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Behavior of household water consumption in Mexico during the COVID-19 pandemic

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ABSTRACT

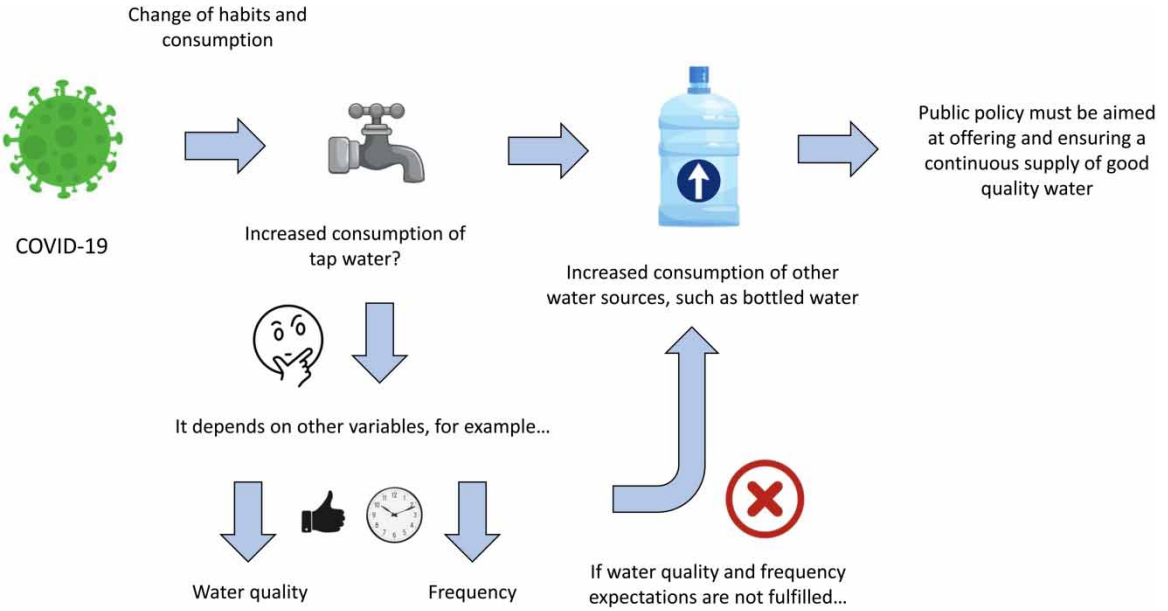
Populations have changed their habits and consumption as a result of COVID-19. In the case of Mexico City, this situation has possibly led households to purchase more products such as bottled water and to consume the same amount or less tap water. This behavior was confirmed by analyzing tap water consumption data before and during the arrival of COVID-19 using Pearson chi-square, and by conducting a survey of bottled and tap water consumption and analyzing that data with a bivariate econometric model. It was found to be related to the perception of poor-quality service. Consequently, tap water consumption will not always increase when health emergencies such as COVID-19 occur, but rather, this will depend on other environmental variables. Therefore, public water policies should be aimed at offering and ensuring a continuous supply of good quality water, as well as providing clear and objective information to prevent this type of behavior

Key words: Bottled water, Consumption, COVID-19, Quality, Tap water

HIGHLIGHTS

- The COVID-19 infection has saturated health systems throughout the world and led to a change in habits and consumption in the population.
- This situation has also led families to purchase more alternative products that are on the market as a supply measure to cope with an uncertain scenario, as is the case of increased purchases of bottled water.
- There is evidence of a relationship between not consuming tap water and a higher consumption of bottled water as a possible alternative to reduce the risk of COVID-19.
- Public policy must be aimed at offering and ensuring a continuous supply of good quality water, especially for vulnerable sectors, to stop the spread of infection.

GRAPHICAL ABSTRACT



1. INTRODUCTION

The novel coronavirus infection (SARS-CoV-2), better known as COVID-19 disease, is associated with acute respiratory distress. The first human cases occurred in the city of Wuhan, China in late 2019, and it rapidly spread throughout the world during the year 2020 (Amankwaa & Fischer, 2020; Rodríguez-Izquierdo *et al.*, 2020). The rapid spread of the virus saturated health systems throughout the world, and 6.6 million deaths were reported worldwide by December 19, 2022, with a global lethality rate of 1.1% (Health Secretary, 2022). Health authorities have issued basic protection measures for everyone, including the use of masks, social distancing, hand sanitizer and especially handwashing (World Health Organization, 2020).

Nevertheless, what is also clear is that the pandemic has made society's socioeconomic problems even more notable (Merino-Pérez *et al.*, 2020; Almulhim & Aina, 2022). For example, the consumption of several products has increased as the pandemic has developed worldwide, such as toilet paper, kitchen paper towels, sanitizer, hand soap, detergents, disinfectants and tap and bottled water (Statista, 2020; Abu-Bakar *et al.*, 2021; Siqueira Campos *et al.*, 2021; Bera *et al.*, 2022). In the case of tap water, scientific evidence already exists that shows that household water consumption has increased mainly because families spend more hours at home and more time and water on hand washing and household cleaning, among other activities (Abu-Bakar *et al.*, 2021; Siqueira Campos *et al.*, 2021; Almulhim & Aina, 2022; Bera *et al.*, 2022). But at the same time, the possible increase in household consumption of bottled water has been observed throughout the pandemic (Statista, 2020) despite the availability of drinking water, as is the case in Mexico City. The purchase of bottled water may primarily be due to: (i) the society lacking information, given that people may come to think that the virus spreads through tap water, (ii) having access to water other than tap water, (iii) bottled water being the main and in many cases the only access to water for hygiene and consumption and (iv) spending more time at home due to confinement and (v) the perception of poor-quality tap water.

It is interesting to note that the above behaviors have occurred in spite of the fact that, to-date, consuming water has not been shown to be a cause for the spread of SARS-CoV-2 (La Rosa *et al.*, 2020). Nevertheless, there is a long history of distrust in the quality of the water that is supplied to the population (by formal and informal systems) (EHCSCA, 2011), and it would not be strange for that to be noted under pandemic conditions.

In the case of Mexico City, CONAGUA (2018) estimates that a resident in a middle- to upper-income neighborhood (2% of the population) consumes roughly 567 L of tap water while one in a low-income neighborhood (77% of the population) consumes 128 L and does not receive water daily or 24 h/day. Given the inequities in the supply of drinking water, Mexico City is known as one of the cities with the highest per capita consumption of bottled water worldwide, even before the pandemic (Revollo-Fernández *et al.*, 2019; INEGI, 2020).

Meanwhile, with the increase in cases of people infected by the coronavirus worldwide, preventive measures have been focused on avoiding going out, suspending classes, performing many work-related activities remotely and spending more time at home (Bedford *et al.*, 2020). Daily activities have changed under these new social measures, which has affected household purchases and consumption (Bejarano-Roncancio *et al.*, 2020; Hermi-Zaar & García-Ávila, 2020; Statista, 2020). In the case of Mexico City, while it was already known that the consumption of bottled water per capita was high, this is one of the top 10 products whose market demand has increased due to COVID-19 since the beginning of the pandemic (Statista, 2020).

Under this scenario, the present study was aimed at studying the behavior of household consumption of bottled and tap water in Mexico City and its determinants in the wake of the emergence of the COVID-19 respiratory disease outbreak. In addition to achieving the proposed objective, this research sought to generate scientific debate around the hypothesis that poor drinking water quality, whether real or perceived by users, can trigger increased consumption of bottled water and maintain or reduce tap water consumption, especially among the most vulnerable sectors, and generally those with less income (Revollo-Fernández, *et al.*, 2023). Unlike other studies that were identified in the literature, most of which were conducted in developed countries, the present research considers the quality of tap water to be an important variable that should be included in the design of public policies for situations where COVID-19 is present.

2. BACKGROUND

2.1. The situation with COVID-19 in Mexico

In the case of Mexico, as of that same date, a total of 7,222,611 accumulated cases and 331,030 deaths had been confirmed, with an incidence of accumulated cases of 5,550.8 per 100,000 inhabitants (Health Secretary, 2022). An analysis of the information on cases by state shows that the 10 that have accumulated the greatest number of cases are Mexico City (CDMX), Estado de México (MEX), Nuevo León (NL), Guanajuato (GTO), Jalisco (JAL), Sonora (SON), Coahuila (COAH), Puebla (PUE), Tabasco (TAB) and Veracruz (VER), which together represent roughly two-thirds (65%) of all the cases registered in the country. Mexico City has registered the majority of the accumulated cases in the country, and alone represents 23% of all confirmed cases. With regard to deaths, the situation is very similar. As can be seen, the impact of COVID-19 is especially acute in areas such as Mexico City, whose geographic location contributes to high population density (5,966 inhab/km^2) and serious water supply problems.

2.2. The situation with water consumption in Mexico City

Mexico City is part of a megacity that is home to roughly 8.8 million residents (INEGI, 2020). It covers 1,495 km^2 and generates roughly 18% of Mexico's production. Nevertheless, in spite of its economic dynamism, poverty and unequal access to income and services at the household level are considered critical issues (Fuentes, 2020; López-Guerrero & Aguilar-Martínez, 2020; Ortiz-Hernández & Pérez-Sastré, 2020). To meet the drinking water demand

by the residents of this city, an average flow of 32.3 m^3/s is supplied (Revollo-Fernández *et al.*, 2019). Sixty-seven percent of the total demand for drinking water is supplied by groundwater sources, which are overexploited. The remaining 33% is obtained from surface water sources (Morales-Novelo & Rodríguez-Tapia, 2007; Escolero *et al.*, 2016).

The water supplied to households in Mexico City registers a coverage of roughly 97% (INEGI, 2020). Although the supply of piped water is the highest in the country, the quality of the service continues to be a key concern, particularly with regard to water quality and the frequency of the supply (Mazari-Hiriart *et al.*, 2005; Perló & González, 2005; Espinosa-García *et al.*, 2015).

The water management problems in Mexico City have been found to be similar to those reported by studies of the quality of drinking water services in other countries. Those studies indicate that while advances have been observed in greater access to drinking water worldwide through the development of infrastructure (Tanellari *et al.*, 2015), primarily in developing countries, there is a clear and growing interest in having access to better quality water (Casey *et al.*, 2006; Onjala *et al.*, 2013; So-Yoon *et al.*, 2013) and a more continuous supply (Trow & Farley, 2006; de Franca-Doria *et al.*, 2009; Orgill *et al.*, 2013), especially on the part of consumers (Whittington *et al.*, 1991; Ferrier, 2021).

Furthermore, there is a general perception in Mexico City that the quality of the water supply is poor (Mazari-Hiriart *et al.*, 2005). Households frequently boil tap water or use special filters or other purification techniques, while others purchase bottled water or use a combination of preventive measures. Conservative estimates indicate that a person in Mexico consumes between 180 and 250 L of bottled water per year, while the worldwide average is between 80 and 100 L, making this country the largest per capita consumer in the world (Beverage Marketing Corporation, 2016). In the case of Mexico City, it has been found that a household consumes an average of seven 20-L water jugs per month at a total cost of roughly USD $10 (EHCSCA, 2011), and in terms of per capita, roughly 350 L are consumed, much higher than the national average, and first in the world. This high consumption of bottled water in the city is largely explained by: (i) people's perception that the quality of the tap water is poor, and/or (ii) the custom of consuming bottled water and/or (iii) poor-quality tap water in certain areas of Mexico City where water comes from wells and is treated only by disinfection with chlorination, which is insufficient for water that is extracted from a depth of over 200 m and that transports contaminants that are difficult to remove, such as heavy metals or organic compounds (Mazari-Hiriart *et al.*, 2019).

3. METHODS

3.1. Data

This research focused on the consumption of tap and bottled water by households in Mexico City before and during the presence of the pandemic.

Data on tap water consumption were obtained by requesting information from the company that provides water services in the city (Mexico City Water System, SACMEX in Spanish). Information about bottled water consumption was collected using a survey, since there was no official information on household consumption. The data were obtained from the Mexico City COVID-19 and Water Survey (ECACDMX), designed and administered by the Specialization in Economics and Water Management of the Metropolitan Autonomous University, and the Sustainability Sciences National Laboratory of the Institute of Ecology, National Autonomous University of Mexico. With regard to the survey, this was administered online through a digital platform from September to November 2020. It was aimed at analyzing water use and consumption behavior by Mexico City households under the impact of the COVID-19 respiratory disease outbreak. There were approximately 2.8 million households in Mexico City in 2020. Taking that number of households as the population size and with a 95%

confidence level and a margin of error of 5%, the minimum survey sample size was estimated to be 385 households. Information was initially obtained from 800 households, which was analyzed for the quality and quantity of the information provided. After cleaning the data, the final ECACDMX database was composed of 603 surveys, which was a statistically representative sample of households in Mexico City.

3.2. Methods to perform the analysis

For the analysis of household tap water consumption, average consumption before and during the presence of COVID-19 was compared using an analysis of means. The consumption of bottled water was analyzed based on the ECACDMX using a statistical analysis of the main variables and a bivariate probit model (Greene, 2018). The objective of the econometric model was to identify which independent variables had the greatest impact on the two independent variables. This type of econometric model is used when an interaction between the two dependent variables is considered, either as substitutes or complementary. It is also important to mention that the literature review did not find any study that used this type of model, which is an important contribution to this field. The general specification for this type of two-equation model is:

$$y_1^* = \beta_1 x_1 + \varepsilon_1,\ y_1 = 1 \text{ if } y_1^* > 0,\ \text{or 0 if not,} \tag{1}$$

$$y_2^* = \beta_2 x_2 + \varepsilon_2,\ y_2 = 1 \text{ if } y_2^* > 0,\ \text{or 0 if not,} \tag{2}$$

$$E[\varepsilon_1] = E[\varepsilon_2] = 0,$$

$$VAR[\varepsilon_1] = VAR[\varepsilon_2] = 1,$$

$$COV[\varepsilon_1,\ \varepsilon_2] = \rho$$

where the variable Y_1 represents yes 'the household is accustomed to drinking and/or cooking with tap water' (Tap) and Y_2 represents yes 'the household began to purchase more bottled water (20-L jugs) since the beginning of the COVID-19 outbreak.' For both cases, the answer can be YES, which takes the value of 1, or NO, which takes the value of 0. The supposition that random perturbations of the equations are correlated makes it possible to model the decisions that involve common environments (Zellner, 1962).

In terms of the set of determinants of tap water consumption (Y_1) and bottled water consumption (20-L jugs) (Y_2), the following independent variables (X_1, X_2) were included (Table 1): (i) *socioeconomic characteristics of households,* for example, education, number of persons in a household and household income, (ii) *variables related to COVID-19 respiratory disease*, such as whether household members wash their hands, number of known people to contract the disease, whether they have a history of an illness and if they spend more time working from home as a result of COVID-19 and lastly, (iii) *variables related to tap water service,* such as the perception of quality and quantity and whether another source of water is used.

4. RESULTS

4.1. Consumption of water from Mexico City's public network as of the presence of COVID-19

Due to the unprecedented COVID-19 pandemic, greater and better prevention practices are needed to stop the spread of the virus. Greater prevention requires households to have a stable water supply. Nevertheless, little is known about how households have changed their water consumption before and after COVID-19. Internationally, studies in Brazil (Siqueira *et al.*, 2021), the Arab Emirates (Rizvi *et al.*, 2021) and Uganda (Sempewo *et al.*, 2021) have shown that the majority of households consumed more water after March 2020 than before that date. In Mexico City, the information solicited from the Mexico City Water System (SACMEX) shows a

Table 1 | Dependent and independent variables included in the econometric model.

	Dependent variables	
	Equation (1) **Y_2: Tap** Variable: Is drinking and/or cooking with tap water common in the household? Variable type: Dichotomous variable (YES = 1/NO = 0)	**Equation (2)** **Y_2: COVIDjug** Variable: Did the household start purchasing more water jugs since the COVID-19 outbreak began? Variable type: Dichotomous variable (YES = 1/NO = 0)
Independent variables		
networkcolor (Equations (1) and (2))	Variable: How does the color of the water supply seem to you? Variable type: Scale of 1–5, where 1 is low or not pleasant and 5 is high or pleasant	
networkpurity (Equation (1))	Variable: How does the purity of the water supply seem to you? Variable type: Scale of 1–5, where 1 is low or not pleasant and 5 is high or pleasant	
jug (Equation (1))	Variable: In your household, are water jugs purchased (20 L jugs)? Variable type: Dichotomous variable (YES = 1/NO = 0)	
education (Equations (1) and (2))	Variable: What was the last educational level completed? Variable type: Scale of 1–9 where 1 is no formal studies and 9 is a doctorate	
people (Equations (1) and (2))	Variable: How many people currently live in your household, including yourself? Variable type: Continuous numerical variable	
income (Equations (1) and (2))	Variable: How much total monthly income does your household earn in Mexican pesos? Variable type: Continuous numerical value	
handwashing (Equations (2))		Variable: When returning home after going out, do you wash your hands with soap and water as a measure to reduce the likelihood of infection from the COVID-19 respiratory disease outbreak? Variable type: Scale of 1–6, where 1 is never wash hands and 6 is always
highbp (Equations (2))		Variable: Has a doctor diagnosed you with high blood pressure? Variable type: Dichotomous variable (YES = 1/NO = 0)
covidnumber (Equations (2))		Variable: How many people close to you had or have the coronavirus? Variable type: Continuous numerical variable
workfromhome (Equations (1) and (2))	Variable: Have work activities been carried out from home since the beginning of the COVID-19 outbreak? Variable type: Dichotomous variable (Yes = 1/No = 0)	
networkdays (Equations (2))		Variable: Of the 7 days in a week, how many days do you receive drinking water? Variable type: Continuous numerical variable

slight decrease in the average per capita consumption of water from the public network, by roughly 3% ($p < 0.01$) (Table 2). That is, during the pandemic, the consumption of water jugs by households was little affected, in spite of the need for more and better prevention practices and the period of confinement to homes. Therefore, it is important to identify whether the presence of COVID-19 led to the use and/or consumption of water from other sources, such as bottled water.

4.2. Consumption of water jugs since the COVID-19 outbreak began

The information collected by the ECACDMX indicates that roughly 66% of the households surveyed obtained water jugs as an alternative for accessing water for use in cooking and/or drinking, in spite of having access to tap water. This behavior confirms what was found by other authors, such as Mazari-Hiriart *et al.* (2019) and Espinosa-García *et al.* (2015), among others, who have reported that many households in Mexico City do not trust the quality and/or quantity of the water service that reaches their homes. The survey also shows that a household with five people consumed between three and nine jugs of water per month, on average, and spent a total of approximately USD $10 to USD $25. Furthermore, the ECACDMX indicates that one-quarter (26%) of all the households that purchased water jugs as an alternative way to get access to water increased their consumption after the COVID-19 health emergency began. These households increased their consumption of this product by between two and four jugs, on average.

Table 2 | Consumption of drinking water by Mexico City households.

	Number of users (paid bills)			Consumption (M3)			Average per capita consumption (M3/paid bills)		
Municipality in Mexico City	SEM 2-6/2019	SEM 2-6/2020	Δ%	SEM 2-6/2019	SEM 2-6/2020	Δ%	SEM 2-6/2019	SEM 2-6/2020	Δ%
Alvaro Obregon	273,074	270,651	−0.9	19,970,514	19,037,240	−4.7	4,286.4	3,992.4	−6.9
Azcapotzalco	125,814	124,409	−1.1	11,092,890	11,101,183	0.1	7,992.5	8,020.0	0.3
Benito Juarez	49,468	49,322	−0.3	15,011,598	14,657,677	−2.4	14,725.3	14,365.7	−2.4
Coyoacan	135,480	134,503	−0.7	13,833,382	13,433,240	−2.9	9,811.1	9,604.6	−2.1
Cuajimalpa	26,602	31,224	17.4	5,449,149	5,208,718	−4.4	10,252.3	8,897.5	−13.2
Cuauhtemoc	23,038	23,089	0.2	15,214,297	14,941,894	−1.8	18,164.9	17,949.3	−1.2
Gustavo A. Madero	206,022	206,008	0.0	20,443,790	19,996,505	−2.2	8,488.1	8,395.5	−1.1
Iztacalco	43,540	41,241	−5.3	9,445,223	9,383,991	−0.6	13,345.4	13,639.4	2.2
Iztapalapa	162,254	169,577	4.5	15,678,000	15,477,830	−1.3	5,198.9	5,020.7	−3.4
Magdalena Contreras	24,419	24,074	−1.4	2,342,296	2,272,302	−3.0	5,720.8	5,482.2	−4.2
Miguel Hidalgo	102,478	98,697	−3.7	16,510,440	16,049,559	−2.8	12,701.4	12,514.7	−1.5
Milpa Alta	12,256	11,673	−4.8	264,783	247,267	−6.6	18.4	18.3	−0.2
Tlahuac	51,450	52,791	2.6	2,347,357	2,359,335	0.5	1,697.7	1,784.2	5.1
Tlalpan	116,485	118,459	1.7	7,743,009	7,521,175	−2.9	4,846.1	4,499.7	−7.1
Venustiano Carranza	105,416	107,239	1.7	9,011,714	8,783,195	−2.5	6,911.2	6,631.1	−4.1
Xochimilco	88,498	86,195	−2.6	3,486,215	3,386,038	−2.9	1,967.2	1,979.5	0.6
Total	1,546,293	1,549,150	0.2	167,844,657	163,857,148	−2.4	6,936.4	6,750.8	−2.7

4.3. Relationship between the use of tap water and the consumption of water jugs after the presence of COVID-19

The Pearson chi-square test was used to determine the relationship between tap water consumption and the consumption of water jugs since the COVID-19 outbreak began, which verified the relationship ($Chi^2 = 10.88$). The Pearson correlation also showed that one-quarter (26%) of all households that did not consume tap water had been consuming water jugs since the beginning of the COVID-19 outbreak, while one-tenth (11.4%) of all households that did consume tap water increased their consumption of water jugs. That is, the consumption of water jugs since the beginning of the COVID-19 outbreak by households that did not consume tap water was twice that of households that did consume tap water ($p < 0.01$) (Table 3).

4.4. Determinants of the consumption of tap water and the consumption of water jugs after the presence of COVID-19

Considering the statistical certainty that was found regarding the relationship between tap water consumption and the consumption of water jugs after the presence of COVID-19, it was of interest to investigate the variables that could explain this relationship. The econometric model shows that 75% of the independent variables are statistically significant for the first equation, with the dependent variable 'tap water consumption,' while 80% are statistically significant for the second equation, with the dependent variable 'water jug consumption since the beginning of the COVID-19 outbreak.' Both of the model's equations together show high statistical significance ($Prob > chi^2$: 0.000). Therefore, the model's construction is adequate in terms of both the independent variables individually and the set (Table 4).

In two-equation models where the dependent variables are bivariate or dichotomous, the marginal effects of the dependent variables should be interpreted based on the coefficients in the original regression. At the same time, with a two-equation model containing two dependent dichotomous variables, it is possible to have four results for the marginal effects of the independent variables, depending on the value of the dependent variables: (1) the household HAD NOT BEEN consuming tap water and HAD NOT BEEN consuming more water jugs since the beginning of the COVID-19 outbreak, (2) the household HAD NOT BEEN consuming tap water and HAD BEEN consuming water jugs since the beginning of the COVID-19 outbreak, (3) the household HAD BEEN consuming tap water and HAD NOT BEEN consuming water jugs since the COVID-19 outbreak began and (4) the household HAD BEEN consuming tap water and HAD BEEN consuming water jugs since

Table 3 | Relationship between tap water consumption and purchase of water jugs.

	COVIDjug		
Tap	**NO**	**YES**	**Total**
NO	174	61	235
	74.0%	26.0%	100.0%
	34.8%	59.2%	39.0%
SI	326	42	368
	88.6%	11.4%	100.0%
	65.2%	40.8%	61.0%
Total	500	103	603
	82.9%	17.1%	100.0%
	100.0%	100.0%	100.0%
Pearson chi^2 (1)	10.88	Pr =	0.001

The value of Pr = is the statistical significance of the chi^2 test ($p < 0.01$).

Table 4 | Results of the econometric model of two equations.

bivariate probit		Number of observations	603
		Wald chi^2 (16)	81.02
log likelihood:	−149.23803	Prob > chi^2	0.0000
	Coefficient	Z	$P > \|z\|$
Equation (1): (Y_1) Tap			
networkcolor	0.1739141	1.44	0.100
networkpurity	0.1469846	1.23	0.018
jug	−0.7989932	−3.02	0.003
education	0.1849128	1.46	0.100
people	0.06651	0.88	0.381
income	−0.0000313	−5.12	0.000
workfromhome	−0.3671499	−1.39	0.100
constant	−1.624928	−1.66	0.096
Equation (2): (Y_2) COVIDjug			
people	0.1898949	2.12	0.034
education	−0.444489	−3.1	0.003
handwashing	−0.3745189	−1.95	0.051
income	−0.00000492	0.69	0.488
highbp	0.6972404	2.04	0.042
covidnumber	0.0765288	−0.74	0.458
networkdays	−0.2316679	−2.48	0.013
networkcolor	−0.4274445	−3.89	0.000
workfromhome	0.4770966	1.47	0.100
constant	6.569051	3.98	0.000
likelihood-ratio test of rho = 0	chi^2 (1) = 12.7778	Prob > chi^2:	0.0004

the beginning of the COVID-19 outbreak. Of these four scenarios, the results that are of most interest to this study are the second, third and fourth, since they include the possibility of households consuming water jugs since the beginning of the COVID-19 outbreak (Table 5).

With regard to the variables perceived color and purity of the tap water, the likelihood of consuming water jugs after the presence of COVID-19 decreased as household members' perceptions shifted from not pleasant to pleasant, or as they perceived that the purity improved, regardless of whether they consumed tap water. Both variables show that when households perceived better quality tap water, they consumed that more and reduced their consumption of water jugs. With respect to the number of days per week that households received water, the results indicate that when they registered more continuous service the consumption of water jugs after the presence of COVID-19 decreased and the consumption of tap water increased. It is worth mentioning that both the quality and continuity of tap water – as measured by the perception of household members – have a large impact on the use and consumption of tap water and water jugs in times of health emergencies such as COVID-19.

The effect of variables related to hygiene was closely connected with water consumption. The results show that as household members more frequently washed their hands with soap and water as a way to reduce the chances

Table 5 | Marginal effects of the possible scenarios of the two-equation econometric model.

Marginal effects	Scenario 1: tap (NO)/COVIDjug (NO)	Scenario 2: tap (NO)/ COVIDjug (YES)	Scenario 3: tap (YES)/ COVIDjug (NO)	Scenario 4: tap (YES)/COVIDjug (YES)
networkcolor	0.0049499[a]	−0.0686763[a]	0.0911477[a]	−0.0274213[a]
networkpurity	−0.0457012[a]	−0.00081576[a]	0.0457012[a]	0.0081576[a]
networkdays	0.0319901[a]	−0.0319901[a]	0.0200932[a]	−0.0200932[a]
jug	0.2484271[a]	0.0443437[a]	−0.2484271[a]	−0.0443437[a]
handwashing	0.0517159[a]	−0.0577159[a]	0.032483[a]	−0.032483[a]
highbp	−0.0962792[a]	0.09628[a]	−0.0604735[a]	0.0604735[a]
covidnumber	−0.0105676	0.0105676	−0.0066375	0.00066375
casatrabajo	0.0482757[a]	0.086257[a]	−0.155536[a]	0.0210032[a]
education	−0.0038837	−0.0716403[a]	0.0960457[a]	−0.0282892[a]
people	−0.0450735[a]	0.0228495[a]	0.0023918[a]	0.0198322[a]
income	0.00000905	0.00000242	0.0000102	0.00000131

[a]Marginal effects are statistically significant at 90, 95 or 99%.

of infection from COVID-19, the likelihood of consuming water jugs after the presence of COVID-19 decreased and the consumption of tap water increased. That is, when households followed the hygiene measure of hand-washing their interest in consuming water jugs decreased. This may also be related to not having discussed at any time the possibility of the virus and the disease being transmitted by drinking water, and there is no evidence of that to-date (La Rosa *et al.*, 2020). It is also interesting to consider that the data indicate that for those who had been diagnosed with some type of chronic illness, such as high blood pressure or diabetes, there was a greater likelihood of using water jugs after the presence of COVID-19 regardless of tap water consumption.

Furthermore, it is important to note that the data show that confinement and working from home as a result of COVID-19 increase the consumption of water jugs and reduce the consumption of tap water. This is reinforced by the relationship that exists between poor quality and continuity of tap water and increased consumption of water jugs. That is, it is not the case that confinement, in this case, due to the presence of COVID-19, would result in increased consumption of tap water by household members, but rather, they more often seek water from another source, such as water jugs, when the perception is that the quality of tap water is not good. Lastly, when comparing the marginal effects of the variable's quality of tap water (quality and continuity of water) and spending more time at home (confinement) on households that DID NOT consume tap water and DID consume more water jugs versus those who DID consumer tap water and DID NOT consume more water jugs, it was found that spending more time at home had a larger impact on consuming more water jugs than did the quality of the tap water service.

5. CONCLUSION AND RECOMMENDATIONS

This research confirms that households in a large urban area such as Mexico City perceived a close relationship between the supply of tap water to their homes and the pandemic caused by the COVID-19 virus. The data from the survey confirm that over half (66%) of the households in the city distrusted the quality of the tap water and resorted to purchasing bottled water for drinking and cooking, even when they did not know the source of that water and its quality. Another significant problem experienced by households was the discontinuity in the water supply and the amount of water that reached their homes, which was considered to be insufficient for meeting their needs. In other words, both the quality of the water received by households and the continuity of service

are key determinants of household decisions about whether or not to consume water from another source, such as bottled water. It is also important to note that both the quality and frequency of tap water services are more important in situations of confinement, such as those experienced due to COVID-19. Added to the perception of poor quality and/or insufficient frequency of the service, this disease could trigger increased consumption of bottled water and equal or less consumption of tap water. In light of this, compared to other studies on household consumption of tap water during the presence of COVID-19 (Abu-Bakar *et al.*, 2021; Siqueira Campos *et al.*, 2021; Bera *et al.*, 2022), tap water consumption will not necessarily increase since it will depend on other variables that are related to access.

One-quarter (26%) of the set of households that purchased water jugs as an alternative measure for accessing water reported having increased their consumption since the beginning of the COVID-19 health emergency. The number of jugs purchased by a household is between two and four per month on average. This increase in the purchase of water jugs was twice as much for households that did not consume tap water for drinking and cooking than for those that did consume tap water. This suggests a net increase in water jug consumption primarily due to spending more time at home during a period of confinement, in addition to household perception of poor-quality tap water (Gundy *et al.*, 2009; Medema *et al.*, 2020; Scientific and Technological Advisory Forum, 2020; Yeo *et al.*, 2020).

In terms of the supply of running water, the discontinuity in the service explains why households with water scarcity increased their consumption of water jugs, even for hygiene needs, which involves an unnecessarily high cost. The econometric model indicates that when households did not experience limitations in the piped water supply, they followed handwashing as a hygiene measure and reduced their interest in consuming water jugs. The study also finds that as household members more frequently washed their hands with soap and water as a measure to reduce the likelihood of COVID-19 infection, the likelihood of consuming water jugs and the consumption of tap water increased.

In addition, this study finds that the higher the education level of the head of household the lower the consumption of water jugs. This behavior was observed for households that consumed tap water for drinking as well as for those that did not. This finding suggests that a head of household with more education had a more objective appreciation of the variables that were most closely related to the presence of COVID-19, and set aside subjective views that were not scientifically substantiated. The population should be informed that measures to stop COVID-19 include hand hygiene and physical distancing, and that the quality of water from the public network is adequate for human use when it is disinfected and is similar to the quality of water jugs, so the consumption of either one is recommended for countering COVID-19.

The following recommendations can be made based on the findings. The continuous supply of tap water to the households in the city is indispensable for ensuring that all households in Mexico City follow the recommendations of frequent handwashing. This problem needs to be addressed especially in densely populated, low-income areas, as well in areas with irregular settlements that do not have access to services, which may be high-risk areas for the spread of the virus. In areas without piped water, the water authority is responsible for finding ways to supply enough adequate quality water to meet the basic needs of the population.

The supply of quality water and communicating to households about its quality prevents significant spending on bottled water, especially for low-income households that could redirect their spending to purchase soap and masks.

Changing consumption habits requires transparency and greater dissemination of information about water quality, which is only possible through political will. It is crucial for citizens to recognize the enormous costs involved in purchasing bottled water and to know that the State is required to offer households a sufficient

amount of water with adequate quality, which is a human right that was stipulated in 2012 in Article 4 of the Mexican Constitution (Constitution of the United Mexican States, 2021).

Furthermore, this research is innovative in that it shows that the presence of unforeseen health situations such as COVID-19 can trigger greater consumption of bottled water, but that this increase depends on other variables such as access to tap water, its quality and how frequently households receive it, among others. These are key factors for designing public water policies to benefit households. Lastly, this work had some limitations. One was the reliability of the information that was provided by the households that were surveyed through the online interview, which depended on their ability to estimate the largest purchases of bottled water that they had made. Another was whether the survey reached all the socioeconomic sectors of society. Therefore, it would be valuable for private and/or public institutions to keep a record over time of the monetary values and physical units of the purchases made by households, and that these data are openly accessible.

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DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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