# The Relationship between Drinking Water Sources and Perceptions of Psychological Resilience in Older Adults Following Hurricane Maria

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**Abstract**

Natural hazards significantly impact drinking water availability and reliability, posing challenges in accessing sufficient quality and quantity. Understanding the connection between water access and perceptions of psychological resilience (defined as how individuals bounce back after facing a major trauma) can clarify its role in well-being post-disaster. This study surveyed 208 older adults in Puerto Rico (May-July 2021), aged 64-104 years, 65% of whom were female, to explore this linkage following Hurricane Maria. Results show a strong preference for bottled water, with 86% of participants using it as a drinking source. Municipal tap water is the second most preferred at 71%, while well water is least favored, used by less than 4%. A gender-specific effect was found in the association between municipal tap water consumption and psychological resilience, where municipal tap water consumption was associated with higher psychological resilience only among women. The findings suggest that although bottled water is the preferred choice, municipal tap water use is positively associated with psychological resilience among women post-disaster. Research is needed to replicate these findings to attempt to determine their consistency in other similar contexts, identify underlying reasons and future implications for disaster response and preparedness.

**Keywords**

Psychological Resilience, Drinking Water, Puerto Rico, Hurricane Maria, Older Adults

**Synopsis**

This study explored the implications of drinking water sources on psychological resilience of older adults in Puerto Rico after Hurricane Maria.

## Introduction

In September 2017, Puerto Rico experienced one of the most catastrophic natural disasters in its history when Hurricane Maria, a Category 5 hurricane, struck. Hurricane Maria stands out as a significant milestone in the recorded meteorological history of Puerto Rico due to its magnitude and impact (1). One of the most profound impacts of Hurricane Maria was on the island's water supply and sanitation systems. The damage to these systems led to a water insecurity crisis where access to safe drinking water has become a significant challenge for the residents of Puerto Rico (2–4). The island's socioeconomic conditions played a crucial role in shaping the impact of the hurricane. The aging population of Puerto Rico, exacerbated by the migration of younger individuals to the mainland United States, meant that a significant portion of the population was older adults (1,5,6). This demographic shift has several implications, especially in a natural disaster, as this vulnerable group of older adults was affected by shifts in water drinking patterns and their primary water source.

The concept of a drinking water source encompasses the point where water is made available for use (7,8). A crucial category within this is 'improved drinking water sources,' designed and constructed to safeguard against external contamination (9). Among various types of improved drinking water sources, municipal tap water is the most prevalent globally (10). This source type typically involves direct water delivery to households via a plumbing system specifically for potable water. Drinkable tap water is crucial for maintaining hygiene and preventing the spread of waterborne disease-causing pathogens such as cholera, E. coli, and Legionella (11). Regular access to uncontaminated tap water supports overall health by providing essential hydration, which is vital for all bodily functions.

The public trust in municipal tap water in Puerto Rico has long been eroded because of past incidents where tap water safety was compromised, such as Hurricane Maria, where water contamination led to public health emergencies (12). Earlier events such as the contamination issues at superfund sites on the island of Vieques, where long-term pollution from military bomb testing has raised significant health concerns, and the coal ash piles in Guayama, which have posed severe risks to water safety during hurricanes have also contributed to public mistrust (13). Such events can erode public confidence in tap

water safety, leading to increased reliance on bottled water, which has environmental and economic drawbacks (14). On the other hand, water service disruptions refer to the interruptions in water supply. These can be due to infrastructure failures, maintenance works, or resource scarcity. Aging water infrastructure, especially in Puerto Rico, is prone to breakdowns, resulting in frequent and sometimes prolonged water outages (15). Additionally, climate change impacts, such as droughts or floods, can disrupt water sources, affecting the availability and quality of tap water (16).

Residents in Puerto Rico have historically had doubts about the safety and reliability of their tap water. Due to years of inconsistency and public skepticism regarding tap water, many residents have turned to alternative water sources instead of relying on the supply from their local water utility. The water service in Puerto Rico, managed by the *Puerto Rico Aqueduct and Sewer Authority (PRASA)*, is known for its interruptions and safety violations (3). These abrupt disruptions in service compel residents to seek other water sources. Such alternatives include hand-dug wells (6), bottled water (12), and, in more extreme situations, rainwater harvesting (17). Obtaining water from these sources demands considerable time and effort from individuals or community members (18). Additionally, the accessibility of these alternative water sources can be inconsistent or seasonal, influenced by factors such as resource limitations (e.g., a malfunctioning pump), environmental conditions (e.g., extreme weather), financial constraints in obtaining access, or social issues, including disputes within communities (19). Moreover, these alternative sources can pose significant health risks due to potential contamination and lack of treatment, as seen with hand-dug wells and harvested rainwater, which may harbor pathogens and harmful chemicals (20,21). Studies have also indicated that issues related to drinking water sources can significantly affect psychological health (22). Problems with drinking water can lead to stress, anxiety, and other mental health issues, which in turn can impair individuals' abilities to cope with and recover from these challenges (23).

The availability of safe drinking water can significantly influence the disaster recovery process, playing a crucial role in preventing the spread of waterborne diseases, which are a major risk in post-disaster environments (24). It offers a sense of security and normality in a situation where much has been lost or

altered (25). Moreover, managing and securing water resources can foster community cohesion and collective action, vital in building psychological resilience (26). Psychological resilience refers to the ability of individuals and communities to recover from traumatic events, adapt to changes, and return to a state of normalcy (27,28). Understanding the linkage between access to water and perceptions of psychological resilience may help understand the role of water access in psychological well-being following disasters. Despite its importance, studies specifically examining psychological resilience, particularly among the older adult population in Puerto Rico, are scarce. Psychological resilience is often influenced by factors like emotional health and well-being, perceptions of successful aging, social interactions with family and friends, optimism, and cognitive functioning (29,30).

Older adults often have fewer resources, such as physical mobility, financial means, and social support networks, to handle the stress and anxiety that can result from difficulty accessing safe and reliable drinking water (25). For instance, limited mobility can hinder their ability to travel to distribution points for clean water. Additionally, marginalized communities in Puerto Rico, such as low-income neighborhoods in Loíza, face significant challenges in accessing clean and safe drinking water. These communities often experience prolonged water service disruptions and contamination issues, which are exacerbated by historical patterns of discrimination and unequal distribution of resources (5,12). This lack of access to safe drinking water disproportionately impacts these groups, increasing their risk of health issues and psychological stress (33).

This paper examines the relationship between drinking water sources and the psychological resilience of older adults in low-income communities in Puerto Rico. Specifically, it investigates how reliance on municipal tap water, bottled water, and well water affects their psychological resilience. We hypothesize that using municipal tap water is associated with perceptions of psychological resilience. Additionally, we explore how demographic factors influence water source use patterns and their impact on psychological resilience.

## Materials and Methods

### *Site Selection and Data Collection*

A total of 208 in-person door-to-door surveys were conducted in 200 households in Loíza, Puerto Rico, between May and July 2021. The timing of the survey, a few years after Hurricane Maria, allowed for the capturing the enduring impacts of Hurricane Maria on the community's psychological resilience and water-related challenges. This timeframe also enabled the assessment of sustained changes in access to basic necessities, such as municipal tap drinking water, and how these changes have affected mental well-being and coping mechanisms over a more extended period. Loíza, situated approximately 39 km (24 miles) from the capital city, San Juan, is a densely populated municipality with a predominantly Black population. The selection of this municipality was based on several factors: First, Loíza's distinct socioeconomic status, characterized by economic challenges and disparities, made it an important location to study the impact of water-related challenges on marginalized communities. Second, Loíza had a significant population of older adults specifically targeted for the surveys due to their increased susceptibility to the effects of environmental hazards and unique challenges in the aftermath of natural disasters such as Hurricane Maria. Lastly, Loíza experienced considerable damage to its water infrastructure due to Hurricane Maria, making it one of the worst affected regions in Puerto Rico during this devastating hurricane (12,34). This history of vulnerability to hurricanes made Loíza an ideal location to study the long-term effects of such disasters on the community.

Surveys were initially distributed in a manner that corresponded proportionately to the various neighborhoods, known as barrios. Within these barrios, the sampling focused on residents who were available and willing to participate. To qualify for participation in the survey, individuals had to meet three specific criteria: they needed to be older adults (aged 64 and above), have been present in Puerto Rico during Hurricane Maria, and have faced flooding issues on their streets or properties. The surveys were conducted through face-to-face interactions, with a PhD student and two local field research assistants directly posing the questions and providing additional explanations when necessary. In a limited number of cases, surveys were left at homes with the occupants' consent and later retrieved on the same day. This

research adhered to ethical standards and received approval from the Institutional Review Board (IRB) of Iowa State University, ensuring the ethical conduct of research involving human subjects. Additionally, each local field research assistant underwent comprehensive training on IRB guidelines before conducting the survey.

The surveys constituted a segment of a broader study conducted in Puerto Rico, aiming to assess the challenges related to water insecurity in the aftermath of Hurricane Maria. Respondents typically spent an average of 30 to 45 minutes completing each survey, with a consistent question sequence maintained across all participants. Initially prepared in English, the surveys were subsequently translated into the Puerto Rican Spanish dialect by a research team member for administration.

### ***Dependent Variable***

*Psychological Resilience*

The primary variable of interest, Psychological Resilience, was evaluated using the 10-item Connor-Davidson Resilience Scale (CD-RISC-10) (35). Example items include; "I can deal with whatever comes my way", "I believe stress can strengthen me", and "I tend to bounce back after illness, injury or other hardships". Each question is scored on a 5-point scale, ranging from 0 to 4, where a higher score indicates a greater level of psychological resilience. The CD-RISC-10 has also been validated in Spanish among individuals in Puerto Rico (34). Internal consistency in this sample was measured using Cronbach's alpha, which was 0.78.

### ***Independent Variables***

*Drinking Water Sources*

In the survey, we included the following questions to gauge the primary drinking water sources used by the residents:

a) "Do you drink water from a tap water source?" (Yes/No)

b) "Do you drink water from a well water source?" (Yes/No)

c) "Do you drink water from a bottled water source?" (Yes/No)

## Control and Moderator Variables

*Demographics*

The study incorporated basic demographic information as control variables. Initially, the survey gathered essential demographic data from the participants, including their age, gender, level of education, and race.

*Tap Water Quality Perception*

The perception of tap water quality among residents was measured using the Water Quality Perception Scale (WQPS) (36), and this measurement was employed to understand tap water use better. This inclusion was essential to accurately assess the relationship between tap drinking water sources and psychological resilience. With initial positive psychometric properties, the WQPS is a tool to gauge individuals' perceptions and concerns regarding tap water quality (36). An individual's perception of their environment, including the quality of tap water they consume, can profoundly impact their mental health and resilience (23). For instance, a negative perception of tap water quality affects use patterns and psychological resilience. Internal consistency in this sample was measured using Cronbach's alpha, which was 0.73.

*Depression*

Depression was utilized as a control variable in the study, recognizing its heightened prevalence in Puerto Rico following Hurricane Maria. To gauge depression levels among participants, we employed the Center for Epidemiologic Studies Depression Scale (CES-D) (37), a tool known for its efficacy in measuring depressive symptoms across diverse populations (38,39). Studies have also documented significant increases in depression and PTSD symptoms among Puerto Ricans post-Maria (40).

Using the CES-D as a control variable was a strategic choice in our study, mainly when predicting psychological resilience in a post-disaster context. Depression, as a mental health condition, can significantly influence an individual's capacity to adapt and recover from stress and adversity (41). By measuring and controlling for depression levels, considering the elevated baseline of mental health challenges in Puerto Rico post-Hurricane Maria, we could more accurately isolate and understand the direct effects of drinking water sources on psychological resilience.

### *Data Analysis*

Descriptive analyses were used to examine rates of water source use. Correlations, multiple linear regression analysis, and post hoc tests were used to estimate six models, incorporating interaction effects to explore the collective impact of various variables on psychological resilience. Interaction effects occur when two or more explanatory variables interact, leading to a combined effect on a response variable that significantly differs from the sum of their individual effects (42).

## Results

### *Descriptive Statistics*

Table 1 presents a summary of the descriptive statistics for the sample population. The survey included 208 participants in the aftermath of Hurricane Maria, predominantly older adults with a minimum age of 64, a mean age of 74.1, and a maximum of 104. The median age was 73. Regarding gender distribution, 35% (72 individuals) were men, and 65% (134 individuals) were women, with 2 missing values. Regarding education, 48% (99 individuals) had less than a high school education, 45% (94 individuals) held a high school diploma, and 7% (15 individuals) had a bachelor's degree or higher. The racial composition was diverse: 43% Black/African American (89 individuals), 4% White (8 individuals), 7% Mixed (15 individuals), 20% Other (14 individuals), and 39% Missing/No Answer (82 individuals).

As for drinking water sources, 71% (145 individuals) reported drinking tap water, and 29% (60 individuals) did not, with 3 missing values. Bottled water was consumed by 86% (178 individuals), while 14% (29 individuals) did not drink bottled water, and there was one missing value. Only 4% (8 individuals) drank well water, whereas 96% (200 individuals) did not.

Table 1 Survey Sample Descriptive Statistics

| Variable | Obs. (N) | Descriptive Statistics | Value | Valid Percent |
|---|---|---|---|---|
| Gender | 208 | Men | 72 | 35% |
| | | Women | 134 | 65% |
| | | Missing Values | 2 | - |
| Age | 208 | Minimum | 64 | - |
| | | Mean | 74.1 | - |
| | | Median | 73 | - |
| | | Maximum | 104 | - |
| | | Missing Values | 0 | - |

| | | | | |
|---|---|---|---|---|
| Education | 208 | Less than High School | 99 | 48% |
| | | High School Diploma | 94 | 45% |
| | | Bachelor's Degree or Higher | 15 | 7% |
| | | Missing Values | 0 | - |
| Race | 208 | Black/African American | 89 | 43% |
| | | White | 8 | 4% |
| | | Mixed | 15 | 7% |
| | | Other | 14 | 6% |
| | | Missing/No Answer | 82 | 39% |
| Tap Water Source | 208 | Drink Tap Water | 145 | 71% |
| | | Do Not Drink Tap Water | 60 | 29% |
| | | Missing Values | 3 | - |
| Bottled Water Source | 208 | Drink Bottled Water | 178 | 86% |
| | | Do Not Drink Bottled Water | 29 | 14% |
| | | Missing Values | 1 | |
| Well Water Source | 208 | Drink Well Water | 8 | 4% |
| | | Do Not Drink Well Water | 200 | 96% |
| | | Missing Values | 0 | - |

Table 2 presents the distribution of the survey sample across three drinking water sources. Among the age groups, individuals aged 75+ show the highest percentages for drinking tap (41%) and bottled water (37%). Women are more likely to consume all three water types than men, with 63% drinking tap water, 66% bottled water, and 63% well water. In terms of education, 48% of those with less than a high school education drink tap water, while 46% consume bottled water. For high school graduates, 45% drink tap water, and 46% drink bottled water. Black/African Americans exhibit the highest percentages for all water sources, with 40% drinking tap water and 42% bottled water.

Of those who drink tap water, 81% (118 individuals) also drink bottled water, and 3% (4 individuals) drink well water. Conversely, among non-tap water drinkers, 97% (58 individuals) drink bottled water, and 7% (4 individuals) drink well water. For bottled water consumers, 66% (118 individuals) also drink tap water, and 3% (6 individuals) drink well water. Non-bottled water drinkers rely on other sources, with 7% (2 individuals) drinking tap water and 7% (2 individuals) drinking well water. Regarding well water, 50% (4 individuals) of well water drinkers also consume tap water, and 75% (6 individuals) drink bottled water. Among non-well water drinkers, 86% (172 individuals) consume bottled water and 71% (141 individuals) consume tap water.

Table 2 Survey Sample Distribution Across Drinking Water Sources

| Variable | Descriptive Statistics | Drinking Water Sources | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tap Water Source | | | | Bottled Water Source | | | | Well Water Source | | | |
| | | Drink Tap Water | | Do Not Drink Tap Water | | Drink Bottled Water | | Do Not Drink Bottled Water | | Drink Well Water | | Do Not Drink Well Water | |
| | | N | % | N | % | N | % | N | % | N | % | N | % |
| **Age** | 60 - 64 | 2 | 1% | 2 | 3% | 3 | 2% | 1 | 3% | 0 | 0% | 4 | 2% |
| | 65 - 69 | 45 | 31% | 24 | 40% | 65 | 37% | 4 | 14% | 1 | 13% | 69 | 35% |
| | 70 - 74 | 39 | 27% | 13 | 22% | 44 | 25% | 8 | 28% | 3 | 38% | 49 | 25% |
| | 75+ | 59 | 41% | 21 | 35% | 66 | 37% | 16 | 55% | 4 | 50% | 78 | 39% |
| | Missing/No Answer | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| | Total | 145 | | 60 | | 178 | | 29 | | 8 | | 200 | |
| **Gender** | Men | 51 | 35% | 20 | 33% | 58 | 33% | 13 | 45% | 3 | 38% | 69 | 35% |
| | Women | 92 | 63% | 40 | 67% | 118 | 66% | 16 | 55% | 5 | 63% | 129 | 65% |
| | Missing/No Answer | 2 | 1% | 0 | 0% | 2 | 1% | 0 | 0% | 0 | 0% | 2 | 1% |
| | Total | 145 | | 60 | | 178 | | 29 | | 8 | | 200 | |
| **Education** | Less than High School | 70 | 48% | 27 | 45% | 82 | 46% | 16 | 55% | 3 | 38% | 96 | 48% |
| | High School Diploma | 63 | 43% | 30 | 50% | 81 | 46% | 13 | 45% | 5 | 63% | 89 | 45% |
| | Bachelor's Degree or Higher | 12 | 8% | 3 | 5% | 15 | 8% | 0 | 0% | 0 | 0% | 15 | 8% |
| | Missing/No Answer | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| | Total | 145 | | 60 | | 178 | | 29 | | 8 | | 200 | |
| **Race** | Black/African American | 58 | 40% | 30 | 50% | 75 | 42% | 13 | 45% | 3 | 38% | 86 | 43% |
| | White | 4 | 3% | 4 | 7% | 6 | 3% | 2 | 7% | 0 | 0% | 8 | 4% |
| | Mixed | 12 | 8% | 2 | 3% | 13 | 7% | 2 | 7% | 0 | 0% | 15 | 8% |
| | Other | 7 | 5% | 6 | 10% | 13 | 7% | 1 | 3% | 3 | 38% | 11 | 6% |
| | Missing/No Answer | 64 | 44% | 18 | 30% | 71 | 40% | 11 | 38% | 2 | 25% | 80 | 40% |
| | Total | 145 | | 60 | | 178 | | 29 | | 8 | | 200 | |
| **Tap Water Source** | Drink Tap Water | N/A | N/A | N/A | N/A | 118 | 66% | 2 | 7% | 4 | 50% | 141 | 71% |
| | Do Not Drink Tap Water | N/A | N/A | N/A | N/A | 58 | 33% | 27 | 93% | 4 | 50% | 56 | 28% |
| | Missing/No Answer | N/A | N/A | N/A | N/A | 2 | 1% | 0 | 0% | 0 | 0% | 3 | 2% |
| | Total | N/A | N/A | N/A | N/A | 178 | | 29 | | 8 | | 200 | |
| **Bottled Water Source** | Drink Bottled Water | 118 | 81% | 58 | 97% | N/A | N/A | N/A | N/A | 6 | 75% | 172 | 86% |
| | Do Not Bottled Water | 27 | 19% | 2 | 3% | N/A | N/A | N/A | N/A | 2 | 25% | 27 | 14% |
| | Missing/No Answer | 0 | 0% | 0 | 0% | N/A | N/A | N/A | N/A | 0 | 0% | 1 | 1% |
| | Total | 145 | | 60 | | N/A | N/A | N/A | N/A | 8 | | 200 | |
| **Well Water Source** | Drink Well Water | 4 | 3% | 4 | 7% | 6 | 3% | 2 | 7% | N/A | N/A | N/A | N/A |
| | Do Not Drink Well Water | 141 | 97% | 56 | 93% | 172 | 97% | 27 | 93% | N/A | N/A | N/A | N/A |
| | Missing/No Answer | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% | N/A | N/A | N/A | N/A |
| | Total | 145 | | 60 | | 178 | | 29 | | N/A | N/A | N/A | N/A |

***Correlations***

Table 3 summarizes Pearson correlations for all the variables utilized in the study, offering a detailed overview of their interrelationships. Several significant correlations are observed, although generally of low to moderate strength. Notably, tap water consumption exhibits a moderate and significant positive correlation with water quality perception (r = 0.207), indicating that tap water users have a linear relationship with water quality perception. Tap water also shows a moderate positive correlation with psychological resilience (r = 0.225), indicating a stronger linear relationship between tap water consumption and resilience. Finally, psychological resilience has a low but significant negative correlation with gender (r = -0.157), indicating a linear relationship between gender and psychological resilience levels. Tables 4 and 5 also show the correlations for men and women, respectively.

Table 3 Survey Sample Correlation Table

| Variable | Gender | Age | Education | WQPS | CES-D | Tap | Bottle | Well | Psych. Resilience |
|---|---|---|---|---|---|---|---|---|---|
| 1. Gender | — | | | | | | | | |
| 2. Age | 0.085 | — | | | | | | | |
| 3. Education | 0.038 | -0.105 | — | | | | | | |
| 4. WQPS | 0.009 | 0.020 | 0.047 | — | | | | | |
| 5. CES-D | 0.126 | -0.091 | -0.021 | -0.060 | — | | | | |
| 6. Tap | -0.022 | 0.049 | 0.000[a] | 0.207 ** | -0.096 | — | | | |
| 7. Bottle | 0.087 | -0.101 | 0.098 | -0.079 | -0.068 | -0.200 ** | — | | |
| 8. Well | -0.011 | 0.027 | 0.009 | -0.123 | -0.004 | -0.092 | -0.063 | — | |
| 9. Psych. Resilience | -0.157 * | -0.038 | -0.009 | 0.045 | -0.089 | 0.225 ** | -0.023 | 0.036 | — |

* p < .05, ** p < .01, *** p <.001, [a] $-9.351\times10^{-21}$

Table 4 Survey Sample Correlation Table - Men

| Variable | Age | Education | WQPS | CES-D | Tap | Bottle | Well | Psych. Resilience |
|---|---|---|---|---|---|---|---|---|
| 1. Age | — | | | | | | | |
| 2. Education | -0.001 | — | | | | | | |
| 3. WQPS | -0.078 | 0.232* | — | | | | | |
| 4. CES-D | -0.048 | 0.048 | 0.022 | — | | | | |
| 5. Tap | -0.007 | -0.025 | 0.357** | -0.016 | — | | | |
| 6. Bottle | -0.100 | -0.031 | -0.112 | 0.007 | -0.300* | — | | |
| 7. Well | -0.031 | 0.035 | -0.295* | -0.150 | -0.180 | 0.100 | — | |
| 8. Psych. Resilience | -0.093 | 0.062 | -0.034 | -0.128 | -0.050 | 0.130 | 0.097 | — |

* p < .05, ** p < .01, *** p < .001

Table 5 Survey Sample Correlation Table - Women

| Variable | Age | Education | WQPS | CES-D | Tap | Bottle | Well | Psych. Resilience |
|---|---|---|---|---|---|---|---|---|
| 1. Age | — | | | | | | | |
| 2. Education | -0.167 | — | | | | | | |
| 3. WQPS | 0.097 | -0.041 | — | | | | | |
| 4. CES-D | -0.131 | -0.060 | -0.115 | — | | | | |
| 5. Tap | 0.086 | 0.022 | 0.100 | -0.133 | — | | | |
| 6. Bottle | -0.112 | 0.175* | -0.065 | -0.134 | -0.144 | — | | |
| 7. Well | 0.060 | -0.006 | 0.000[b] | 0.078 | -0.042 | -0.17* | — | |
| 8. Psych. Resilience | 0.012 | -0.023 | 0.081 | -0.041 | 0.331*** | -0.075 | 0.006 | — |

* p < .05, ** p < .01, *** p < .001, [b] $5.715\times10^{-4}$

***Multiple Linear Regressions***

Table 6 summarizes the multiple linear regression results, focusing on the relationships of various drinking water sources with psychological resilience. Gender is statistically significant and associated with psychological resilience in most models, with women generally having lower resilience scores across models. Age, however, does not demonstrate a statistically significant association with psychological resilience across the models. Similarly, education shows no statistically significant relationship in any model. Depression, measured continuously, also lacks a statistically significant association in these analyses. The interaction terms between gender and drinking water sources are shown in models 4, 5, and 6, respectively. In Model 4, the interaction term for women and tap water was significant.

Table 6 Multiple Regressions for Psychological Resilience

| Variables | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Gender *(0 if Men, 1 if Women)* | -2.820*** | -2.700** | -2.290** | -7.274*** | 0.569 | -2.179* |
| | (1.058) | (1.092) | (1.129) | (1.941) | (2.752) | (1.150) |
| Age *(Continuous)* | -0.0638 | -0.0495 | -0.0332 | -0.0708 | -0.0507 | -0.0314 |
| | (0.0635) | (0.0656) | (0.0680) | (0.0626) | (0.0655) | (0.0682) |
| Education *(0 if Less than High School, 1 if High School Diploma, 2 if Bachelor's Degree or Higher)* | -0.526 | -0.646 | -0.453 | -0.563 | -0.541 | -0.462 |
| | (0.763) | (0.786) | (0.816) | (0.751) | (0.789) | (0.817) |
| Depression *(Continuous)* | -0.0367 | -0.0600 | -0.0647 | -0.0275 | -0.0659 | -0.0604 |
| | (0.0611) | (0.0626) | (0.0651) | (0.0602) | (0.0627) | (0.0657) |
| Water Quality Perception *(Continuous)* | -0.0227 | 0.0128 | 0.0248 | -0.00531 | 0.0135 | 0.0285 |
| | (0.0397) | (0.0398) | (0.0416) | (0.0396) | (0.0397) | (0.0422) |
| Tap Water *(0 if No, 1 if Yes)* | 3.625*** | | | | | |
| | (1.118) | | | | | |
| Bottled Water *(0 if No, 1 if Yes)* | | -0.261 | | | | |
| | | (1.494) | | | | |
| Well Water *(0 if No, 1 if Yes)* | | | 1.639 | | | |
| | | | (2.766) | | | |
| [a] Gender x Tap Water | | | | 6.251*** | | |
| | | | | (2.300) | | |
| [a] Gender x Bottle Water | | | | | -3.859 | |
| | | | | | (2.984) | |
| [a] Gender x Well Water | | | | | | -3.081 |
| | | | | | | (5.805) |
| Constant | 35.44*** | 36.30*** | 33.90*** | 38.30*** | 34.58*** | 33.52*** |
| | (5.069) | (5.506) | (5.387) | (5.099) | (5.655) | (5.444) |
| Observations | 203 | 205 | 206 | 203 | 205 | 206 |
| R-squared | 0.097 | 0.046 | 0.034 | 0.130 | 0.054 | 0.036 |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, [a] Interaction Terms

***Interaction Effects***

To understand the statistically significant interaction model, it is visually represented in Figure 1. The figure illustrates the relationship between tap water consumption and psychological resilience, with gender as a moderating variable. Psychological resilience scores are plotted on the y-axis, while the x-axis distinguishes between individuals who drink tap water and those who do not. Two lines represent the gender groups: men (depicted by open circles) and women (depicted by filled circles). For women, there is an increase in psychological resilience scores, from approximately 26 for those who do not drink tap water to around 31 for those who do, showing that, among women, tap water consumption significantly and positively correlates with psychological resilience (simple slope = 5.675, p = 0.000). Conversely, among men, the psychological resilience scores appear to show a slight decrease from those who do not drink tap water to those who do, with resilience scores dropping from approximately 32 to 31, however this observation was

not statistically significant among men (simple slope = -0.576, p = 0.762).

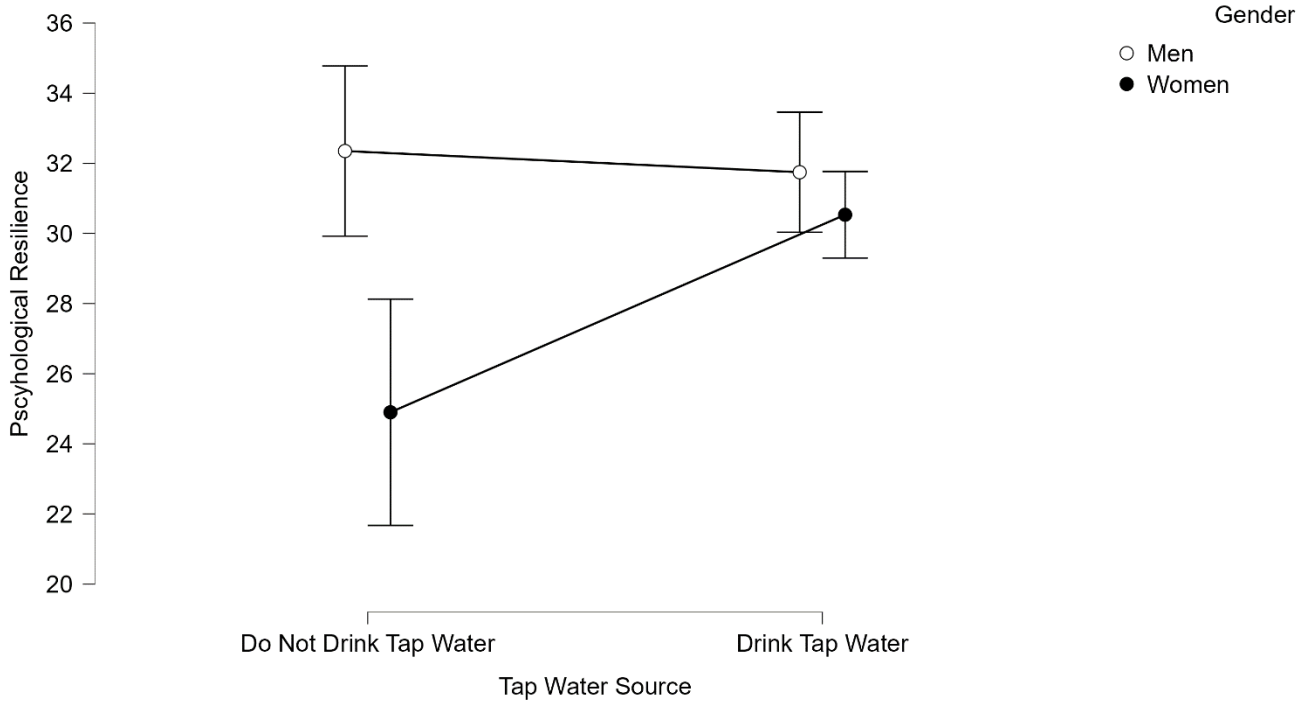


*Figure 1 Psychological resilience as a function of gender and tap water source.*

Table 7 Post Hoc Comparisons for Interaction Effects

| | | Mean Difference | SE | t | Cohen's d | $p_{tukey}$ |
|---|---|---|---|---|---|---|
| Men - Do Not Drink Tap Water | Women - Do Not Drink Tap Water | 7.45 | 1.899 | 3.923 | 1.074 | < .001*** |
| | Men - Drink Tap Water | 0.605 | 1.829 | 0.331 | 0.087 | 0.987 |
| | Women - Drink Tap Water | 1.817 | 1.711 | 1.062 | 0.262 | 0.713 |
| Women - Do Not Drink Tap Water | Men - Drink Tap Water | -6.845 | 1.464 | -4.674 | -0.987 | < .001*** |
| | Women - Drink Tap Water | -5.633 | 1.313 | -4.289 | -0.812 | < .001*** |
| Men - Drink Tap Water | Women - Drink Tap Water | 1.212 | 1.21 | 1.002 | 0.175 | 0.749 |

** p < .01, *** p < .001

Table 7 shows a post hoc analysis to examine the interaction effects between gender and tap water source. For men who do not consume tap water versus women who do not, a substantial mean difference of 7.45 (SE = 1.899) was observed, indicating a significant t-value of 3.923 (p < .001***). Cohen's d-= 1.074. Conversely, no significant differences were found between men and women who drink tap water, with mean differences of 0.605 (SE = 1.829) and 1.817 (SE = 1.711), respectively, yielding non-significant

t-values and p-values. When comparing women who do not drink tap water to men who do, a significant mean difference of -6.845 (SE = 1.464) was found, accompanied by a significant t-value of -4.674 ($p < .001$) (Cohen's d = -0.987). Similarly, women who drink tap water exhibit a significant mean difference of -5.633 (SE = 1.313) compared to women who do not, with a t-value of -4.289 ($p < .001$***), again indicating a large effect size (Cohen's d = -0.812). Lastly, no significant differences were observed between men and women who consume tap water, with a mean difference of 1.212 (SE = 1.21) and a non-significant t-value.

**Discussion**

While bottled water was most commonly used, municipal tap water emerged as the second most commonly consumed drinking water, with 71% of individuals indicating its usage. This may reflect accessibility, cost-effectiveness, and perceived tap water quality in the study area. The high proportion of participants drinking tap water suggests either a level of trust in municipal water sources or a lack of complete access to viable or preferred alternatives such as bottled water (12). Indeed, bottled water was consumed more commonly by the participants, with significant overlap in use with municipal tap water with 81% (118 individuals) of tap water consumers also drink consuming bottled water (Table 2). This preference for bottled water could stem from concerns about the quality of tap water, convenience, or lifestyle choices (12,43). The relatively low proportion of individuals not consuming bottled water may indicate its ubiquitous availability and marketing influence. Well water, however, is the least preferred option, with only a tiny fraction reporting its consumption. This may be due to concerns about safety and quality, particularly contamination risks and regulatory oversight.

The study's main finding was that the association between tap water consumption and psychological resilience differs by gender. Psychological resilience was lower for women who do not drink tap water compared to men in the same category. The variation in how tap water consumption is related to psychological resilience across genders may be linked to specific health issues and environmental concerns. The simplest explanation is that women who feel comfortable about drinking tap water have similar levels of perceived psychological resilience as their male counterparts but that those who do not drink tap water

311 also feel less psychological resilience. They may prefer to drink bottled water but may not have full access
312 to bottled water, given budgetary constraints, and this is associated with feeling less likely to "deal with
313 whatever comes my way", or bounce back after illness, injury or other hardships. While research is needed
314 to confirm these findings, we can speculate on several theoretical reasons for these findings.

315 Women, often the primary focus of health and diet culture (44), may receive more information and
316 messages about water quality (45). This exposure can lead to heightened concerns regarding tap water
317 quality, potentially influencing their consumption habits and affecting psychological resilience negatively.
318 Moreover, gender differences in risk perception, particularly around health and safety, suggest that women
319 might perceive tap water as riskier than men (46), impacting their stress levels and, consequently, their
320 psychological resilience negatively. Environmental concerns further compound these effects; increased
321 awareness of environmental pollutants and their health implications could lead women to avoid tap water,
322 fearing exposure to contaminants. Such avoidance, fueled by stress or anxiety over potential health risks,
323 may manifest as lower psychological resilience. Access to clean water also plays a crucial role, as
324 environmental pollution may compromise tap water quality in certain areas, exacerbating health fears and
325 impacting psychological resilience. Studies have shown that environmental concerns, health anxieties, and
326 societal messaging about water safety can significantly influence water consumption choices and
327 psychological well-being, highlighting the need for comprehensive public health strategies that address
328 these gender-specific perceptions and concerns.

329 On the other hand, men may be less likely to perceive tap water as a threat due to several factors.
330 They might have a lower awareness or concern regarding the potential health risks associated with water
331 contamination, such as exposure to pathogens or chemicals. This could be due to a generally lower level of
332 engagement in family healthcare responsibilities or a difference in how men and women are socialized to
333 perceive and respond to environmental and health risks (47). Additionally, men might place more trust in
334 public water systems and regulatory bodies, assuming that the tap water provided is safe until proven
335 otherwise (48). As a result, tap water consumption might not be instrumental in their psychological

resilience, as they do not perceive it as a significant stressor. This difference in perception could explain the varying impacts of tap water consumption on psychological resilience between genders, as shown in Figure 1.

In Puerto Rico, where women are often pivotal in household-level economic decision-making (49), the affordability of tap water may be a factor influencing psychological resilience, particularly among older adults. Tap water, generally less expensive than bottled water, offers an economic advantage, enabling women to manage their household resources more efficiently (10). This efficiency in managing basic necessities like drinking water allows for the reallocation of funds towards other essential areas, including healthcare, education, or savings. Such financial flexibility contributes to a sense of security and stability, which are vital components of psychological resilience. In situations where bottled water is heavily relied upon due to natural disasters or concerns about water safety, the cost implications can become burdensome (12,50). Women tasked with budget management may allocate a substantial portion of their budget to water purchases, potentially leading to financial strain. Consequently, when tap water is both available and trusted, it emerges as a more economically viable option, easing the economic pressures faced by households. This choice alleviates financial strain and promotes a sense of resilience by fostering self-reliance and independence. For women in Puerto Rico, the ability to economically meet basic needs reinforces confidence in managing broader life challenges, thereby bolstering psychological resilience (51–53).

***Study Limitations***

We wish to clarify that we do not, and cannot, claim that there is a causal or directional relationship between tap drinking water and psychological resilience based on the methods used. The most prominent limitation of this study is our ability to generalize the findings beyond Puerto Rico and limitations on directional and causal conclusions. However, we hope the data has implications beyond Puerto Rico, especially for areas facing the direct impacts of climate change through natural hazards with increased socioeconomic vulnerabilities. By sharing lessons learned and best practices, these communities can leverage collective knowledge to adapt and thrive in the face of climate-related threats, further bolstering resilience efforts

362 worldwide.

363 Additionally, the timing of the surveys, conducted four years after Hurricane Maria, presents
364 another limitation. This extended timeframe may have influenced the results in several ways. Over the
365 course of four years, individuals and communities may have experienced varying levels of recovery and
366 adaptation, which could affect their current levels of psychological resilience and perceptions of water-
367 related challenges. Some respondents might have developed coping mechanisms or received external
368 assistance that mitigated the immediate impacts of the hurricane, potentially altering their responses.

369 While the timing of our surveys allowed us to capture these enduring impacts, it also means that
370 the immediate, acute stressors experienced shortly after the hurricane are less likely to be reflected in our
371 data. This delay may result in an underestimation of the initial psychological and infrastructural challenges
372 faced by the community. Despite these limitations, the insights gained from this study are useful for
373 understanding the long-term effects of natural disasters on psychological resilience and for developing
374 strategies to enhance resilience and support long-term recovery in similar communities.

375 **Future Work Recommendations**

376 Based on the findings and implications of this preliminary study, several avenues for future research and
377 action are recommended to further enhance the resilience of older adults in Puerto Rico to water-related
378 issues. First, community-based participatory research can facilitate the development of locally relevant
379 solutions that are more likely to be adopted and sustained. In the context of Puerto Rico and the United
380 States at large, using community-based participatory research methods in conducting longitudinal studies
381 to monitor changes in water source reliance among older adults is crucial to ensuring the development of
382 locally relevant solutions that are more likely to be adopted and sustained. This will help understand how
383 interventions impact behavior over time and how reliance on municipal tap water, bottled water, and well
384 water evolves. Implementing these interventions and evaluating the effectiveness of gender-specific
385 educational and empowerment programs will measure changes in water use behavior, knowledge about
386 water safety, and participation in water management activities. Engaging older adults in participatory

research to co-create solutions for water-related resilience ensures that interventions are culturally relevant and directly address the community's needs and preferences. Second, assessing and improving communication strategies to build public trust in municipal water systems can enhance also community resilience. Evaluating the different communication strategies to improve public trust in municipal tap water, including testing various messaging techniques, media channels, and the role of local leaders in disseminating information, is essential. Finally, integrating water management with emergency preparedness can ensure comprehensive disaster response strategies that safeguard water safety. Additionally, studying the integration of water management with broader emergency preparedness plans and assessing how well current disaster response strategies incorporate water safety will help identify areas for improvement to support older adults. Gender-specific intervention trials can reveal the best practices for tailoring public health campaigns to different demographics.

## Conclusion

Our study investigated the relationship between drinking water sources and the psychological resilience of older adults in a Puerto Rican community, particularly post-Hurricane Maria. We discovered that tap water consumption is significantly correlated with higher levels of psychological resilience. Notably, this positive effect is stronger in women than in men, suggesting that gender, along with cultural and social factors, plays a crucial role in the benefits derived from tap water.

These findings contribute to understanding how engineering and environmental factors link to psychological factors such as perceived resilience in disaster-affected areas (54–56). The study suggests some preliminary ideas for policy reforms to improve water quality and distribution systems. By addressing these issues, we can enhance the community's resilience to future disasters, highlighting the urgent need for targeted interventions that consider gender-specific responses to environmental stressors.

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