International Journal of Sustainable Development and Planning
Vol. 19, No. 6, June, 2024, pp. 2115-2123
Journal homepage: http://iieta.org/journals/ijsdp

Is Bottled Water More Reliable Than Tap Water in Mexico? A Case Study of Household Mental Health Conditions in Two States

Mohsen Sanei, Mina Khodadad*

Department of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology, Luleå 97187, Sweden

Corresponding Author Email: mina.khodadad@associated.ltu.se

https://doi.org/10.18280/ijsdp.190611

Received: 10 April 2024
Revised: 28 May 2024
Accepted: 6 June 2024
Available online: 24 June 2024

Keywords:
bottled water, drinking water quality, Mexico, public mental health, public network water, public (dis)trust, tap water

ABSTRACT

Most Mexicans do not trust the water provided by the public network to be healthy enough to drink. This has made Mexico a key consumer of bottled water worldwide. Besides the inadequate quality of water and health concerns, there are other studied reasons for promoting bottled water usage among Mexicans, such as debilitated regulatory frameworks and the power of multinational corporations. Therefore, an argument arises of how much the Mexicans' distrust of the public water network is based on the actual quality of water. This article contributes to this argument by analyzing national household survey data. The association between the two dominant types of drinking water (containers/bottles and public tap water) and mental health conditions (remembering difficulty, depression, and nervousness) are studied in Chihuahua and Nuevo León states, where the usage rates of the two water types are the closest (to minimize biased results). Our results illustrate different conditions for the states demonstrating that, considering mental health conditions, not trusting the quality of public network water in all Mexican regions may not be appropriate. Nevertheless, there might be rightful health concerns in some regions. The outcomes are helpful for authorities to prioritize policies to address water quality management/education actions.

1. INTRODUCTION

Ensuring water security is a top concern for politicians and governments globally [1-3]. Like many other countries, water infrastructure and services in Mexico have spontaneously experienced several accomplishments and unremitting challenges. Over the last couple of years, the country has seen a noteworthy nationwide escalation in access to the public water network and enhanced sanitation in urban and rural areas. However, still many challenges remain in the water infrastructure sector, among which a problematic issue is the inadequate quality of drinking water [4, 5].

Most people in Mexico do not trust the public water network (i.e., the network providing water delivered from water taps; hereafter referred to as PWN) to provide safe drinking water, leading to the usage of containers/bottles (hereafter referred to as C/B). According to the latest version of the Households and Environment Module (MOHOMA) [6], a questionnaire annexed to the national household survey (ENH) [7], 76.3% of Mexican households used containers/bottles (hereafter referred to as C/B) for drinking water in 2017, which shows a 5 percent increase compared to the 2015 rate. This makes Mexico a key consumer of bottled water in the world. The country led globally in per-capita consumption of bottled water while being the third top consumer of bottled water after China and the United States, in 2020 [8].

The main motivation for Mexicans to choose C/B is health concerns and related perceived risks (69.4%) [6], leading to public distrust towards PWN. The literature frequently associates risk and (dis)trust [9], which orients the public perception of drinking water. Additionally, several experts in the field of ecological psychology [10] would refute the idea of separating perception and action, asserting that perception and action are inherently interconnected [11]. This rationalizes a positive correlation between risk perception and safety behavior [12], which can be choosing an option with superior safety (as perceived by the public) for drinking [13].

However, there are serious concerns regarding the wide usage of bottled water. An overarching concern is the adverse environmental consequences, including the production of plastic waste, which contributes to environmental contamination and poses challenges in managing solid waste [14]. Generating, transporting, and disposing of plastic bottles also impose financial costs on society [15]. Moreover, bottled water costs significantly more than tap water, ranging from 100 to 1000 times higher, intensifying economic inequalities, particularly in underprivileged populations [16]. Thus, the wide usage of C/B among Mexicans is a significant issue requiring further attention. Additionally, and more specifically, studies have shown that bottled water does not necessarily have higher quality than tap water [17, 18], and there are other factors, such as marketing and debilitated regulatory frameworks, promoting C/B as the healthier option [19]. Therefore, it remains unclear to what extent the public

fear of becoming sick by drinking from PWN is associated with the actual quality of water they use. The present research tries to contribute to this argument.

There are multiple previous studies done in the Mexican context, trying to find the relationship between drinking water quality and the user's health condition. For example, Cifuentes et al. [20] evaluated the youngsters' enteric illnesses in a water reclamation region in Mexico City. Gutiérrez et al. [21] analyzed the fluctuations in water quality of the San Pedro River in Chihuahua, Mexico, and investigated the potential health consequences associated with these variations. Jiménez-Moleón and Gómez-Albores [22] presented an analysis of waterborne diseases in the State of Mexico during the 2000 – 2005 period, focusing on regional and temporal patterns. Rojas-Fabro et al. [23] utilized statistical and geostatistical approaches to evaluate the concentration and geographical distribution of nitrate in the karstic aquifer of Merida, and the connected health risks. López-Carrillo et al. [24] examined the possible connections between the women's capacity to methylate inorganic arsenic, which exists in drinking water in many regions, and the breast cancer risk, in northern Mexico.

Nonetheless, these studies mainly focus on physical health conditions, such as gastrointestinal and parasitic diseases. As a result, less attention has been placed on how drinking water is associated with mental health issues in the Mexican context. This article tries to fill this gap by focusing on mental health aspects that significantly contribute to public health and well-being [25]. Accordingly, the main objective of this research is to find possible associations between different drinking water types and household mental health issues, both of which are vital topics and specifically mentioned among the 17 goals (Goals 3 and 6) of the UN 2030 Agenda for Sustainable Development [26]. They also play important parts as markers in sustainability assessment methods and tools [27-30].

To perform our analysis, we investigated the possible correlations between PWN and C/B water types and three mental health conditions among Mexican households, namely remembering difficulty, depression, and nervousness. This would be helpful to assess how much the current Mexicans (dis)trust of PWN is based on the actual quality of water. We evaluated the data from the latest version of EHN and MOHOMA national household surveys done by INEGI [6, 7]. The analyses were done separately for two Mexican states, Chihuahua and Nuevo León, in which the consumption rates of PWN and C/B were the closest on a national scale (highest rates for PWN usage). This helped to minimize the biased results of the analyses. The outcomes are helpful for authorities to prioritize adequate policies to address water quality management/education actions.

2. METHODOLOGY AND DATA

This paper used the data provided by the national household survey (ENH) performed by INEGI in 2017, which is the latest version of the survey [7]. The data relating to the types of drinking water was gathered from the basic questionnaire of the survey. Likewise, the information explaining the mental health status of households was gathered from the Module on Households and Environment (MOHOMA) [6], which was conducted in a questionnaire annexed to the ENH 2017. In total, the information from 15880 Mexican houses was obtained and analyzed in the MOHOMA module survey. The module shared with the original (ENH) survey, both the sample of housing units in which the basic questionnaire was applied and the field operation, the sampling, and analysis unit, as well as some of the methodological foundations [6]. A detailed description of the survey methodology and the utilized paper questionnaires is available at the INEGI official website [31].

The data of the surveys were organized by the 'Folioviv' identifier, a unique 10-digit code assigned to each dwelling unit of the survey, showing its geographic specifications. On this basis, the dwellings included in both questionnaire surveys (ENH and the MOHOMA module) were selected for further analysis. As the next phase, to decrease biased results, the Mexican states in which the water consumption rates for PWN and C/B were the most similar were selected. Two states were selected on this basis namely, Chihuahua (53.1% of total usage from C/B and 44.4% from PWN) and Nuevo León (55.5% of total usage from C/B and 43.1% from PWN). The analyzed population sample slightly differs for the three sections of the analysis (in general, between 2600 to 3000 household participants for each health issue). The exact sample size used for each health problem analysis is reported in the related results section.

In each of these two states, to come up with the final results, the possible associations between the types of drinking water and the frequency of mental health problems (separately) were comparatively analyzed through cross-tabulation and the Mann-Whitney U test. Cross-tab analysis is a statistical method widely used to examine the relationship between variables by creating a contingency table to summarize data [32, 33]. It has been widely used in health-related research [34, 35]. Additionally, the Mann-Whitney U test was chosen, as a non-parametric test, because the data distribution was not normal. The method is generally used to see whether there is a dissimilarity in the dependent variable (ordinal data) for independent binary groups (nominal data) and to evaluate whether the distribution of the dependent variable is similar for both groups. The test is a frequent method used by scientists for comparing two sets of data when the data distribution is not normal [36]. It also has many benefits, including simplicity in explanation, handling ordinal responses, being implemented for large samples, being robust to outliers, and requiring few assumptions [37], which makes it an efficient method for testing the significance of associations for the present study.

The data were tested using IBM SPSS Statistics version 26 [38]. As the dataset was too large for the exact algorithms and calculating the exact p-value was memory-intensive, Monte Carlo algorithms were used substitutionally for estimating the exact p-values, with 1000000 sampled tables and a 99.5% confidence interval, to be sure that the resulted p-values were assumed to be so similar to the exact ones (p-values below 0.05 were considered statistically significant).

For the analysis, the two independent groups were C/B and PWN users (nominal data) and the dependent variable was the frequency of the mental health problems (ordinal data). To confirm the results of the Mann-Whitney U test, the cross-tab reports were utilized to observe individual correlations between different analyzed variables. It should be noted that although the adopted methodology can discover statistically significant dependencies, it does not identify the form and the direction of these associations, which opens a window for possible future research.

3. RESULTS

The results of analyses are depicted in the following sections explaining the associations between the drinking water types and each of the three studied mental health problems in the two selected states. The explanations for each health problem and the general trend for each state are described in the following sections. The null hypothesis is that there is no connection between drinking water types and mental health issues in Mexican households.

3.1 Remembering difficulty

Table 1 explains the results of the remembering difficulties analysis. Four different levels of remembering difficulties are shown. In total, 2920 individuals participated in the survey (1274 for Chihuahua and 1646 for Nuevo León). Based on the outcomes, in Chihuahua State, 92.2% of the people who use C/B have reported no difficulty remembering issues. It is 3.9% more than the people who use PWN. A similar trend exists in Nuevo León, where more C/B users have reported no difficulty remembering compared to PWN consumers (92.7% vs. 90.0%). The tendency is different considering the next two levels of the remembering problem (some and much difficulty). This means the numbers are higher for the people who use PWN as their drinking water for both states. The highest difference rate can be seen for the level of 'some difficulty' for the Chihuahua State (C/B = 6.6%, PWN = 10.2%). The rates are closer for the 'much difficulty' level with 0.7% and 1.6% in Chihuahua and 0.8% and 1.3% in Nuevo León. Considering the last level of remembering difficulty, which is 'not able to remember', in contrast with the previous stages, the slightly higher rates are related to C/B users.

Table 1. Cross-tab analysis report for different types of drinking water and levels of remembering difficulty in study areas

State	Drinking Water		Levels of Remembering the Difficulty				Total
			No Difficulty	Some Difficulty	Much Difficulty	Not Able to Remember	
Chihuahua	Container or Bottle	Count	640	46	5	3	694
		Percentage	92.2%	6.6%	0.7%	0.4%	100.0%
	Public Water Network	Count	512	59	9	0	580
		Percentage	88.3%	10.2%	1.6%	0.0%	100.0%
Nuevo León	Container or Bottle	Count	859	59	7	2	927
		Percentage	92.7%	6.4%	0.8%	0.2%	100.0%
	Public Water Network	Count	647	62	9	1	719
		Percentage	90.0%	8.6%	1.3%	0.1%	100.0%

A correlation between drinking water types and remembering problems can be seen in both states. Higher rates of people who consume water from C/B have reported no difficulty remembering, while in almost all other levels of remembering problems, higher rates of health issues are seen for PWN users. This is not true when considering the 'not able to remember' level when the rates are higher —with very little difference— for the C/B sector. Here, few numbers of respondents (for this level of health issue) and the fact that, in general, more respondents use C/B can affect the viability of results. Nevertheless, the results from other sections of the comparison between C/B and PWN show there can be an association between the level of this mental issue and the drinking water types. In other words, the people who use PWN suffer more from remembering difficulties compared to C/B users.

To see the significance of the associations (each state), the results of the Mann-Whitney U test are used. The p-value for the data from Chihuahua is below 0.05 (p=0.019), while this value is 0.056 for Nuevo León, showing that the correlation is statistically significant only in Chihuahua. Although the observation of crass-tab data showed a similar trend in both states, the null hypothesis cannot be rejected in Nuevo León. Nevertheless, a p-value below 0.1 can indicate a low assumption for the null hypothesis.

3.2 Depression

Table 2 shows the crosstabulation of the results regarding the frequency of depression, as the second studied mental health problem. 1165 and 1517 individuals participated in the survey, in Chihuahua and Nuevo León respectively (2682 participants in both states). The frequency of depression is divided into five different stages including 'daily', 'weekly', 'monthly', 'sometimes a year', and 'never'. The results in Chihuahua State illustrate a direct correlation between water types and the disease frequency, in all five levels. This means people who use PWN suffer more from depression. To bring more details, they represent 1% more in 'daily', 0.7% more in 'weekly', 0.2% percent in 'monthly', and 4.4% more in 'sometimes a year' frequency levels compared to people who use C/B. Also, 78.5% of C/B users have said that they never had depression, compared to 72.2% of PWN users, which shows the biggest difference between C/B and PWN consumers.

The conditions are not so clear for Nuevo León. Here, while three out of five levels show the same trend, the situation differs in two other depression levels. Slightly higher rates of 'daily' (0.8% more) and 'monthly' (0.1 % more) frequency of depression are stated for PWN users, while they have conveyed less 'weekly' (0.2% less) and 'sometimes a year' (0.3% less) suffering from depression. The condition is slightly better for C/B consumers when it comes to the fraction of people who never had depression, as well. Here the rate is 69.0% for C/B and 68.7% for PWN users. While, as mentioned, three out of five depression levels show the same tendency in Nuevo León as well, it can be said that the overall trend in this state is not clear compared to Chihuahua as the rates are so close for Nuevo León, when 0.8% represents the biggest difference (for daily problems).

Considering the significance of the associations for both states, the p-values are 0.014 for Chihuahua and 0.817 for Nuevo León. This shows again that a statistically significant correlation exists for the Chihuahua analysis, while the null hypothesis cannot be rejected for the Nuevo León case. Therefore, a significant association between the type of drinking water and the depression frequency of participants exists only in Chihuahua.

Table 2. Cross-tab analysis report for different types of drinking water and frequency of depression in study areas

State	Drinking Water		Frequency of Depression					Total
			Daily	Weekly	Monthly	Sometimes a Year	Never	
Chihuahua	Container or Bottle	Count	25	14	11	86	497	633
		Percentage	3.9%	2.2%	1.7%	13.6%	78.5%	100.0%
	Public Water Network	Count	26	16	10	96	384	532
		Percentage	4.9%	3.0%	1.9%	18.0%	72.2%	100.0%
Nuevo León	Container or Bottle	Count	13	25	24	203	591	856
		Percentage	1.5%	2.9%	2.8%	23.7%	69.0%	100.0%
	Public Water Network	Count	15	18	19	155	454	661
		Percentage	2.3%	2.7%	2.9%	23.4%	68.7%	100.0%

3.3 Nervousness

The outcomes of the cross-tab analysis related to the frequency of nervousness, as the last studied mental health problem, are illustrated in Table 3. The number of participants is 1164 for Chihuahua and 1517 for Nuevo León (in general, 2681 individuals in both states). It can be seen that the general conditions of C/B users are better in Chihuahua at almost all levels. The only exception is the 'monthly' frequency in which 6.2% of C/B users have reported nervousness which is slightly higher than the PWN users' rate which is 5.8%. Other frequency rates favor the C/B users with 2.7%, 1.1%, and 3.6% less suffering in 'daily', 'weekly', and 'sometimes a year' stages, and 7.1% more participants who have 'never' sensed nervousness.

However, the situation is the opposite in Nuevo León. The trend remains similar in Nuevo León only in 'daily' frequency, where 5.6% of C/B users have sensed nervousness versus 7.4% of PWN users. In contrast, in the other 4 levels, the situation is better for PWN users. They have reported 0.6%, 1.9%, and 7.2% less nervousness in 'weekly', 'monthly', and 'sometimes a year' frequencies. Also, they have stated that 55.5% of them 'never' felt nervousness compared to 47.7% of C/B users.

Table 3. Cross-tab analysis report for different types of drinking water and frequency of nervousness in study areas

State	Drinking Water		Frequency of Nervousness					Total
			Daily	Weekly	Monthly	Sometimes a Year	Never	
Chihuahua	Container or Bottle	Count	48	37	39	119	389	632
		Percentage	7.6%	5.9%	6.2%	18.8%	61.6%	100.0%
	Public Water Network	Count	55	37	31	119	290	532
		Percentage	10.3%	7.0%	5.8%	22.4%	54.5%	100.0%
Nuevo León	Container or Bottle	Count	48	49	60	291	408	856
		Percentage	5.6%	5.7%	7.0%	34.0%	47.7%	100.0%
	Public Water Network	Count	49	34	34	177	367	661
		Percentage	7.4%	5.1%	5.1%	26.8%	55.5%	100.0%

The Mann-Whitney U test results are contradictory, as well. Here the p-values are 0.015 and 0.021 for Chihuahua and Nuevo León, respectively. This means that significant associations have been found for both states in opposite directions. While it can be said that, in Chihuahua, the rates favor the C/B users (less nervousness degree), the situation in Nuevo León is the opposite, where the conditions are better for PWN users.

3.4 Overall comparison of the states

As the main aim of this study is to see whether the PWN water can be trusted to drink, considering public mental health conditions, the results for each state should be considered separately to have the overall outcome. As was described, for Chihuahua, there are clear and statistically significant correlations between the type of drinking water and all three mental health issues. It can be seen that the most important association is found for depression frequency, followed by nervousness frequency and remembering difficulty. For all these sections, the individuals who use C/B for drinking have reported fewer (frequency of difficulty of) mental disorders. This result might be linked to the deficiency of the PWN, in comparison to C/B, to provide safe and high-quality water for households to secure their mental health and show the necessity of further improvements in this sector.

However, the situation is not similar in Nuevo León. Based on the results of the analysis, C/B users have better mental health conditions only when remembering difficulty is taken into account. Even in this case, although the trend is consistent and clear for almost all disorder levels (except the 'not able to remember' level in which the number of participants is very limited) the association is not significant enough to reject the null hypothesis. Considering the depression frequency, the conditions are almost the same for C/B and PWN consumers, with no clear trend of difference observed between the two groups. On the other hand, taking nervousness frequency into account, a significant association is found, however in the opposite direction. This means, taking all mental disorders into account, C/B users have not reported better mental health conditions and the situation is even a little better for PWN consumers. This might address the overall efficiency of PWN in providing safe high-quality water, compared to C/B.

4. DISCUSSION

Generally, there is a significant association between environmental quality, including the quality of water, and the rates of human neuropsychiatric disorders [39]. Various

contaminants in drinking water can negatively influence brain functionality. This contamination, however, does not often encompass serious evidence of poisoning but instead involves a little-by-little and developing weakening of health [40]. Accordingly, drinking water can affect human mental health which shows the practical significance of our results, as they show the correlations between drinking water types and mental health issues. It could contribute to finding out whether the public distrust of PWN in Mexico is baseless or not.

The outcomes depict that it may not be correct to distrust Mexican PWN all over the country, as using C/B was not always correlated with better health conditions. Nuevo León is an example of these areas (considering mental health), where PWN could be trusted to provide safe drinking water (considering the scope of our analysis). However, in Chihuahua, it was presented that PWN users were in worse mental health situations, and therefore, the distrust of PWN cannot be considered baseless.

A possible contributor to the difference between these states might be the amount of arsenic contamination in drinking water. Many studies have shown adverse physical health impacts of chronic exposure to high levels of arsenic [41-44]. Nevertheless, it can also have negative mental health impacts. Drinking arsenic-contaminated water for a lengthy period has caused a deficiency in cognitive [45, 46] and motor [47] functions in children. According to the studies done in Bangladesh, reduced intellectual function (e.g., performance and processing speed) is also correlated with exposure to arsenic-contaminated drinking water in a dose-response way [46, 48]. An investigation in the United States described that individuals consuming arsenic-contaminated water are more likely to report experiencing depression [49]. Moreover, a cross-sectional comparative study between arsenic-affected (high level of arsenic in groundwater) and arsenic-free villages in China illustrated that the mental health conditions of the inhabitants were generally worse in the villages exposed to arsenic-contaminated water [50].

As stated in various previous studies, the level of arsenic in drinking water samples in Chihuahua State had been above the WHO maximum permissible limits and the current Mexican standard level (10 μg/L) [51-54]. However, although no recent study was found to express the arsenic level of drinking water in Nuevo León, it had been reported as much lower than the Chihuahua rate and below WHO and Mexican standard maximum limits in 2004 [54]. This assumption needs to be verified by further studies on this subject showing a possible future research direction.

Arsenic is not the only water physicochemical parameter with the potential to influence mental health conditions. Results from epidemiological analyses express that the level of aluminum in drinking water can be linked to the prevalence of Alzheimer's disease [55]. Also, studies on experimental animals depict that chronic exposure to levels of aluminum traced in some drinking water may be associated with neuroinflammation and oxidative stress [56, 57]. Croen et al. [58] have shown that neural tube defects are four times greater in the progeny of women whose public water supply contained nitrate above the US maximum contaminant level. Bondy and Campbell [40] have stated that copper in drinking water might be the reason for unfavorable neurological impacts through many distinct but interlaced mechanisms. Epidemiological studies and investigations on animals reveal that copper in drinking water may also produce neurotoxicity [56, 59-61]. Future research can investigate these parameters in C/B and PWN in different regions to see if they could lead to differences in mental health conditions.

Besides the actual inadequate quality of water, other studied reasons also promote the usage of bottled water among Mexicans. For example, Pacheco-Vega [19] has studied the role of debilitated regulatory frameworks and the power of multinational corporations in encouraging bottled water usage over public network-distributed water. According to his survey, even people in cities with high-efficiency water treatment programs delivering high-quality drinking water refuse to drink PWN water, as they are afraid of being sick [19]. According to Qian's [13] study, bottled water is preferred over tap water due to the belief that it is safer, tastes better, and is more convenient. This inclination represents a bigger struggle for public trust and authority, in settings where people are worried about their health and the potential dangers they face [62].

In this case, a baseless perception of the risk is a vital issue that should be noted to decline the environmental, economic, and sometimes, health impacts associated with undue C/B consumption. According to Saefi et al. [14], a great concern about the wide usage of C/B is the production of plastic waste, which contributes to environmental contamination and poses challenges in managing solid waste. Anguera-Torrell and Arrieta-Valle [15] noted that society bears monetary costs associated with plastic bottle generation, transportation, and disposal. In addition, the price of C/B is critically greater than that of tap water, which exacerbates economic disparities, especially in low-income communities [16]. Moreover, there are some health risks associated with using bottled water. For example, children's dental health can be negatively impacted by bottled water as it does not contain fluoride, which is often provided to public water systems [63]. Likewise, there are potential health concerns posed by phthalates residues in plastic bottled water [64].

Thus, the public knowledge in areas where the quality of PWN is adequate should be increased, to prevent the unnecessary usage of C/B. The findings of Aslani et al. [65] indicate that to decrease the consumption of bottled water, it is necessary to provide public education, ensure the quality of public water, enforce preventive measures, and promote extended producer responsibility. This could be the case for Nuevo León as we could not find a clear trend showing better mental health conditions among C/B users. However, as we did not analyze other possible health impacts (e.g., physical health) further investigation is needed to provide enough data for adequate reasoning and judgment.

Preventing unnecessary use of C/B could bring many benefits, including environmental and economic, for Mexican households who are, according to Khodadad et al. [66], willing to adopt behaviors and measures that can be advantageous in sustainable water management. On the other hand, the authorities must enhance the quality of PWN in areas where water quality is not efficient and rightful public health risks exist. In this regard, it is crucial to consider both physical and mental concerns.

5. CONCLUSIONS

Prior studies have shown that comprehending the attitudes, preferences, and behavior of water consumers is the initial stage in implementing an effective water efficiency initiative [66, 67]. In this regard, this article tries to find out how much

the Mexicans' distrust to PWN and their preference to use C/B is based on the actual quality of water. To do this we analyzed the mental health conditions of PWN and C/B users. Mental health is chosen for this analysis, as while being vital for overall health and well-being, less attention is paid to it than physical health. Also, only a limited number of researchers have studied the impacts of water quality on mental health in the Mexican context. The analysis is done on data gathered from ENH [7] and MOHOMA [6] national surveys done by INEGI in Mexico. To have less biased outcomes, the analysis is done in two Mexican states (Chihuahua and Nuevo León), where the usage rates of C/B and PWN are the closest among other states.

The results show clear and statistically important correlations between types of drinking water and all three studied mental health issues (remembering difficulty, depression frequency, and nervousness frequency) in Chihuahua. In other words, PWN users have suffered more from these mental disorders in comparison to the individuals who utilize C/B for drinking water. Consequently, considering mental health, the distrust of the PWN cannot be rejected in this state. However, the outcomes are different in Nuevo León. While PWN users have reported more difficulty in remembering (not statistically significant association), the situation is the opposite for nervousness frequency, where individuals who consume water from PWN benefit from better health conditions (statistically significant association). Finally, for depression, the conditions are almost similar for both C/B and PWN users, and no significant correlation is found.

Our results depict that it could be a wrong approach not to have trust in the quality of Mexican public network water in all regions. While using C/B can provide healthier conditions for the people in some regions (Chihuahua as an example), it may be unnecessary in other areas (Nuevo León as an example, considering mental health). Therefore, it is required to increase public knowledge in cities with adequate public network water quality to decline the unnecessary usage of C/B. On the other hand, the authorities must enhance the quality of PWN in areas where water quality is not efficient. In this regard, it is vital to consider both physical and mental concerns.

As an assumption for a possible cause, the high arsenic contamination of drinking water in Chihuahua can be related to mental issues, which needs further validation. The results of this paper are on the state-level scale and there might be differences in the outcomes on smaller scales, such as municipalities, between the studied cases. Another limitation is that physical health conditions are not included in the analyses, which can affect the overall outcomes regarding the efficiency of PWN. For future studies, it is recommended to utilize association/causality analyses, in other areas of the country, including other aspects of physical and mental health status, to have a more comprehensive database concerning the PWN efficiency throughout the country and to increase the public knowledge in this regard.

ACKNOWLEDGMENT

We appreciate Kempestiftelserna for supporting our research at Luleå Tekniska Universitet.

REFERENCES

[1] Babel, M.S., Shinde, V.R., Sharma, D., Dang, N.M. (2020). Measuring water security: A vital step for climate change adaptation. Environmental Research, 185: 109400. https://doi.org/10.1016/j.envres.2020.109400

[2] Khodadad, M., Aguilar-Barajas, I., Khan, A.Z. (2023). Green infrastructure for urban flood resilience: A review of recent literature on bibliometrics, methodologies, and typologies. Water, 15(3): 523. https://doi.org/10.3390/w15030523

[3] Khodadad, M., Aguilar-Barajas, I., Cárdenas-Barrón, L.E., Ramírez-Orozco, A.I., Sanei, M., Khan, A.Z. (2024). Addressing local water security through green infrastructure implementation: A review of urban plans in Monterrey, Mexico, and Brussels, Belgium. Water, 16(5): 727. https://doi.org/10.3390/w16050727

[4] N-OHCHR. (2017). Report of the special rapporteur on the human rights to safe drinking water and sanitation on his mission to Mexico. A/HRC/36/45/Add.2New York: United Nations Human Rights Council. https://www.ohchr.org/en/documents/country-reports/ahrc3645add2-report-special-rapporteur-human-rights-safe-drinking-water, accessed on Apr. 25, 2023.

[5] Water.org. (2022). Mexico's water and sanitation crisis https://water.org/our-impact/where-we-work/mexico/, accessed on Apr. 14, 2023.

[6] INEGI. (2017). Module on Households and Environment (MOHOMA) 2017 https://en.www.inegi.org.mx/programas/mohoma/2017/, accessed on Apr. 5, 2023.

[7] INEGI. (2017). Encuesta Nacional de los Hogares (ENH) 2017 https://www.inegi.org.mx/programas/enh/2017/, accessed on Apr. 5, 2023.

[8] Rodwan Jr, J.G. (2021). Bottled water 2020: Continued upward movement - U.S. and international developments and statistics. Bottled Water Reporter, The International Bottled Water Association (IBWA). https://bottledwater.org/wp-content/uploads/2021/07/2020BWstats_BMC_pub2021BWR.pdf, accessed on Apr. 13, 2023.

[9] Das, T.K., Teng, B.S. (2004). The risk-based view of trust: A conceptual framework on JSTOR. Journal of Business and Psychology, 19(1): 85-116. https://doi.org/10.1023/b:jobu.0000040274.23551.1b

[10] Khodadad, M., Moosavi Nadoshan, S.M., Khodadad, S., Sanei, M. (2018). Operative guidelines for sustainable designing of child-oriented architectural spaces. Journal of Civil Engineering and Urbanism, 8(1): 6-11.

[11] Smeets, J.B.J., Brenner, E. (2001). Perception and action are inseparable. Ecological Psychology, 13(2): 163-166. https://doi.org/10.1207/S15326969ECO1302_8

[12] Hiep, H.Y., Hien, N.N. (2023). Safety leadership, covid-19 risk perception, and safety behavior: The moderator role of work pressure. International Journal of Safety & Security Engineering, 13(2): 255-66. https://doi.org/10.18280/ijsse.130208

[13] Qian, N. (2018). Bottled water or tap water? A comparative study of drinking water choices on university campuses. Water, 10(1): 59. https://doi.org/10.3390/w10010059

[14] Saefi, M., Fauzi, A., Kristiana, E., Adi, W.C., Islami, N.N., Ikhsan, M.A., Ramadhani, M., Ningrum, D.E.A.F., Setiawan, M., Muchson, M. (2023). Theory of planned behavior to analyze students' intentions in consuming tap water. EURASIA Journal of Mathematics, Science and Technology Education, 19(3): 1-12. https://doi.org/10.29333/ejmste/12976

[15] Anguera-Torrell, O., Arrieta-Valle, Á.E. (2021). The potential of filtered water in the restaurant industry: A case study in Barcelona. Tourism and Hospitality Research, 22(3): 336-348. https://doi.org/10.1177/14673584211048705

[16] Wilson, A.M., Victory, K.R., Reynolds, K.A., Cabrera, N.L., Larson, D., Latura, J., Sexton, J.D., Burgess, J.L., Beamer, P.I. (2022). Measured and modeled comparisons of chemical and microbial contaminants in tap and bottled water in a US-Mexico border community. ACS EST Water, 2(12): 2657-2667. https://doi.org/10.1021/acsestwater.2c00400

[17] Espinosa-García, A.C., Díaz-Ávalos, C., González-Villarreal, F.J., Val-Segura, R., Malvaez-Orozco, V., Mazari-Hiriart, M. (2015). Drinking water quality in a Mexico City university community: Perception and preferences. EcoHealth, 12(1): 88-97. https://doi.org/10.1007/s10393-014-0978-z

[18] Ghassan Adham AL-Dulaimi, Mohammad, K.Y. (2017). Assessment of potable water quality in Baghdad city, Iraq. Air, Soil and Water Research, 10: 1178622117733441. https://doi.org/10.1177/1178622117733441

[19] Pacheco-Vega, R. (2019). (Re)theorizing the politics of bottled water: Water insecurity in the context of weak regulatory regimes. Water, 11(4): 658. https://doi.org/10.3390/w11040658.

[20] Cifuentes, E., Leticia, S., Solano, M., René, S. (2002). Diarrheal diseases in children from a water reclamation site in Mexico City. Environmental Health Perspectives, 110(10): A619-24. https://doi.org/10.1289/ehp.021100619

[21] Gutiérrez, R.L., Rubio-Arias, H., Quintana, R., Ortega, J.A., Gutierrez, M. (2008). Heavy metals in water of the San Pedro River in Chihuahua, Mexico and its potential health risk. International Journal of Environmental Research and Public Health, 5(2): 91-98. https://doi.org/10.3390/ijerph5020091

[22] Jiménez-Moleón, M.C., Gómez-Albores, M.A. (2011). Waterborne diseases in the state of Mexico, Mexico (2000-2005). Journal of Water and Health, 9(1): 200-207. https://doi.org/10.2166/wh.2010.149

[23] Rojas-Fabro, A.Y., Pacheco Ávila, J.G., Esteller Alberich, M.V., Cabrera Sansores, S.A., Camargo-Valero, M.A. (2015). Spatial distribution of nitrate health risk associated with groundwater use as drinking water in Merida, Mexico. Applied Geography, 65: 49-57. https://doi.org/10.1016/j.apgeog.2015.10.004

[24] López-Carrillo, L., Hernández-Ramírez, R.U., Gandolfi, A.J., Ornelas-Aguirre, J.M., Torres-Sánchez, L., Cebrian, M.E. (2014). Arsenic methylation capacity is associated with breast cancer in northern Mexico. Toxicology and Applied Pharmacology, 280(1): 53-59. https://doi.org/10.1016/j.taap.2014.07.013

[25] Royal College of Psychiatrists. (2010). No health without public mental health: The case for action. Position statement PS4/2010, London: Royal College of Psychiatrists. https://www.rcpsych.ac.uk/docs/default-source/improving-care/better-mh-policy/position-statements/ps04_2010.pdf?sfvrsn=b7316b7_4, accessed on Jun. 18, 2023.

[26] UN. (2015). Transforming our world: The 2030 agenda for sustainable development. A/RES/70/1 United Nations. https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf, accessed on May. 13, 2023.

[27] Sanei, M. (2022). The comparative analysis of the scoring system used in BREEAM International New Construction 2016 and the recent trends in housing sustainability-related literature. Prostor, 30(1(63)): 106-125. https://doi.org/10.31522/p.30.1(63).10

[28] Sanei, M., Khodadad, M., Calonge Reillo, F. (2022). The most influential factors on urban housing sustainability based on a comprehensive review of the recent literature. Figshare. https://doi.org/10.6084/m9.figshare.20477112.v2

[29] Sanei M, Khodadad M, Calonge Reillo F. (2023). Identifying the most significant factors affecting urban housing sustainability and their scales/sectors of influence: A systematic review of the recent literature. In Advances in Environmental Sustainability. ICOAER 2022. Springer Proceedings in Earth and Environmental Sciences. Springer International Publishing, Cham.

[30] Sanei, M., Khodadad, M., Reillo, F.C. (2022). Analyzing LEED scoring system based on the priorities in urban housing sustainability literature. Urbanism Architecture Constructions, 13(2): 151-164.

[31] INEGI. (2017). Módulo de hogares y medio ambiente 2017. MOHOMA. Documento metodológico https://www.inegi.org.mx/app/biblioteca/ficha.html?upc=702825104399, accessed on May. 20, 2024.

[32] Hair, J.F., Black, W.C., Babin, B.J. (2010). Multivariate Data Analysis: A Global Perspective. London: Pearson Education.

[33] Worku, Z. (2016). Barriers to the growth of small, micro and medium-sized business enterprises in the Vaal Triangle region of South Africa. African Journal of Science, Technology, Innovation and Development, 8(2): 134-141. https://doi.org/10.1080/20421338.2015.1128135

[34] Getachew, M., Tadesse, H., Degefu, N. (2022). The severity of mental health problems in healthcare professionals and its associated risk factors during COVID-19 pandemic. Frontiers in Emergency Medicine, 7(1): 11693. https://doi.org/10.18502/fem.v7i1.11693

[35] Bekele, G.E., Tadesse, T., Negaw, R., Zewde, T. (2018). Magnitude and associated factors of hypertension in Addis Ababa public health facilities, Ethiopia. MOJ Public Health, 7(6): 280-286. https://doi.org/10.15406/mojph.2018.07.00252

[36] Bergmann, R., Ludbrook, J., Spooren, W.P.J.M. (2000). Different outcomes of the Wilcoxon—Mann—Whitney test from different statistics packages. The American Statistician, 54(1): 72-77. https://doi.org/10.1080/00031305.2000.10474513

[37] Fay, M.P., Malinovsky, Y. (2018). Confidence intervals of the Mann-Whitney parameter that are compatible with the Wilcoxon-Mann-Whitney test. Statistics in Medicine, 37(27): 3991-4006.

https://doi.org/10.1002/sim.7890
[38] IBM. IBM SPSS Statistics https://www.ibm.com/products/spss-statistics, accessed on Oct. 8, 2023.
[39] Khan, A., Plana-Ripoll, O., Antonsen, S., Brandt, J., Geels, C., Landecker, H., Sullivan, P.F., Pedersen, C.B., Rzhetsky, A. (2019). Environmental pollution is associated with increased risk of psychiatric disorders in the US and Denmark. PLOS Biology, 17(8): e3000353. https://doi.org/10.1371/journal.pbio.3000353
[40] Bondy, S.C., Campbell, A. (2018). Water quality and brain function. International Journal of Environmental Research and Public Health, 15(1): 2. https://doi.org/10.3390/ijerph15010002
[41] Bhowmick, S., Pramanik, S., Singh, P., Mondal, P., Chatterjee, D., Nriagu, J. (2018). Arsenic in groundwater of West Bengal, India: A review of human health risks and assessment of possible intervention options. Science of the Total Environment, 612: 148-169. https://doi.org/10.1016/j.scitotenv.2017.08.216
[42] Hong, Y.S., Song, K.H., Chung, J.Y. (2014). Health effects of chronic arsenic exposure. Journal of Preventive Medicine and Public Health, 47(5): 245-252. https://doi.org/10.3961/jpmph.14.035
[43] Palma-Lara, I., Martínez-Castillo, M., Quintana-Pérez, J.C., Arellano-Mendoza, M.G., Tamay-Cach, F., Valenzuela-Limón, O.L., García-Montalvo, E.A., Hernández-Zavala, A. (2020). Arsenic exposure: A public health problem leading to several cancers. Regulatory Toxicology and Pharmacology, 110: 104539. https://doi.org/10.1016/j.yrtph.2019.104539
[44] Shakoor, M.B., Nawaz, R., Hussain, F., Raza, M., Ali, S., Rizwan, M., Oh, S.E., Ahmad, S. (2017). Human health implications, risk assessment and remediation of as-contaminated water: A critical review. Science of the Total Environment, 601-602: 756-769. https://doi.org/10.1016/j.scitotenv.2017.05.223
[45] Tsai, S.Y., Chou, H.Y., The, H.W., Chen, C.M., Chen, C.J. (2003). The effects of chronic arsenic exposure from drinking water on the neurobehavioral development in adolescence. NeuroToxicology, 24(4-5): 747-753. https://doi.org/10.1016/S0161-813X(03)00029-9
[46] Wasserman Gail, A., Xinhua, L., Faruque, P., Habibul, A., Factor-Litvak Pam, Jennie, K., van Geen, A., Vesna, S., LoIacono Nancy, J., Diane, L., Zhongqi, C., Graziano Joseph, H. (2007). Water arsenic exposure and intellectual function in 6-year-old children in Araihazar, Bangladesh. Environmental Health Perspectives, 115(2): 285-289. https://doi.org/10.1289/ehp.9501
[47] Parvez, F., Wasserman Gail, A., Factor-Litvak Pam, Xinhua, L., Vesna, S., Siddique Abu, B., Rebeka, S., Ruksana, S., Tariqul, I., Diane, L., Mey Jacob, L., van, G.A., Khalid, K., Jennie, K., Habibul, A., Graziano Joseph, H. (2011). Arsenic exposure and motor function among children in Bangladesh. Environmental Health Perspectives, 119(11): 1665-1670. https://doi.org/10.1289/ehp.1103548
[48] Wasserman Gail, A., Xinhua, L., Faruque, P., Habibul, A., Factor-Litvak Pam, van, G.A., Vesna, S., Lolacono Nancy, J., Zhongqi, C., Iftikhar, H., Hassina, M., Graziano Joseph, H. (2004). Water arsenic exposure and children's intellectual function in Araihazar, Bangladesh. Environmental Health Perspectives, 112(13): 1329-1333. https://doi.org/10.1289/ehp.6964
[49] Zierold, K.M., Knobeloch, L., Anderson, H. (2004). Prevalence of chronic diseases in adults exposed to arsenic-contaminated drinking water. American Journal of Public Health, 94(11): 1936-1937. https://doi.org/10.2105/AJPH.94.11.1936
[50] Fujino, Y., Guo, X., Liu, J., You, L., Miyatake, M., Yoshimura, T. (2004). Mental health burden amongst inhabitants of an arsenic-affected area in inner Mongolia, China. Social Science & Medicine, 59(9): 1969-1973. https://doi.org/10.1016/j.socscimed.2004.02.031
[51] Jiménez-Córdova, M.I., Sánchez-Peña, L.C., Barrera-Hernández, Á, González-Horta, C., Barbier, O.C., Del Razo, L.M. (2019). Fluoride exposure is associated with altered metabolism of arsenic in an adult Mexican population. Science of the Total Environment, 684: 621-628. https://doi.org/10.1016/j.scitotenv.2019.05.356
[52] Osuna-Martínez, C.C., Armienta, M.A., Bergés-Tiznado, M.E., Páez-Osuna, F. (2021). Arsenic in waters, soils, sediments, and biota from Mexico: An environmental review. Science of the Total Environment, 752: 142062. https://doi.org/10.1016/j.scitotenv.2020.142062
[53] Silva Rodríguez De San Miguel, J.A. (2017). Urban water supply in Mexico. Alicante: 3Ciencias. https://3ciencias.com/libros/libro/urban-water-supply-in-mexico/, accessed on Dec. 2, 2023.
[54] Westerhoff, P., Esparza-Soto, M., Mata, P.C., Parry, W.T., Johnson, W.P. (2004). Drinking water quality in the US-Mexico border region. W-03-19 Southwest Center from Environmental Research and Policy. https://www.researchgate.net/publication/237439708_Drinking_water_quality_in_the_US-Mexico_Border_Region, accessed on May, 19, 2023.
[55] Rondeau, V., Jacqmin-Gadda, H., Commenges, D., Helmer, C., Dartigues, J. (2008). Aluminum and silica in drinking water and the risk of Alzheimer's disease or cognitive decline: Findings from 15-year follow-up of the PAQUID cohort. American Journal of Epidemiology, 169(4): 489-496. https://doi.org/10.1093/aje/kwn348
[56] Becaria, A., Lahiri, D.K., Bondy, S.C., Chen, D., Hamadeh, A., Li, H., Taylor, R., Campbell, A. (2006). Aluminum and copper in drinking water enhance inflammatory or oxidative events specifically in the brain. Journal of Neuroimmunology, 176(1-2): 16-23. https://doi.org/10.1016/j.jneuroim.2006.03.025
[57] Campbell, A., Becaria, A., Lahiri, D.K., Sharman, K., Bondy, S.C. (2004). Chronic exposure to aluminum in drinking water increases inflammatory parameters selectively in the brain. Journal of Neuroscience Research, 75(4): 565-572. https://doi.org/10.1002/jnr.10877
[58] Croen, L.A., Todoroff, K., Shaw, G.M. (2001). Maternal exposure to nitrate from drinking water and diet and risk for neural tube defects. American Journal of Epidemiology, 153(4): 325-331. https://doi.org/10.1093/aje/153.4.325
[59] Kitazawa, M., Cheng, D., LaFerla, F.M. (2009). Chronic copper exposure exacerbates both amyloid and tau pathology and selectively dysregulates cdk5 in a mouse model of AD. Journal of Neurochemistry, 108(6): 1550-1560. https://doi.org/10.1111/j.1471-4159.2009.05901.x
[60] Kitazawa, M., Hsu, H.W., Medeiros, R. (2016). Copper exposure perturbs brain inflammatory responses and

impairs clearance of amyloid-beta. Toxicological Sciences, 152(1): 194-204. https://doi.org/10.1093/toxsci/kfw081

[61] Larry Sparks, D., Schreurs, B.G. (2003). Trace amounts of copper in water induce β-amyloid plaques and learning deficits in a rabbit model of Alzheimer's disease. Pnas, 100(4): 11065-11069. https://doi.org/10.1073/pnas.1832769100

[62] Wilk, R. (2006). Bottled water. Journal of Consumer Culture, 6(3): 303-325. https://doi.org/10.1177/1469540506068681

[63] Jaffee, D. (2024). Unequal trust: Bottled water consumption, distrust in tap water, and economic and racial inequality in the United States. WIREs Water, 11(2): e1700. https://doi.org/10.1002/wat2.1700

[64] Al-Saleh, I., Shinwari, N., Alsabbaheen, A. (2011). Phthalates residues in plastic bottled waters. The Journal of Toxicological Sciences, 36(4): 469-478. https://doi.org/10.2131/jts.36.469

[65] Aslani, H., Pashmtab, P., Shaghaghi, A., Mohammadpoorasl, A., Taghipour, H., Zarei, M. (2021). Tendencies towards bottled drinking water consumption: Challenges ahead of polyethylene terephthalate (PET) waste management. Health Promot Perspect, 11(1): 60-68. https://doi.org/10.34172/hpp.2021.09

[66] Khodadad, M., Sanei, M., Narvaez-Montoya, C., Aguilar-Barajas, I. (2022). Climatic hazards and the associated impacts on households' willingness to adopt water-saving measures: Evidence from Mexico. Sustainability, 14(10): 5817. https://doi.org/10.3390/su14105817

[67] Balnave, J., Adeyeye, K. (2013). A comparative study of attitudes and preferences for water efficiency in homes. Journal of Water Supply: Research and Technology-Aqua, 62(8): 515-524. https://doi.org/10.2166/aqua.2013.057