	❑

5. Characteristics of tap water quality can vary over time. Some people find that variation acceptable while others do not. In the past six months, how often did you notice unacceptable changes in the smell, appearance, or taste of tap water in your home?

I noticed *unacceptable* changes in my tap water's:	Never	Rarely	Sometimes	Often	Extremely often
Smell................................	❑	❑	❑	❑	❑
Appearance	❑	❑	❑	❑	❑
Taste................................	❑	❑	❑	❑	❑

6. Overall, how would you evaluate the quality of the tap water in your home? Would you say it is:

- ❑ Very poor
- ❑ Poor
- ❑ Fair
- ❑ Good
- ❑ Very good

7. How frequently do you notice changes in the quality of water coming from your tap?

- ❑ I never, or almost never, notice changes in quality
- ❑ I rarely notice changes in quality
- ❑ I sometimes notice changes in quality
- ❑ I often notice changes in quality

8. How concerned do you feel about the current quality of your tap water?

- ❑ Not concerned
- ❑ Slightly concerned
- ❑ Moderately concerned
- ❑ Very concerned
- ❑ Extremely concerned

9. Drinking my home's tap water directly from the faucet…

- ❑ is completely unsafe for me
- ❑ is somewhat unsafe for me
- ❑ is somewhat safe for me
- ❑ is completely safe for me

10. Drinking bottled water is __________________ safe than drinking the tap water in my home.

- ❑ much less
- ❑ somewhat less
- ❑ neither more nor less
- ❑ somewhat more
- ❑ much more

11. If a friend or family member asked you about the water quality in your neighborhood, about how much information do you think you'd be able to give them?

- ❑ No information
- ❑ A little information
- ❑ A moderate amount of information
- ❑ A lot of information
- ❑ A great deal of information

12. If tomorrow, for some reason, you were unable to use the water from your tap for drinking, how would that impact you?

If tomorrow I could not drink water from my tap, it would:	Not at all	A little bit	A moderate amount	A lot	A great deal
inconvenience me	❑	❑	❑	❑	❑
worry me.................................	❑	❑	❑	❑	❑
anger me	❑	❑	❑	❑	❑
change my daily routine	❑	❑	❑	❑	❑

13. How familiar are you with what your local water utility does to provide tap water to your home? By water utility we mean the organization in charge of treating and delivering water to your home.

- ❑ Not familiar
- ❑ Slightly familiar
- ❑ Moderately familiar
- ❑ Very familiar
- ❑ Extremely familiar

SECTION C: PLEASE TELL US YOUR THOUGHTS ON YOUR LOCAL WATER UTILITY.

Based on your address, your local water utility is the *Western Virginia Water Authority* **in** *Roanoke, VA*. **Please answer the following questions about them.**

14. To what extent do you *trust* your local water utility to provide drinking water to your home that is safe to drink?

Don't trust at all		Slightly trust		Moderately trust		Mostly trust		Completely trust
❑	❑	❑	❑	❑	❑	❑	❑	❑

15. To what extent are you *comfortable* with your local water utility controlling the quality of water delivered to your home?

Not comfortable at all		Slightly comfortable		Moderately comfortable		Mostly comfortable		Completely comfortable
❑	❑	❑	❑	❑	❑	❑	❑	❑

The following questions ask you about your opinions on your water utility, *Western Virginia Water Authority*. We understand that you might not have strong feelings on all of these statements, but please share your impressions with us to the best of your ability.

16. Please indicate the degree to which you think the following statements about your local water utility are true or not.

My local water utility:	Definitely not true	Probably not true	Probably true	Definitely true	Unsure
is required to obey laws that ensure they distribute safe water	❑	❑	❑	❑	❑
is required to listen to public input......	❑	❑	❑	❑	❑
would face consequences from the government if they failed to distribute safe water..	❑	❑	❑	❑	❑
has procedures in place to resolve any problem I might bring to their attention	❑	❑	❑	❑	❑

17. Please indicate the degree to which you agree or disagree with the following statements about your local water utility.

My local water utility:	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Neutral
cares about the quality of my drinking water at least as much as I do	❑	❑	❑	❑	❑	❑	❑
is capable of delivering safe drinking water to me	❑	❑	❑	❑	❑	❑	❑
has my best interests at heart ...	❑	❑	❑	❑	❑	❑	❑
shares values similar to mine.....	❑	❑	❑	❑	❑	❑	❑
has consistently delivered safe drinking water to me..................	❑	❑	❑	❑	❑	❑	❑
will consistently meet my drinking water expectations	❑	❑	❑	❑	❑	❑	❑
cares about my well-being	❑	❑	❑	❑	❑	❑	❑
is highly skilled at delivering safe drinking water to my home	❑	❑	❑	❑	❑	❑	❑

SECTION D: PLEASE TELL US A LITTLE MORE ABOUT YOURSELF.

In this section, we ask you to reflect on some aspects of your life in general. Your willingness to share this information can help us understand the scope and trends of people's opinions about drinking water throughout the Roanoke Valley.

18. In general, how satisfied are you with your life?

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Satisfied
- ☐ Very satisfied

19. In general, would you say your health is:

- ☐ Poor
- ☐ Fair
- ☐ Good
- ☐ Very good
- ☐ Excellent

20. Please indicate the degree to which you agree or disagree with the following statements about people in general.

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Neutral
I find it hard to trust others......	☐	☐	☐	☐	☐	☐	☐
Most people are basically honest	☐	☐	☐	☐	☐	☐	☐
You can't be too careful when dealing with others	☐	☐	☐	☐	☐	☐	☐
I generally trust others...........	☐	☐	☐	☐	☐	☐	☐

21. In total, how many years have you lived in the Roanoke Area?

__________ years

22. In what year did you move to your current residence?

Year: ___ ___ ___ ___

23. Are you:

- ❑ Male
- ❑ Female
- ❑ Other *(please specify)* ____________________

24. What is your current employment status?

- ❑ Unemployed
- ❑ Employed – Full Time
- ❑ Employed – Part Time
- ❑ Student
- ❑ Employed – Temporary
- ❑ Other (*please specify*) ____

25. What year were you born?

Year: __ __ __ __

26. What is your race? *Check all that apply.*

- ❑ African American/Black
- ❑ Asian, including Japanese, Chinese, Vietnamese, Asian Indian, Filipino, Vietnamese, Korean
- ❑ Pacific Islander, Native Hawaiian, Guamanian or Chamorro, Samoan
- ❑ Native American or Alaskan Native
- ❑ Caucasian/White
- ❑ Other *(please specify)* ____________________

27. Are you of Hispanic, Latino, or Spanish origin?

- ❑ No, not Spanish, Hispanic, or Latino
- ❑ Yes, Mexican, Mexican American, or Chicano
- ❑ Yes, Cuban
- ❑ Yes, Puerto Rican
- ❑ Yes, other Hispanic, Latino, or Spanish group (*please specify*): _____________________

28. What is the highest level of formal education you've completed?

- ❑ Some high school or less
- ❑ High school diploma or GED
- ❑ Some college
- ❑ Trade school, Associates, or two year degree
- ❑ Bachelors degree
- ❑ Some graduate schooling
- ❑ Masters degree
- ❑ Doctorate degree or Professional degree (Ex: PhD, EdD, MD, DDS, LLB)

29. What was your approximate total income for your household in 2018 (before taxes)?

- ❑ <$15,000
- ❑ $15,000 - $24,999
- ❑ $25,000 - $34,999
- ❑ $35,000 – $44,999
- ❑ $45,000 - $54,999
- ❑ $55,000 - $74,999
- ❑ $75,000 - $99,999
- ❑ $100,000 – $200,000
- ❑ > $200,000

30. Including yourself, what is the size of your family living in your household? Include non-married partners and foster children. Do not include unrelated people (e.g., roommates).

Number of family members in your household over the age of 18 __________

Number of family members in your household under the age of 18 __________

Is there anything else you would like to share with us about your water quality or drinking water habits?

We really appreciate the time and effort you have put into helping this study.

Please seal your completed survey in its envelope and hang it in its bag from your doorknob. We'll come back to pick it up in a day or two.

Thank You

Vignettes

SCC CONTROL
SECTION C: Tell us your thoughts on your local water utility.

Based on your address, your local water utility is the *Western Virginia Water Authority* **in** *Roanoke, VA*. **Please read the short description about them and then answer the questions that follow.**

14. **In the past 12 months, do you remember hearing about any specific technology that the WVWA uses to treat their water?**

    ❑ No
    ❑ Yes
    ↳If Yes, then please write which specific technology you've heard of:

    ____

15. **To what extent do you *trust* your local water utility to provide drinking water to your home that is safe to drink?**

Don't trust at all		Slightly trust		Moderately trust		Mostly trust		Completely trust
❑	❑	❑	❑	❑	❑	❑	❑	❑

16. **To what extent are you *comfortable* with your local water utility controlling the quality of water delivered to your home?**

Not comfortable at all		Slightly comfortable		Moderately comfortable		Mostly comfortable		Completely comfortable
❑	❑	❑	❑	❑	❑	❑	❑	❑

SCC TECHNOLOGY VIGNETTE
SECTION C: Please tell us your thoughts on your local water utility.

Based on your address, your local water utility is the *Western Virginia Water Authority* **in** *Roanoke, VA***. Please read the short description about them and then answer the questions that follow.**

The Western Virginia Water Authority is in charge of providing clean and safe drinking water to the residents in the Roanoke Valley. Their process involves treating water from reservoirs and then delivering the drinking water to your home.

Changes in the environment can cause problems for these reservoirs that lead to algae growing out of control. It can also increase metal concentrations. These can all cause taste, color, and odor changes in the drinking water.

The Western Virginia Water Authority is using ***newly developed technology*** to help them predict changes in reservoir water. This system uses water quality sensors and ***computer forecasting*** to alert the water authority when conditions will change in the future. This is intended to allow the water authority to cope with changes early on by adding additional treatments, or by obtaining water from other reservoirs.

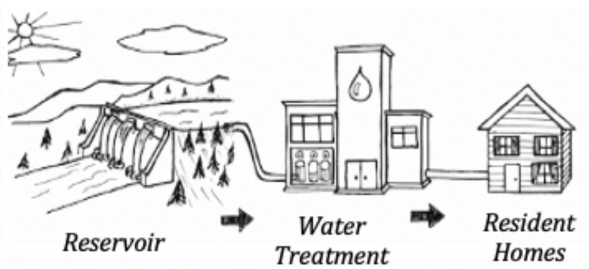
The goal of this technology is to help managers detect and respond to changes in reservoirs ***more quickly*** and deliver safe drinking water to your home.

14. Have you heard of this technology before?
- ❑ Yes
- ❑ No

SCC INFORMATION VIGNETTE
SECTION C: Please tell us your thoughts on your local water utility.

Based on your address, your local water utility is the *Western Virginia Water Authority* **in** *Roanoke, VA*. **Please read the short description about them and then answer the questions that follow.**

The Western Virginia Water Authority is in charge of providing clean and safe drinking water to the residents in the Roanoke Valley. Their process involves treating water from reservoirs and then delivering the drinking water to your home.



Changes in the environment can cause problems for these reservoirs that lead to algae growing out of control. It can also increase metal concentrations. These can all cause taste, color, and odor changes in the drinking water.

Your water authority is using five surface reservoirs and one spring to ***store water*** until it is ready to be treated for drinking. This system uses pipes to ***distribute*** water to customers' homes. This is intended to allow the water authority to maintain and distribute water throughout their utility operation.

The goal of this system is to help managers ***deliver*** safe drinking water to your home.

14. Have you heard of the water treatment system before?

- ❑ Yes
- ❑ No

Appendix E. Distribution Method and Materials

Study design (as explained in Virginia Tech's Institutional Review Board proposal)

The procedure study design is a self-administered drop off/pick up survey given to a randomly selected sample of residents who are customers of the Western Virginia Water Authority and receive water treated in Carvins Cove or Spring Hollow reservoirs. The drop off/pick up procedure is based off of recommendations from Dillman et al. (2014). The survey itself will be a factorial survey experiment with a three group between subjects design.

Residents will be randomly selected from the pool of eligible subjects. Residents will be informed about the survey through a modified proceedure based off of Dillman's (2014) recommendations for survey research. Residents will be contacted at the mailing address listed for them in the public records obtained from the Western Virginia Water Authority's list of customers. Addresses are a part of public property records. If addresses belong to homeowners of record whose names a part of public property records, those names will also be used for research communications.

An introduction letter will be sent to the resudent's address approxomately one week prior to in person researcher contact. The introductory letter will tell the subject to expect a visit from Virginia Tech researchers in the following week.

Researchers will then visit the selected residents to introduce the project, the purpose of the survey, and to invite them to participate. The resident will be free to choose whether or not they want to participate and surveys will not be left with them if they decide against participation. Surveys and cover letters (containing informed consent) will be left with willing residents. Researchers contact information will be included in the cover letter should the participants have any questions about the survey or the project. Residents will be informed that the survey will take 15-20 minutes to complete. If a resident agrees to participate, they will be informed of a date when researchers will return to pick up the survey. They will also be told that they can seal their completed survey in a bag and hang it from their doorknob on that date for ease of pick up. If a resident is away from home when researchers visit, surveys, cover letters, and a note explainging the pick up date will be hung on the doorknob in plastic bags.

Following the Dillman method, researchers will visit participating residents multiple times to elicit a higher response rate. Researchers will visit each resident a second time approximately two days after initial visits to pick up the survey or to remind participants to complete it if they have not already done so. On this second visit, a replacement survey will be given to the participant if they lost the first. Returning a completed survey will indicate the respondent's implied consent to participate in this research.

Researchers will visit participants a third and final time approximately two days after the second visit to pick up completed surveys or remind participants to finish uncompleted surveys. Researchers will provide participants with another replacement survey if needed and a pre-paid return envelope, so participants can mail the survey back to researchers at their convinience. If at any point a resident expresses the desire to be removed from the study, either verbally, by email, or by phone, those wishes will be respected and the resident will not be contacted further. Additionally, participants who returned a completed survey would not be visited again.

Introduction note

Dear First name (if name is not publically available, write "Hello" as a greeting instead),

I am a student at Virginia Tech writing to let you know about a research study I'm conducting in the Roanoke Valley area. My team and I are going door-to-door asking residents like you for your opinions on the quality of your city or town's local drinking water. People in the area have wide ranging opinions on their drinking water. Each of these viewpoints is valuable to our project and we'd like to hear from you on the topic.

We are writing in advance of our visit because many people like to know ahead of time that they will be contacted. We will be in your area in the next week or so. When one of my team members stops by, they will explain more about the project and will invite you to participate. This should only take five minutes. If they happen to stop by at an inconvenient time, please let them know and they will return later.

You are one of only 800 people in the Roanoke Valley invited to participate. Your help in our effort to understand how people in the area think about their tap water is essential to the study's success. Your input will be a valuable resource to understanding water use in the Roanoke Valley.

Within the next week or so, myself or a member of my research team will be knocking on your door to tell you more about this study and to see if you'd be interested in participating. If you have any questions, please don't hesitate to ask. You may contact me either by phone, (201) 794-1744 or email, maddyag@vt.edu. You may also contact my graduate advisor, Michael Sorice, at (540)231-8303 or msorice @vt.edu.

Thank you in advance for your time and help.

Sincerely,

Madeline Grupper
Graduate Student – Virginia Tech
Forest Resources and Environmental Conservation

This research study has been reviewed and approved by the Virginia Tech Institutional Review Board. You may communicate with them at 540-231-3732 or irb@vt.edu if you cannot reach the research team, you have questions about your rights, your questions or concerns are not being answered by the research team, or you want to talk to someone besides the research team.

Script

First Visit:

Hello, My name is _________. I am a student at Virginia Tech.

If name was available in public records, add the following:
Is Mr/Ms. [insert first and last name] home? I had sent them a letter saying I'd be around to talk about a research study I'm working on at Virginia Tech.

When person arrives at front door
Hi Mr/Ms. [Last name]. My name is _________ and I'm a student at Virginia Tech.

If name was not available in public records, skip to this part

About a week ago, my research team sent you a letter about a project of we're doing at Virginia Tech that has to do with your drinking water quality. It mentioned that someone from our research team would stop by to talk to you about the project.

We are doing a survey collecting opinions from local residents like you about your views on tap water quality in your home. At this point, I'm here to tell you about the project, what's involved, and see if you'd be interested in helping us out. Would you have a few minutes for that?

If yes
Thank you. We're focusing on adult's opinions of their water. Are you over the age of 18?

If no
Is there anyone else here who lives in this household who is 18 or older?
When person arrives at door, start from the beginning

If yes
As we mentioned in the letter, we obtained your address from the records of people who drink city water in the Roanoke Area. We're interested in the ways people think about their tap water here in the Roanoke Valley.

People in the area have wide ranging opinions on the water that comes out of their faucets: from strong positive and negative opinions to not much of an opinion at all. Each of these viewpoints is valuable to our project and we'd like to hear from you on the topic.

We'd really appreciate your participation in our survey.

It *gesture to the survey* should take 10 to 15 minutes to complete. It will ask you questions about your opinions on your drinking water and experiences with water in your home. If you are interested, I can leave it with you for you to complete in your own time. We return to neighborhoods periodically to pick up completed surveys. I think we'll be back in this area on [insert day of week that is 1-2 days later than today]. Most people put their finished survey in this bag and leave it on their front doorknob so they don't have to be around when we come by.

We're hoping the results of this study will be useful to community members, local policy makers, and water researchers. Your participation is essential to the success of this study and can ultimately help us better understand your drinking water here in Western Virginia.

Would you be interested in helping us out on this project?

If participant does not agree

That's perfectly fine. Thank you for your time. I hope you have a good rest of your evening.

If participant agrees

Great, thank you! I'll leave this packet with you. It has an introduction letter that has more detail about the project and the process, so please be sure to look that over. Again, it should take 10 to 15 minutes. Just fill it out to the best of your ability and myself or someone else from the research team will return to your house to pick it up. Would it be too early if I came back tomorrow? I can come on [Day of the Week] between [Hour pm] and [Hour pm] (two hour block) to pick it up. Again, feel free to hang the survey in its envelope in this bag on your door so you don't have to be around when we come back. Do you have any questions?

Answer any questions they might have

If you think of any other questions, feel free to email or call Madeline Grupper—she's the graduate student who's leading the survey effort. You can find her contact information on the first page of the survey

<u>Second Visit</u> – if survey is not hanging from the door:

Hi, you might remember me. My name is __________. I dropped off a survey with you ________ days ago for a research project Virginia Tech is doing on people's perceptions of drinking water. I mentioned that we'd be back in the neighborhood today to pick up surveys. Have you had the chance to fill it out?

If yes

Great, were you able to fill out all the survey questions okay? Did you have any questions for me?

**If yes, look at the question and try to clarify the question. Do not hint at an answer. **

If no

That's fine, we'd be happy to come back another day if you'd like more time to complete it. Would you be able to finish it if we came back in 2 days on [insert weekday]? It's no problem for us to return. We'll be in the area then as well. We're in the Roanoke area on a pretty daily basis for the next week or so.

Try to accommodate their schedule.

Do you still have the survey I gave you? I can give you a replacement one just in case, if you're not sure. *[Write ID on the back of the survey!]* You can seal the survey in this *gesture* envelope and leave it in this *gesture* bag on the doorknob for us to pick it up.

Thank you for your time. I hope you have a good evening.

If they no longer wish to participate

That's perfectly fine. I just want to be sure because we getting some interesting responses and your input would be really helpful to ensure we get an idea of the variety of opinions here in [County Name] County. Your responses are, of course, completely confidential, and your participation would be hugely beneficial to this study and can ultimately help us better our understanding of water resources in Western Virginia. Have a good day.

<u>Third Visit:</u>

Hi, you might remember me or someone else on my research team. My name is __________. One of us/I came by ________ days ago to pick up a survey for a research project Virginia Tech is doing on people's perceptions of drinking water. We told you we'd be by to pick it up today. Have you had the chance to fill it out?

If yes

Great, were you able to fill out all the questions okay? Do you have any questions for me?

**If yes, look at the question and try to clarify the question. Do not hint at an answer. **

If no

That's fine, we can give you more time to complete it if you'd like. I brought you another spare survey if you need it. Our study is winding down and this will be our last visit to your neighborhood. But here is a return envelope. You can finish the survey at your own convenience and when you're done, just put it in the envelope and send it in the mail to us. The postage is already paid for, so you don't have to worry about that. Does that make sense?

Thank you for your time. I hope you have a good evening.

If they no longer wish to participate

That's perfectly fine. Your input is really important so that we can get an idea of the variety of opinions here in [Insert County Name]. Your responses would be completely confidential, and your participation would be hugely beneficial to this study and can ultimately help us better our understanding of water resources in Western Virginia.

No-contact notes

VIRGINIA TECH. College of Natural Resources and Environment

Madeline Grupper
310 W. Campus Drive
Blacksburg, VA 24061
((540)-231-8303; maddyag@vt.edu

First Visit, No Contact Note

«fname» «mname» «lname»«suffix» ID: «surveyid»
«address1»
«address2»
«city», «state» «zip»

Dear «salutation»,

Sorry we missed you!

My name is Madeline Grupper. I am a graduate student at Virginia Tech. You might remember getting a letter from my research team about a week ago about a project of we're doing at that has to do with your drinking water quality. My research team stopped by here today to try to tell you more about the project and see if you'd be interested in helping us out, but you weren't home. We're hoping you would still consider participating in our study.

We are doing a survey collecting opinions from local residents like you about your views on tap water quality in your home. People in the area have a wide range of opinions about their tap water, from strong positive and negative to not much of an opinion at all. Each of these viewpoints is valuable to our study. We're hoping our results will be useful to your community, policy makers, and water researchers.

We'd really appreciate your participation in our survey. It will ask you questions about your opinions and experiences with drinking water in your home. I left the survey in this packet for you to complete in your own time. It should only take 10 to 15 minutes. A return envelope is also in the packet. When you finish the survey, just fold in in half, put it in the envelope, and send it in the mail to us. The postage is already paid for and the address is written in, so you don't have to worry about that.

There is also an introduction letter that has more details about the project and process. If you have any questions, feel free to email me. You can find my contact information on the first page of the survey. Your participation is essential to the success of this study and can help us better understand your drinking water here in Western Virginia.

Thank you in advance for your time and help.

Sincerely,

Maddy Grupper

Madeline Grupper, Project Director
Graduate Research Assistant
Virginia Tech

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An equal opportunity, affirmative action institution

VIRGINIA TECH. *College of* Natural Resources and Environment

Madeline Grupper
310 W. Campus Drive
Blacksburg, VA 24061
((540)-231-8303; maddyag@vt.edu

Second or Third Visit, No Contact Note

«fname» «mname» «lname»«suffix» ID: «surveyid»
«address1»
«address2»
«city», «state» «zip»

Dear «salutation»,

Sorry we missed you!

My name is Madeline Grupper. I am a graduate student at Virginia Tech. My research team dropped a survey off with you or a member of your household a few days ago for you to complete for a research project we are doing about your perceptions of your drinking water quality. We stopped by today to pick up the survey, but you weren't home. Our study is winding down and this will be our last visit to your neighborhood, but we're hoping you could still return the survey to us.

In this packet you'll find a return envelope. The postage is already paid for and the address is written in. You will also find a copy of the survey that you can use. You can finish the survey at your own convenience and when you're done, just fold it in half, put it in the envelope and send it in the mail to us.

Your input is really important so that we can get an idea of the variety of opinions here in the Roanoke area. Your responses are completely confidential. Your participation is valuable to this study and can ultimately help us better our understanding of water resources in Western Virginia. If you have any questions, feel free to email me. You can find my contact information on the first page of the survey.

Thank you in advance for your time and help.

Sincerely,

Maddy Grupper

Madeline Grupper, Project Director
Graduate Research Assistant
Virginia Tech

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An equal opportunity, affirmative action institution


Sorry we missed you!!
We will return on:
VIRGINIA TECH
DRINKING WATER IN THE ROANOKE VALLEY

Notice of Virginia Tech IRB Approval

VIRGINIA TECH.

Division of Scholarly Integrity and
Research Compliance
Institutional Review Board
North End Center, Suite 4120 (MC 0497)
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-3732
irb@vt.edu
http://www.research.vt.edu/sirc/hrpp

MEMORANDUM

DATE: October 8, 2019

TO: Michael G Sorice, Madeline A Grupper

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)

PROTOCOL TITLE: Social Trust in Emerging Water Forecasting Technology

IRB NUMBER: **19-023**

Effective October 8, 2019, the Virginia Tech Human Research Protection Program (HRPP) and Institutional Review Board (IRB) determined that this protocol meets the criteria for exemption from IRB review under 45 CFR 46.104(d) category(ies) 2(ii).

Ongoing IRB review and approval by this organization is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities impact the exempt determination, please submit a new request to the IRB for a determination.

This exempt determination does not apply to any collaborating institution(s). The Virginia Tech HRPP and IRB cannot provide an exemption that overrides the jurisdiction of a local IRB or other institutional mechanism for determining exemptions.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

https://secure.research.vt.edu/external/irb/responsibilities.htm

(Please review responsibilities before beginning your research.)

PROTOCOL INFORMATION:

Determined As: **Exempt, under 45 CFR 46.104(d) category(ies) 2(ii)**
Protocol Determination Date: **July 12, 2019**

ASSOCIATED FUNDING:

The table on the following page indicates whether grant proposals are related to this protocol, and which of the listed proposals, if any, have been compared to this protocol, if required.

Invent the Future

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SPECIAL INSTRUCTIONS:

This amendment, submitted October 4, 2019, changes the research protocol by rewording information regarding procedures to be followed if a resident is away from home when researchers visit on the promised date to pick up a survey in section 8.3. Recruitment materials were also changed by adding new materials titled "No Contact, Next Attempt Date Note".

Date*	OSP Number	Sponsor	Grant Comparison Conducted?
05/14/2019	PMOXHDS-N	National Science Foundation (Title: SCC-IRG Track 2: Resilient water systems: Integrating environmental sensor networks and real-time forecasting to adaptively manage drinking water quality and build social trust)	Not required (Exempt approval)

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this protocol is to cover any other grant proposals, please contact the HRPP office (irb@vt.edu) immediately.