water

MDPI

Article

Tap Water, Bottled Water or In-Home Water Treatment Systems: Insights on Household Perceptions and Choices

Hug March [1,2,*], Xavier Garcia [3], Elena Domene [3] and David Sauri [4]

1 Estudis d'Economia i Empresa, Universitat Oberta de Catalunya, Av. Tibidabo, 39-43, E-08035 Barcelona, Spain
2 TURBA Lab, Internet Interdisciplinary Institute (IN3), Universitat Oberta de Catalunya, Av. Carl Friedrich Gauss, 5, E-08860 Castelldefels, Barcelona, Spain
3 Institut d'Estudis Regionals i Metropolitans de Barcelona, Edifici MRA, Universitat Autònoma de Barcelona, E-08193 Bellaterra, Barcelona, Spain; Xavier.Garcia.Acosta@uab.cat (X.G.); elena.domene@uab.cat (E.D.)
4 Departament de Geografia, Universitat Autònoma de Barcelona, E-08193 Bellaterra, Barcelona, Spain; david.sauri@uab.cat
* Correspondence: hmarch@uoc.edu

Received: 9 April 2020; Accepted: 1 May 2020; Published: 6 May 2020

check for updates

Abstract: This article addresses household strategies for coping with perceived tap water quality issues. By using a household survey (n = 581) in Catalonia (Spain) and three models, this article analyses the drivers and motivations behind the installation of in-home water treatment systems, and the use of bottled water for drinking and cooking. The main explanatory factors of the higher consumption of bottled water were the perception of poor tap water quality, the lack of in-home treatment systems, and the presence of children at home. Income did not appear as a significant variable explaining the use of bottled water, unlike in other studies. The presence of in-home treatment systems is related to factors, such as perceived bad water quality, larger households, and single-family housing. Income and housing tenure appeared as explanatory variables only when considering systems requiring some kind of installation: lower incomes or renting a multi-family house reduce the probability of having an in-home water treatment that required installation because of important investments and operating costs, and the space needed in the housing units. In-house water treatment systems may become a solid alternative to bottled water when tap water raises problematic perceptions related to bad taste, odor, or lime presence.

Keywords: bottled water; in-home water treatment; tap water quality perception; Catalonia

---

1. Introduction

The perception of the merits and pitfalls of tap water and bottled water constitute one of the more significant issues in domestic water use and management [1–5]. Health and safety concerns appear to play a major role in deciding which type of water source will be used as drinking water, since the quality of tap water continues to raise preoccupations among the public [1,4,6–11], with some countries asking for the derogation of European water quality standards [12]. However, for most users, perceived quality is usually based on organoleptic properties, and especially flavor, although related factors, such as water hardness or the presence of chlorine, may be also relevant [11,13]. In sum, mistrust in tap water for drinking [14], but in some cases for cooking as well [15,16], is still widespread, especially when risk communication fails to provide adequate messages [17].

However, the use of bottled water is not the only alternative for households dissatisfied with the quality of their tap water. There is a rapidly expanding market for the so-called in-home water treatment systems that, using more or less sophisticated technologies, are able to substantially improve not only the organoleptic properties of household flows, but also their overall quality [18]. These systems appear as an alternative to bottled water, but may be also convenient for other household uses, such as bathing/showering, washing clothes, or dishwashing, especially in areas with high water hardness [19].

This article addresses household strategies for coping with poorly perceived tap water quality (either organoleptic or fear of harmful elements) in a developed country, and attempts to discern the relative importance of possible causes leading to the adoption of either bottled water or in-home treated tap water for drinking and cooking. Beyond data on the perception of tap water, the paper includes some household sociodemographic and urban data seldom discussed in the literature (for example, housing tenure or spatial variables) as potential drivers of bottled water use or in-home water treatments. The paper analyses the interactions between the use of bottled water and in-home water systems to provide a more complex picture of water flows in households, beyond the bottled water/tap water divide, and with significant implications for both the bottled water and the public and private water supply sectors.

Literature Review: Bottled Water and In-Home Water Treatment Systems; Complementary or Alternative?

Bottled water reigns supreme in the world beverage market, with its market distance from other refreshment beverages widening year after year. While there is not a consensus on the size of the global bottled water market, some figures point to market sizes in the early 2020s of around 300 billion euros [11]. Figures for 2010 indicated a global annual consumption of 230 billion liters, with an annual growth above 6% [11]. Middle- and high-income countries top the list of bottled water consumption per capita [20]. In relative terms, Mexico and Thailand rank first in consumption (244 and 203 L/person/year respectively in 2015) followed by Italy, Germany, and the United States [20]. In 2018, Spain registered a consumption of 2.6 billion liters of bottled water. In relative terms, the highest consumptions were found in the coastal and touristic regions of Canary and Balearic Islands, followed by Valencia and Catalonia. Apart from the weight of tourism use, the high concentration of bottled water consumption in the Mediterranean areas may have other causes, such as the historically poor quality (in the organoleptic sense) of water in certain areas, and the high hardness associated with the mostly calcareous nature of Mediterranean basins. Average domestic bottled water consumption in Spanish households was estimated in 61 L/person/year in 2018, representing half of the total consumption in the country. The rest of it can be attributed to consumption in bars, restaurants, and hotels, largely by tourists [21].

Other than health and safety concerns regarding tap water, the success of bottled water is also related to its identification with certain lifestyles through marketing and branding [11,22]. Marketing and branding have played an important role in the steady increase in the bottled water trade, using the historically grounded cultural meanings of water, such as the power of nature, as well as the symbolism of the modern technology, and the conquest of water by purification systems [22]. Part of the cultural power of water is rooted in the geographic and class associations of early brands of mineral water, which carried prestige and supposedly quasi magical healing powers.

Beyond these general drivers, it is important to shed light on how multiple socio-demographic and political factors, including age, gender, income, education, ethnicity, age, political ideology, the number of children in their household, previous experience, place of residence, and trust in the government affect the perception and preference of consumers towards bottled water [15]. For instance, on average ethnic minorities in developed countries tend to consume more bottled water than the general population [23,24]. In this regard, a study in the USA found that minority children drank three times more bottled water than non-minority children [25] (see also [16]). This result is consistent with the broad literature on the legacy of residential segregation, and consequent variations in the quality of public services. In particular, the literature has identified predominantly African Americans and Hispanic neighborhoods as likely to experience poor tap water quality [25]. Women also tend to consume more bottled water than men, in line with their higher risk awareness, in this case of tap water [4]. Furthermore, the consumption of bottled water appears to be higher in households with more than three members and in households with children, possibly because of a "caregiver effect" [26]. There is inconclusive evidence regarding income as a significant driver of bottled water consumption, with some studies showing that water bottled usage increases with household income [10,27], while in others, it appears insensitive to changes in income [5].

Bottled water is also open to a variety of criticisms. First, in terms of quality, substantial differences between bottled water and tap water may be no longer present in many water supply systems. Modern water treatment plants can eliminate the organoleptic impacts common in the past. In fact, with just a simple treatment, blind tests indicate that consumers do not appreciate substantial differences between the two [3]. In this respect, it must be borne in mind that an important share of bottled water in some contexts is no more than tap water treated to comply with the chemical, microbiological, and radiological safety requirements stipulated for pre-packaged water [11]. Second, supplying costs, including energy or packaging [11], remain another important issue with bottled water, which is between 240 and 10,000 times per liter more expensive than tap water [28]. Third, plastic waste, most of which is accumulated in landfill, or contributing to the concentration of microplastics in the oceans [29] is another important concern. The environmental costs of bottled water, including those related to energy needs, embedded CO_2 emissions, or waste production, are said to be 100 times higher than tap water [14]. Fourth, environmental and human health concerns about bottled water are also rising, especially those related to plastic bottles and exacerbated by the current preoccupation with microplastics found in the water. A recent study in the US concluded that consumers of bottled water could be ingesting annually up to 90,000 plastic particles with the water, compared to 4000 for those drinking tap water [30]. However, a recent report by the World Health Organization did not find significant health risks, although it also warned that more research mas needed [31]. Likewise, the leaching of other chemicals, such as BPA or antimony in the water ingested [32], remains an important issue as well.

As mentioned in the introduction, a second strategy to address concerns about drinking water quality is the use of different in-home water treatment systems. These systems are divided into two main categories: Point of Entry (POE) systems, which are installed at the entrance of water into the home (e.g., water softeners, disinfection equipment, etc.), and Point of Use (POU) systems, which may be installed directly into any of the water sources existing at home (reverse osmosis, active carbon filter, etc.) [33]. While POU systems have lower capacities and higher operational costs, they are less expensive and easier to install than POE. Of all these systems, pitchers or bottles dominate the market in terms of sales and value. The success of pitchers or bottles equipped with filters can be attributed to their low cost and the fact that they do not need any installation [34].

In-home water treatment systems have been subject to special attention in developing countries where chronic problems in water quality leading to mortal diseases remain a serious cause of concern [35,36]. In contrast, empirical studies dealing with in-home water treatment systems in the developed world are less common despite a global market, growing from a value of UDS 19.9 billion in 2018, to an estimated value of USD 34.6 billion in 2026. Asia is projected to lead the market for POU technologies in the coming decades, followed by North America, which currently holds the majority of the market for POU systems, and Europe. Rapid urbanization and rising standards of living, coupled with concerns about water quality, explain the expansion of these technologies, especially in countries such as India and China [37].

Given the fact that filtered tap water using in-home water treatment systems can be an effective substitute for bottled water consumption, some studies have compared three possible choices for drinking water consumption in households: unfiltered tap water, filtered tap water, and bottled water [18,27,38]. While the consumption of bottled water is mainly linked to doubts about the safety of tap water, the consumption of filtered tap water is more related to sensory matters such as foul smelling and taste. Another interesting finding is that the purchase of filters is closely associated with income, unlike the case of bottled water, as noted above [5]. It has to be noted that some of these in-home water treatments imply the increase of the household water and energy consumption, imposing higher costs to families. Still, an economic analysis developed in Barcelona showed that water treated by domestic reverse osmosis equipment was between 8 and 19 times cheaper than bottled water [39]. Mackey et al. [18], in their survey of alternatives to tap water in the United States, found that in-home treatment systems were more favored by females, the non-white population, young people, higher income groups, and higher education groups. Concerning the presence of children in households, Mackey et al. [18] found that a much higher percentage of households with one or two children used these systems, compared to households with no children. However, the percentage of households with three or more children used these alternatives even less than households with no children. Thus, in the context of perceived low quality of the water supply service, richer households tend to have more often in-home water treatment systems than poorer households. At any rate, either for the installation of in-home water treatment systems, or for bottled water consumption, we do not know much about the role other factors, such as housing type or tenure. And perhaps most importantly, we do not know how both water flows interact with each other.

2. Materials and Methods

A computer-assisted telephone survey of households in Catalonia, Spain, was designed to explore the use of alternative sources of water supply (defined as those different from the public water network) particularly in-home water treatment systems. A sample population of households (n = 581) was obtained through a random selection with unbiased sampling and stratified by geographical area. Stratification was based on the distribution of Catalan population as of 1 January 2014 from census of the Statistical Institute of Catalonia (IDESCAT). Accordingly, 20% of the sample lived in the city of Barcelona, 20% in the Metropolitan Area of Barcelona (MAB) excluding Barcelona, and 20% in the Metropolitan Region of Barcelona excluding the MAB. The remaining 40% was distributed among the other seven Catalan territorial areas. Our survey was conducted by a specialized company during the second half of April 2015, and interviews took 20 min on average. The content of the questionnaire was structured in three sections (public water supply features, use of alternative water supplies, and use of in-home water treatment systems). In addition, the survey also compiled data on household socio-demographics.

Three models were developed explaining the factors conditioning bottled water consumption: the use of any in-home water treatment system, and having an in-home water treatment system except for water filter pitchers or bottles. Table 1 describes these variables, and indicates which of them are included in each of the three models.

The independent variables in the three models include perception of tap water (Perc_wqual); the characteristics of the household, such as household size (Household_size); having children at home (Child_5orless); and income (Income). Housing characteristics, such as the type of the building in which the housing unit is located (Building), and the tenure regime of the household (Ten_regime) were added, because we hypothesized that this variable might be important in the case of installing some types of in-home water treatment technologies. Some spatial variables, such as living in a municipality below or above 10,000 inhabitants (Pop_10,000), or living in the Metropolitan Area of Barcelona (MABarc) were added as well, with the aim of ascertaining whether there was an urban/metropolitan lifestyle effect regarding bottled water use. On the other hand, in rural areas, households sometimes use more than one water source [40]. Accordingly, having an in-home water system (WTS) was added. This variable operates as an independent variable in model 1 and as a dependent variable in model 2, and as a modified version of that variable as dependent variable in model 3, (WTS_nonfilterPB), as we detail below.

Table 1. List of dependent and sociodemographic variables.

Label	Description	Units	Models		
			1	2	3
BotW_index	Index of consumption of bottled water	1–5 index	D1		
WTS	Having an in-home water treatment system	Yes = 1 No = 0	x	D	
WTS_nofilterPB	Having an in-home water treatment system except for water filter pitchers or bottles	Yes = 1 No = 0			D
Perc_wqual2	Average perceived quality of the local water supply network for drinking and cooking	From 1 (very bad) to 5 (very good)	x	x	x
Household_size	Number of persons living in the household	n	x	x	x
Child_5orless	Having a 5-year-old or less child	Yes = 1 No = 0	x	x	x
Income	Average income per household in the municipality (2016)	Euros/year	x	x	x
Building	Type of building where the household is located	Multifamily = 1 Single family = 0		x	x
Ten_regime	Housing tenure regime	Property = 1 Rental = 0		x	x
MABarc	Living in a locality within the Metropolitan Area of Barcelona	Yes = 1 No = 0	x	x	x
Pop_10,000	Living in a locality with a population of 10,000 or more	Yes = 1 No = 0	x	x	x

Note: 1: "D" indicates that this is the dependent variable of the model. 2: The perceived quality of the local water supply network was asked separately for drinking and for cooking purposes using a 5-point Likert scale (1 very bad–5 very good). Perc_wqualis: the average of the score of both questions.

Model 1 analyses the relationships between selected sociodemographic, housing, and spatial independent variables and bottled water consumption, and it was developed using an ordinal regression method with a logit function. The particularity of this model is that the dependent variable is an ordinal categorical variable (BotW_index). In this case, a combination of the responses to the questions concerning the frequency of bottled water usage for drinking (1 = never; 2 = sometimes; 3 = always) and for cooking (1 = never; 2 = sometimes; 3 = always) was employed. Based on the sum of the scores, a bottled water consumption index was built, in which a score of 5 represents the consumption with the maximum frequency, and a score of 1 represents no consumption of bottled water neither for drinking nor for cooking. Model 2 was aimed at exploring the influence of the independent variables (Table 1) on the use of any kind of in-home water treatment system. Similarly, Model 3 had the same purpose, but in this case the dependent variable (in-home water treatment system usage) did not include water filter pitchers or bottles. This distinction was made because, compared to the other surveyed in-home water treatment systems, water filter pitchers do not need a complex installation requiring extra space in the house, or any significant initial investment. Given that in Model 2 and 3 the dependent variable was dichotomous, a logistic regression method was applied.

3. Results

The survey results show that using tap water for drinking raised more concerns than for cooking (Figure 1). While 26% of the respondents considered that tap water was 'bad' or 'very bad' for drinking, the percentage fell to 13% in the case of cooking. In other words, while over 80% of the sample qualified tap water for cooking as at least acceptable, this figure was only around 65% regarding drinking water. Table 2 is a contingency table, confronting the frequency of bottled water consumption for drinking and cooking purposes. We can detect two extreme cases: those who are strict tap water users (49.1% of the respondents 'never' consume bottled water neither for drinking nor for cooking) and those that are strict bottled water users (5.9% of the respondents 'always' use bottled water for drinking and cooking). Among the remaining 45.1% of survey participants not pertaining to any of these two groups, it is worth highlighting the 28.9% 'always' use bottled water for drinking, but 'never' for cooking, and 9.5% 'sometimes' use bottled water for drinking, but 'never' for cooking. Hence, we have an important group of participants (around 38% of the respondents) regularly (always or sometimes) using water for drinking but never for cooking. When asked about the main motivations for using bottled water for drinking, respondents mentioned two reasons: better taste and smell of water (51.3%), and health reasons (34.2%).

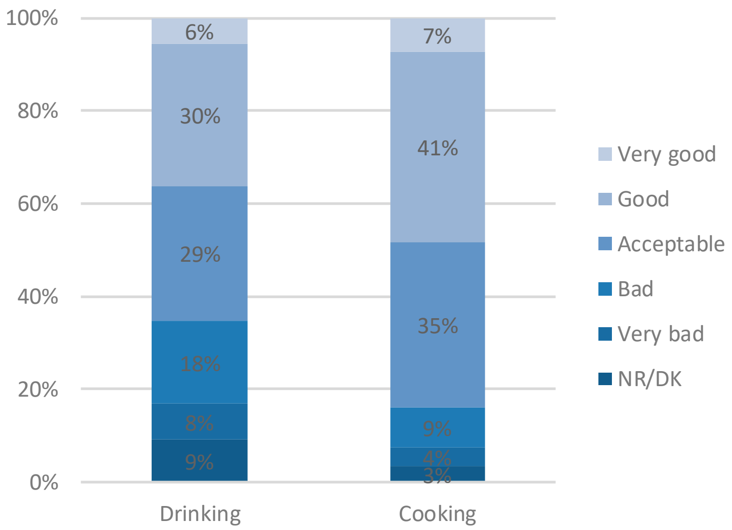

Figure 1. Perceived quality of the local water supply network for drinking (**left**) and for cooking (**right**) (n = 581).

Table 2. Frequency of consumption of bottled water for drinking and for cooking (n = 581).

Water Use	Frequency	Units	Cooking			Total
			Never	Sometimes	Always	
Drinking	Never	Count	285	1	1	287
		% Total	49.05	0.17	0.17	49.40
	Sometimes	Count	55	4	0	59
		% Total	9.47	0.69	0.00	10.15
	Always	Count	168	33	34	235
		% Total	28.92	5.68	5.85	40.45
Total		Count	508	38	35	581
		% Total	87.44	6.54	6.02	100

Concerning the prevalence of in-home water treatment systems, 31.2% of the households surveyed possessed (at least) one of such systems. The most common systems were water softeners (n = 76), followed by reverse osmosis (n = 68) and water filter pitchers or bottles (n = 60) (Figure 2). The main motivations to install water softeners were removing lime, followed by bad taste and smell (13.6%), and, finally, by health concerns (9.1%). In the case of the reverse osmosis, the main drivers reported in the survey were improving tasted and smell (42.7%), health concerns (19.1%) and removing lime (17.7%). Lastly, for filter pitchers or bottles, the main motivations were taste and smell (43.3%), removing the lime (16.7%), health concerns (10.0%), and comfort (10.0%). The 23.8% of those households with an in-home water treatment system reported that they "always" consumed bottled water for drinking.

On the contrary, the households without this kind of system that "always" consumed bottled water for drinking rose to 48%.

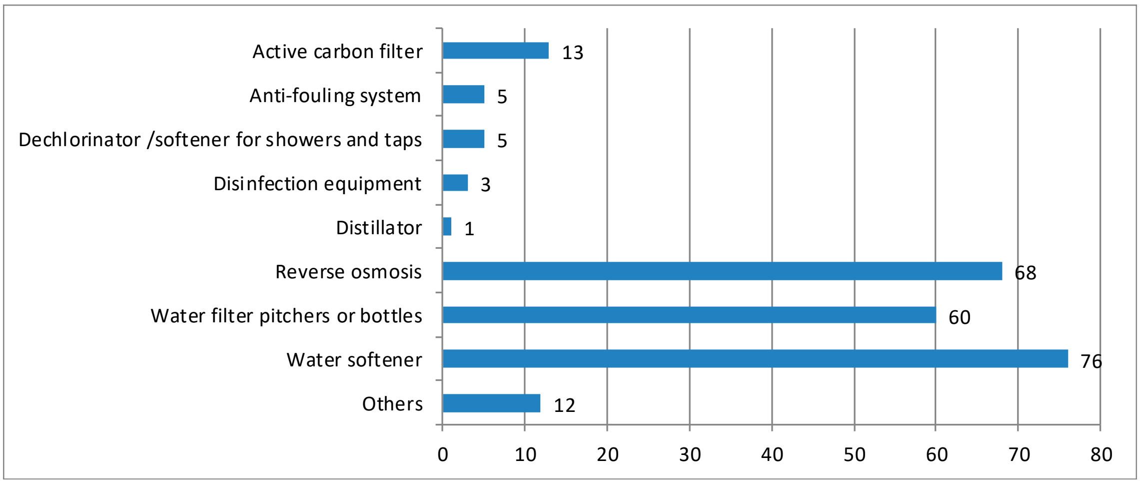

Figure 2. Frequency of households that have in-home water treatment systems.

Bottled Water and In-Home Water Treatment Systems Usage Models

The household sample showed a medium-low consumption of bottled water (BotW_index = 2.1), and the presence of in-home water treatment systems in approximately one third of the households (see Table 3).

Table 3. Descriptive statistics of the dependent and independent variables of the models.

Variable	n	%	Avrg.	Std. Dev.
BotW_index	581		2.10	1.24
WTS (=1)	581	31.15		
WTS_nofilterPB	581	20.83		
Perc_wqual	564		3.24	0.93
Household_size	555		2.81	1.28
Child_5orless (=1)	555	8.29		
Income	581		28,301.97	11,633.13
Building (=1)	581	62.48		
Ten_regime (=1)	573	88.83		
MABarc (=1)	581	40.26		
Pop_10,000 (=1)	581	74.00		

Model 1 analyses which of the considered independent variables has a greater influence in the consumption of bottled water (Table 4). Only three out of the seven independent variables showed statistically significant effects on this consumption. Results indicate that perceived (negative) quality of the local water supply network is the most significant variable in explaining (higher) bottled water consumption. Secondly, having an in-home water treatment system implies a significant reduction in the consumption of bottled water. Third, but in a less important way but still statistically significant, having a 5-year old or younger child at home implies an increase in the consumption of bottled water.

Table 4. Ordinal regression model 1 results.

Variable	Estimate	Std. Error	Wald	p-Value
WTS	−1.258	0.206	37.231	<0.001 *
Perc_wqual	−1.075	0.104	107.365	<0.001 *
Household_size	−0.125	0.073	2.934	0.087
Child_5orless	0.894	0.317	7.928	0.005 *
Income	<0.001	0.000	0.008	0.927
MABarc	−0.147	0.218	0.456	0.499
Pop_10,000	0.176	0.217	0.657	0.417

Note: BotW_index is the dependent variable. Pearson's chi-square test: Chi-squared = 977.787(d.f. = 948, p = 0.244, n = 540). Cox and Snell R Square is 0.232. * Variable significant at the 0.05 level.

Table 5 summarizes the results of Model 2, which explores the drivers behind the implementation of in-home water treatment systems. As in Model 1, a better perceived quality of the local water supply network negatively and significantly influenced the presence of these systems in the household. Household size was found significant as well: the larger the household, the greater the likelihood of having in-home water treatment systems. Conversely, living in a multifamily building made it less probable to have one of these systems. Therefore, in-home systems were more often present in single-family dwellings.

Table 5. Logistic regression model 2 results.

Variable	Odd Ration	Std. Error	Wald	p-Value
Perc_wqual	0.666	0.107	14.359	<0.001 *
Household_size	1.272	0.078	9.450	0.002 *
Child_5orless	0.842	0.374	0.210	0.647
Income	1.000	0.000	3.533	0.060
Building	0.522	0.236	7.596	0.006 *
Ten_regime	1.800	0.361	2.648	0.104
MABarc	1.087	0.260	0.102	0.750
Pop_10,000	0.903	0.263	0.151	0.698

Note: WTS is the dependent variable. Hosmer-Lemeshow test: Chi-squared = 7.898 (d.f. = 8, p = 0.443, n = 535). Cox and Snell R Square is 0.08. * Variable significant at the 0.05 level.

Model 3 explores the presence of in-home water treatment systems, in this case excluding the water filter pitchers or bottles, and including only systems that imply some kind of installation (Table 6). Apart from the significant variables identified previously, in this case, in-home water treatment systems were more frequent in higher income households (estimated as average income per household in the municipality). In addition, a significant (but at 0.1 level) relationship with housing tenure regime was found. According to this, living in a rented house reduces the probability of having an in-home water treatment of these characteristics.

Table 6. Logistic regression model 3 results.

Variable	Odd Ration	Std. Error	Wald	p-Value
Perc_wqual	0.644	0.124	12.627	<0.001 *
Household_size	1.264	0.088	7.170	0.007 *
Child_5orless	0.570	0.485	1.343	0.246
Income	1.000	0.000	7.603	0.006 *
Building	0.410	0.275	10.525	0.001 *
Ten_regime	2.567	0.495	3.623	0.057
MABarc	0.962	0.298	0.017	0.896
Pop_10,000	0.977	0.301	0.006	0.939

Note: WTS_nofilterPB is the dependent variable. Hosmer-Lemeshow test: Chi-squared = 3.635 (d.f. = 8. p = 0.888. n = 535). Cox and Snell R Square is 0.093. * Variable significant at the 0.05 level.

The three models show a moderate explanatory power, even though the respective goodness-of-fit tests demonstrated that the model adequately fitted the data. In the case of the ordinal model (Model 1), the significance value of the Pearson's chi-square test statistic ($p > 0.05$) demonstrate that. For the case of the logistic models (Models 2 and 3), the significance value of the Hosmer-Lemeshow statistic ($p > 0.05$) indicates also, in both cases, a good fit.

4. Discussion

According to the survey presented in this paper, poorly perceived water quality was the most statistically significant driver of the use of bottled water and/or of the presence of in-home water treatments in Catalonia. This confirms previous findings in different geographical contexts [1,4,6–11], especially regarding the use of bottled water, but also regarding in-home treatment systems. Results of the survey also indicate that the concept of water quality might include different issues, such as bad taste and/or smell, presence of lime, as well as safety concerns. Bottled water is the main alternative for those preoccupied about the quality or the security of tap water. Thus, about half of the respondents always or sometimes drank bottled water. This is a slightly higher rate compared to other developed countries such as the USA (45.4%, as reported by Hu et al. [8]) and far higher percentage compared to lower-income countries such as Malaysia (17%, according to Aini et al. [41]).

In addition, an important use of in-home water treatment technologies was observed, since approximately a third of the households had (at least) one of these systems. Again, this result contrasts with higher figures in other areas such as the British Columbia (Canada), where approximately 47% of households use this kind of system [38], Saskatchewan (Canada) (47.6% based on McLeod et al. [40]), or in Malaysia, where this rate is even higher (85%, according to Aini et al. [41]). Concerning the type of in-home water treatment systems installed, water softeners, reverse osmosis devices, and water filter pitchers and bottles were the most cited in the survey. This result might differ from other contexts where water filters pitchers or bottles are the most common option [38].

In the case of Catalonia, the central motivation for using bottled water instead of tap water is taste, followed by safety. A study in Québec, Canada, similarly found that taste, not safety, was the major motivation for drinking bottled water [42]. The main motivation for in-home water treatment systems was the removal of lime from the water, and taste and smell, while health concerns appeared as a secondary motivation, perhaps contrary to what might be expected [41]. It is important to mention that in some areas of Catalonia, the presence of lime in water is quite high, due to the hydromorphological nature of the rivers and aquifers supplying water to the population. In fact, the high water hardness of most Catalan basins has forced the water administration to install electrodialysis in one of the most important drinking water treatment plants of the Metropolitan area of Barcelona. On the other hand, the use of water softeners in dishwashers and washing machines may represent a non-negligible item in household budgets [43]. All in all, this might explain why water softener treatments are the most common system in Catalonia.

Results also show how the motivations related to the improvement of water quality for drinking and for cooking are different. First, as expected, perceived water quality exerts more influence on drinking than on cooking. Of those always drinking bottled water (40.45%), only 11.53% always or sometimes use bottled water for cooking. In total, approximately 6% of the respondents always use bottled water for drinking and for cooking. This confirms that water quality demand is higher for drinking than cooking [16]. For cooking, other health related factors may intervene, such as the idea that boiling water as a home-made purifying method can prevent some bad water condition, or that the amount of water absorbed by food when cooking is insignificant.

Concerning the specific results of the models, there appear to be a number of factors conditioning the use of bottled water for drinking and cooking, which are consistent with previous findings. In our case, the main explanatory factors of higher consumption of bottled water were the perception of poor tap water quality, the lack of in-home treatment systems [38], and the presence of children at home [40]. Income did not appear as a significant variable explaining the use of bottled water, unlike in other studies [10,27]. Although some authors have identified bottled water as a sign of rising social status [22], the perception related to bad smell and taste might have a stronger effect than income, in contrast with the significant role of income in determining bottled water used as found by McSpirit and Reid [10] and Johnstone and Serret [27]. This means that, in our context, regardless of income, if the perception on tap water is bad, households would buy bottled water. In low-income households, this may mean prioritizing water over other items, for the sake of improving taste, or for safety reasons. Similarly, the main driver of cooking with bottled water instead of tap water may be related to the desire of improving taste and smell, rather than to health reasons.

On the other hand, the presence of in-home treatment systems is related to factors such as perceived bad water quality, larger households [27], and single-family housing. Income and housing tenure appeared as explanatory variables only when considering systems requiring some kind of installation: lower incomes or renting a multi-family house reduced the probability of having an in-home water treatment that required installation because of important investments and operating costs [5], and the space needed in the housing units. This might explain why, in other studies, income did not significantly predict in-home water treatment use if pitchers and other lower cost treatments were considered [38]. Hence, and as in other environmentally efficient fixtures, wealthier households are more likely to adopt these systems [44].

5. Conclusions

The perception of the merits and pitfalls of tap water and bottled water constitute one of the more significant issues in domestic water use and management. Health and safety concerns appear to play a major role in deciding which type of water source will be used as drinking water, since the quality of tap water continues to raise concerns among the public. However, the use of bottled water is not the only alternative for households dissatisfied with the quality of their tap water. There is a rapidly expanding market for the so-called in-home water treatment systems that, using more or less sophisticated technologies, are able to improve substantially not only the organoleptic properties of household flows, but also their overall quality. By using a household survey in Catalonia (Spain), this article has addressed household strategies for coping with poorly perceived tap water quality (either organoleptic or out of fear of harmful elements) in a developed country. In addition, it has attempted to discern the relative importance of possible causes leading to the adoption of either bottled water or in-home treated tap water for drinking and cooking. The novelty and singular contribution of this paper is that, first, it has taken into account drinking, as well as cooking, to better understand the motivations and drivers behind using (or not being willing to use) bottled or treated tap water. Second, beyond the data on the perception of tap water, the paper also considered some household sociodemographic and urban data seldom discussed in the literature (for example housing tenure or spatial variables) as potential drivers of bottled water use or of in-home water treatments. Third, the paper has analyzed the interactions between the use of bottled water and in-home water systems to provide a more complex picture of water flows in households beyond the divide bottled water/tap water, and with significant implications for both the bottled water and the public and private water supply sectors.

Since about one third of our sample argued that their consumption of bottled water was motivated by health concerns, public institutions, bulk water suppliers, and tap water provides (either private or public) have still a long way to go in convincing users that the safety of tap water in terms of health is assured, especially in cases where the public may be right in their perceptions. A more difficult issue is to overcome the reluctance of users to use tap water especially for drinking, because of the bad taste or odor, or the presence of lime. Any intervention trying to increase the reliance on tap water and reduce bottled water consumption will have to deal with the organoleptic properties of tap water. While, in practical terms, this could be managed through new treatments in drinking water production plants, the costs might be disproportionate, given the relatively small amount of drinking/cooking needs, compared to the total urban water use. Still, as our survey showed, there is another alternative adopted by an increasing number of households: in-home treatment technologies for the most quality-demanding uses (drinking and cooking). It appears to be certain, however, that the capacity to install some of those systems, especially those that require significant investments and operating costs (in terms of energy and water consumption) is related to the tenure status of the home (renters may not have an incentive to make such an investment) and to the income of the household. Nevertheless, less costly and mobile systems, such as active carbon water pitchers or bottles, appear to be relatively unaffected by income or the tenure status of the households. Hence, these POU in-home water treatment systems could become a more universal and available alternative to bottled water, because of their effectivity and capacity in terms of removing some of the elements that cause mistrust among the public (bad taste, odor, or lime presence). Further research on the potentialities and limitation of those technologies, both in environmental and distributive terms, as well as on the characterization of the use of those systems in other geographies, is needed.

Author Contributions: Conceptualization, H.M. and D.S.; methodology, X.G.; formal analysis, H.M., X.G., E.D.; investigation, H.M., X.G., E.D., D.S.; resources, H.M. and D.S.; data curation, H.M. and D.S.; writing—original draft preparation, H.M., X.G., E.D., D.S.; writing—review and editing, H.M., X.G., E.D., D.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by CICYT grant number CSO 2012 36996. The APC was funded by grant numbers 2017 SGR 1351 and 2017 SGR 130 (Generalitat de Catalunya)".

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Anadu, D.; Harding, A. Risk perception and bottled water use. *J. Am. Water Work. Assoc.* **2000**, *92*, 82–91. [CrossRef]
2. Doria, M.F. Bottled water versus tap water: Understanding consumers' preferences. *J. Water Health* **2006**, *4*, 271–276. [CrossRef] [PubMed]
3. Teillet, E.; Urbano, C.; Cordelle, S.; Schlich, P. Consumer perception and preference of bottled and tapwater. *J. Sens. Stud.* **2010**, *25*, 463–480. [CrossRef]
4. Saylor, A.; Prokopy, L.S.; Amberg, S. What's wrong with the tap? Examining perceptions of tap water and bottled water at Purdue University. *Environ. Manag.* **2011**, *48*, 588–601. [CrossRef]
5. Triplett, R.; Chatterjee, C.; Johnson, C.K.; Ahmed, P. Perceptions of quality and household water usage: A representative study in Jacksonville, FL. *Int. Adv. Econ. Res.* **2019**, *25*, 195–208. [CrossRef]
6. Doria, M.; Pidgeon, N.; Hunter, P.R. Perceptions of drinking water quality and risk and its effect on behaviour: A cross-national study. *Sci. Total Environ.* **2009**, *407*, 5455–5464. [CrossRef]
7. Dupont, D.P. Tapping into consumers' perceptions of drinking water quality in Canada: Capturing customer demand to assist in better management of water resources. *Can. Water Resour. J.* **2005**, *30*, 11–20. [CrossRef]
8. Hu, Z.; Morton, L.W.; Mahler, R.L. Bottled water: United States consumers and their perceptions of water quality. *Int. J. Environ. Res. Public Health* **2011**, *8*, 565–578. [CrossRef]
9. Jakus, P.M.; Douglass Shaw, W.; Nguyen, T.N.; Walker, M. Risk perceptions of arsenic in tap water and consumption of bottled water. *Water Resour. Res.* **2011**, *45*, W05405. [CrossRef]
10. McSpirit, S.; Reid, C. Residents' perceptions of tap water and decisions to purchase bottled water: A survey analysis from the Appalachian, big sandy coal mining Region of West Virginia. *Soc. Nat. Resour.* **2011**, *24*, 511–520. [CrossRef]
11. Jain, B.; Singh, A.K.; Hasan Suan, A.B. The world around bottled water. In *Bottled and Packaged Water. Volume 4: The Science of Beverages*; Grumezescu, A.M., Holban, A.M., Eds.; Woodhead Publishing: Kidlington, UK, 2019.
12. Azara, A.; Castiglia, P.; Piana, A.; Masia, M.D.; Palmieri, P.; Arru, B.; Maida, G.; Dettori, M. Derogation from drinking water quality standards in Italy according to the European Directive 98/83/EC and the Legislative Decree 31/2001—A look at the recent past. *Ann. Di Ig. Med. Prev. Comunita* **2018**, *30*, 517–526.
13. Doria, M.F. Factors influencing public perception of drinking water quality. *Water Policy* **2010**, *12*, 1–19. [CrossRef]

14. Parag, Y.; Roberts, J. A battle against the bottles: Building, claiming, and regaining tap-water trustworthiness. *Soc. Nat. Resour.* **2009**, *22*, 625–636. [CrossRef]
15. York, A.M.; Barnett, A.; Wutich, A.; Crona, B.I. Household bottled water consumption in Phoenix: A lifestyle choice. *Water Int.* **2011**, *36*, 708–718. [CrossRef]
16. Huerta-Saenz, L.; Irigoyen, M.; Benavides, J.; Mendoza, M. Tap or bottled water: Drinking preferences among urban minority children and adolescents. *J. Community Health* **2012**, *37*, 54–58. [CrossRef] [PubMed]
17. Dettori, M.; Azara, A.; Loria, E.; Piana, A.; Masia, M.D.; Palmieri, A.; Cossu, A.; Castiglia, P. Population distrust of drinking water safety. Community outrage analysis, prediction and management. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1004. [CrossRef]
18. Mackey, E.D.; Davis, J.; Boulos, L.; Brown, J.C.; Crozes, G.L. *Consumer Perceptions of Tap Water, Bottled Water and Filtration Devices*; IWA Publishing: London, UK, 2003.
19. Lanz, B.; Provins, A. The demand for tap water quality: Survey evidence on water hardness and aesthetic quality. *Water Resour. Econ.* **2016**, *16*, 52–63. [CrossRef]
20. Statista. Per Capita Consumption of Bottled Water Worldwide in 2017, by Leading Countries. Available online: https://www.statista.com/statistics/183388/per-capita-consumption-of-bottled-water-worldwide-in-2009/ (accessed on 8 March 2020).
21. Efeagro. El Consumo De Agua Envasada En España Se Recupera Tras La Crisis. Available online: https://www.efeagro.com/noticia/agua-embotellada-envasada-consumo/ (accessed on 9 March 2020).
22. Wilk, R. Bottled water: The pure commodity in the age of branding. *J. Consum. Cult.* **2006**, *6*, 303–325. [CrossRef]
23. Onufrak, S.J.; Park, S.; Sharkey, J.R.; Sherry, B. The relationship of perceptions of tap water safety with intake of sugar-sweetened beverages and plain water among US adults. *Public Health Nutr.* **2012**, *17*, 179–185. [CrossRef]
24. Graydon, R.; Gonzalez, P.; Laureano-Rosario, A.; Pradieu, G. Bottled water versus tap water. *Int. J. Sustain. High. Educ.* **2019**, *20*, 654–674. [CrossRef]
25. Gorelick, M.H.; Gould, L.; Nimmer, M.; Wagner, D.; Heath, M.; Bashir, H.; Brousseau, D. Perceptions about water and increased use of bottled water in minority children. *Arch. Pediatr. Adolesc. Med.* **2011**, *165*, 928–932. [CrossRef] [PubMed]
26. Blocker, T.J.; Eckberg, D.L. Environmental issues as women's issues: General concerns and local hazards. *Soc. Sci. Q.* **1989**, *70*, 586.
27. Johnstone, N.; Serret, Y. Determinants of bottled and purified water consumption: Results based on an OECD survey. *Water Policy* **2012**, *14*, 668–679. [CrossRef]
28. Font-Ribera, L.; Colomer Cotta, J.; Gómez-Gutiérrez, A.; Villanueva, C.M. Trihalomethane concentrations in tap water as determinant of bottled water use in the city of Barcelona. *J. Environ. Sci.* **2017**, *58*, 77–82. [CrossRef]
29. Avio, C.G.; Gorbi, S.; Regoli, F. Plastics and microplastics in the oceans: From emerging pollutants to emerged threat. *Mar. Environ. Res.* **2017**, *128*, 2–11. [CrossRef] [PubMed]
30. Cox, K.D.; Covernton, G.A.; Davies, H.L.; Dower, J.F.; Juanes, F.; Dudas, S.E. Human consumption of Microplastics. *Environ. Sci. Technol.* **2019**, *53*, 7068–7074. [CrossRef]
31. World Health Organization (WHO). *Microplastics in Drinking Water*; WHO: Geneva, Switzerland, 2019.
32. Díez, J.R.; Antigüedad, I.; Agirre, E.; Rico, A. Perceptions and consumption of bottled water at the University of the Basque Country: Showcasing tap water as the real alternative towards a water-sustainable university. *Sustainability* **2018**, *10*, 3431. [CrossRef]
33. EPA. Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems. EPA 815-R-06-010; April 2006. Available online: https://www.epa.gov/sites/production/files/2015-09/documents/guide_smallsystems_pou-poe_june6-2006.pdf (accessed on 8 March 2020).
34. Marketsandmarkets. Point-of-Use Water Treatment Systems Market by Device (Tabletop, Faucet-mounted, Countertop, Under-the-sink) Technology (RO, Ultrafiltration, Distillation, Disinfection, Filtration), Application (Residential, Non-residential), & Region—Forecast to 2023. Available online: https://www.marketsandmarkets.com/Market-Reports/point-of-use-water-treatment-systems-market-131277828.html (accessed on 8 March 2020).
35. Lantagne, D.S.; Quick, R.; Mintz, E.D. *Household Water Treatment and Safe Storage Options in Developing Countries: A Review of Current Implementation Practices*; The Wilson Center: Washington, DC, USA, 2006.

36. Sobsey, M.D.; Stauber, C.E.; Casanova, L.M.; Brown, J.M.; Elliott, M.A. Point of use household drinking water filtration: A practical, effective solution for providing sustained access to safe drinking water in the developing world. *Environ. Sci. Technol.* **2008**, *42*, 4261–4267. [CrossRef]
37. Reports and Data. Point of Use Water Treatment Systems Market Analysis, By Type (Faucet, under the sink, Table top, Pitchers) By Filtration Techniques (Reverse Osmosis, Carbon Filtration, Distillation, Ultrafiltration, Disinfection) By Application (Residential, Non-residential), Forecasts to 2026. Available online: https://www.reportsanddata.com/report-detail/point-of-use-water-treatment-systems-market (accessed on 8 March 2020).
38. Jones, A.Q.; Majowicz, S.E.; Edge, V.L.; Thomas, M.K.; MacDougall, L.; Fyfe, M.; Atashband, S.; Kovacs, S.J. Drinking water consumption patterns in British Columbia: An investigation of associations with demographic factors and acute gastrointestinal illness. *Sci. Total Environ.* **2007**, *388*, 54–65. [CrossRef]
39. Garfí, M.; Cadena, E.; Sanchez, D.; Ferrer, I. Life cycle assessment of drinking water: Comparing conventional water treatment, reverse osmosis and mineral water in glass and plastic bottles. *J. Clean. Prod.* **2016**, *137*, 997–1003. [CrossRef]
40. McLeod, L.; Bharadwaj, L.; Waldner, C. Risk factors associated with the choice to drink bottled water and tap water in rural Saskatchewan. *Int. J. Environ. Res. Public Health* **2014**, *11*, 1626–1646. [CrossRef] [PubMed]
41. Aini, M.S.; Fakhrul-Razi, A.; Mumtazah, O.; Chen, J.M. Malaysian households' drinking water practices: A case study. *Int. J. Sustain. Dev. World Ecol.* **2007**, *14*, 503–510. [CrossRef]
42. Levallois, P.; Grondin, J.; Gingras, S. Evaluation of consumer attitudes on taste and tap water alternatives in Québec. *Water Sci. Technol.* **1999**, *40*, 135–139. [CrossRef]
43. Van der Bruggen, B.; Goossens, H.; Everard, P.A.; Stemgée, K.; Rogge, W. Cost-benefit analysis of central softening for production of drinking water. *J. Environ. Manag.* **2009**, *91*, 541–549. [CrossRef] [PubMed]
44. Schleich, J. Energy efficient technology adoption in low-income households in the European Union—What is the evidence? *Energy Policy* **2019**, *125*, 196–206. [CrossRef]