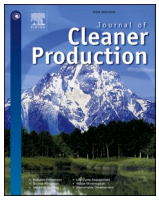
Journal of Cleaner Production 429 (2023) 139587

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro



Public tap water perceptions and potable reuse acceptance: A cognitive dissonance theoretical understanding

Jesse L. Barnes [a,*], Anjala S. Krishen [b], Han-fen Hu [c]

[a] Department of Political Science at the University of Nevada, Reno, 1664 N. Virginia St., Reno, NV, 89557, USA
[b] Department Chair of Marketing in the Lee Business School at the University of Nevada Las Vegas, 4505 Maryland Parkway, Las Vegas, NV, 89154, USA
[c] Department of Management, Entrepreneurship, and Technology in the Lee Business School, University of Nevada, Las Vegas, 4505 S. Maryland Parkway, Las Vegas, NV, 89154-4030, USA

ARTICLE INFO

Handling Editor: Pai Zheng

Keywords:
Potable wastewater reuse
De facto reuse perceptions
Consumer trust
Tap water
Cognitive dissonance theory
Prosocial consumer behavior

ABSTRACT

Water scarcity is a pressing issue caused by many factors, including urban water demand, poor wastewater management, and climate change. To address this growing issue, wastewater recycling for potable use is encouraged worldwide. Planned potable reuse (PPR) involves reusing treated wastewater intentionally as a drinking water source. PPR promotes a circular water economy and reduces local water shortages. However, public acceptance of PPR remains low due to the psychological disgust associated with consuming treated wastewater, known as the yuck factor. Traditional educational marketing campaigns have been ineffective in increasing PPR acceptance, necessitating further investigation into other approaches to do so. This study analyzes whether consumers' perceptions about their current tap water significantly links to their attitudes toward PPR. Guided by the cognitive dissonance theoretical framework, our study examines if public tap water customers who (1) already believe their drinking water contains treated wastewater (de facto reuse) and (2) trust their public water suppliers (PWS) are more likely to accept PPR. Two separate survey-based studies were conducted in 2019 and 2020 on adult public water consumers in the US. Statistical analyses reveal that those participants who believe their tap water contains de facto reuse water, have high trust in their PWS, or primarily consume tap water (behavioral trust) demonstrate greater acceptance of PPR. Additionally, our results suggest that acceptance toward PPR increased after the COVID pandemic, but this effect is moderated by gender. Overall, our study results indicate that addressing cognitive dissonance in consumer attitudes toward PPR may lead to more sustainable solutions for water management in the US. Further research should explore the interplay between de facto reuse beliefs, trust, and PPR acceptance, to enable the development of effective prosocial marketing strategies that can overcome the yuck factor and ultimately promote wider consumer acceptance of PPR.

1. Introduction

Drinking water resources are becoming scarcer in communities across the US, partly due to increasing urban water demand, poor wastewater management techniques, and climate-induced droughts (Gleick, 2010; Griffin, 2016; Koebele et al., 2022). A 2019 Government Accountability Office (GAO) report to the Committee on Armed Services indicates that 80 percent of state water managers, given average weather conditions, will experience water shortages in their respective states by 2024 (US EPA, 2019). Given the growing water scarcity concern, the US Environmental Protection Agency (EPA) recommends that state and local governments implement new initiatives to expand their regional water portfolios, including reusing treated wastewater for potable purposes (i.e., planned potable reuse) to prevent water scarcity related issues that could drastically worsen in coming decades (US EPA, 2017, 2019). The EPA formally defines planned potable reuse (PPR) as "the publicly acknowledged, intentional use of reclaimed wastewater for drinking water supply" (US EPA, 2017, p.1). Reusing treated wastewater for potable purposes helps alleviate local surface water and groundwater scarcity concerns. By reusing wastewater, communities become less reliant on locally available water resources and operate in a more locally centered circular water economy (Tsatsou et al., 2023).

While some urban communities across the world have successfully implemented PPR systems to increase the local drinking water supply,

* Corresponding author.
E-mail addresses: jessebarnes@unr.edu (J.L. Barnes), anjala.krishen@unlv.edu (A.S. Krishen), han-fen.hu@unlv.edu (H.-f. Hu).

https://doi.org/10.1016/j.jclepro.2023.139587
Received 12 June 2023; Received in revised form 26 September 2023; Accepted 30 October 2023
Available online 6 November 2023
0959-6526/© 2023 Elsevier Ltd. All rights reserved.

only approximately 7–8% of the 32 billion gallons of municipal wastewater produced daily in the US is intentionally reused, and less than one percent of that reused wastewater is used for potable purposes (US EPA, 2017). Although PPR could positively impact water availability, actual community-level implementation of PPR is low. Both the EPA and extant research suggest that unfavorable public acceptance of drinking treated wastewater is a primary barrier to PPR implementation in the US and can predominantly be attributed to the *yuck factor* phenomenon (US EPA, 2017).

The yuck factor can be described as the emotional or psychological disgust or risk people experience when considering treated wastewater consumption (Fielding et al., 2019). Prior studies identify emotional reactions to consuming treated wastewater (i.e., yuck factor) as a primary factor in resistance to wastewater reuse. This psychological phenomenon has stalled and even completely halted the prospect of implementing PPR in many communities across the globe (Leong and Lebel, 2020; Ross et al., 2014; Smith et al., 2018).

The conventional approach to overcoming low PPR acceptance includes increasing individual knowledge about PPR through educational marketing campaigns (Furlong et al., 2019). However, educational and social marketing campaigns have consistently underperformed at overcoming low public reuse acceptance (Po et al., 2003; Rice et al., 2016). For example, in an online survey of US-based adults, Wester et al. (2016) find that individuals identify disgust as the strongest predictor for a lack of willingness to consume recycled water. However, this study also argues that respondents' willingness to reuse treated wastewater remains low even after they are provided with educational materials articulating the benefits of wastewater reuse. Thus, efforts to update individual knowledge about PPR may not singularly be the most useful approach to overcoming the yuck factor for a less educated population. Generally, the US public has little knowledge about public drinking water, and knowledge about PPR is even more limited (Fielding et al., 2019; Hu et al., 2011; Hu et al., 2023; Macpherson and Snyder, 2013; Smith et al., 2018). Therefore, scholars have called on PPR researchers to disentangle how individual perceptions about one's current tap water situation link to their PPR acceptance rather than solely focusing on general PPR knowledge and perceptions (Macpherson and Snyder, 2013; Rice et al., 2016; Smith et al., 2018). This study helps fill this gap in the literature by analyzing how consumer beliefs about their current drinking water source associates with PPR acceptance.

To identify consumer perception-based factors that can mitigate the yuck factor and increase PPR acceptance, this study focuses on perceptions of de facto reuse (DFR) occurrence and trust in public water suppliers (both cognitive and behavioral trust). The EPA defines de facto reuse (DFR) as "a situation where reuse of treated wastewater is practiced but is not officially recognized (e.g., a drinking water supply intake located downstream from a wastewater treatment plant [WWTP] discharge point)" (US EPA, 2017, p. 1). At least 50% of surface waters used to supply 10,000 people or more in the continental US are impacted by at least one upstream WWTP discharge (Rice and Westerhoff, 2015). Overall, it is widely known in the literature that DFR is extremely pervasive in the US and globally, but public knowledge of this fact is limited (Smith et al., 2018). However, recent findings suggest that when members of the public perceive that they already consume DFR water in some capacity, they may be inclined to accept PPR more, given that PPR is treated to a level that is safe for human consumption (Rice et al., 2016).

Further, public water suppliers play a critical role in ensuring the quality of potable water, regardless of the water source (Teodoro et al., 2022). As such, when the public believes that public water suppliers are capable of treating water to a safe level, they may also have a higher tendency to accept PPR (Ormerod and Scott, 2013; Ormerod et al., 2019; Redman et al., 2019). In addition to analyzing the correlation between reported trust in public water suppliers and PPR, we also explore how reported drinking water consumption habits (e.g., primarily consuming tap water rather than filtered or bottled water) link to PPR acceptance.

We apply Cognitive Dissonance Theory (CDT) to guide our hypotheses and explain why individuals who (1) think they already consume treated wastewater (DFR) and (2) trust their public water suppliers, would be expected to have a higher acceptance towards PPR. Although some recent scholarship proposes that DFR perceptions and trust in public water suppliers likely impact individual PPR acceptance, the empirical evidence in the literature is limited. The present study results show that both DFR perception and trust in public water suppliers are positively linked to PPR acceptance. This study makes key contributions to the literature on water reuse acceptance. The results suggest that promoting better water quality by transitioning from DFR to PPR and increasing trust in public water suppliers may be effective strategies for overcoming the yuck factor. The manuscript is organized as follows. Section two overviews CDT and presents this study's hypotheses. Section three provides the methods used to collect and analyze the survey data. Section four provides the results. Section five discusses the study's findings, implications, and study limitations. Section six concludes the manuscript.

2. Background and literature review

2.1. Cognitive Dissonance Theory

CDT is a psychological theory proposed by Leon Festinger in the 1950s (Harmon-Jones and Mills, 2019) This theory suggests that individuals seek consistency among their attitudes, behaviors, and beliefs. If inconsistencies emerge, individuals may experience discomfort or dissonance and will take actions to bring their attitudes, behaviors, and beliefs into consistency to alleviate their psychological discomfort (Vaidis and Bran, 2019). For example, if a habitual smoker believes that smoking is harmful to their health and continues smoking, they may experience dissonance because their beliefs and actions are not in alignment (Fotuhi, et al., 2013). To reduce dissonance, the smoker may change their attitude towards smoking, which could lead them to quit smoking and ultimately bring their beliefs, attitudes, and behavior into alignment. Similarly, individuals who believe that recycling products (e.g., cans and bottles) is an important sustainable action, failing to do so could cause dissonance.

This theory postulates that individuals overcome dissonance by updating their attitudes towards their own actions, especially when the context is of salience to the individual (Starzyk et al., 2009). If an individual generally lacks interest in a particular topic, they may not experience dissonance of the inconsistencies in their attitudes, perceptions, and behaviors. For example, following the recycling example, individuals may update their attitude towards their own recycling habits not only because their attitudes and behavior are inconsistent, but also because they are concerned enough about the issue that psychological inconsistency leads to cognitive discomfort. In the context of drinking water, we expect that safe drinking water is a generally salient issue for all individuals. Overall, this theory explains how individuals operating under a state of cognitive dissonance may update their attitudes or behaviors to reduce cognitive discomfort.

2.2. De facto reuse perceptions

The first hypothesis emphasizes individual perceptions about one's tap water. Recent literature on PPR public acceptance suggests that perceptions about DFR occurrence may impact the acceptance of PPR policies and initiatives (Furlong et al., 2019; Honeycutt, 2015; Rice et al., 2016; Smith et al., 2018). DFR is a widely implemented practice simply because wastewater treatment plants must discharge effluent after it has been treated (Rice and Westerhoff, 2015). Despite the wide prevalence of DFR water in the drinking water supply, knowledge of DFR water, or the more general understanding that all water is recycled, is generally lacking in the US public (Smith et al., 2018).

In an exploratory US-based study, Rice et al. (2016) analyze the link

between DFR perceptions and wastewater reuse acceptance. Their study results indicate that individuals are ten times more likely to accept potable wastewater reuse if they believe their tap water already contains DFR water (Rice et al., 2016). Similarly, Honeycutt (2015) found that community members in Denver, Colorado, who reviewed visual aids of how treated wastewater enters the water cycle, were significantly more likely to accept PPR. When the community members in this study realized they were likely already consuming treated wastewater, they promptly increased their acceptance of PPR water. These results suggest that DFR perceptions may associate with PPR acceptance. However, whether these novel results regarding DFR perceptions extend beyond the two studies discussed is unclear.

Through the CDT lens, assuming that safe drinking water is a priority for public water consumers, it is expected that individuals who think their tap water contains DFR water would be impacted less by the psychological disgust linked to consuming PPR water. The literature finds that individuals have low attitudes toward PPR because they cannot overcome the yuck factor associated with consuming recycled sewage (Etale et al., 2020; Garcia-Cuerva et al., 2016; Leong and Lebel, 2020; Schmidt, 2008; Smith et al., 2018). However, it is expected that it would be mentally challenging to reconcile the perception that one already consumes treated wastewater (i.e., DFR water) that is not treated to a safe level while also not supporting PPR water, which is treated to a safe level for consumption. Individuals operating under this dissonance could reduce their psychological discomfort by increasing their attitude towards PPR as a source of drinking water.

Given these CDT theoretical expectations, we expect that individuals who believe or are aware that they consume treated wastewater (DFR) will have a higher attitude towards planned potable reuse (PPR) because they have resolved the cognitive dissonance associated with consuming recycled sewage water, and thus are more accepting of PPR. They may view PPR as a more acceptable source of drinking water because it aligns with their beliefs about their current tap water composition. The first hypothesis is presented as follows.

H1. Public water consumers who perceive that they already consume treated wastewater from their tap have a higher attitude toward planned potable reuse.

2.3. Trust in public water systems

In the marketing literature, trust is defined as exchanging or transacting with a reliable, responsible, and accountable partner who has integrity (Moorman et al., 1993). Providing both intrinsic and extrinsic value, trust in organizations enhances at both micro (e.g., individuals) and macro (e.g., society) levels (de Jager, 2017). Poulin and Haase (2015) show that when individuals have higher levels of trust over time, they experience increases in well-being. The extrinsic value of trust in society centers around its ability to increase individual-level social capital, thereby increasing productivity (Bjørnskov, 2022). Higher levels of societal trust are also linked with increased innovation; Kondo et al. (2021) find that ideas are less likely to be stolen when relational contracting enables safe collaboration.

In the context of public utilities, Wolske et al. (2017) indicate that homeowners who trust them are more willing to adopt solar panels. Similarly, when homeowners see their neighbors adopt solar panels, they are more likely to do the same due to trusting their peers (Barnes et al., 2022). For existing solar photovoltaic owners, those who trust energy utilities are more likely to engage in additional services such as energy storage (Hoffmann and Mohaupt, 2020). As part of the process of gaining trust, consumers often rely on sharing sensitive information with organizations and expect that it will be protected and stored securely. Reliability, reputation, quality information provision, and service quality are important antecedents to building trust with a utility service provider (ter Huurne et al., 2017). When consumers trust corporations, they are more willing to maintain long-term relationships with them, upgrade, and increase services with them (Marinova and Singh, 2014; Ormerod and Scott, 2013).

In public drinking water administration, local governments are predominantly responsible for implementing local PPR initiatives in the US since they own and operate nearly all public water systems (US EPA, 2017). From the yuck factor perspective, trust in public water utilities links to the perceived risk of consuming PPR water (Furlong et al., 2019). PPR is deemed risky due to the disgust associated with consuming treated wastewater, but the perception of risk may be reduced if individuals trust their public water systems to effectively implement PPR (Ormerod et al., 2019; Redman et al., 2019; Scruggs et al., 2020). Teodoro et al. (2022) find that one's tap water consumption patterns link to trust in public water suppliers. Those that consume their tap water directly are assumed to have a higher trust in the organizations that supply their tap water. In contrast, individuals that filter their water before consumption or primarily consume bottled water are expected to have lower trust in their public water supplier (Allaire et al., 2019).

If individuals do not trust their current public water system, one can surmise that they may not trust their water system to implement a new PPR system. However, per CDT, individuals with a high level of trust but low acceptance towards PPR would be expected to experience dissonance because it would create tension to trust one's public water system to provide safe drinking water while not trusting them to provide safe PPR water. To resolve this cognitive dissonance, consumers may increase their attitudes towards PPR as a source of drinking water. Hence, we hypothesize that individuals who trust their public water supplier(s) will have a higher attitude towards PPR water because they have already resolved the cognitive dissonance associated with trusting their water supplier but not accepting PPR as a viable drinking water source. The second hypothesis is presented as follows.

H2. Public water consumers who have more trust in their water systems have a higher attitude towards planned potable reuse.

3. Materials and methods

3.1. Study design

We designed two survey based-studies to capture DFR perceptions, trust in public water suppliers, and attitudes toward PPR. Survey participants completed an online questionnaire administered by the professional online marketing research agency, Qualtrics™. This professional agency was used to collect the survey data to increase ecological validity and achieve appropriate heterogeneity of our anonymous samples. In total, three cross-sectional survey samples were collected for two separate studies to analyze the key dependent and independent variables. The survey agency randomly drew each sample from its online panel in all 50 states of the US (i.e., US population only) to represent the total population in terms of age, education, gender, and region (i.e., simple random sampling) broadly. Furthermore, the surveys specifically captured responses from public tap water consumers (i.e., respondents who do not have a private well) who are at least 18 years old (i.e., adult public water consumers). The study 1 sample was collected between May 14, 2019, and June 2, 2019 ($N = 551$), and the two samples for study 2 were collected between February 27, 2020, and March 2, 2020 ($N = 188$) and between September 30, 2020, and November 3, 2020 ($N = 158$), respectively. In study 2, the first sample (i.e., sample two) was collected before the COVID-19 pandemic lockdown in the US, and sample three was collected after the first major waves and lockdowns occurred. Study one's and two's survey results were analyzed with a 95% confidence level. Given our sample size of 551 respondents in study 1 and 346 respondents in study 2, the margin of error for our survey findings is approximately ±4.17% for study one and ±5.27% for study 2. This indicates that if this survey was conducted multiple times, we would expect the true population parameters to fall within the range

measured by the surveys in both studies 95 out of 100 instances. Fig. 1 provides the study area and the respondent locations in study one (S1) and study two (S2). Respondent locations fall in the most urbanized regions of the country (i.e., metropolitan and micropolitan areas).

Two previously validated survey constructs were used to capture (1) attitude towards PPR (Construct 2, Table 1) to represent PPR acceptance and (2) trust towards public water suppliers (Construct 1, Table 1). The attitude toward PPR scale used three items from Lord et al. (1994). Trust toward public water suppliers was measured with six items adapted from Gefen et al. (2003). We made several minor wording changes to the scale items, when necessary, to fit our study context and respondents. The multi-item scales with their corresponding references are provided in Table 1. Following recent literature, a behavioral trust measure (Question 2, Table 1) was included in the survey. This measure is deemed a behavioral trust measure to complement reported trust.

Lastly, for study 1, to capture self-reported perceptions about DFR occurrence at the tap and DFR acceptance, we adapted a survey question from Rice et al. (2016) for replication purposes. However, for study two (i.e., samples 1 and 2), we used a Likert-scaled question to provide respondents with a broader range of answer choices, augmenting the "Yes, "No," and "Unsure" ones and increasing the measurement granularity of DFR perceptions in study two.

3.2. Dependent variable

The dependent variable analyzed in this study is attitude towards planned potable reuse. This variable is measured using the survey construct 2 presented in Table 1. The three scales were averaged, and this value was used as a continuous measure of PPR attitude (referred to as *PPR*). The dependent variable was measured using the same construct for both studies.

3.2.1. Key independent variables

Two different survey instruments were used to capture DFR perceptions in studies 1 and 2. For study 1, the DFR perceptions independent variable is measured using the Rice et al. (2016) survey instrument (Q1a, Table 1). Individuals who answered "Yes" to Q1a were coded as 1, while individuals who answered "Unsure" or "No" were coded as 0. For study 2, the DFR perceptions variable is coded as 1 for individuals with the "somewhat agree," "agree," or "strongly agree" choices arguing that their tap water contains treated wastewater, while individuals who chose "neither agree or disagree," "somewhat disagree," "disagree," or "strongly disagree" that their tap water contains treated wastewater were coded as 0. As a binary measure, in both studies, DFR perceptions is referred to as *DFR (Yes)*.

Trust in public water systems is measured using survey construct one presented in Table 1 for both studies. The six items were averaged, and this averaged value is used as a continuous measure of trust toward

Table 1
Terms, definitions, primary survey questions provided to respondents, and construct alpha scores.

Terms and definitions	TREATED WASTEWATER is sewage from household, municipal, and industrial sources that has gone through cleaning processes to improve its quality. PLANNED REUSE is the reuse of highly purified wastewater deemed by scientists as safe for human consumption.
Question 1a: Perception of De Facto Reuse Water at tap (DFR) (Study 1) Rice et al. (2016)	Does your tap water contain TREATED WASTEWATER? Yes No Unsure
Question 1 b: Perception of De Facto Reuse Water at tap (DFR) (Study 2)	Please indicate your beliefs regarding your tap water: It contains treated wastewater: Strongly disagree Disagree Somewhat disagree Neither agree nor disagree Somewhat agree Agree Strongly agree *7-point scale
Question 2: Behavioral Trust in Local Public Water Suppliers (Study 1 &2)	Select one of the water types below that you most commonly consume: Tap Water Filtered Water Bottled Water Other
Construct 1: Trust Towards Public Water Suppliers (PWS) 6-item construct (Study 1 & 2) (Gefen et al. (2003) Study 1 ∝: 0.91 Study 2: ∝: 0.91	Please indicate your opinion about public water suppliers (e.g., municipality, county, city, town, etc.): **Item 1**: Based on my experience in the past, I know public water suppliers are honest **Item 2**: Based on my experience in the past, I know public water suppliers care about customers **Item 3**: Based on my experience in the past, I know public water suppliers are not opportunistic **Item 4**: Based on my experience in the past, I know public water suppliers are predictable **Item 5**: Based on my experience in the past, I know public water suppliers are trustworthy **Item 6**: Based on my experience in the past, I know public water suppliers know their market *7-point scale for each item in this construct
Construct 2: Attitude Towards Planned Potable Reuse (PPR) 3-item construct (Study 1 & 2) Lord et al. (1994) Study 1 ∝: 0.91 Study 2: ∝: 0.90	In your opinion, Planned Reuse is … **Item 1**: Good/Bad^{R} **Item 2**: Unpleasant/Pleasant **Item 3**: Unfavorable/Favorable *7-point scale for each item in this construct

R = reverse scaled item.

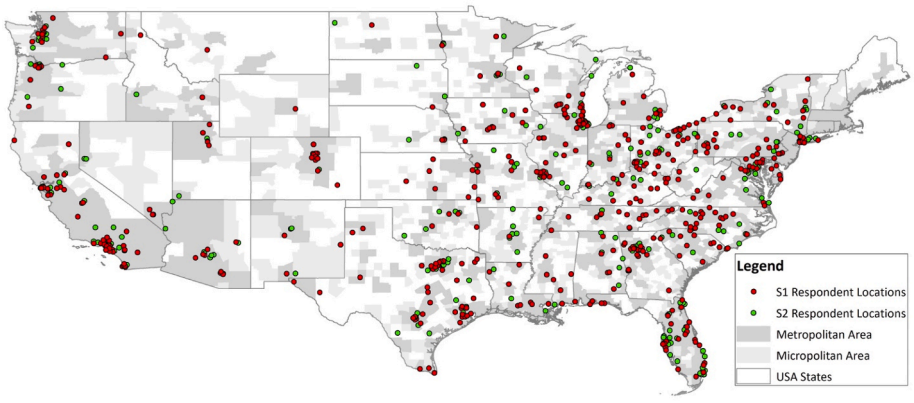


Fig. 1. Study area and respondent locations.

public water suppliers (*Trust in PWS)*. The second measure of trust (i.e., behavioral trust) was captured using question 2, presented in Table 1. Individuals who indicated that they primarily consume "Tap Water" were coded as 1 while individuals that indicated they primarily consume "Filtered Water" or "Bottled Water" were coded as 0. As a binary measure, the behavioral trust in public water suppliers is referred to as *Behavioral Trust* (*Tap*) and is used in both studies.

3.3. Control variables

Although the samples were randomly collected for both studies, several control measures were included in all regression models to eliminate as much individual-level non-random error in PPR attitudes as is feasible (Leonidou et al., 2015). Models used to analyze both studies include a continuous age measure (*Age*), a binary gender measure (*Female*), three binary race measures (*White/Caucasian*, *Black/African American*, *and Asian/East Asian American*), an ordinal education measure (*Education*), an ordinal income measure (*Income*), three binary employment measures (*Employment (Fulltime), Employment (Retired), Employment (Unemployed)*), and two binary political measures (*Political Party (D), Political Party (R)*).

An additional control variable was included to account for any respondents in the sample who work for or know someone who works in the water industry (coded as 1) versus those who do not (coded as 0). These individuals are expected to have greater exposure to water knowledge and thus may have systematically different attitudes towards PPR relative to individuals without water industry exposure (Rice et al., 2016). This binary independent measure is referred to as *Water Industry*.

An additional control variable was included in study 2 to account for the potential effect of the COVID-19 pandemic on the respondents in sample 3, which was collected between September and November of 2020 after the pandemic began throughout the US population for approximately six months. Respondents in sample 3 were coded as 1, and those in sample 2 were coded as 0. This binary independent measure is referred to as *COVID Sample.* See Table A1 for the list of study variable measures and coding.

3.4. Statistical analysis

As shown in Table 1, Cronbach alpha values were conducted on the constructs to ensure they reliably captured attitude towards PPR and trust in public water systems, showing an acceptable value of $a \geq 0.7$. Pairwise correlations were also calculated between all variables in both studies to test for discriminant validity. To identify significant interaction effects between the key independent variables and control variables, individual regression models were run where a key independent variable was interacted with all other measures in the model. Any interaction terms that were significant at the 0.05 level between any of the key variables and control measures were included in a follow-up model. This interaction-based procedure was conducted for all three key independent variables, and the *COVID Sample* measure for study 2. Only interactions that remained significant at the 0.05 level were retained in the final exploratory interaction models.

We employed a series of tests to assess the assumptions and validity of our models. Firstly, the Shapiro-Wilk test was utilized to examine the normality assumption, specifically testing whether the residuals adhered to a normal distribution. Additionally, the Ramsey Test, also known as RESET, was implemented to detect potential omitted variable bias. To evaluate multicollinearity, we employed the Variance Inflation Factor (VIF) test, which provided a measure of the inflation of coefficient variances due to correlated predictors. Lastly, Akaike's Information Criterion (AIC) was employed to aid in model selection by considering both goodness of fit and the number of estimated parameters. Regional differences in respondent locations could correlate with survey responses for a variety of reasons (e.g., policy differences, source water differences, economic differences, etc.); therefore, to account for potential proximity-based correlations among respondents and to ensure the robustness of our findings, we employed regression models with clustered robust standard errors at multiple levels, including the individual, county, and state levels. By considering differing clustering levels, we aimed to mitigate potential biases arising from spatial dependencies between respondents. All statistical analyses were conducted using STATA SE 16.1.

4. Results

4.1. Descriptive statistics

Table 2 provides the response breakdown for the categorical survey instruments used to capture DFR perceptions and behavioral trust. In terms of DFR perceptions, Table 3 shows an interesting descriptive finding. In study 1, most individuals (44%) responded with "Unsure" when asked to choose among three options regarding their beliefs about the presence of treated wastewater in their tap water. However, in study 2, a large percentage of individuals chose either affirmative or negative responses instead of the neutral or unsure option ("Neither agree nor disagree"), with roughly 20% of respondents selecting the neutral response. This observation suggests that the Likert scale response is more effective in capturing DFR perceptions, particularly for individuals who lean towards a yes/no response regarding the presence of treated wastewater in their tap water but lack strong enough conviction to respond with those choices. Additionally, regarding behavioral trust, roughly 38% of respondents in study 1, and 40% in study 2 indicated that they primarily consume tap water versus filtered or bottled water (Table 2). Fig. 2 provides the histogram distributions for constructs 1 and 2 in the survey. Whereas the distributions are similar across the two studies, descriptive findings indicate that respondents in study 2 have higher PPR attitudes and Trust in PWS compared to study 1.

Table 3 provides the sample demographics and socio-economic characteristics for studies 1 and 2. In study 1, 21% of respondents had a high school degree only, while study 2 shows that 15% had a high school degree only. Additionally, 42% of respondents in study 1 indicated they work full time, while 53% of respondents in study 2 indicated that they work full time. Lastly, it is notable that roughly 2% of respondents from study 1 and 7% of respondents from study 2 indicated they work in or know someone who works in the water industry. Table 4 provides summary statistics for this study's variable measures.

Fig. 3 provides the pairwise correlations between all variable measures included in both regression models for both studies. Most of the significant correlations are near zero. In study 1, all three key independent variables are significantly correlated with PPR. In study 2, DFR (Yes) and Trust in PWS are significantly correlated with PPR, but

Table 2
Survey response breakdown of key survey instruments.

Categorical Survey Measure Breakdown (Key Variables)	Study 1		Study 2	
	N	%	N	%
Study 1: De Facto Reuse Water at Tap				
Yes	140	25.4	NA	NA
No	170	30.9	NA	NA
Unsure	241	43.7	NA	NA
Study 2: De Facto Reuse Water at Tap				
Strongly disagree (No)	NA	NA	43	12.5
Disagree (No)	NA	NA	47	13.6
Somewhat disagree (No)	NA	NA	12	3.5
Neither agree nor disagree (Unsure)	NA	NA	70	20.3
Somewhat agree (Yes)	NA	NA	61	16.7
Agree (Yes)	NA	NA	65	18.8
Strongly Agree (Yes)	NA	NA	47	13.6
Behavioral Trust in Public Water Supplier				
Tap Water	210	38.1	136	39.4
Filtered Water	154	28.0	85	24.6
Bottled Water	187	33.9	124	35.9

Table 3
Survey response breakdown of control variables for study 1 and two.

	Study 1		Study 2	
Sample Characteristics	N	%	N	%
Gender Identity				
Male	269	48.8	179	51.9
Female	280	50.8	165	47.8
Other	2	0.4	1	0.3
Race				
White/Caucasian	457	82.9	279	80.9
African American/Black	47	8.5	32	9.3
Asian/East Asian American	17	3.1	32	9.3
Other	30	5.4	22	6.4
Education				
Less than high school	4	0.7	8	2.3
High school graduate	113	20.5	54	15.7
Some college, no degree	112	20.3	81	23.5
2 year degree/vocational school	91	16.5	36	10.4
4 year-college degree	144	26.1	98	28.4
Some graduate school	70	12.7	46	13.3
Doctorate	17	3.1	22	6.4
Income				
Less than $10,000	35	6.4	22	6.4
$10,000-$19,999	50	9.1	29	8.4
$20,000-$29,999	67	12.2	30	8.7
$30,000-$39,999	73	13.3	34	9.9
$40,000-$49,999	58	10.5	36	10.4
$50,000-$59,999	62	11.3	32	9.3
$60,000-$69,999	32	5.8	19	5.5
$70,000-$79,999	31	5.6	27	7.8
$80,000-$89,999	26	4.7	20	5.8
$90,000-$99,999	28	5.1	15	4.4
$100,000-$149,999	54	9.8	45	13.1
More than $150,000	35	6.4	36	10.4
Employment				
Working (full-time employee)	232	42.1	181	52.5
Working (part-time employee)	62	11.3	31	9.0
Student (full-time student)	16	2.9	15	4.4
Student (part-time student)	2	0.4	1	0.3
Unemployed	76	13.8	39	11.3
Retired	123	22.3	62	18.0
Other	40	7.3	16	4.6
Political Party				
Republican	186	33.8	108	31.3
Democrat	197	35.8	144	41.7
Independent	145	26.3	86	24.9
Other	6	1.1	0	0.0
No preference	17	3.1	7	2.0
Works in/knows person in Water Industry				
Yes	13	2.4	25	7.3
No	538	97.6	320	92.8

Behavioral Trust (Tap) is not. Furthermore, several control measures significantly correlate with PPR and the key independent variables.

4.2. Study 1 statistical results

Table 5 provides the MLR coefficient estimates for study 1. The model 1 ($F(16, 534) = 4.96$, $p < 0.000$), model 2 ($F(16, 313) = 5.97$, $p < 0.000$), and model 3 ($F(16, 47) = 8.46$, $p < 0.000$) summary statistics are all significant. Model 2 in Table 5 is the preferred model because standard errors are clustered at the county level which accounts for localized factors that could influence survey responses (e.g., local water quality, local governmental institutions, etc.). Holding all else constant, these model results indicate that DFR (Yes) and Trust in PWS are both positively associated with PPR. Additionally, the control measure, White/Caucasian, is significant. These results are robust to differing standard error clustering levels at the 0.1 level.

Regarding model diagnostics, the Shapiro-Wilk W Test for normality emerged significant indicating there is potential evidence that residuals from these model estimations significantly deviated from a normal distribution (see Appendix 1 to view the residual distribution). Given the relatively large sample size in study 1 (i.e., $N > 500$), we expect that the issue associated with normally distributed residuals is inconsequential to the interpretation of the model coefficients (Knief and Forstmeier, 2021). The Ramsey Test for omitted variable bias is significant, indicating that there is potential evidence of omitted variable bias. The average and individual VIF values show low collinearity between independent variables.

Table 6 reports the exploratory study 1 models that include interaction terms. The model 1 ($F(18, 532) = 5.64$, $p < 0.000$), model 2 ($F(18, 313) = 7.12$, $p < 0.000$), and model 3 ($F(18, 47) = 9.57$, $p < 0.000$) summary statistics are significant. Holding all else constant and focusing on model 2 (standard errors clustered at the county level), the model results indicate that DFR (Yes) and Trust in PWS remain positively associated with PPR when including interaction terms. The presence of the two significant interaction terms suggests that, holding all else constant, there are correlational negative interaction effects between (1) White/Caucasian respondents and Trust in PWS, and between (2) full-time employees and Trust in PWS. Specifically, among White/Caucasian individuals, there is a significant negative correlation between Trust in PWS and the dependent variable (PPR acceptance). Similarly, among full-time employees, there is a significant negative correlation between Trust in PWS and the dependent variable (PPR acceptance). Lastly, the control variable, age, emerged significant and negatively associated with PPR acceptance. These results are robust to differing standard error clustering levels at the 0.1 level.

Regarding model diagnostics, the Shapiro-Wilk W Test for normality remained significant indicating there is potential evidence that residuals from these model estimations significantly deviated from a normal distribution; however, the relatively large sample size in study 1 is expected to eliminate bias associated with non-normally distributed residuals (Knief and Forstmeier, 2021). The Ramsey Test for omitted variable bias did not emerge significant indicating evidence of omitted variable bias was not detected for these models. The average VIF value and individual VIF values were higher in the interaction models, as is generally expected. Lastly, across the models presented in Tables 5 and 6, the interaction models in Table 6 have a lower AIC score indicating the interaction models do not suffer from an overfitting concern.

4.3. Study 2 statistical results

Table 7 provides the MLR coefficient estimates for study 2. The model 1 ($F(17, 327) = 7.38$, $p < 0.000$), model 2 ($F(17, 194) = 11.54$, $p < 0.000$), and model 3 ($F(17, 44) = 24.26$, $p < 0.000$) summary statistics are significant. Model 2 in Table 7 is the preferred model because it clusters standard errors at the county level, accounting for localized factors that may influence survey responses (e.g., local water quality, local governmental institutions, etc.). Holding all else constant, these model results indicate that all key independent variables, including DFR (Yes), Trust in PWS, and Behavioral Trust (Tap) are significantly positively associated with PPR. Additionally, several control measures emerged significant and negatively correlated with PPR acceptance, including Age, Female, and Asian/East Asian American. These results are robust to differing standard error clustering levels at the 0.1 level. Regarding model diagnostics, the Shapiro-Wilk W Test for normality was not significant. The Ramsey Test for omitted variable bias also did not emerge significant, and the average and individual VIF values indicate that there is low collinearity between independent variables.

Table 8 reports the exploratory study 2 interaction models. The model 1 ($F(20, 324) = 8.13$, $p < 0.000$), model 2 ($F(20, 194) = 16.89$, $p < 0.000$), and model 3 ($F(20, 44) = 24.53$, $p < 0.000$) summary statistics are significant. Holding all else constant and focusing on model 2 (standard errors clustered at the county level), the model results indicate that DFR (Yes) and Trust in PWS remain positively associated with PPR when including interaction terms. The presence of the three significant interaction terms suggests that, while controlling for other variables,

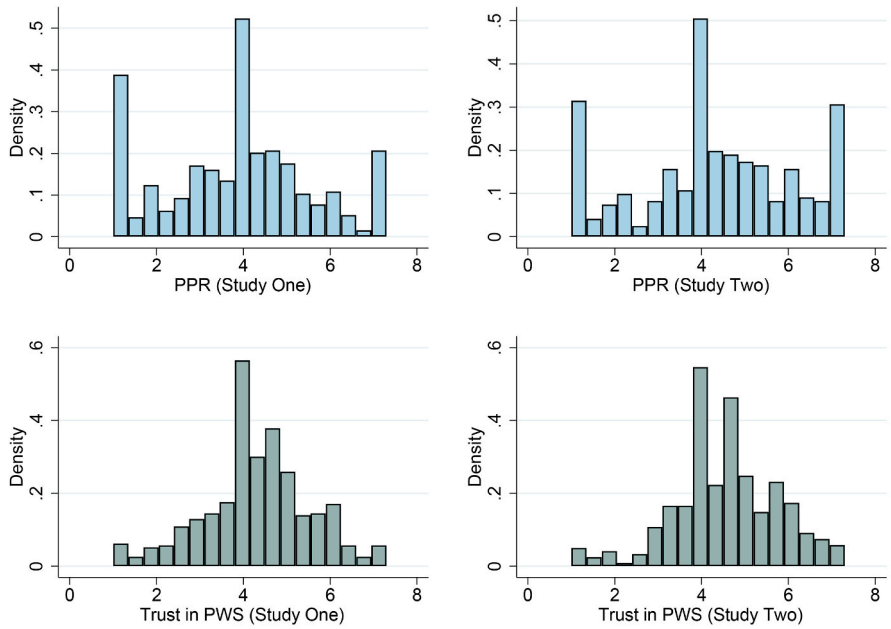


Fig. 2. Histogram distributions of the PPR and Trust in Public Water Systems (PWS) survey constructs.

Table 4
Descriptive statistics for variable measures included in regression models.

Study 1					
Variable	Obs.	Mean	Std. Dev.	Min	Max
PPR	551	3.857	1.685	1	7
DFR (Yes)	551	0.254	.436	0	1
Trust in PWS	551	4.292	1.219	1	7
Behavioral Trust (Tap)	551	0.381	.486	0	1
Age	551	46.993	12.963	19	61
Female	551	0.508	.5	0	1
White/Caucasian	551	0.829	.376	0	1
Black/African American	551	0.085	.28	0	1
Asian/East Asian American	551	0.031	.173	0	1
Education	551	3.973	1.463	1	7
Income	551	5.971	3.324	1	12
Employment (Fulltime)	551	0.421	.494	0	1
Employment (Retired)	551	0.223	.417	0	1
Employment (Unemployed)	551	0.138	.345	0	1
Political Party (D)	551	0.358	.48	0	1
Political Party (R)	551	0.338	.473	0	1
Water Industry	551	0.024	.152	0	1
Study 2					
Variable	Obs.	Mean	Std. Dev.	Min	Max
PPR	345	4.279	1.758	1	7
DFR (Yes)	345	0.501	.501	0	1
Trust in PWS	345	4.534	1.196	1	7
Behavioral Trust (Tap)	345	0.394	.489	0	1
Age	345	45.438	16.476	18	80
Female	345	0.478	.5	0	1
White/Caucasian	345	0.809	.394	0	1
Black/African American	345	0.093	.291	0	1
Asian/East Asian American	345	0.035	.183	0	1
Education	345	4.125	1.566	1	7
Income	345	6.62	3.532	1	12
Employment (Fulltime)	345	0.525	.5	0	1
Employment (Retired)	345	0.18	.385	0	1
Employment (Unemployed)	345	0.113	.317	0	1
Political Party (D)	345	0.417	.494	0	1
Political Party (R)	345	0.313	.464	0	1
Water Industry	345	0.072	.26	0	1
COVID Sample	345	0.455	.499	0	1

there are negative interaction effects between (1) Behavioral Trust (Tap) and Trust in PWS, and (2) COVID Sample and Female, and positive interaction effects between (1) Trust in PWS and Income. Specifically, among individuals who primarily consume tap water, there is a significant negative correlation between Trust in PWS and PPR. Similarly, in the sample collected after the COVID-19 pandemic was in effect for approximately six months, there is a significant negative correlation between female respondents and PPR. Holding other variables constant, the significant and positive interaction between Trust in PWS and Income suggests there is a positive association between Trust in PWS and PPR as Income increases. Additionally, the control variables Age, Income, and COVID Sample all emerged significant. These results are robust to differing standard error clustering levels at the 0.1 level.

Regarding model diagnostics, neither the Shapiro-Wilk W Test for normality nor the Ramsey Test for omitted variable bias emerged as significant. The average and individual VIF values were higher in the interaction models, as expected. Lastly, across the models presented in Tables 7 and 8, the interaction models in Table 8 have a lower AIC score, indicating that the interaction models do not suffer from an overfitting issue.

5. Discussion

5.1. Linking results to previous potable reuse findings

This study examined how an individual's prior experience with public tap water links to their attitude towards PPR. As hypothesized, DFR perceptions and trust both positively correlated with PPR acceptance. Additionally, across both studies, multiple control measures emerged as significant and correlated with PPR as expected from the PPR acceptance literature. The findings regarding age being negatively associated with PPR acceptance (Fielding et al., 2019; Smith et al., 2018), and female respondents having significantly lower acceptance of PPR (Ormerod et al., 2019; Redman et al., 2019) are both consistent with other studies. Race also emerged as significant in some models, and the results show that white/Caucasian, Asian/East Asian American consumers have lower acceptance of PPR. Thus, the alignment between our control measure results and previous findings in the literature

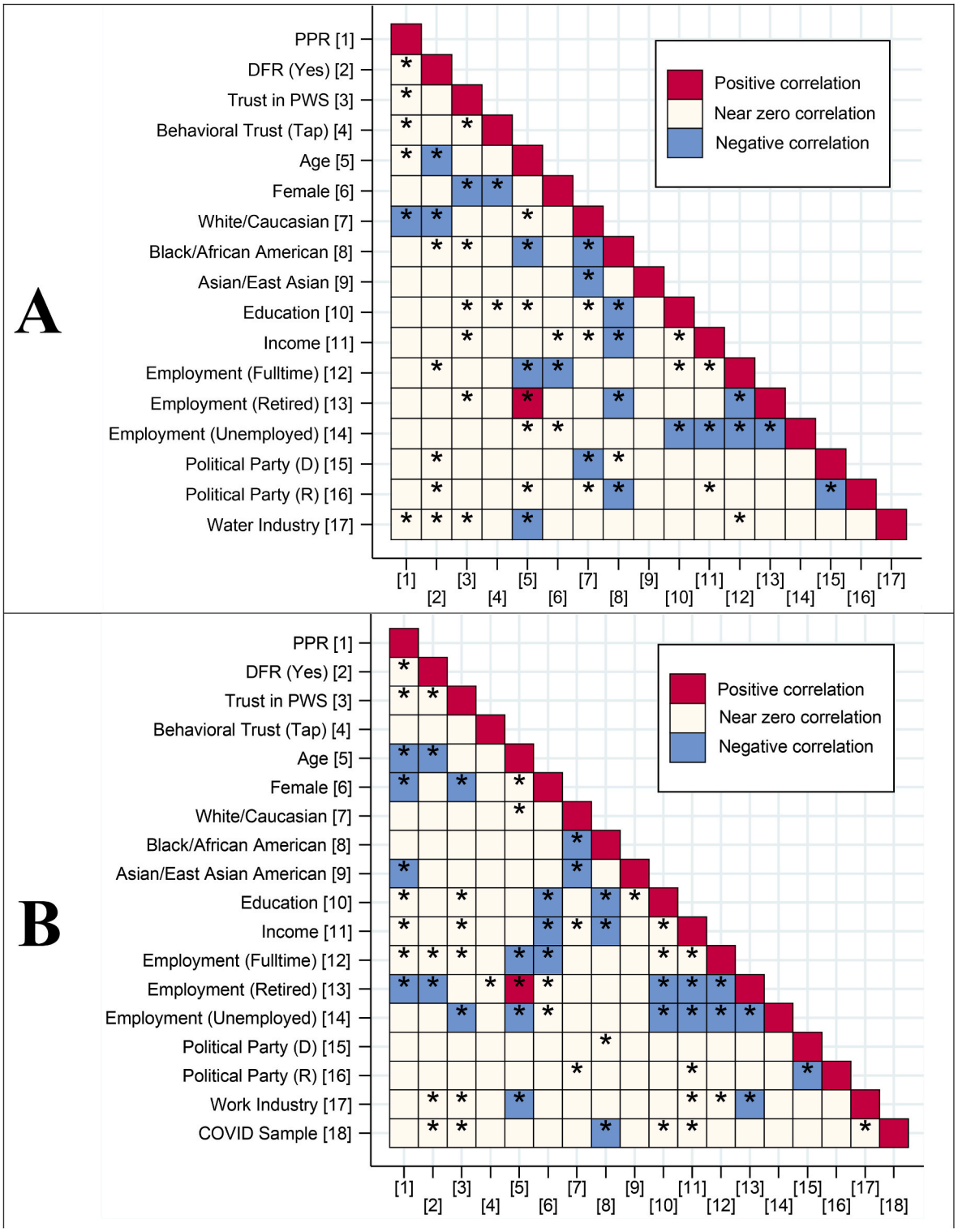


Fig. 3. Pairwise correlations test results for study one (A) and study two (B).

validates our findings and highlights the importance of controlling for demographic and socio-economic factors.

In addition, study 2 results provide correlational evidence that attitudes toward PPR water increased after the COVID-19 pandemic started in the US. This finding contradicts existing research which suggests that individuals would be less accepting of PPR water in response to the pandemic (e.g., Gul et al., 2021; Prins et al., 2022). Hence, our study makes a significant contribution to the literature since, to our knowledge, no other studies have directly analyzed or measured the potential change in PPR attitudes in response to the COVID pandemic. In line with this finding, we also identified a significant negative interaction effect between COVID-19 and female respondents (i.e., post-pandemic, female respondents had lower attitudes towards PPR). Previous literature on PPR acceptance suggests that female consumers are more risk-averse than male consumers (Ormerod et al., 2019; Redman et al., 2019). As such, the COVID pandemic may have reduced PPR

Table 5
Study 1 models.

VARIABLES	(1)	(2)	(3)
	PPR	PPR	PPR
DFR (Yes)	0.379**	0.379**	0.379**
	(0.162)	(0.168)	(0.169)
Trust in PWS	0.338***	0.338***	0.338***
	(0.0682)	(0.0589)	(0.0600)
Behavioral Trust (Tap)	0.135	0.135	0.135
	(0.146)	(0.138)	(0.154)
Age	−0.0123*	−0.0123*	−0.0123*
	(0.00688)	(0.00650)	(0.00672)
Female	−0.0447	−0.0447	−0.0447
	(0.148)	(0.147)	(0.173)
White/Caucasian	−0.856***	−0.856***	−0.856**
	(0.304)	(0.329)	(0.325)
Black/African American	−0.557	−0.557	−0.557
	(0.396)	(0.438)	(0.346)
Asian/East Asian American	−0.481	−0.481	−0.481
	(0.409)	(0.436)	(0.486)
Education	0.0345	0.0345	0.0345
	(0.0541)	(0.0530)	(0.0547)
Income	0.0380	0.0380	0.0380
	(0.0255)	(0.0266)	(0.0275)
Work Full-time	−0.153	−0.153	−0.153
	(0.201)	(0.207)	(0.236)
Retired	−0.0720	−0.0720	−0.0720
	(0.249)	(0.243)	(0.251)
Unemployed	0.149	0.149	0.149
	(0.241)	(0.231)	(0.200)
Democrat	−0.00893	−0.00893	−0.00893
	(0.174)	(0.177)	(0.235)
Republican	−0.174	−0.174	−0.174
	(0.177)	(0.187)	(0.234)
Water Industry	0.702	0.702	0.702
	(0.538)	(0.544)	(0.505)
Constant	3.370***	3.370***	3.370***
	(0.558)	(0.497)	(0.529)
Observations	551	551	551
R-squared	0.123	0.123	0.123
Robust Standard Errors (SE)	Yes		
Robust SE Clustered (County)		Yes	
Robust SE Clustered (State)			Yes
Shapiro-Wilk W Test for Normality	0.989***		
Ramsey Test for Omitted Variable Bias	3.32**		
Variance Inflation Factor (VIF)	1.57 (1.08–2.83)		
Akaikes Information Criterion (AIC)	2099.38		

***p < 0.01, **p < 0.05, *p < 0.1.

Table 6
Study 1 models with interactions.

VARIABLES	(1)	(2)	(3)
	PPR	PPR	PPR
DFR (Yes)	0.393**	0.393**	0.393**
	(0.161)	(0.166)	(0.174)
Trust in PWS	0.767***	0.767***	0.767***
	(0.145)	(0.122)	(0.147)
Behavioral Trust (Tap)	0.136	0.136	0.136
	(0.144)	(0.137)	(0.151)
Age	−0.0138**	−0.0138**	−0.0138*
	(0.00688)	(0.00656)	(0.00693)
Female	−0.0830	−0.0830	−0.0830
	(0.148)	(0.149)	(0.170)
White/Caucasian	0.775	0.775	0.775
	(0.742)	(0.615)	(0.805)
Black/African American	−0.455	−0.455	−0.455
	(0.363)	(0.404)	(0.302)
Asian/East Asian American	−0.482	−0.482	−0.482
	(0.403)	(0.425)	(0.443)
Education	0.0422	0.0422	0.0422
	(0.0548)	(0.0544)	(0.0556)
Income	0.0396	0.0396	0.0396
	(0.0254)	(0.0263)	(0.0270)
Employment (Fulltime)	0.845	0.845	0.845*
	(0.586)	(0.557)	(0.488)
Employment (Retired)	−0.120	−0.120	−0.120
	(0.248)	(0.246)	(0.252)
Employment (Unemployed)	0.105	0.105	0.105
	(0.240)	(0.228)	(0.203)
Political Party (D)	0.0303	0.0303	0.0303
	(0.174)	(0.177)	(0.232)
Political Party (R)	−0.149	−0.149	−0.149
	(0.178)	(0.188)	(0.237)
Water Industry	0.747	0.747	0.747
	(0.551)	(0.563)	(0.513)
White/Caucasian × Trust in PWS	−0.384**	−0.384***	−0.384**
	(0.162)	(0.139)	(0.167)
Employment (Fulltime) × Trust in PWS	−0.249*	−0.249**	−0.249**
	(0.128)	(0.124)	(0.0958)
Constant	1.622**	1.622***	1.622**
	(0.756)	(0.608)	(0.786)
Observations	551	551	551
R-squared	0.142	0.142	0.142
Robust Standard Errors (SE)	Yes		
Robust SE Clustered (County)		Yes	
Robust SE Clustered (State)			Yes
Shapiro-Wilk W Test for Normality	0.949***		
Ramsey Test for Omitted Variable Bias	0.92		
Variance Inflation Factor (VIF)	4.82 (1.09–17.64)		
Akaikes Information Criterion (AIC)	2091.57		

***p < 0.01, **p < 0.05, *p < 0.1.

acceptance more for female consumers due to risk beliefs and structural gendered health inequities (Pirtle and Wright, 2021). Given the nature of this correlational finding and the inability on our part to exclude potential covariates (e.g., isolation, misinformation, loneliness, illness), this finding should be explored in future research.

5.2. Theoretical implications

Through the lens of Cognitive Dissonance Theory, we designed our methodological framework with two studies to identify antecedents to positive attitudes toward PPR water. In doing so, our findings highlight the importance of a priori perceptions of treated wastewater consumption and trust in public water suppliers. As suggested by CDT, our findings show that the increased attitudes towards PPR water occur because, to resolve the cognitive dissonance associated with consuming de facto reuse water and trusting their water supplier, consumers must accept PPR as a viable drinking water supply. Therefore, our results suggest that marketing strategies should focus on increasing consumer perceptions and trust in their current tap water situation; such campaigns may provide a feasible avenue for overcoming the yuck factor associated with low PPR acceptance. However, given the interaction effect between reported trust and behavioral trust in study 2, it is prudent that future research identifies whether consumers are resistant to PPR due to being extremely satisfied with their current tap water experience (i.e., status quo bias) (Falk et al., 2007). Overall, the theoretical implications of this study provide avenues for future potable reuse acceptance scholarship, and other prosocial and community-based literature focused on increasing acceptance of sustainable technologies, practices, and policies.

5.3. Practical implications

Our findings have implications for water utilities that require public approval to implement potable wastewater reuse programs. This is important because potable reuse initiatives are commonly halted due to low public approval (Furlong et al., 2019). Increasing consumer

Table 7
Study two models.

VARIABLES	(1)	(2)	(3)
	PPR	PPR	PPR
DFR (Yes)	0.373**	0.373**	0.373**
	(0.177)	(0.180)	(0.143)
Trust in PWS	0.388***	0.388***	0.388***
	(0.0803)	(0.0782)	(0.0644)
Behavioral Trust (Tap)	0.308*	0.308**	0.308**
	(0.170)	(0.153)	(0.131)
Age	−0.0166**	−0.0166**	−0.0166**
	(0.00703)	(0.00697)	(0.00679)
Female	−0.563***	−0.563***	−0.563***
	(0.187)	(0.189)	(0.171)
White/Caucasian	−0.0121	−0.0121	−0.0121
	(0.427)	(0.407)	(0.396)
Black/African American	0.223	0.223	0.223
	(0.529)	(0.521)	(0.500)
Asian/East Asian American	−1.506**	−1.506**	−1.506**
	(0.702)	(0.660)	(0.565)
Education	0.0980	0.0980	0.0980*
	(0.0627)	(0.0595)	(0.0547)
Income	−0.00309	−0.00309	−0.00309
	(0.0309)	(0.0297)	(0.0288)
Employment (Fulltime)	0.189	0.189	0.189
	(0.256)	(0.244)	(0.180)
Employment (Retired)	−0.0435	−0.0435	−0.0435
	(0.351)	(0.335)	(0.269)
Employment (Unemployed)	0.182	0.182	0.182
	(0.322)	(0.299)	(0.343)
Political Party (D)	−0.0814	−0.0814	−0.0814
	(0.213)	(0.207)	(0.187)
Political Party (R)	−0.201	−0.201	−0.201
	(0.226)	(0.210)	(0.191)
Water Industry	−0.335	−0.335	−0.335
	(0.320)	(0.331)	(0.246)
COVID Sample	0.180	0.180	0.180
	(0.177)	(0.179)	(0.141)
Constant	2.817***	2.817***	2.817***
	(0.690)	(0.634)	(0.557)
Observations	345	345	345
R-squared	0.232	0.232	0.232
Robust Standard Errors (SE)	Yes		
Robust SE Clustered (County)		Yes	
Robust SE Clustered (State)			Yes
Shapiro-Wilk W Test for Normality	0.993		
Ramsey Test for Omitted Variable Bias	0.65		
Variance Inflation Factor (VIF)	1.63 (1.04–2.81)		
Akaikes Information Criterion (AIC)	1312.02		

***p < 0.01, **p < 0.05, *p < 0.1.

Table 8
Study two models with interactions.

VARIABLES	(1)	(2)	(3)
	PPR	PPR	PPR
DFR (Yes)	0.420**	0.420**	0.420***
	(0.179)	(0.178)	(0.134)
Trust in PWS	0.209	0.209	0.209
	(0.169)	(0.161)	(0.160)
Behavioral Trust (Tap)	1.636**	1.636***	1.636**
	(0.653)	(0.594)	(0.616)
Age	−0.0142**	−0.0142**	−0.0142**
	(0.00687)	(0.00647)	(0.00614)
Female	−0.142	−0.142	−0.142
	(0.240)	(0.246)	(0.244)
White/Caucasian	−0.164	−0.164	−0.164
	(0.415)	(0.391)	(0.361)
Black/African American	0.0264	0.0264	0.0264
	(0.519)	(0.511)	(0.462)
Asian/East Asian American	−1.451**	−1.451**	−1.451**
	(0.676)	(0.639)	(0.580)
Education	0.0675	0.0675	0.0675
	(0.0610)	(0.0588)	(0.0538)
Income	−0.190**	−0.190**	−0.190**
	(0.0955)	(0.0882)	(0.0768)
Employment (Fulltime)	0.223	0.223	0.223
	(0.255)	(0.244)	(0.174)
Employment (Retired)	−0.0510	−0.0510	−0.0510
	(0.345)	(0.326)	(0.257)
Employment (Unemployed)	0.228	0.228	0.228
	(0.314)	(0.291)	(0.346)
Political Party (D)	−0.101	−0.101	−0.101
	(0.209)	(0.197)	(0.168)
Political Party (R)	−0.262	−0.262	−0.262
	(0.225)	(0.206)	(0.193)
Water Industry	−0.479	−0.479	−0.479*
	(0.322)	(0.321)	(0.258)
COVID Sample	0.599**	0.599***	0.599***
	(0.242)	(0.223)	(0.184)
Behavioral Trust (Tap) × Trust in PWS	−0.283*	−0.283**	−0.283**
	(0.144)	(0.128)	(0.126)
Trust in PWS × Income	0.0399*	0.0399**	0.0399**
	(0.0203)	(0.0183)	(0.0184)
COVID Sample × Female	−0.899***	−0.899***	−0.899***
	(0.334)	(0.324)	(0.284)
Constant	3.601***	3.601***	3.601***
	(0.941)	(0.882)	(0.684)
Observations	345	345	345
R-squared	0.268	0.268	0.268
Robust Standard Errors (SE)	Yes		
Robust SE Clustered (County)		Yes	
Robust SE Clustered (State)			Yes
Shapiro-Wilk W Test for Normality	0.988		
Ramsey Test for Omitted Variable Bias	0.655		
Variance Inflation Factor (VIF)	5.47 (1.13–17.21)		
Akaikes Information Criterion (AIC)	1301.74		

***p < 0.01, **p < 0.05, *p < 0.1.

knowledge of DFR occurrence through education campaigns (e.g., flyers, ad campaign) may help increase public beliefs (cognitive) and sentiment (feelings or emotions) toward PPR. In addition, prosocial marketing messages could focus on increasing consumer mindfulness about de facto reuse, the natural water cycle, and the trustworthiness of local public water suppliers (Barnes et al., 2021; Bernedo et al., 2014; Pereira et al., 2022; Zhen et al., 2020). Furthermore, consumers who believe that public water suppliers can provide safe drinking water are more inclined to accept PPR water. Management strategies aimed at increasing trust in public water suppliers may reduce consumer-based emotional reactions brought on by the yuck factor.

5.4. Policy implications

The practical implications of this study provide potential avenues for policy advancement at the federal, state, and local levels in the US. The federal level could spearhead or promote nationwide educational campaigns about the prevalence of DFR water across the entire US and simultaneously inform the public about the safety and benefits of PPR. These federal efforts could operate in collaboration with national water organizations and environmental agencies (e.g., EPA). Furthermore, the federal government, predominantly through the Centers for Disease Control and Prevention (CDC), consistently emphasized the importance of clean water (i.e., clean water needed to wash hands, concern about COVID-19 contaminating drinking water from wastewater). Given that our study indicates PPR acceptance increased overall after the pandemic began, federal policies or initiatives may garner further PPR support by emphasizing the importance of potable reuse initiatives and how they bolster water quality and support national water security. Furthermore, adopting a federal potable reuse policy or amending the Safe Drinking Water Act (federal policy regulating public water systems in the US), to

regulate and fund potable reuse initiatives could help increase potable reuse acceptance and implementation nationwide.

Similarly, in conjunction with federal efforts, state governments could increase state-level education campaigns and provide local financial incentives to implement potable reuse. Education campaigns could also focus on the prevalence of unplanned reuse or DFR within the state to emphasize the need for potable reuse. Additionally, states could offer financial incentives or grants to water utilities that wish to implement potable wastewater reuse programs. This would encourage utilities to take steps toward potable reuse, knowing they have both financial and political support from their state.

Local governments may benefit the most from increasing trust in the local water utility or utilities. Given that consumers who trust their public water suppliers are more inclined to accept PPR water, local utilities should prioritize transparency, regular quality checks, and open communication with their consumers. By addressing and demystifying the yuck factor through trust-building measures, water utilities can reduce consumer-based emotional reactions to planned reuse initiatives. Education campaigns at the local level could also improve localized acceptance of PPR. Local water utilities could engage the community through town hall meetings, feedback sessions, and workshops to provide avenues for consumers to voice their concerns, ask questions, and get direct answers, fostering an environment of transparency and trust.

5.5. Limitations and future research

While our study contributes to the literature in several ways, it does have limitations that can be addressed in future research. The final sample sizes were $N = 551$ and $N = 345$ US public tap water consumers, respectively, in studies 1 and 2. Larger samples would potentially allow for a more robust analysis of interaction effects and demographic factors that may link to PPR attitudes. Despite this potential sample size limitation, the samples collected for both studies were randomly selected and the sampling margin of error, based on the sample sizes, ranged between 4.17% and 5.27%, an acceptable range in the social sciences (Taherdoost, 2016). The data for both studies were collected with cross-sectional (i.e., snapshots in time) descriptive surveys over three separate periods in 2019 (one sample in study 1) and 2020 (two samples in study 2). These samples provide valuable insight into PPR acceptance; however, we recommend that future studies analyze the same respondents over time (i.e., repeated measures) to identify if PPR attitudes, DFR perceptions, and trust vary over time. Our correlational findings indicate that PPR acceptance increased after the pandemic began, but due to our design, we cannot be certain of the mechanism. Longitudinal studies could deduce whether PPR acceptance, DFR perceptions, and trust in public water suppliers, among multiple potential factors, are systematically changing over time (e.g., PPR attitudes consistently increasing).

The reuse terms and definitions provided to survey respondents should be carefully designed to avoid potential response-based methodological errors such as acquiescence bias, question order bias, or neutral response bias. Because our sample of consumers was not aware of the definitions of PPR and DFT, we had to provide definitions of these terms prior to administering our survey. We recommend that future research separate the provision of definitions of these types of water from the survey administration so that the definitions do not serve as a mindset prime. Similarly, as knowledge about planned reuse types (i.e., direct and indirect potable reuse) is low in the general US population (McClaran et al., 2020), we opted to use simplified language (e.g., planned reuse vs. unplanned reuse) to ensure planned (i.e., PPR) and unplanned (i.e., DFR) potable reuse could be easily distinguished by low knowledge survey respondents. Future studies are needed to identify specific links between DFR perceptions and direct or indirect potable reuse. Similarly, our study utilized validated survey methods and constructs predominantly from marketing and psychology literature, but other methodological methods should be employed in future scholarship to validate this study's findings (Scruggs et al., 2023). Finally, our study focused on DFR beliefs, trust, and behavioral trust as key determinants of PPR acceptance. Future research can analyze other potential antecedents and location-based factors (e.g., water scarcity, water quality, local policy measures) that link to public knowledge about the pervasiveness of de facto wastewater reuse and garner public trust in the local public water supplier(s) to overcome the yuck factor.

6. Conclusion

Analyzing the associations between DFR perceptions, trust in public water suppliers, and attitudes towards PPR provided an opportunity to understand better how an individual's current experience with their public tap water links to their attitude towards PPR. This analysis demonstrates, with two studies, that individuals who think they already consume treated wastewater have significantly higher attitudes toward PPR water, matching previous findings and affirming hypothesis 1 (Rice et al., 2016). This effect persists when analyzing responses both before and after the COVID-19 pandemic went into effect. Additionally, consumers with a higher level of trust in their public water suppliers (both reported and behavioral trust) also have a higher attitude towards planned potable reuse water, matching previous findings and affirming hypothesis 2 (Ormerod and Scott, 2013; Ormerod et al., 2019; Redman et al., 2019). Furthermore, the exploratory interaction model results suggest that the correlation between reported trust in public water suppliers and attitude towards PPR is likely moderated by one's demographic/socio-economic characteristics. Interestingly, primary effects persisted after the onset of the COVID-19 pandemic, and our results provide correlational evidence that attitudes towards PPR may have increased after the onset of the pandemic. Future studies are needed to validate the correlational nature of the findings of this study.

CRediT authorship contribution statement

Jesse L. Barnes: Conceptualization, Methodology, Software, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Anjala S. Krishen:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition. **Han-fen Hu:** Data curation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Appendix

Table A1
Variable descriptions

Variable Type	Variable Name	Description
Dependent Variable	PPR	Attitude Towards Planned Potable Reuse Construct from construct 2 (Table 1) (continuous variable)
Independent Variables	DFR (Yes)	Study 1: Answered "Yes" to question 1a (Table 1) coded 1; and 0 otherwise (binary variable) Study 2: Answered "Somewhat agree," "Agree," or "Strongly agree" to question 1 b (Table 1) coded 1; and 0 otherwise (binary variable)
	Trust in Public Water Supplier (PWS)	Trust in Public Water Supplier Construct from construct 1 (Table 1) (continuous variable)
	Behavioral Trust (Tap)	Answered "Tap" to question 2 (Table 1) coded 1; and 0 otherwise (binary variable)
Control Variables	Female	Respondents that identified as female were coded 1; and otherwise (binary variable)
	Race	Three binary measures either representing White/Caucasian, African American/Black, and Asian/East Asian American respondents were included in the regression models (binary measures)
	Education	Education is used as a continuous measure given the ordinal nature of the data (continuous variable)
	Income	Income is used as a continuous measure given the ordinal nature of the data (continuous variable)
	Employment	Three binary measures either representing fulltime, unemployed, or retired respondents were included in the regression models (binary measures)
	Political Party	Two binary measures either representing democrats or republicans were included in the regression models (binary measures)
	Water Industry	Individuals who answered "Yes" that they either work in the water sector or know someone who does was coded as 1; and 0 otherwise

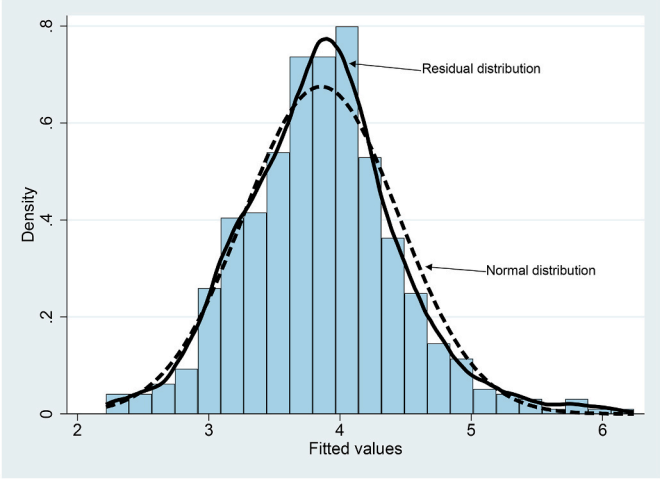


Fig. A1. Residual distribution of Model 1 with normality curve

References

Allaire, M., Mackay, T., Zheng, S., et al., 2019. Detecting community response to water quality violations using bottled water sales. Proc. Natl. Acad. Sci. U.S.A. 116 (42), 20917–20922.

Barnes, J.L., Krishen, A.S., Chan, A., 2022. Passive and active peer effects in the spatial diffusion of residential solar panels: a case study of the Las Vegas Valley. J. Clean. Prod. 363, 132634.

Barnes, J.L., Krishen, A.S., Hu, H-f, 2021. Untapped knowledge about water reuse: the roles of direct and indirect educational messaging. Water Resour. Manag. 35 (1), 2601–2615.

Bernedo, M., Ferraro, P.J., Price, M., 2014. The persistent impacts of norm-based messaging and their implications for water conservation. J. Consum. Pol. 37 (3), 437–452.

Bjørnskov, C., 2022. Social trust and patterns of growth. South. Econ. J. 89 (1), 216–237.

de Jager, C.E., 2017. A question of trust: the pursuit of consumer trust in the financial sector by means of EU legislation. J. Consum. Pol. 40 (1), 25–49.

Etale, A., Fielding, K., Schäfer, A.I., Siegrist, M., 2020. Recycled and desalinated water: consumers' associations, and the influence of affect and disgust on willingness to use. J. Environ. Manag. 261, 110217.

Falk, T., Schepers, J., Hammerschmidt, M., Bauer, H.H., 2007. Identifying cross-channel dissynergies for multichannel service providers. J. Serv. Res. 10 (2), 143–160.

Fielding, K.S., Dolnicar, S., Schultz, T., 2019. Public acceptance of recycled water. Int. J. Water Resour. Dev. 35 (4), 551–586.

Fotuhi, O., Fong, G.T., Zanna, M.P., Borland, R., Yong, H.H., Cummings, K.M., 2013. Patterns of cognitive dissonance-reducing beliefs among smokers: a longitudinal analysis from the International Tobacco Control (ITC) Four Country Survey. Tobac. Control 22 (1), 52–58.

Furlong, C., Jegatheesan, J., Currell, M., et al., 2019. Is the global public willing to drink recycled water? A review for researchers and practitioners. Util. Pol. 56, 53–61.

Garcia-Cuerva, L., Berglund, E.Z., Binder, A.R., 2016. Public perceptions of water shortages, conservation behaviors, and support for water reuse in the US. Resour. Conserv. Recycl. 113, 106–115.

Gefen, D., Karahanna, E., Straub, D.W., 2003. Trust and TAM in online shopping: an integrated model. MIS Q. 51–90.

Gleick, P.H., 2010. Roadmap for sustainable water resources in southwestern North America. Proc. Natl. Acad. Sci. USA 107 (50), 21300–21305.

Griffin, R.C., 2016. Water Resource Economics: the Analysis of Scarcity, Policies, and Projects. MIT press.

Gul, S., Gani, K.M., Govender, I., Bux, F., 2021. Reclaimed wastewater as an ally to global freshwater sources: a PESTEL evaluation of the barriers. J. Water Supply Res. Technol. - Aqua 70 (2), 123–137.

Harmon-Jones, E., Mills, J., 2019. An Introduction to Cognitive Dissonance Theory and an Overview of Current Perspectives on the Theory.

Hoffmann, E., Mohaupt, F., 2020. Joint storage: a mixed-method analysis of consumer perspectives on community energy storage in Germany. Energies 13 (11), 3025.

Honeycutt, B.L., 2015. Public Opinion of Potable Water Reuse in Denver, Colorado. University of Colorado at Denver.

Hu, H.F., Krishen, A.S., Barnes, J.L., 2023. Through narratives we learn: exploring knowledge-building as a marketing strategy for prosocial water reuse. J. Bus. Res. 158, 113655.

Hu, Z., Morton, L.W., Mahler, R.L., 2011. Bottled water: United States consumers and their perceptions of water quality. Int. J. Environ. Res. Publ. Health 8 (2), 565–578.

Knief, U., Forstmeier, W., 2021. Violating the normality assumption may be the lesser of two evils. Behav. Res. Methods 53 (6), 2576–2590.

Koebele, E.A., Singletary, L., Hockaday, S.E., Ormerod, K.J., 2022. A role for water markets in enhancing water security in the western United States?: lessons from the Walker River Basin. Water Pol. 24 (11), 1757–1771.
Kondo, J., Li, D., Papanikolaou, D., 2021. Trust, collaboration, and economic growth. Manag. Sci. 67 (3), 1825–1850.
Leong, C., Lebel, L., 2020. Can conformity overcome the yuck factor? Explaining the choice for recycled drinking water. J. Clean. Prod. 242, 118196.
Leonidou, L.C., Coudounaris, D.N., Kvasova, O., et al., 2015. Drivers and outcomes of green tourist attitudes and behavior: sociodemographic moderating effects. Psychol. Market. 32 (6), 635–650.
Lord, K.R., Lee, M.-S., Sauer, P.L., 1994. Program context antecedents of attitude toward radio commercials. J. Acad. Market. Sci. 22 (1), 3–15.
Macpherson, L., Snyder, S.A., 2013. Downstream: context, understanding, acceptance: effect of prior knowledge of unplanned potable reuse on the acceptance of planned potable reuse. WateReuse Research Foundation. WERF project Reuse-09-01.
Marinova, D., Singh, J., 2014. Consumer decision to upgrade or downgrade a service membership. J. Acad. Market. Sci. 42 (6), 596–618.
McClaran, N., Behe, B.K., Huddleston, P., Fernandez, R.T., 2020. Recycled or reclaimed? The effect of terminology on water reuse perceptions. J. Environ. Manag. 261, 110144.
Moorman, C., Deshpande, R., Zaltman, G., 1993. Factors affecting trust in market research relationships. J. Market. 57 (1), 81–101.
Ormerod, K.J., Redman, S., Kelley, S., 2019. Public perceptions of potable water reuse, regional growth, and water resources management in the Reno-Sparks area of northern Nevada, USA. City and Environment Interactions 2, 100015.
Ormerod, K.J., Scott, C.A., 2013. Drinking wastewater: public trust in potable reuse. Sci. Technol. Hum. Val. 38 (3), 351–373.
Pereira, M.C., Simoes, P., Cruz, L., et al., 2022. Mind (for) the water: an indirect relationship between mindfulness and water conservation behavior. J. Consum. Behav. https://doi.org/10.1002/cb.2023.
Pirtle, W.L.N., Wright, T., 2021. Structural gendered racism revealed in pandemic times: intersectional approaches to understanding race and gender health inequities in COVID-19. Gend. Soc. 35 (2), 168–179.
Po, M., Nancarrow, B.E., Kaercher, J.D., 2003. Literature review of factors influencing public perceptions of water reuse. Perth: CSIRO Land and Water 54 (3), 1–44.
Poulin, M.J., Haase, C.M., 2015. Growing to trust: evidence that trust increases and sustains well-being across the life span. Soc. Psychol. Personal. Sci. 6 (6), 614–621.
Prins, F.X., Etale, A., Ablo, A.D., Thatcher, A., 2022. Water scarcity and alternative water sources in South Africa: can information provision shift perceptions? Urban Water J. 1–12.
Redman, S., Ormerod, K.J., Kelley, S., 2019. Reclaiming suburbia: differences in local identity and public perceptions of potable water reuse. Sustainability 11 (3), 564.
Rice, J., Westerhoff, P., 2015. Spatial and temporal variation in de facto wastewater reuse in drinking water systems across the U.S.A. Environ. Sci. Technol. 49 (2), 982–989.
Rice, J., Wutich, A., White, D.D., et al., 2016. Comparing actual de facto wastewater reuse and its public acceptability: A three city case study. Sustain. Cities Soc. 27, 467–474.
Ross, V.L., Fielding, K.S., Louis, W.R., 2014. Social trust, risk perceptions and public acceptance of recycled water: Testing a social-psychological model. J. Environ. Manag. 137, 61–68.
Schmidt, C.W., 2008. The Yuck Factor When Disgust Meets Discovery. Environ. Health Perspect. 116 (12), A524.
Scruggs, C.E., Heyne, C.M., Rumsey, K.N., 2023. Understanding questions and concerns about potable water reuse: An analysis of survey write-in responses. AWWA Water Science 5 (2), e1333.
Scruggs, C.E., Pratesi, C.B., Fleck, J.R., 2020. Direct potable water reuse in five arid inland communities: an analysis of factors influencing public acceptance. J. Environ. Plann. Manag. 63 (8), 1470–1500.
Smith, H.M., Brouwer, S., Jeffrey, P., et al., 2018. Public Responses to Water Reuse – Understanding the Evidence. Academic Press, pp. 43–50.
Starzyk, K.B., Fabrigar, L.R., Soryal, A.S., Fanning, J.J., 2009. A painful reminder: The role of level and salience of attitude importance in cognitive dissonance. Pers. Soc. Psychol. Bull. 35 (1), 126–137.
Taherdoost, H., 2016. Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. *How To Choose a Sampling Technique for Research. April 10, 2016)*.
Teodoro, M.P., Zuhlke, S., Switzer, D., 2022. The Profits of Distrust. Cambridge University Press.
ter Huurne, M., Rontelтap, A., Corten, R., et al., 2017. Antecedents of trust in the sharing economy: A systematic review. J. Consum. Behav. 16 (6), 485–498.
Tsatsou, A., Frantzeskaki, N., Malamis, S., 2023. Nature-based solutions for circular urban water systems: A scoping literature review and a proposal for urban design and planning. J. Clean. Prod., 136325
US EPA, 2017. Potable Reuse Compendium. Retrieved from. https://www.epa.gov/sites/production/files/2018-01/documents/potablereusecompendium_3.pdf.
US EPA, 2019. National Water Reuse Action Plan - Collaborative Implementation V1 (February), 43. Retrieved from. https://www.epa.gov/sites/production/files/2019-09/documents/water-reuse-action-plan-draft-2019.pdf.
Vaidis, D.C., Bran, A., 2019. Respectable challenges to respectable theory: Cognitive dissonance theory requires conceptualization clarification and operational tools. Front. Psychol. 10, 1189.
Wester, J., Timpano, K.R., Çek, D., et al., 2016. The psychology of recycled water: Factors predicting disgust and willingness to use. Water Resour. Res. 52 (4), 3212–3226.
Wolske, K.S., Stern, P.C., Dietz, T., 2017. Explaining interest in adopting residential solar photovoltaic systems in the United States: Toward an integration of behavioral theories. Energy Res. Social Sci. 25, 134–151.
Zhen, N., Barnett, J., Webber, M., 2020. Is Trust Always a Precondition for Effective Water Resource Management? Water Resour. Manag. 1–14.