Title: Report on water-related behaviour leading to DBP exposure in Europe and recommendations.

Deliverable 6.1

WP 6 – EXPOSURE



Author: Fang Fang Chen Chen, Bozidarka Prole, Cristina Villanueva

Date: 01/10/2025

Funded by the European Union

GRANT AGREEMENT NUMBER	101081728		
FULL TITLE / ACRONYM	Innovative tools to control organic matter and disinfection by-products in drinking water. intoDBP		
START DATE	01/12/2022	**DURATION**	48 months
END DATE	30/11/2026		
PROJECT URL	**https://intodbp.eu/**		
DELIVERABLE	**6.1. Report on water-related behaviour leading to DBP exposure in Europe and recommendations**		
WORK PACKAGE	**6- EXPOSURE- Human Exposure**		
CONTRACTUAL DATE OF DELIVERY	30/11/2025		
ACTUAL DATE OF DELIVERY	28/11/2025		
NATURE	**REPORT**	**DISSEMINATION LEVEL**	SEN
LEAD BENEFICIARY	ISGlobal		
RESPONSIBLE AUTHOR	Cristina Villanueva		
CONTRIBUTIONS FROM	Bozidarka Prole, Valerie McCarthy, Vasiliki G Beretsou, Maria Karekla, Despo Fatta-Kassinos, Carolina Donat-Vargas, Miquel Vallbona-Vistós, Fang Fang Chen Chen, Maria José Farré		
ABSTRACT	The study aimed to describe drinking water consumption patterns and water use involving DBP exposure across three European regions: Spain (Barcelona), Cyprus, and Ireland, and identify drivers of drinking water choice at home. We conducted a cross-sectional survey in approximately 2000 participants (1000 Barcelona, 412 Cyprus, 532 Ireland) to ask about socio-demographics, lifestyle markers, tap water perception, drinking water habits at home and outside, showering, bathing, and swimming frequency. We evaluated associations between drinking choice at home and socio-demographics, lifestyle, and tap water perception through a bivariate analysis and a multivariate logistic regression. Tap water was predominantly used for cooking, while bottled water remained the primary choice for drinking, especially outside the home. Trust in tap water supply was lowest in Cyprus. Showering, bathing and swimming in pools slightly differed between study areas. Results revealed that subjective perception of tap water quality was the most consistent predictor of drinking water choice across all study area, while sociodemographic characteristics showed context-specific associations.		

Disclaimer

Any dissemination of results reflects only the author's view and the European Commission is not responsible for any use that may be made of the information it contains.

Copyright message

© intoDBP Consortium, 2022
This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation, or both. Reproduction is authorised provided the source is acknowledged.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS 5

LIST OF FIGURES 5

LIST OF TABLES 6

EXECUTIVE SUMMARY 7

1. INTRODUCTION 8

1.1. Household water cycle: DBP, a public health matter 8
1.2. Overview of the case study regions 9
1.2.1. Barcelona 9
1.2.2. Ireland 9
1.2.3. Cyprus 9

2. METHODS 11

2.1. Study design and population 11
2.2. Survey 11
2.3. Drinking water quality 12
2.4. Statistical analysis 12

3. RESULTS 13

3.1. Sample characteristics 13
3.2. Drinking water habits 14
3.3. Risk perception and attitudes 18
3.4. Determinants of water use behaviour 21
3.5. Hygiene behaviours 28

4. DISCUSSION 31

5. CONCLUSION AND RECOMMENDATIONS 36

5.1. Conclusion 36
5.2. Recommendations 36

REFERENCES 38

ANNEX 1. MAIN GEOLOCATION OF STUDY AREAS 41

LIST OF ABBREVIATIONS

CI – confidence interval
DBPs – disinfection by-products
EU – European Union
N – number of observations
NA – not ascertained (missing value)
OR – odds ratio
SINAC – Sistema de información nacional de aguas de consumo
THMs - Trihalomethanes

LIST OF FIGURES

Figure 1. Tap water. Association (odds ratio-OR, 95% confidence interval-CI) between consuming tap water (unfiltered) at home and different personal characteristics in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532)1, 2023, 2024.

Figure 2. Filtered water. Association odds ratio-OR, 95% confidence interval-CI) of consuming tap water filtered at home by different personal characteristics in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532)1, 2023, 2024.

Figure 3. Bottled water. Association odds ratio-OR, 95% confidence interval-CI) of consuming tap water filtered at home by different personal characteristics in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532)1, 2023, 2024.

Figure 4. Tap water perception by type of water consumed at home in Barcelona, Spain (N=1000), Cyprus (N=412), and Ireland (N=532). P-value calculated by Chi-Square test. *p value≤0.05

Figure 5. Association (odds ratio-OR, 95 confidence interval-CI) between positive tap water quality perception and socio-demographic and lifestyle variables in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532), 2023, 2024.

LIST OF TABLES

Table 1. Socio demographic characteristics and lifestyle among study participants in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532), 2023, 2024.

Table 2. Drinking water habits among study participants in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532), 2023-2024.

Table 3. Type of water consumed, chemical characteristics (conductivity, pH) and trihalomethane (THM) levels among study participant living in Barcelona city versus the rest of the metropolitan area, Cyprus provinces, and Ireland region.

Table 4. Type of water consumption by geographical divisions: municipalities in Barcelona, provinces in Cyprus, and counties in Ireland.

Table 5. Water perception among study participants in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532), 2023-2024

Table 6. Household drinking water choices in relation to tap water satisfaction, housing factors, and water issues: a comparative study in Spain, Cyprus, and Ireland in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412) and Ireland(N=532)1, 2023-2024.

Table 7. Tap water perception by European origin. P-value from a chi2-test.

Table 8. Tap water perception by household size. P-value from a chi2-test.

Table 9. Tap water perception by education. P-value from a chi2-test.

Table 10. Tap water perception by sex. P-value from a chi2-test

Table 11. Showering, bathing and swimming pool attendance frequency.

EXECUTIVE SUMMARY

Disinfection by-products (DBPs) such as trihalomethanes (THMs) are ubiquitous in chlorinated drinking water, and have been linked to health risks. Human exposure occurs through ingestion, inhalation, and dermal absorption in water-contact activities. This study explores drinking water consumption habits and water use activities leading to DBP exposure across three European countries with reported high THM levels: Spain (Barcelona), Cyprus and Ireland. Through a large scale, population-based survey we assessed how sociodemographic factors, water quality perception and daily habits influence ingestion by a bivariate and multivariate regression analysis.

Study participants included 1000 volunteers in Barcelona, 412 in Cyprus, and 532 in Ireland. Our findings show that bottled water is the dominant drinking water source in all three countries, especially as a drinking source at home (55% of Barcelona respondents, 41% in Cyprus and 35% in Ireland), and it even higher outside home (80% of Barcelona respondents, 85% in Cyprus and 66% in Ireland). In contrast, tap water remained the preferred choice for cooking in most regions. Filtered tap water was frequently used in Cyprus and among more educated individuals, especially where trust in tap water was low.

A consistent finding across all study areas was that perceived tap water quality, was the strongest predictor of drinking water behaviour, more influential than sociodemographic factors and lifestyle variability such as age, gender or education. The role of socio-demographic characteristics was context-specific. Notably, Cyprus had the lowest public trust in tap water (36%), coinciding with lower tap water use.

Regarding showering, bathing, and swimming, habits varied by study area, with Barcelona and Cyprus reporting higher frequencies. These activities can lead to THM exposure through inhalation and dermal routes, especially when hot water and enclosed environments are involved.

Recommendations include improvement of public water system transparency and facility to access water data, education on environmental impacts of bottled water, public health campaigns tailored to the study setting, and more research on non-ingestion behaviours exposure pathways. Our findings emphasize that behavioural and subjective factors such as tap water perception must be considered in designing effective water-related sustainability policies under the EU Drinking Water Directive.

1. Introduction

1.1. Household water cycle: DBP, a public health matter

The use of disinfectants in water treatment result in the formation of disinfection-by-products (DBPs) such as trihalomethanes (THM), through reactions with organic matter in water. THMs and other DBPs are regulated under the Directive 2020/2184 (1), due to their potential health impacts. Epidemiological studies have associated long-term exposure to THMs with an increased bladder and colorectal cancer risk (2). *In vitro* studies have further shown THM may exert hepatotoxic effects (3). Therefore, understanding household water use and consumption remains essential for developing effective public health policies aimed to minimize DBP exposure while ensuring microbiological water safety.

Exposure to DBPs occurs primarily through water ingestion but also through inhalation and dermal absorption, particularly during activities involving warm water and direct skin contact such as showering, bathing, swimming or hand washing. Dermal and inhalation exposure can vary across different social and demographic groups (4).

Bottled water consumption has increased in the last few years worldwide (5), and more sharply in low- and middle-income countries (6). The resulting environmental impact (7) and contribution to plastic debris has motivated policy action to reduce bottled water use in Europe (1) to decrease greenhouse gas emissions and marine litter, and adhere to the European Strategy for Plastics (8). Alternatives such as the use of domestic filters has been reported in some settings (9). Activated carbon-based filters and reverse osmosis have shown to remove trihalomethanes (THMs) and other disinfection by-products (DBPs) (10,11), and also reduce environmental impacts as compared to bottled water (7). However, systematic international knowledge about water consumption habits including the use of filters is partial and limited to specific populations such as pregnant women (12) or geographically limited studies (9).

Drivers of drinking water choices are complex and may include multiple factors such as organoleptic ones, risk perception, socioeconomic status, environmental concerns, etc. (13,14). Scientific knowledge is needed to understand motivations and develop evidence-based interventions that effectively influence consumer's behaviour to contribute to a long-term sustainable transformative change, which is recognized as necessary in the Global Plastics Treaty discussions (15).

This research endeavours to characterize drinking water consumption patterns and evaluate their potential determinants, including socio-demographic factors, lifestyle, and risk perception, across

Cyprus, Ireland, and Barcelona (Spain), that are EU countries showing diverse drinking water quality issues in the past (16,17). Additionally, we analysed non-ingestion exposure routes such as showering, bathing and swimming, to provide a descriptive assessment of these behaviours. Selected study areas warrant specific scientific attention and provide the optimal context for examining the complex interplay between water quality challenges and human behavioural responses.

1.2. Overview of the case study regions

1.2.1. Barcelona

Barcelona´s drinking water supply is mostly sourced from surface water mixed with other sources, including a growing proportion of desalinated sea water. The city faces high hydric stress due to dense urbanization, warm climate and periodic droughts. Historically, public trust in tap water quality has been low, often attributed to elevated levels of chlorination required to maintain safety in a complex network (18). This distrust partly explains Barcelona´s high bottled water consumption and a rising market of in-home filter systems. Following the 2008 drought, public authorities implemented infrastructure upgrades, such as connecting different treatment plants and expanding desalination capacity (19).

1.2.2. Ireland

Ireland primarily sources its drinking water from surface water, with some areas with significant input from peatland with high organic matter that can react with chlorine to form DBP(20). The country has faced challenges in meeting EU-mandated DBP thresholds in part due to its historically decentralized water infrastructure, which has led to inconsistencies in water treatment and quality across regions(21). Recent years have seen efforts to centralize water services and improve its coordination through Irish Water, but public resistance to water charges and historical trust issues continue to influence water use behaviours. Ireland remains under scrutiny for compliance with EU water quality directives(22).

1.2.3. Cyprus

Cyprus presents a highly contrasting scenario, shaped by geopolitical and climatic conditions. The northern part of the island receives water via pipeline from Turkey, while the Republic of Cyprus continues to struggle with chronic water scarcity and patchy water infrastructure (23). Water supply in the south relies on a mix of groundwater and desalinated seawater, often stored in household tanks due to intermittent supply (23). Like Barcelona, Cyprus has high seasonal water demand due to tourism. These challenges, combined with public concerns over water quality, lead to elevated bottled water consumption and increased use of household filtration systems. Therefore, understanding regional

differences in risk perception, trust in water infrastructure and daily water practices is essential for designing context sensitive public health interventions and communication strategies.



2. Methods

2.1. Study design and population

A cross-sectional study was conducted in the Barcelona Metropolitan Area, Spain (N≈3.3 million inhabitants), Cyprus (N≈920.000 inhabitants), and the Republic of Ireland (N≈5 million inhabitants). A stratified sampling was conducted to enrol participants representative of the study area by age, gender and geographical area distribution. Sample size was calculated separately in the three study sites using a survey specific formula (24), and accepting an error of 5%, 95% confidence, and 50% response distribution. The recruitment of study participants was conducted through a subcontracted international survey platform (www.cint.com), who contacted volunteers in their databases fulfilling age, sex, and geographical distribution quota. This method was preferred to CS-specific methodologies (e.g. survey focused on Group Water Schemes in Ireland) to ensure methodological comparability between areas, and also expand the study area to National-level in Ireland and Cyrpus, and thus the representativity and generalizability of findings. In Cyprus, participants were recruited from all five main regions: Nicosia, Limassol, Larnaca, Paphos, and Famagusta. A small subset (N=12) of participants in Cyprus aged ≥65 years were contacted using hard copies of the questionnaire to interview friends and relatives of researchers. The total number of participants included were 1000 in Barcelona, 412 in Cyprus and 532 in Ireland. This was a small percentage compared to the original 10% of each population targeted, since it was not feasible to include the 10%, and in the end, we calculated the sample size through power estimations. Study participants were contacted in July 10 to September 15, 2023 in Barcelona, November 24 to December 12, 2023 in Cyprus, and 18 to 24 of June 2024 in Ireland, and provided informed consent to participate before enrolment. The study was approved by the Ethics Committees of the respective study areas or countries.

2.2. Survey

A questionnaire, that was translated to the local languages, was developed to ascertain socio-demographics (age, gender, education, ethnicity, municipality of residence), lifestyle indicators including: smoking (ever, never), having a specific dietary requirement (no specific diet, vegetarian, vegan, gluten-free, other), number of people living at home, water consumption habits, and 17 questions on organoleptic and risk perception of tap water. Specifically, we ascertained the type of water consumed through closed ended options including bottled, tap, filtered, private wells, street tanks (only in Cyprus), group water scheme (only in Ireland), and other, consumed at home to drink, cook, prepare coffee and tea, and consumed outside home. Among those reporting the use of filtered water, we

ascertained the type of filter among the closed-ended options: reverse osmosis, filtering jar/reverse osmosis, ion exchange, softener, ceramic, other, 'don't know'. The amount of water consumed (liters/day), and the percentage of water consumed at home was assessed through open-ended questions. The questionnaire was self-administered online via a secure platform. For specific elderly groups in Cyprus, in-paper copies were also provided.

2.3. Drinking water quality

We collected markers of drinking water quality for the years 2022 and 2023 from routine monitoring records. Data was retrieved from the SINAC website for Spain, from the Environmental Protection Agency from Ireland (https://eparesearch.epa.ie/safer/dataAndResources/publiclyAvailableDatasets.jsp), and the National Open Data Portal for Cyprus (https://www.data.gov.cy/en). Conductivity and pH were selected as general quality indicators, and THMs were selected because they had been shown to be high in the study areas (16) and because the concentrations differ between the drinking water options examined (4,11).

2.4. Statistical analysis

Descriptive statistics were used to summarize participant characteristics, drinking water consumption and related variables. Median and interquartile range were calculated for the continuous variables, while frequency and percentages were computed for categorical variables. We conducted bivariate analysis to examine the association between the type of water consumed to drink at home and socio-demographics, lifestyle variables, and risk perception. Statistical significance has been tested by using Chi-Square test for categorical variables. Multiple logistic regressions were conducted to estimate the odds ratio (OR) and 95% confidence intervals (CI), for the type of water consumed to drink at home associated with socio-demographic characteristics, lifestyle, and tap water quality perception in mutually adjusted models. OR (95% CI) from a multiple regression model provides an estimate of association between the outcome (e.g., drinking water choice in this case) and each variable, adjusted for the effect of other variables in the model. Similarly, multiple logistic regression was used to estimate the association between positive tap water quality perception with socio-demographic and lifestyle variables mutually adjusted. The Variance Inflation Factor (VIF) was calculated to detect multicollinearity between variables. Statistical analysis was performed in R software (version 4.3.2)

3. Results

3.1. Sample characteristics

Sociodemographic and lifestyle characteristics of the study populations are shown in Table 1. The median age of study participants were 38 years in Cyprus, 39 in Ireland, and 45 in Barcelona. Approximately half of the study population were women, and the most frequent level of education attained was University (49% in Barcelona, 68% in Ireland, and 79% in Cyprus). The most frequent self-reported ethnicity, approximately 90%, was White-European in all three study areas. The proportion of smokers was 51% in Ireland, 56% in Cyprus, and 58% in Barcelona, and a similar proportion of participants in the three areas (17-19%) reported following a diet. Most of the study participants (64-67%) lived in households with three or more co-habitants (Table1).

Table 1: Socio demographic characteristics and lifestyle among study participants in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532), 2023, 2024.

	Barcelona		Cyprus		Ireland	
	N	%	N	%	N	%
Age, years						
Median (P25, P75)	45 (34, 56)		38 (30, 50)		39 (29, 50)	
18-24	93	9.3	47	11.4	85	16.0
25-34	168	16.8	115	27.9	122	22.9
35-44	233	23.3	101	24.5	126	23.7
45-54	222	22.2	76	18.4	108	20.3
55-64	171	17.1	59	14.3	61	11.5
65+	113	11.3	14	3.4	30	5.6
Gender						
Men	470	47.0	203	49.3	263	49.4
Women	525	52.5	207	50.2	268	50.4
Non-Binary/Other	5	0.5	2	0.5	1	0.2
Ethnicity						
White/European	797	79.7	388	94.2	461	86.6
Hispano/Latino	165	16.5	1	0.2	12	2.3
Other	38	3.8	23	5.6	65	12.2
Education						
< Secondary School	34	3.4	7	1.7	5	0.9
Secondary	232	23.2	76	18.4	158	29.7
University	492	49.2	326	79.1	367	69.0
Other	242	24.2	3	0.7	2	0.4
Smoking						
Never	422	42.2	180	43.7	263	49.4
Ever	578	57.8	232	56.3	269	50.6
Diet followed						
No	812	81.2	332	80.6	441	82.9
Yes	188	18.8	80	19.4	91	17.1
Number of people living at home						
1	76	7.6	54	13.1	53	10.0
2	253	25.3	93	22.6	123	23.1
≥3	671	67.1	265	64.3	356	66.9

3.2. Drinking water habits

Drinking water habits in the study population are shown in Table 2. Bottled water was consumed at home among 55% of participants in Barcelona, 41% in Cyprus, and 35% in Ireland. Similarly, bottled water was the most frequently consumed outside home (85% in Cyprus, 80% in Barcelona, and 66% in Ireland). Tap water (unfiltered) was consumed to drink at home among 30% in Ireland, 20% in Barcelona, and 10% in Cyprus. Filtered tap was consumed among 24% in Barcelona, 26% in Ireland, and 34% in Cyprus. Other water types showed lower percentages. In contrast, the most frequent type of water used to cook was tap water in Barcelona (57%) and Ireland (50%), and filtered tap water in Cyprus (43%). The median water consumption (litres/day) was 1.5 in Cyprus, and 2.0 in Barcelona and Ireland. The percentage of water consumed at home relative to the total represented approximately 90% in Cyprus, 70% in Barcelona and 65% in Ireland. Data on the type of filter was gathered in Barcelona and Ireland, showing filtering jar/active carbon was most frequently used (34% in Ireland, 33% in Barcelona, relative to all other filter types).

Table 2: Drinking water habits among study participants in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532), 2023-2024.

	Barcelona		Cyprus		Ireland	
	N	%	N	%	N	%
Type of water consumed at home to drink						
Tap water	196	19.6	39	9.5	161	30.3
Filtered	244	24.4	138	33.5	138	25.9
Bottled	546	54.6	170	41.3	188	35.3
Private well	5	0.5	3	0.7	27	5.1
Street tanks (Cyprus)	-	-	55	13.3	-	-
Group Water Scheme (Ireland)	-	-	-	-	12	2.3
Other	9	0.9	7	1.7	6	1.1
Type of water consumed at home to cook						
Tap water	565	56.5	155	37.6	267	50.2
Filtered	312	31.2	175	42.5	147	27.6
Bottled	116	11.6	59	14.3	55	10.3
Private well	5	0.5	6	1.5	37	7.0
Street tanks (Cyprus)	-	-	15	3.6	-	-
Group Water Scheme (Ireland)	-	-	-	-	21	3.9
Other	2	0.2	2	0.5	5	0.9
Type of water consumed at home to prepare coffee and tea						
Tap water	352	35.2	92	22.3	260	48.9
Filtered	313	31.3	165	40.0	169	31.8
Bottled	323	32.3	109	26.5	44	8.3
Private well	8	0.8	6	1.5	36	6.8
Street tanks (Cyprus)	-	-	37	9.0	-	-
Group Water Scheme (Ireland)	-	-	-	-	16	3.0
Other	4	0.4	3	0.7	7	1.3
Type of water consumed outside home						
Tap water	77	7.7	12	2.9	75	14.1
Filtered	108	10.8	32	7.8	78	14.7
Bottled	795	79.5	350	85.0	350	65.8
Private well	9	0.9	7	1.7	11	2.1
Street tanks (Cyprus)	-	-	8	1.9	-	
Group Water Scheme (Ireland)	-	-	-	-	13	2.4
Other	11	1.1	3	0.7	5	0.9
Type of filter (among filter users)						
Reverse Osmosis	102	23.1	-	-	13	5.5
Filtering Jar/Active Carbon	147	33.3	-	-	81	34.2
Ionic Exchange	72	16.3	-	-	17	7.2
Softener	55	12.4	-	-	41	17.3
Ceramic	16	3.6	-	-	17	7.2
Other/Don't know	50	11.3	-	-	68	28.7
Water consumed (liters /day)						
Median (p25, 75)	2.0 (1.6, 2.0)		1.5 (1.5, 2.5)		2.0 (1.0, 3.0)	
Percentage of water consumed at home						
Median (p25, 75)	70 (40, 80)		90 (58, 100)		65 (45, 80)	

Table 3 illustrates how the type of water consumed and THM concentrations, conductivity and pH vary geographically within each case study. Bottled water consumption in Cyprus varied from 33% in Nicosia to 71% in Paphos provinces, while the frequency was similar in Ireland regions (34-35%) and Barcelona (53-56%). Filtered water consumption ranged from 0% in Paphos to 45% in Nicosia (Cyprus), 22-26% in Barcelona and 22-28% in Ireland. Tap water consumption varied between regions in Ireland (22-32%), (from 17% in Barcelona city to 23% in the Metropolitan Area), and Cyprus provinces (5% in Paphos to 18% in Nicosia). The median concentration of THMs in Barcelona city and Metropolitan area were similar (32 vs.30 µg/L, respectively). THM levels in Cyprus were lower, with the highest median reported in Larnaca (9.4 µg/L), as compared to other provinces (2.5 µg/L). In Ireland, median THM concentrations ranged from 9 µg/L in Munster to 54 µg/L in areas other than Leinster or Munster (Table 3). Water quality data was presented as a descriptive between areas. Personal estimates of concentrations were not possible to estimate and analyse water quality as a determinant of drinking water choice. We could only estimate area-level values (province level in Cyprus, municipality level in Barcelona, and county level in Ireland). Participants living at the same province/municipality/county were assigned the same water quality estimate, and this variable did not add more to the model as compared to province/municipality/county. Table 4 describes the type of water consumed at higher geographical detail (municipalities in Barcelona, counties in Ireland).

Table 3. Type of water consumed, chemical characteristics (conductivity, pH) and trihalomethane (THM) levels among study participant living in Barcelona city versus the rest of the metropolitan area, Cyprus provinces, and Ireland region.

Study area			Type of water consumed to drink at home				THMs (µg/L)	Conductivity (µS/cm)	pH
	N	%	Tap %	Filtered %	Bottled %	Other %	Median (p25, p75)	Median (p25, p75)	Median (p25, p75)
Barcelona (N=1000)									
Barcelona city	526	53	17	26	56	1	32 (16.8, 44.2)	657 (471, 1004)	7.8 (7.7, 8.0)
Rest of Metropolitan Area	474	48	23	22	53	2	30 (15.7, 43.8)	903 (493, 1107)	7.7 (7.6, 7.0)
Cyprus (N=412)									
Nicosia	195	47	18	45	33	3	2.5 (0, 46.1)	704 (514, 762)	8.1 (7.9, 8.2)
Limassol	96	23	10	39	45	6	2.5 (0, 12.9)	696 (570, 845)	8.1 (7.9, 8.2)
Larnaca	67	16	10	37	42	10	9.4 (2.5, 26.4)	800 (690, 913)	8.0 (7.8, 8.2)
Paphos	33	8.	5	0	71	24	2.5 (0, 16.7)	736 (613, 844)	7.9 (7.7, 8.1)
Famagusta (Ammochostos)	21	5	8	31	37	24	2.5 (2.5, 9.5)	837 (772, 894)	9.0 (8.7, 9.1)
Ireland (N=532)									
Leinster	316	60	31	28	34	7	33.6 (0.6, 57.5)	350 (155, 563)	7.4 (7.2, 7.6)
Munster	114	21	32	22	35	11	9.0 (2.5, 38.1)	284 (188, 491)	7.3 (7.0, 7.5)
Other	102	19	22	22	34	22	54.0 (36.0, 72.0)	290 (211, 509)	7.4 (7.2, 7.6)

Table 4. Type of water consumption by geographical divisions: municipalities in Barcelona, provinces in Cyprus, and counties in Ireland.

	Population		Type of water to drink at home			
			Tap	Filtered	Bottled	Other
Barcelona	N	%	%	%	%	%
Barcelona city	526	53	17	26	56	1
L'Hospitalet de Llobregat	79	8	9	14	77	0
Badalona	69	7	39	23	35	3
Santa Coloma de Gramenet	37	4	49	24	24	3
Sant Cugat del Vallès	28	3	21	18	61	0
Cornellà de Llobregat	27	3	22	30	44	4
Sant Boi de Llobregat	26	3	31	12	58	0
Castelldefels	20	2	0	55	45	0
El Prat de Llobregat	19	2	16	21	63	0
Viladecans	19	2	5	47	47	0
Esplugues de Llobregat	17	2	47	12	41	0
Montcada i Reixac	15	1	60	13	27	0
Gavà	13	1	8	15	77	0
Sant Feliu de Llobregat	12	1	8	25	58	8
Cervelló	10	1	10	30	60	0
Molins de Rei	10	1	10	20	60	10
Rest*	73	7	16	22	59	3
All	1000	100	20	24	55	1
Cyprus						
Nicosia	195	47	18	45	33	3
Limassol	96	23	10	39	45	6
Larnaca	67	16	10	37	42	10
Paphos	33	8	5	0	71	24
Famagusta (Ammochostos)	21	5	8	31	37	24
All	412	100	9	33	41	16
Ireland						
Dublin City Council	92	17	28	28	41	2
Fingal County Council	39	7	36	41	21	3
Kildare County Council	33	6	30	18	39	12
Cork City Council	28	5	43	29	29	0
South Dublin County Council	26	5	46	31	19	4
Cork County Council	24	5	25	29	21	25
Limerick City and County Council	22	4	23	23	41	14
Meath County Council	21	4	24	24	43	10
Galway City Council	19	4	21	32	37	10
Unknown	19	4	5	21	63	10
Dun Laoghaire/Rathdown	16	3	56	25	19	0
Wicklow County Council	16	3	31	44	25	0
Donegal County Council	15	3	53	13	27	7
Tipperary County Council	14	3	21	14	50	14
Westmeath County Council	13	2	38	38	15	9
Kerry County Council	12	2	58	0	33	8
Louth County Council	12	2	25	17	58	0
Offaly County Council	12	2	25	0	42	33
Mayo County Council	11	2	27	45	27	0
Kilkenny County Council	10	2	30	10	40	20
Rest*	78	15	23	26	38	13
All	532	100	30	26	35	8

* Includes the municipalities (Barcelona) or counties (Ireland) with 10 or less study participants each.

3.3. Risk perception and attitudes

Different dimensions of tap water quality perception are presented in Table 5. Positive perception of tap water quality was highest in Barcelona (42% of participants), followed by Ireland (36%) and Cyprus (33%). Satisfaction with taste, colour, odour, and trust in the water company was highest in Ireland (62%, 76%, 70%, 57%, respectively), and lowest for most items in Cyprus (38%, 64%, 52%, 42%, respectively). Social acceptance of tap water among family and friends was highest in Ireland (64%) and lowest in Cyprus (39%). Approximately 49% reported to be satisfied with tap water in Barcelona, and 67% in Ireland (Table 6, data not collected in Cyprus). Negative tap water perception because of microbial or chemical risks was highest in Cyprus (59%, 52%, respectively) and lowest in Barcelona (41%, 40%, respectively). Negative comments about tap water from family and friends, believing that tap water caused health problems, and perceiving lead pollution was highest in Ireland (52%, 25%, 18%, respectively) and lowest in Cyprus (39%, 15%, 10%, respectively). Perception of excessive chlorine was similar in Barcelona and Cyprus (36%), and higher compared to Ireland (28%). Perception of excessive lime or hard water was highest in Barcelona (56%) and lowest in Ireland (39%). Convenience and economy (cheapest option) were reported as reasons to prefer tap water in highest percentage among participants in Ireland (60%, 64%, respectively) and lowest in Cyprus (36%, 29%). Willingness to pay more for better tap water quality was highest in Cyprus (62%) and lowest in Ireland (47%). Notably, willingness to change drinking water habits for environmental reasons was similar across the three areas (67% in Barcelona, 68% in Cyprus and in Ireland).

Table 5. Water perception among study participants in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532), 2023-2024

		Barcelona	Cyprus	Ireland
		%	%	%
Tap water is of high quality	Agree	42	33	36
	Indifferent	22	31	14
	Disagree	37	36	50
I am happy with taste	Agree	39	38	62
	Indifferent	18	20	14
	Disagree	43	42	24
I am happy with colour	Agree	60	64	76
	Indifferent	25	24	12
	Disagree	15	12	12
I am happy with odour	Agree	56	52	70
	Indifferent	26	19	14
	Disagree	19	29	16
I trust the company supplying tap water	Agree	51	42	57
	Indifferent	33	39	22
	Disagree	16	19	21
Drinking tap water is socially accepted among family and friends	Agree	48	39	64
	Indifferent	26	22	21
	Disagree	26	40	15
There are microbiological risks	Agree	41	59	45
	Indifferent	26	24	24
	Disagree	34	17	31
There are chemical risks	Agree	40	52	47
	Indifferent	28	29	21
	Disagree	32	19	32
Family/friends told me negative comments concerning tap water	Agree	45	39	52
	Indifferent	25	26	17
	Disagree	30	34	31
I think tap water has caused health problems to me or my family	Agree	20	15	25
	Indifferent	28	32	20
	Disagree	53	54	55
My tap water is polluted with lead	Agree	15	10	18
	Indifferent	51	57	36
	Disagree	34	33	46
My tap water has too much chlorine	Agree	36	36	28
	Indifferent	37	37	26
	Disagree	28	27	46
My tap water is too hard/too much lime	Agree	56	53	39
	Indifferent	26	25	22
	Disagree	18	22	39
I drink tap water because it is the most convenient option	Agree	43	36	60
	Indifferent	19	19	18
	Disagree	38	45	23
I drink tap water because it is the cheapest option	Agree	41	29	64
	Indifferent	22	24	15
	Disagree	37	47	21
I am willing to pay more to receive better tap water quality	Yes	53	62	47
	No	31	18	38
	Don't know	16	19	15
I am willing to change drinking water habits to help our environment	Already did	5	2	3
	Agree	62	66	65
	Indifferent	19	19	18
	Disagree	14	13	14

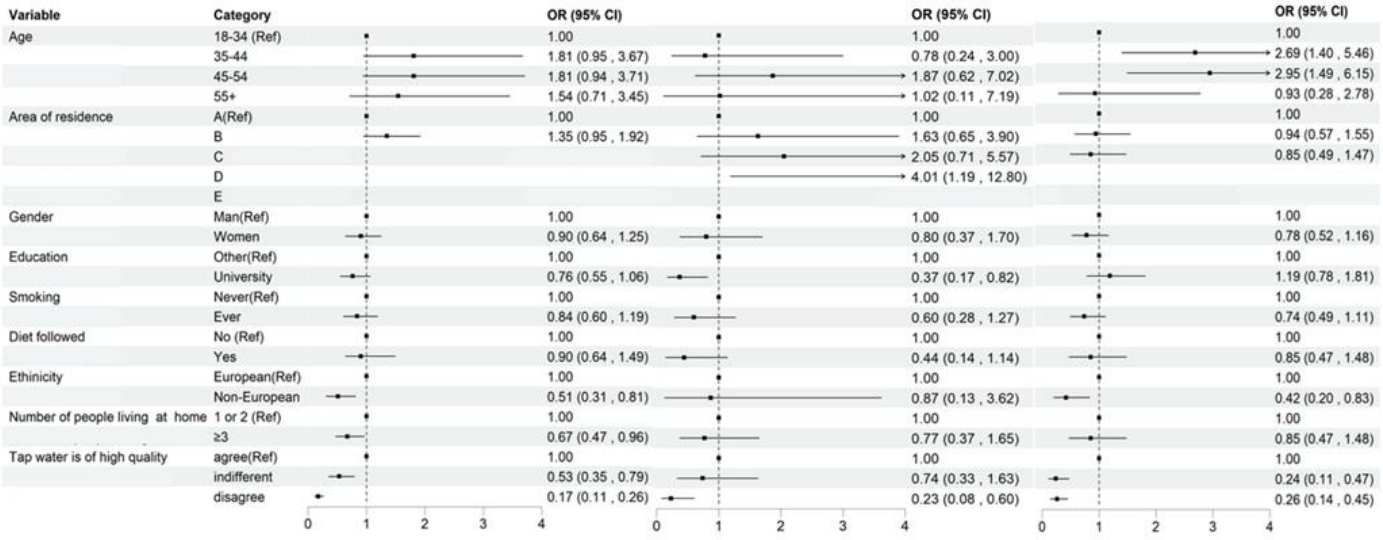
Table 6. Household drinking water choices in relation to tap water satisfaction, housing factors, and water issues: a comparative study in Spain, Cyprus, and Ireland in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412) and Ireland(N=532)[1], 2023-2024.

	Barcelona	Cyprus	Ireland	Type of water consumed at home				pvalue
				Tap (%)	Filtered (%)	Bottled (%)	Other (%)	
Satisfaction with tap water								
Satisfied	48.8%	-	67.3%	36.0	27.6	31.7	4.7	<0.01
Not satisfied	22.5%	-	11.7%	11.9	21.3	63.4	3.4	
Dissatisfied	29.1%	-	21.0%	5.0	22.1	70.7	2.2	
Owner of the household								
Yes	-	58.3%	80.6%	24.1	30.6	35.3	10.0	<0.01
No	-	41.7%	19.4%	14.2	25.8	44.4	15.6	
Type of water pipes								
Plastic	-	45.1%	-	11.3	35.5	40.9	12.3	<0.01
Metal	-	18.2%	-	5.3	33.3	42.7	18.7	
Other	-	2.2%	-	0	66.7	0	33.3	
Don't know	-	34.5%	-	9.9	28.9	43.7	17.5	
Water cut problems								
Yes	-	18.5%	-	5.3	36.8	42.4	15.5	0.83
No	-	76.9%	-	10.7	32.5	40.1	16.7	
Don't know	-	4.6%	-	5.3	36.8	52.6	5.3	
Other water problems								
Yes	-	19.4%	-	8.8	21.5	55.0	14.7	0.23
No	-	72.8%	-	9.3	36.7	38.3	15.7	
Don't know	-	7.8%	-	12.5	34.4	24.4	28.7	
Household construction year								
Median	-	2000	-	2000	2000	2003	1998	0.01
Percentile 25, 75	-	1990, 2010	-	1990, 2010	1990, 2009	1993, 2010	1985, 2009	

The association between tap water consumption at home with socio-demographics, lifestyle, and tap perception variables mutually adjusted is shown in Figure 1. Negative vs. positive tap water quality perception led to lower tap water consumption odds in all study areas (83% lower in Barcelona, 77% in Cyprus, and 74% in Ireland). Non-white/European participants showed lower odds of consuming tap water in Barcelona and Ireland (49%, 58%, respectively). Other variables showed different statistically significant patterns between areas. In Barcelona, living in a household with 3 or more led to lower odds of consuming tap water. In Cyprus, Famagusta compared to Nicosia residents were four times more likely to drink tap water, and having a university degree led to lower odds of tap water consumption. In Ireland, participants aged 35 to 54 years were 2-3 times more likely to consume tap water compared to the younger ones (18-34 years).

3.4. Determinants of water use behaviour

Figure 1. Tap water. Association (odds ratio-OR, 95% confidence interval-CI) between consuming tap water (unfiltered) at home and different personal characteristics in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532)1, 2023, 2024

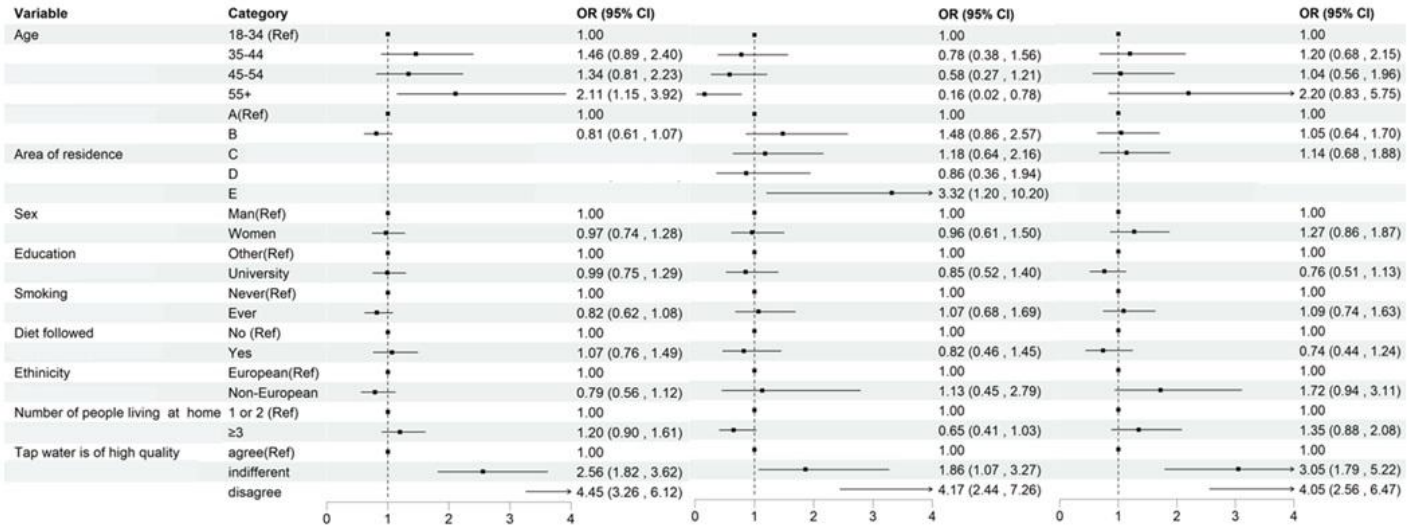


Area of residence codes: Barcelona: A=Barcelona city, B=Metropolitan area, Cyprus: A=Nicosia, B=Limassol, C=Larnaca, C=Paphos, D=Famagusta (Ammochostos)

The association between filtered tap water and personal characteristics mutually adjusted is shown in Figure 2. Negative perception of tap water quality and age was associated with lower filtered water consumption in all areas, although the association was stronger and statistically significant in Barcelona and Cyprus. Age (being ≥35 vs. <35 years) was associated with lower filtered water use in Barcelona and Ireland, and higher filtered water use in Cyprus, where those 55+ years old had almost 5 times more odds of consuming filtered water compared to those <35. Education (having vs. not having a university degree) led to higher odds of filtered water use in Barcelona and more strongly in Cyprus. Smoking was associated with higher probability of consuming filtered tap water in all areas, although it was statistically significant only in Barcelona, OR 1.51 (1.10-2.09). Ethnicity (being non-white/European) led to 2 times more probability of using filtered water in Barcelona. In Famagusta (Cyprus), participants were 86% less likely to consume filtered water compared to the reference group (Nicosia), although only one participant reported consuming filtered tap water.

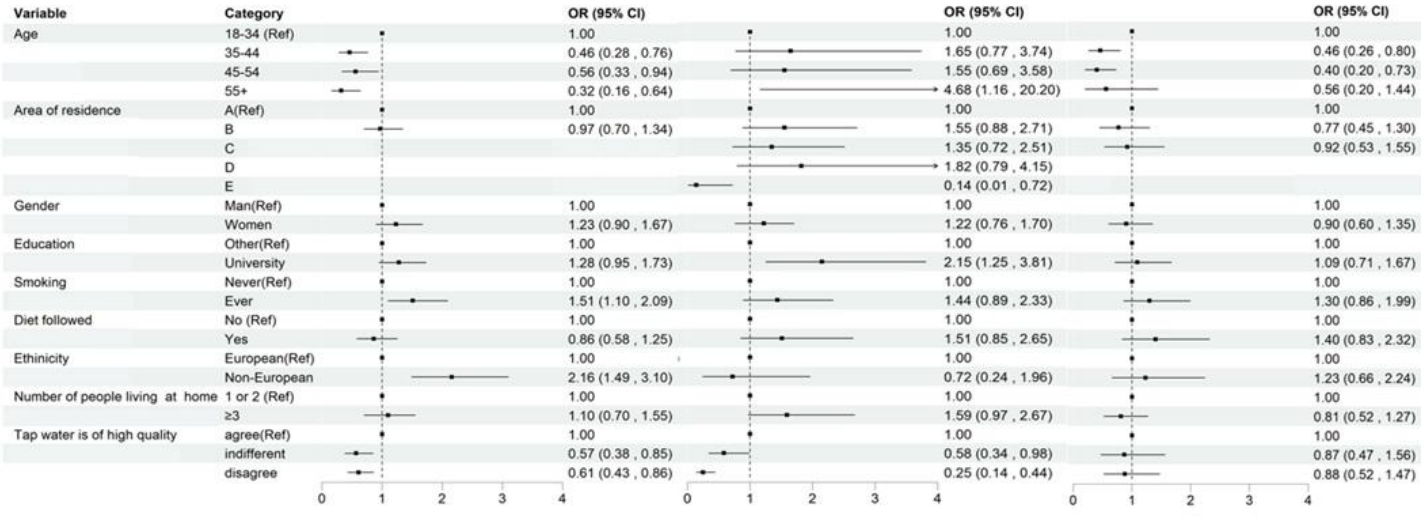
Figure 3 displays the association between bottled water consumption and the evaluated variables. A negative perception of tap water quality led to approximately 4 times higher odds of consuming bottled water in all study areas. Age was related to bottled water use, with a different pattern by area. Age was positively associated with bottled water use specially in Barcelona and the highest age group (≥55 years). However, an inverse pattern was observed in Cyprus, where the oldest (≥55 years) compared to the youngest (<35 years) had approximately 80% less odds of consuming bottled water.

Figure 2. Filtered water. Association odds ratio-OR, 95% confidence interval-CI) of consuming tap water filtered at home by different personal characteristics in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532)1, 2023, 2024.



Area of residence codes: Barcelona: A=Barcelona city, B=Metropolitan area Cyprus: A=Nicosia, B=Limassol, C=Larnaca, C=Paphos, D=Famagusta (Ammochostos) Ireland: A=Leinster, B=Munster, C=Other.

Figure 3. Bottled water. Association odds ratio-OR, 95% confidence interval-CI) of consuming tap water filtered at home by different personal characteristics in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532)1, 2023, 2024.



Area of residence codes: Barcelona: A=Barcelona city, B=Metropolitan area Cyprus: A=Nicosia, B=Limassol, C=Larnaca, C=Paphos, D=Famagusta (Ammochostos) Ireland: A=Leinster, B=Munster, C=Other.

Tables 7-10 show how tap water perception relates to ethnicity (European origin), household size, education, and sex.

Table 7. Tap water perception by European origin. P-value from a chi2-test.

		Barcelona			Cyprus			Ireland		
		European			European			European		
		Yes (N=797) %	No (N=203) %	p-value	Yes (N=388) %	No (N=24) %	p-value	Yes (N=461) %	No (N=71) %	p-value*
Tap water is of high quality	Agree	40	47	<0.01	33	29	0.25	64	66	0.13
	Indifferent	20	28		30	46		13	20	
	Disagree	39	25		37	25		23	14	
I am happy with taste	Agree	38	42	0.17	38	29	0.45	63	51	<0.01
	Indifferent	18	21		19	29		11	30	
	Disagree	44	37		43	42		25	20	
I am happy with colour	Agree	59	63	0.44	65	50	0.03	77	73	0.70
	Indifferent	25	21		23	46		12	15	
	Disagree	15	16		12	4		11	11	
I am happy with odour	Agree	55	59	0.56	53	50	0.73	70	69	0.63
	Indifferent	26	25		19	25		13	17	
	Disagree	19	16		29	25		16	14	
I trust the company supplying tap water	Agree	49	58	0.06	42	33	0.53	57	56	0.31
	Indifferent	34	28		38	50		21	28	
	Disagree	17	14		20	17		21	15	
Drinking tap water is socially accepted among family and friends	Agree	47	50	0.5	39	25	0.13	66	55	0.20
	Indifferent	26	23		21	38		20	28	
	Disagree	26	27		40	38		14	17	
There are microbiological risks	Agree	36	59	<0.01	60	54	0.50	43	62	0.01
	Indifferent	26	24		23	33		25	17	
	Disagree	38	17		17	13		32	21	
There are chemical risks	Agree	35	57	<0.01	52	42	0.17	46	51	0.13
	Indifferent	29	26		28	46		20	27	
	Disagree	36	17		20	13		34	23	
Family/friends told me negative comments concerning tap water	Agree	41	58	<0.01	40	25	0.07	50	61	0.14
	Indifferent	25	23		25	46		17	18	
	Disagree	33	19		35	29		33	21	
I think tap water has caused health problems to me or my family	Agree	15	37	<0.01	14	17	0.24	23	35	0.01
	Indifferent	28	27		31	46		19	25	
	Disagree	57	36		55	38		58	39	
My tap water is polluted with lead	Agree	14	18	0.33	10	25	<0.01	16	34	<0.01
	Indifferent	51	50		58	63		37	30	
	Disagree	35	32		32	13		47	37	
My tap water has too much chlorine	Agree	36	36	0.81	36	21	0.03	28	28	0.87
	Indifferent	36	38		36	63		26	30	
	Disagree	28	26		28	17		47	42	
My tap water is too hard/too much lime	Agree	57	52	0.55	54	25	0.005	39	38	0.66
	Indifferent	26	29		23	54		21	27	
	Disagree	17	19		23	21		40	35	
I drink tap water because it is the most convenient option	Agree	41	51	0.03	36	33	0.74	60	56	0.70
	Indifferent	19	17		19	25		17	21	
	Disagree	40	32		45	42		23	23	
I drink tap water because it is the cheapest option	Agree	39	47	0.07	29	33	0.15	65	55	0.24
	Indifferent	22	22		23	38		15	20	
	Disagree	39	31		48	29		20	25	
I am willing to pay more to receive better tap water quality	Yes	50	62	0.01	62	67	0.40	43	70	<0.01
	No	33	24		19	8		41	23	
	Don't know	17	14		19	25		16	7	
I am willing to change drinking water habits to help our environment	Already did	6	2	<0.01	2	4	0.81	3	1	0.43
	Agree	59	73		66	63		64	73	
	Indifferent	21	12		19	17		18	15	
	Disagree	14	13		13	17		14	10	

Table 8. Tap water perception by household size. P-value from a chi2-test.

		Barcelona			Cyprus			Ireland		
		1 or 2 (N=329)	≥ 3 (N=671)	p-value	1 o r2 (N=147)	≥ 3 (N=265)	p-value	1 or 2 (N=176)	≥ 3 (N=356)	p-value
		%	%		%	%		%	%	
Tap water is of high quality	Agree	34	46		24	37		66	64	
	Indifferent	24	21	0.01	30	32	<0.01	15	13	0.5
	Disagree	42	34		46	31		19	23	
I am happy with taste	Agree	32	43		31	42		64	60	
	Indifferent	18	18	<0.01	20	20	0.07	11	15	0.4
	Disagree	50	39		49	39		24	24	
I am happy with colour	Agree	55	63		61	65		76	76	
	Indifferent	30	22	0.01	24	24	0.5	14	12	0.7
	Disagree	15	15		14	11		10	12	
I am happy with odour	Agree	50	58		46	56		76	76	
	Indifferent	28	25	0.02	22	17	0.1	14	12	0.7
	Disagree	22	17		32	27		10	12	
I trust the company supplying tap water	Agree	43	55		38	43		72	69	
	Indifferent	39	30	<0.01	37	40	0.1	13	14	0.7
	Disagree	18	15		24	17		15	17	
Drinking tap water is socially accepted among family and friends	Agree	44	50		37	40		65	63	
	Indifferent	30	24	0.09	22	22	0.8	20	22	0.9
	Disagree	26	27		41	38		14	15	
There are microbiological risks	Agree	36	43		64	57		44	46	
	Indifferent	27	25	0.09	21	25	0.3	26	23	0.7
	Disagree	37	32		15	18		30	30	
There are chemical risks	Agree	34	42		54	50				
	Indifferent	31	27	0.05	30	29	0.3	43	49	0.3
	Disagree	34	31		16	21		22	20	
Family/friends told me negative comments concerning tap water	Agree	46	44		40	39				
	Indifferent	23	26	0.6	26	26	0.9	47	54	0.2
	Disagree	31	30		34	35		20	16	
I think tap water has caused health problems to me or my family	Agree	13	23		15	14				
	Indifferent	31	27	<0.01	32	32	0.9	22	26	0.5
	Disagree	56	51		53	54		19	21	
My tap water is polluted with lead	Agree	7	18		12	10		17	19	
	Indifferent	57	48	<0.01	63	55	0.2	38	35	0.09
	Disagree	36	34		26	34		45	46	
My tap water has too much chlorine	Agree	33	37		38	34		28	28	
	Indifferent	39	35	0.42	39	37	0.4	24	27	0.3
	Disagree	28	28		22	29		48	46	
My tap water is too hard/too much lime	Agree	59	55		55	51		37	40	
	Indifferent	26	27	0.45	25	25	0.4	24	21	0.7
	Disagree	15	19		20	24		39	39	
I drink tap water because it is the most convenient option	Agree	39	45		33	37		60	60	
	Indifferent	19	18	0.09	14	22	0.02	16	18	0.8
	Disagree	42	36		53	41		23	22	
I drink tap water because it is the cheapest option	Agree	39	42		28	30		64	64	
	Indifferent	21	23	0.35	17	28	0.01	18	14	0.3
	Disagree	40	35		55	42		18	22	
I am willing to pay more to receive better tap water quality	Yes	44	57		67	60		44	48	
	No	36	28	<0.01	16	19	0.2	41	37	0.5
	Don't Know	19	15		16	21		15	15	
I am willing to change drinking water habits to help our environment	Already did	9	3		1	2		4	3	
	agree	57	64	<0.01	69	64	0.7	67	64	0.4
	indifferent	18	19		17	20		14	20	
	disagree	16	13		12	14		15	13	

Table 9. Tap water perception by education. P-value from a chi2-test.

		Barcelona			Cyprus			Ireland		
		University			University			University		
		Yes (N=492) %	No (N=508) %	p-value	Yes (N=291) %	No (N=121) %	p-value	Yes (N=279) %	No (N=253) %	p-value
Tap water is of high quality	Agree	42	41	0.9	33	31	0.7	70	59	0.02
	Indifferent	21	22		31	31		13	15	
	Disagree	36	37		35	39		18	26	
I am happy with taste	Agree	41	38	0.6	38	36	0.5	65	58	0.02
	Indifferent	17	19		19	23		15	12	
	Disagree	42	44		43	40		20	30	
I am happy with colour	Agree	63	57	0.2	65	62	0.6	76	76	0.01
	Indifferent	23	26		24	24		11	14	
	Disagree	14	17		11	14		13	10	
I am happy with odour	Agree	58	54	0.4	52	53	0.5	75	66	0.05
	Indifferent	25	27		18	21		13	15	
	Disagree	18	19		30	26		13	20	
I trust the company supplying tap water	Agree	32	34	0.8	38	40	0.3	59	56	0.01
	Indifferent	16	16		21	25		25	19	
	Disagree	51	50		42	35		16	25	
Drinking tap water is socially accepted among family and friends	Agree	50	46	0.01	35	42	0.2	70	58	0.01
	Indifferent	22	29		22	22		18	25	
	Disagree	29	24		43	36		12	17	
There are microbiological risks	Agree	43	39	0.2	59	60	0.9	41	51	<0.01
	Indifferent	23	28		24	23		23	26	
	Disagree	34	33		17	17		36	24	
There are chemical risks	Agree	41	38	0.01	38	36	0.5	44	49	0.5
	Indifferent	17	19		19	23		22	20	
	Disagree	42	44		43	40		34	30	
Family/friends told me negative comments concerning tap water	Agree	48	41	0.04	13	17	0.4	52	51	0.9
	Indifferent	22	28		35	25		17	18	
	Disagree	30	31		52	58		31	31	
I think tap water has caused health problems to me or my family	Agree	22	17	0.1	13	17	0.1	25	25	0.2
	Indifferent	26	30		35	25		17	23	
	Disagree	52	53		52	58		58	52	
My tap water is polluted with lead	Agree	19	11	<0.01	10	12	0.5	15	21	0.01
	Indifferent	47	55		60	54		33	40	
	Disagree	34	34		30	35		52	39	
My tap water has too much chlorine	Agree	41	30	<0.01	33	40	0.2	24	32	0.2
	Indifferent	33	40		41	31		26	26	
	Disagree	26	30		26	28		50	42	
My tap water is too hard/too much lime	Agree	59	53	<0.01	52	53	0.08	32	46	0.7
	Indifferent	26	27		28	18		24	20	
	Disagree	16	19		20	29		44	34	
I drink tap water because it is the most convenient option	Agree	42	45	<0.01	34	40	0.5	-	-	<0.01
	Indifferent	16	22		20	17		66	53	
	Disagree	42	33		46	43		16	20	
I drink tap water because it is the cheapest option	Agree	42	40	0.36	27	34	0.4	68	59	0.04
	Indifferent	20	24		24	22		15	16	
	Disagree	38	36		48	44		17	25	
I am willing to pay more to receive better tap water quality	Yes	59	53	0.1	65	55	0.1	47	47	0.8
	No	26	27		17	21		39	37	
	Don't know	16	19		18	24		14	16	
I am willing to change drinking water habits to help our environment	Already did	6	4	0.1	2	2	0.6	4	3	0.4
	Agree	62	62		67	63		67	63	
	Indifferent	17	20		17	22		15	21	
	Disagree	15	13		13	13		14	13	

Table 10. Tap water perception by sex. P-value from a chi2-test

		Barcelona			Cyprus			Ireland		
		Man (N=470)	Woman (N=525)	p-value	Man (N=203)	Woman (N=207)	p-value	Man (N=263)	Woman (N=268)	p-value
		%	%		%	%		%	%	
Tap water is of high quality	Agree	47	38	<0,01	34	31	0,5	68	62	0,1
	Indifferent	24	20		32	30		14	13	
	Disagree	30	42		33	39		18	25	
I am happy with taste	Agree	45	34	<0,01	40	36	0,6	63	60	0,03
	Indifferent	20	16		19	21		16	11	
	Disagree	34	50		41	43		20	29	
I am happy with colour	Agree	61	59	<0,01	69	59	0,09	76	76	0,5
	Indifferent	27	22		22	27		14	11	
	Disagree	11	19		9	14		10	13	
I am happy with odour	Agree	59	53	0,02	54	51	0,8	71	70	0,3
	Indifferent	27	25		18	20		15	12	
	Disagree	15	22		28	29		14	18	
I trust the company supplying tap water	Agree	52	49	0,2	52	32	<0,01	62	53	0,6
	Indifferent	33	33		31	47		21	24	
	Disagree	14	18		18	21		18	23	
Drinking tap water is socially accepted among family and friends	Agree	51	45	<0,01	42	35	0,2	67	62	0,1
	Indifferent	28	23		22	22		22	20	
	Disagree	21	31		36	43		11	18	
There are microbiological risks	Agree	41	40	0,89	61	58	0,01	47	44	0,4
	Indifferent	25	26		19	29		22	26	
	Disagree	34	34		21	13		31	29	
There are chemical risks	Agree	45	34	0,6	53	50	<0,01	46	48	0,8
	Indifferent	20	16		22	36		21	21	
	Disagree	34	50		25	14		33	31	
Family/friends told me negative comments concerning tap water	Agree	44	45	0,9	44	34	<0,01	51	52	0,7
	Indifferent	25	25		30	23		19	16	
	Disagree	30	30		26	43		31	31	
I think tap water has caused health problems to me or my family	Agree	22	18	0,2	15	14	0,6	26	23	0,2
	Indifferent	27	29		33	30		22	18	
	Disagree	51	54		52	56		52	59	
My tap water is polluted with lead	Agree	17	13	<0,01	12	10	0,07	22	13	0,01
	Indifferent	45	56		54	62		32	41	
	Disagree	38	31		34	29		46	46	
My tap water has too much chlorine	Agree	39	33	0,003	36	35	0,1	30	25	0,2
	Indifferent	31	41		36	39		22	30	
	Disagree	30	26		28	26		48	45	
My tap water is too hard/too much lime	Agree	53	58	<0,01	54	51	0,1	38	40	0,7
	Indifferent	28	25		24	27		21	24	
	Disagree	19	17		23	23		41	37	
I drink tap water because it is the most convenient option	Agree	45	42	<0,01	39	33	0,1	56	63	0,1
	Indifferent	22	16		21	17				
	Disagree	33	42		40	50		18	18	
I drink tap water because it is the cheapest option	Agree	41	41	0,06	35	24	0,03	62	62	0,1
	Indifferent	25	19		21	26		14	14	
	Disagree	34	40		44	50		24	24	
I am willing to pay more to receive better tap water quality	Yes	50	56	0,03	62	63	0,2	49	44	0,2
	No	31	30		21	15		38	38	
	Don't know	19	13		17	22		13	18	
I am willing to change drinking water habits to help our environment	Already did	4	6	0,3	2	2	0,9	3	4	0,4
	Agree	62	62		67	66		63	67	
	Indifferent	20	17		17	19		21	15	
	Disagree	13	15		14	13		13	14	

The type of water consumed at home by perception of tap water quality is described in Figure 4. Percentage of participants drinking tap water was higher among those in agreement with positive statements concerning tap water (e.g., “my tap water is of high quality”, “I am happy with taste”, “I trust the water

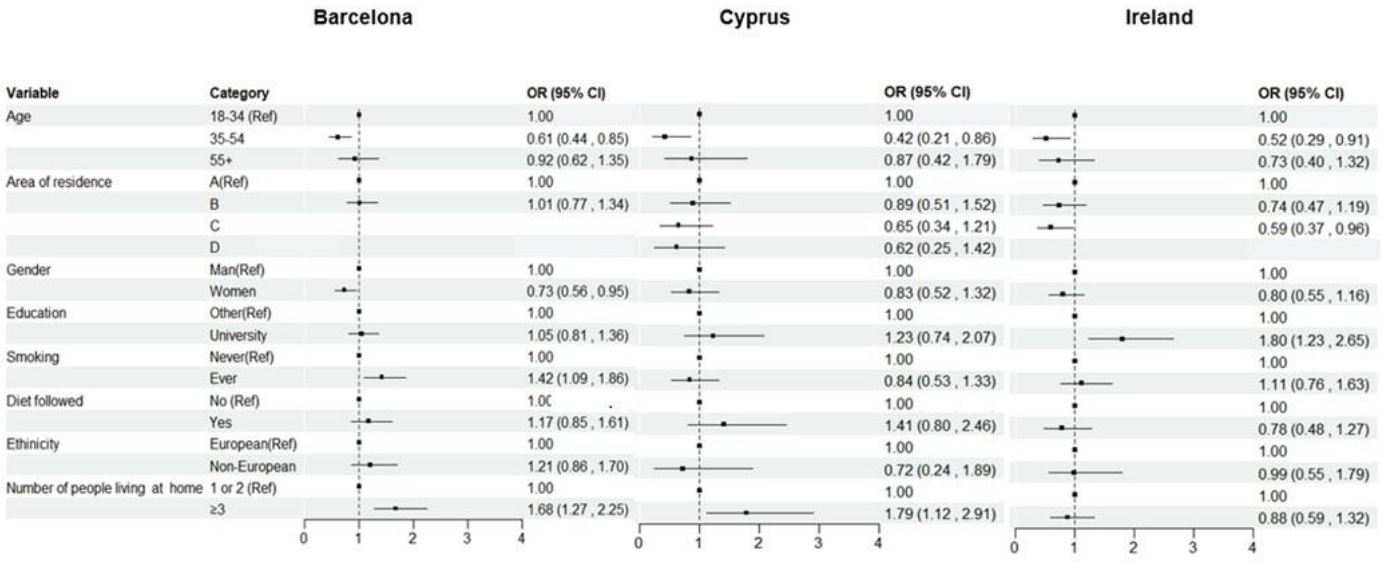
company", etc.) and in disagreement with negative tap water statements (e.g., "There are chemical risks", "Family/friends told me negative comments concerning tap water", etc.). Participants with negative tap water perceptions of reported lower tap water consumption and higher bottled water consumption at home compared to those without such negative perceptions.

Figure 4. Tap water perception by type of water consumed at home in Barcelona, Spain (N=1000), Cyprus (N=412), and Ireland (N=532). P-value calculated by Chi-Square test. *p value≤0.05



The association between positive tap water quality perception with socio-demographic, lifestyle, and number of people living at home mutually adjusted is shown in Figure 5. Participants in an intermediate age (35-54 years) were less likely to have a positive tap water quality perception compared to the younger (18-34 years) in all areas, although it was statistically significant only in Cyprus and Ireland (58%, 48%, respectively). Women were 17% less likely to have a positive perception compared to men in Barcelona, while in Cyprus and Ireland gender led to non-significant association. Education was statistically significant only for Ireland, where participants with university were 80 % more likely to have a positive tap quality perception. Smoking was only significantly associated in Barcelona, while diet was not associated with the tap water quality. For ethnicity the point estimates vary and did not show statistical significance in any of the study areas. Households with 3 or more people living at home were more likely to have a positive perception in Barcelona and Cyprus.

Figure 5. Association (odds ratio-OR, 95 confidence interval-CI) between positive tap water quality perception and socio-demographic and lifestyle variables in Barcelona Metropolitan Area, Spain (N=1000), Cyprus (N=412), and Ireland (N=532), 2023, 2024.



Area of residence codes: Barcelona: A=Barcelona city, B=Metropolitan area; Cyprus: A=Nicosia, B=Limassol, C=Larnaca, C=Paphos, D=Famagusta (Ammochostos). Ireland: A=Leinster, B=Munster

3.5. Hygiene behaviours

Table 11 presents data on showering, bathing, and swimming in pools across the three study sites. Swimming pool attendance varied between regions. In Barcelona 14% of the respondents reported attending swimming pools more than 10 times annually, with an additional 32% attending primarily during

the summer months. In contrast, Cyprus and Ireland had lower reported frequencies of pool attendance, with only, 4% and 11% year-round respectively, and 19% (Cyprus) and 12% (Ireland) attendance only during the summer. These differences may reflect variations of cultural or climatic factors, access to facilities or recreational habits.

Showering was more frequent than bathing in all study sites. This suggests an overall shorter water contact times, and potentially leading to reduced dermal exposure. Notably, respondents in Barcelona and Cyprus reported higher frequencies of daily showering, which could be influenced by warmer climates and seasonal heat in these regions. This behaviour could lead to increased exposure to volatile THMs, particularly via inhalation and dermal absorption, as hot water and enclosed bathroom environments may promote THM volatilization. Regarding shower duration, the median times reported in Ireland and Barcelona were similar in both winter and summer. However, among respondents who reported bathing, seasonal differences were observed, in Barcelona bath duration was longer during winter compared to summer while no such seasonal difference was reported in Ireland.

Table 11. Showering, bathing and swimming pool attendance frequency.

	Barcelona		Cyprus		Ireland	
	N	%	N	%	N	%
Swimming pool attendance						
Never	165	17%	90	22%	144	27%
<10 times/year	384	38%	227	55%	263	49%
≥10 times/year (only in summertime)	315	32%	79	19%	64	12%
≥10 times/year (all year round)	136	14%	16	4%	61	11%
Showering, summer						
≥5 times/week	678	68%	330	80%	294	55%
1-4 times/week	291	22%	67	16%	207	39%
1-3 times/month	22	1.8%	5	1%	29	5%
Never/almost never	9	0.9%	10	2%	2	1%
minutes, median (P25, P75)	10 (5, 15)		NA		10 (5, 15)	
NA	9		412		0	
Showering, winter						
≥5 times/week	504	50%	281	68%	266	50%
1-4 times/week	452	32%	114	28%	224	42%
1-3 times/month	30	2.6%	3	1%	39	7%
Never/almost never	14	1.4%	10	2%	3	1%
minutes, median (P25, P75)	10 (5, 15)		NA		10 (5, 15)	
NA	14		412		0	
Bathing, summer						
≥5 times/week	89	8.9%	152	37%	49	9%
1-4 times/week	130	5.8%	98	24%	59	11%
1-3 times/month	83	4.4%	34	8%	118	22%
Never/almost never	698	70%	128	31%	306	58%
minutes, median (P25, P75)	15 (10, 30)		NA		5 (0, 20)	

NA	701		412		0	
Bathing, winter						
≥5 times/week	73	7.3%	139	34%	46	9%
1-4 times/week	138	5.8%	115	28%	74	14%
1-3 times/month	104	5.1%	33	8%	117	22%
Never/almost never	685	69%	134	33%	295	55%
minutes, median (P25, P75)	20 (10, 30)		NA		10 (0, 20)	
NA	685		412		0	

4. Discussion

Findings show that bottled water is the primary type of drinking water consumed in Barcelona, Cyprus, and Ireland, with key motivations linked to subjective factors related to tap water quality perception. The use of domestic filters was widespread in all the areas, emerging as a growing option.

Bottled water was the predominant choice across all study areas, with notably high consumption rate at home (56% in Barcelona, 41% in Cyprus and 35% in Ireland), and even more frequently outside the home environment (80% in Barcelona, 85% in Cyprus, 66% in Ireland). These consumption patterns reveal substantially higher bottled water usage compared to a previous study in Québec (Canada), where only 15% of participants reported bottled water consumption (25). In contrast, tap water was the primary choice for cooking and for the preparation of beverages such as coffee or tea in Barcelona and Ireland, while filtered tap water was preferred in Cyprus. This result is consistent with previous findings of a study conducted in Catalonia, where only 11.53% of participants reported using bottled water for cooking (9). This observed pattern might suggest that concerns about tap water quality primarily influence drinking rather than cooking water choices. However, there are limited previous studies reporting drinking water habits in the general population, and most studies focus on specific populations such as children (26) or pregnant women (27). Ongoing work analysing drinking water habits during pregnancy using databases from mother-child cohorts in ISGlobal will expand knowledge to other age groups.

Our initial bivariate analysis found associations between certain socio-demographic and lifestyle variables and home drinking choices. However, the multivariate logistic regression model showed that personal factors varied in importance across the different study areas. In contrast, perception that tap water is of high quality was consistently associated with water consumption choices in all study areas. This finding highlights that subjective factor rather than objective characteristics play a central role in drinking water decisions. Consequently, policies aimed at changing drinking water behaviour, such as reducing bottled water consumption, should address cultural beliefs and improve organoleptic characteristics. This is consistent with previous studies that report how risk perception modulates drinking water choice in different settings such as Quebec, Canada (25), Catalonia, Spain (18), Iran (28), Mexico (29), UK and Portugal (30), or Belgium (31).

Tap water perception and social acceptance were generally more negative among participants in Cyprus compared to other study areas. Only 42% of participants in Cyprus trust their tap water supplier, aligning with concerns about chemical and microbiological risks associated with tap water, which may contribute

to lower tap water consumption. As a comparison, according to previous studies in Germany (32–34) the consumption of tap water is very low despite the high levels of trust in tap water quality among participants. In Italy, dissatisfaction with tap water quality is an underlying driver for the high consumption of bottled water as shown in a survey carried out by the European Federation of Bottled Waters in 2017, where participants reported the highest consumption of bottled water among 25 European countries (35). Essentially, consumer's trust in tap water varies among different countries in Europe, where the highest intake of tap water has been reported in Nordic countries, while the lowest consumption has been reported in Malta, Ireland and Cyprus(34), supporting our findings.

Socio-demographic factors are identified as significant determinants of water consumption behaviours include age, ethnicity, and education. In Barcelona, participants aged 55+ years old were more likely to consume bottled water than younger adults (18-34 years old). Similar findings were observed in a study conducted in Belgium (N=2309) where the consumption of bottled water was more common among older people(31). The reasons behind water consumption choices are potentially influenced by generational differences in risk perception and environmental sensitivities. It is plausible that the older population may have higher purchasing power that partly explains this. In addition, drinking water treatments have improved over the years through technical advances and more stringent regulations, and its plausible that older people may retain in past beliefs of negative tap water quality and lower trust in public drinking supply.

Education was found to be a significant determinant of drinking water choice only in Cyprus, where higher education was associated with a higher probability of consuming filtered water and lower tap water consumption. A similar pattern was observed in Barcelona, although the magnitude of association was lower and not statistically significant. Previous studies suggest that participants with higher education tend to drink more tap water due to better perception of scientific studies which generally support tap water quality (36). However, this observation does not fully align with our findings in Cyprus, where results might suggest greater scepticism about tap water among more educated individuals. In fact, the use of filtered water among the most highly educated participants can foster the idea of integrating the best of both approaches, by improving organoleptic properties while reducing bottled water consumption (37,38).

Non-white/European ethnicity was associated with lower tap water consumption in Barcelona and Ireland, and with higher consumption of filtered water in Cyprus. Similar trends were found in other studies where ethnicity showed to influence perception of drinking water among non-white ethnicity groups who preferred other water choices over tap water (39), compared to white ethnicity groups (40). The lower

consumption of tap water among non-European participants in Ireland and Barcelona might be related to socio-cultural beliefs or some potential negative experiences related to the quality of tap water (13). We found that tap water perception was associated with ethnicity in specific dimensions of risk perception, suggesting that this may be an underlying reason behind drinking water choice among non-European participants.

Household size (i.e., number of people living at home) showed complex links with tap water perception and drinking water choice. The comparison of water perception by household size showed that participants living in larger households reported higher percentage of agreement with positive tap water perception statements (e.g., tap water to be of high quality), compared smaller households. This was contradictory with a higher percentage of agreement with negative tap water perception statements, which may explain lower OR of tap water consumption in larger households in the multivariate models, particularly in Barcelona and Cyprus. While previous evidence showed that water preferences are influenced by the age of children in the household (25), our dataset lacks the specific demographic information needed to confirm this hypothesis.

Sex was not shown to be significant in the regression model for any of the study areas. According to our results, both men and women's main water consumption at home choice is bottled water in all three study areas (approx. 54%) with women having a slightly higher percentage (56%) compared to men (53%) in Barcelona, in contrast to tap water usage that has an average of 20% in both sexes. The lowest consumption of tap water was reported in Cyprus, similarly among men and women (9%). These are opposite results to a study performed in Canada (N=1014) where women had a higher percentage of tap water use compared to men (25). Smoking and diet, included as general markers of lifestyle, were barely associated with drinking water choice at home with one exception. Smokers showed a significantly higher probability of consuming filtered tap water at home in Barcelona. This was unexpected and difficult to explain, as non-smoking and water filtering could a priori be linked to health-conscious behaviours.

Consumption of filtered water at home was 24% in Barcelona, 24% in Cyprus, and 26% in Ireland, representing the second most frequent water choice in Barcelona and Cyprus (34%), and the third more frequent in Ireland. Filtering jars with activated carbon was the most commonly utilized filtration method in Barcelona and Ireland. In a previous study conducted in Catalonia, softener was the most commonly used filtering system (9) due to the perception of having a high level of lime in the water system. However, this was centralized in the main water pipe, and not exclusively related to drinking water consumption. Knowledge about specific filters used in Europe is very limited, and we provide novel evidence on the

frequency of filter use and type of filter used. Although some domestic filters (e.g., reverse osmosis and active carbon) are effective in removing some of the most common chemicals (41) found in tap water, it still requires sustained effort such as maintenance, filter replacing, etc. (42).

In terms of non-ingestion exposure to THMs, we provided a descriptive overview of some non-ingestion water exposure including showering, bathing and swimming. Warmer climates and greater swimming pool attendance in Spain (43,44), emphasize the role of climate, culture and infrastructure in shaping water-contact behaviours. These are relevant as THMs are volatile compounds that can be absorbed dermally or inhaled, particularly during hot showers or indoor swimming activities. What is more, it is also reported in literature that ingestion concentration in body return faster to basal as opposed to dermal exposure with some types of THMs such as bromodichloromethanes (4 versus 24 hours) (45). Our resutls contribute to a broader understanding of behavioural factors that could be accounted for in future exposure assessments. Some key limitations in current data are the incomplete of information on showering and bathing duration, the absence of information about the water temperature, ventilation and type of pool (chlorinated versus saltwater) which limits our ability to estimate cumulative exposure or compare risk between subgroups. Nonetheless, by identifying patterns of water use behaviours serves as a first step towards exposure assessment models, as well as it expands the focus of environmental health research beyond ingestion-based paradigms towards a more holistic view of water exposure that reflects real habits.

To the authors' knowledge, this is the largest European systematic study comprehensively covering various water uses at home (drinking, cooking, preparing coffee or tea), drinking water consumption outside home, and a wide range of socio-demographic factors and tap water perception variables. The study offers a nuanced perspective on water consumption patterns and how different social groups perceive drinking water habits. However, this study also has certain limitations. Although our study population was representative in age, gender and geographic distribution, the proportion of participants with higher education or university degree results in a sample not representative of the general population in terms of educational level. Since income level was not included in the survey, this may limit our ability to understand whether preferences for bottled or filtered water reflect affordability concerns. In certain categories in socio-demographic characteristics, statistical power was limited due to a small sample size and lack of variability (e.g., Famagusta in Cyprus). Data on the type of filter used in Cyprus were not available, limiting a complete comparison across the three study areas. Also, the approach to "trust" in terms of risk perception used in this study may have been limited to reflect underlying factors such as institutional behaviour, infrastructural underinvestment or even water insecurity that was not essentially a part of this study(46). The concept of trustworthiness, which focuses on the reliability and transparency of

institutions, provides a broader understanding of how trust in water systems is formed. Following that, studies in the United States emphasize how empirical examples on structural drivers(47), such as race/ethnicity, housing age can potentially predict bottled water dependency.

We contribute relevant evidence to support the Drinking Water Directive (EC 2020) to design actions addressed to minimize single-use drinking water plastic bottles. By integrating multiple datasets across diverse socio-economic and geographical contexts, the study provides novel insights into how risk perception and trust in water sources influence consumption behaviour. Furthermore, the findings have broad global implications, offering a reproducible model that can be applied in other regions facing drinking water quality challenges. Understanding the drivers of drinking water choices provides a foundation for public health interventions, risk communication strategies, and policy development that can be adapted to different cultural and regulatory settings globally. By way of highlighting the interplay between water quality concerns and human behaviour, this research contributes to a more comprehensive understanding of water safety and sustainability on an international scale.

5. Conclusion and recommendations

5.1. Conclusion

Subjective factors linked to tap water quality perception constitute the main drivers of drinking water choice. Socio-demographic characteristics such as age, education, ethnicity, and household size appeared to be associated with drinking water choices in some instances, but no systematic consistent pattern emerged across the evaluated countries. This suggests that water consumption habits are not solely dictated by demographic attributes but are instead influenced by a dynamic interplay of personal beliefs, cultural norms, historical experiences with water quality, and local environmental conditions. For example, in regions where past water contamination incidents have occurred, distrust in public water supplies may persist across generations, reinforcing bottled water preference despite regulatory improvements.

Perception of tap water quality have a strong influence on drinking behaviours, with individuals who choose non-tap water often feeling comfortable cooking with tap water. Our findings suggest that sensory experiences, trust in public water systems, and risk perception, whether scientifically justified or not, plays a significantly role in shaping drinking water choices. These results highlight the need for context-specific policies that address not only cultural beliefs and organoleptic concerns but also psychological and social dimensions of water trust.

Given the environmental and economic costs associated with bottled water consumption, future interventions should incorporate education on the sustainability implications of drinking water choices. This could involve comparative life cycle assessments of bottled versus tap water, highlighting carbon footprints, plastic waste, and resource depletion.

5.2. Recommendations

- Building trust and transparency in water systems

A core focus in water policies should be building trust towards public water systems. Firstly, through more **transparen**t communication and **accessible data** as well as in communication regarding water quality, including THM levels, free chlorine, among other parameters, the improvements and providing consistent updates. Offering clear, accessible explanations of health risk and regulatory safeguards. Engaging communities in decision-making processes, can enhance public confidence and promote more informed water use choices, including those that mitigate high-risk exposure behaviours, such as unnecessary avoidance of tap water.

- Addressing cultural beliefs and organoleptic concerns

Cultural beliefs, taste, smell and other organoleptic characteristics such as appearance of tap water strongly influence drinking behaviours. Policies aimed at reducing bottled water consumption and home filtration device use should focus on improving this sensory aspect of tap water, as well as to address psychological and social dimensions of water trust, aligning perceptions with actual risk, to shift consumer perceptions and build confidence in drinking from the tap.

- Incorporating educational campaigns on sustainability implications of water choices

Given the environmental, economic cost and health issues associated with bottled water consumption, future interventions must incorporate education on sustainability such as campaigns addressing carbon footprint, plastic waste and resource depletion associated with bottled water comparing benefits of tap water consumption and health effects. Comparative life cycle assessment of bottled versus tap water can illustrate the substantial environmental impact of bottled water.

- Public Health campaigns tailored to sociodemographic contexts

Public health campaigns around water use and DBP exposure should be tailored to sociodemographic profiles of the population. It should take into consideration factors such as age, education, ethnicity, household size as well as purchase power, which influences both perception of tap water and behavioural exposure patterns, to ensure the message reaches all citizens. Risk communications strategies should be context-specific and culturally sensitive to effectively promote safe water practices and reduce reliance on bottle water

- Expanding broader behavioural factors into water quality

Policies and scientific studies should also consider the broader water use activities bathing, showering and swimming as non-ingestion exposure routes, which contribute to total internal dose, particularly in warm environments. Therefore, future water studies and exposure risk assessments such as in THM evaluations, should include these additional exposure pathways to provide more comprehensive understanding of risk. More research to clarify the role of non-ingestion DBP exposure routes, that can contribute to the total internal dose.

REFERENCES

1. DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2020 on the quality of water intended for human consumption (recast). 2020/2184 Dec 23, 2020.
2. Helte E, Söderlund F, Säve-Söderbergh M, Larsson SC, Åkesson A. Exposure to Drinking Water Trihalomethanes and Risk of Cancer: A Systematic Review of the Epidemiologic Evidence and Dose–Response Meta-Analysis. Environmental Health Perspectives. 2025 Jan;133(1):016001.
3. New disinfection by-product issues: emerging DBPs and alternative routes of exposure. Global NEST Journal. 2013 Apr 29;7(1):43–60.
4. Font-Ribera L, Kogevinas M, Nieuwenhuijsen MJ, Grimalt JO, Villanueva CM. Patterns of water use and exposure to trihalomethanes among children in Spain. Environmental Research. 2010 Aug;110(6):571–9.
5. Rodwan JG. Bottled water: 2017 staying strong. In US and International Developments and Statistics; 2018.
6. Cohen A, Ray I. The global risks of increasing reliance on bottled water. Nat Sustain. 2018 July 16;1(7):327–9.
7. Villanueva CM, Garfí M, Milà C, Olmos S, Ferrer I, Tonne C. Health and environmental impacts of drinking water choices in Barcelona, Spain: A modelling study. Science of The Total Environment. 2021 Nov;795:148884.
8. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A European Strategy for Plastics in a Circular Economy [Internet]. 2018. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52018DC0028
9. March H, Garcia X, Domene E, Sauri D. Tap Water, Bottled Water or In-Home Water Treatment Systems: Insights on Household Perceptions and Choices. Water. 2020 May 6;12(5):1310.
10. Redondo-Hasselerharm PE, Cserbik D, Flores C, Farré MJ, Sanchís J, Alcolea JA, et al. Insights to estimate exposure to regulated and non-regulated disinfection by-products in drinking water. J Expo Sci Environ Epidemiol. 2024 Jan;34(1):23–33.
11. Carrasco-Turigas G, Villanueva CM, Goñi F, Rantakokko P, Nieuwenhuijsen MJ. The Effect of Different Boiling and Filtering Devices on the Concentration of Disinfection By-Products in Tap Water. Journal of Environmental and Public Health. 2013;2013:1–8.
12. Smith RB, Toledano MB, Wright J, Raynor P, Nieuwenhuijsen MJ. Tap water use amongst pregnant women in a multi-ethnic cohort. Environ Health. 2009;8(Suppl 1):S7.
13. Doria MF. Bottled water versus tap water: understanding consumers' preferences. Journal of Water and Health. 2006 June 1;4(2):271–6.
14. Grupper MA, Schreiber ME, Sorice MG. How Perceptions of Trust, Risk, Tap Water Quality, and Salience Characterize Drinking Water Choices. Hydrology. 2021 Mar 18;8(1):49.
15. Fletcher S, Evans T. Optimism for a global plastics treaty. Science. 2025 Jan 10;387(6730):119–119.
16. Evlampidou I, Font-Ribera L, Rojas-Rueda D, Gracia-Lavedan E, Costet N, Pearce N, et al. Trihalomethanes in Drinking Water and Bladder Cancer Burden in the European Union. Environ Health Perspect. 2020 Jan;128(1):017001.

17. European Environment Agency, editor. European environment outlook. Luxembourg: Office for Official Publications of the European Communities; 2005. 87 p. (EEA report).

18. Font-Ribera L, Cotta JC, Gómez-Gutiérrez A, Villanueva CM. Trihalomethane concentrations in tap water as determinant of bottled water use in the city of Barcelona. Journal of Environmental Sciences. 2017 Aug;58:77–82.

19. Valero F, Barceló A, Medina ME, Arbós R. Barcelona, three years of experience in brackish water desalination using EDR to improve quality. New O&M procedures to reduce low-value work and increase productivity. Desalination and Water Treatment. 2013 Jan;51(4–6):1137–42.

20. Valdivia-Garcia M, Weir P, Frogbrook Z, Graham DW, Werner D. Climatic, Geographic and Operational Determinants of Trihalomethanes (THMs) in Drinking Water Systems. Sci Rep. 2016 Oct 20;6(1):35027.

21. Leakage reduction programme | Projects | Uisce Éireann (formerly Irish Water) [Internet]. [cited 2025 Apr 23]. Available from: https://www.water.ie/projects/local-projects/leakage-reduction-programme

22. EPA. Drinking Water Quality in Public Supplies 2023. 2024 July; Available from: https://www.epa.ie/publications/compliance--enforcement/drinking-water/annual-drinking-water-reports/drinking-water-quality-in-public-supplies-2023.php

23. Park EJ. Strategy of Water Distribution for Sustainable Community: Who Owns Water in Divided Cyprus? Sustainability. 2020 Oct 29;12(21):8978.

24. Taherdoost H. Validity and Reliability of the Research Instrument; How to Test the Validation of a Questionnaire/Survey in a Research. SSRN Journal [Internet]. 2016 [cited 2025 Aug 2]; Available from: https://www.ssrn.com/abstract=3205040

25. Delpla I, Legay C, Proulx F, Rodriguez MJ. Perception of tap water quality: Assessment of the factors modifying the links between satisfaction and water consumption behavior. Science of The Total Environment. 2020 June;722:137786.

26. Levallois P, Gingras S, Marcoux S, Legay C, Catto C, Rodriguez M, et al. Maternal Exposure to Drinking-water Chlorination By-products and Small-for-gestational-age Neonates. Epidemiology. 2012 Mar;23(2):267–76.

27. Barbone F, Valent F, Brussi V, Tomasella L, Triassi M, Di Lieto A, et al. Assessing the Exposure of Pregnant Women to Drinking Water Disinfection Byproducts: Epidemiology. 2002 Sept;13(5):540–4.

28. Sajjadi SA, Alipour V, Matlabi M, Biglari H. Consumer Perception and Preference of Drinking Water Sources. Electron physician. 2016 Nov 25;8(11):3228–33.

29. Espinosa-García AC, Díaz-Ávalos C, González-Villarreal FJ, Val-Segura R, Malvaez-Orozco V, Mazari-Hiriart M. Drinking Water Quality in a Mexico City University Community: Perception and Preferences. EcoHealth. 2015 Mar;12(1):88–97.

30. Doria MDF, Pidgeon N, Hunter PR. Perceptions of drinking water quality and risk and its effect on behaviour: A cross-national study. Science of The Total Environment. 2009 Oct;407(21):5455–64.

31. Geerts R, Vandermoere F, Van Winckel T, Halet D, Joos P, Van Den Steen K, et al. Bottle or tap? Toward an integrated approach to water type consumption. Water Research. 2020 Apr;173:115578.

32. Elmadfa I, Meyer AL. Patterns of drinking and eating across the European Union: implications for hydration status. Nutr Rev. 2015 Sept;73(suppl 2):141–7.

33. Etale A, Jobin M, Siegrist M. Tap versus bottled water consumption: The influence of social norms, affect and image on consumer choice. Appetite. 2018 Feb;121:138–46.

34. Tosun J, Scherer U, Schaub S, Horn H. Making Europe go from bottles to the tap: Political and societal attempts to induce behavioral change. WIREs Water. 2020 May;7(3):e1435.

35. Johnstone N, Serret Y. Determinants of bottled and purified water consumption: results based on an OECD survey. Water Policy. 2012 Aug 1;14(4):668–79.

36. Dupont D, (Vic) Adamowicz WL, Krupnick A. Differences in water consumption choices in Canada: the role of socio-demographics, experiences, and perceptions of health risks. Journal of Water and Health. 2010 Dec 1;8(4):671–86.

37. Sobsey MD, Stauber CE, Casanova LM, Brown JM, Elliott MA. 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 June 1;42(12):4261–7.

38. Kaushal RK. Arsenic removal from water by physico-chemical approach – A Low-cost treatment option.

39. Vanden Esschert K, Barrett CE, Collier SA, Garcia-Williams AG, Hannapel E, Yoder JS, et al. Demographic differences in use of household tap water in a representative sample of US adults, FallStyles 2019. Journal of Water and Health. 2021 Dec 1;19(6):1014–20.

40. Javidi A, Pierce G. U.S. Households' Perception of Drinking Water as Unsafe and its Consequences: Examining Alternative Choices to the Tap. Water Resources Research. 2018 Sept;54(9):6100–13.

41. Schreiber F, Donato FF, Kemmerich M, Zanella R, Camargo ER, Avila LAD. Efficiency of home water filters on pesticide removal from drinking water. Environmental Pollution. 2024 Jan;341:122936.

42. Consumer Reports [Internet]. 2025 [cited 2025 Aug 26]. Best Water Filter Pitchers of 2025. Available from: https://www.consumerreports.org/home-garden/water-filters/best-water-filter-pitchers-of-the-year-a8018112881/

43. Villanueva CM, Cantor KP, Grimalt JO, Castaño-Vinyals G, Malats N, Silverman D, et al. Assessment of lifetime exposure to trihalomethanes through different routes. Occup Environ Med. 2006 Apr;63(4):273–7.

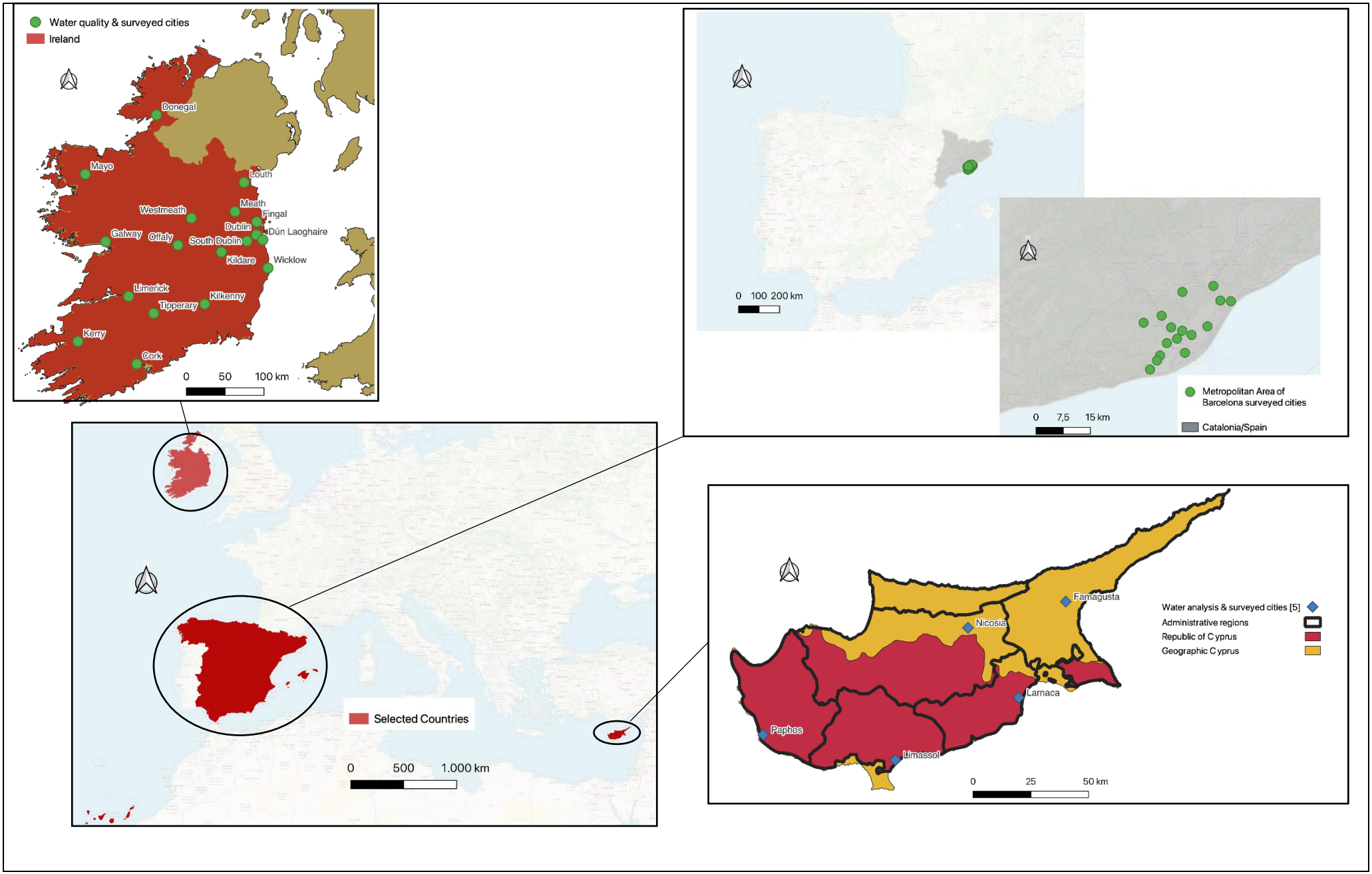
44. Botton J, Kogevinas M, Gracia-Lavedan E, Patelarou E, Roumeliotaki T, Iñiguez C, et al. Postnatal weight growth and trihalomethane exposure during pregnancy. Environmental Research. 2015 Jan;136:280–8.

45. Nuckols JR, Ashley DL, Lyu C, Gordon SM, Hinckley AF, Singer P. Influence of Tap Water Quality and Household Water Use Activities on Indoor Air and Internal Dose Levels of Trihalomethanes. Environ Health Perspect. 2005 July;113(7):863–70.

46. Wilson NJ, Montoya T, Lambrinidou Y, Harris LM, Pauli BJ, McGregor D, et al. From "trust" to "trustworthiness": Retheorizing dynamics of trust, distrust, and water security in North America. Environment and Planning E: Nature and Space. 2023 Mar;6(1):42–68.

47. Wutich A, Budds J, Jepson W, Harris LM, Adams E, Brewis A, et al. Household water sharing: A review of water gifts, exchanges, and transfers across cultures. WIREs Water. 2018 Nov;5(6):e1309.

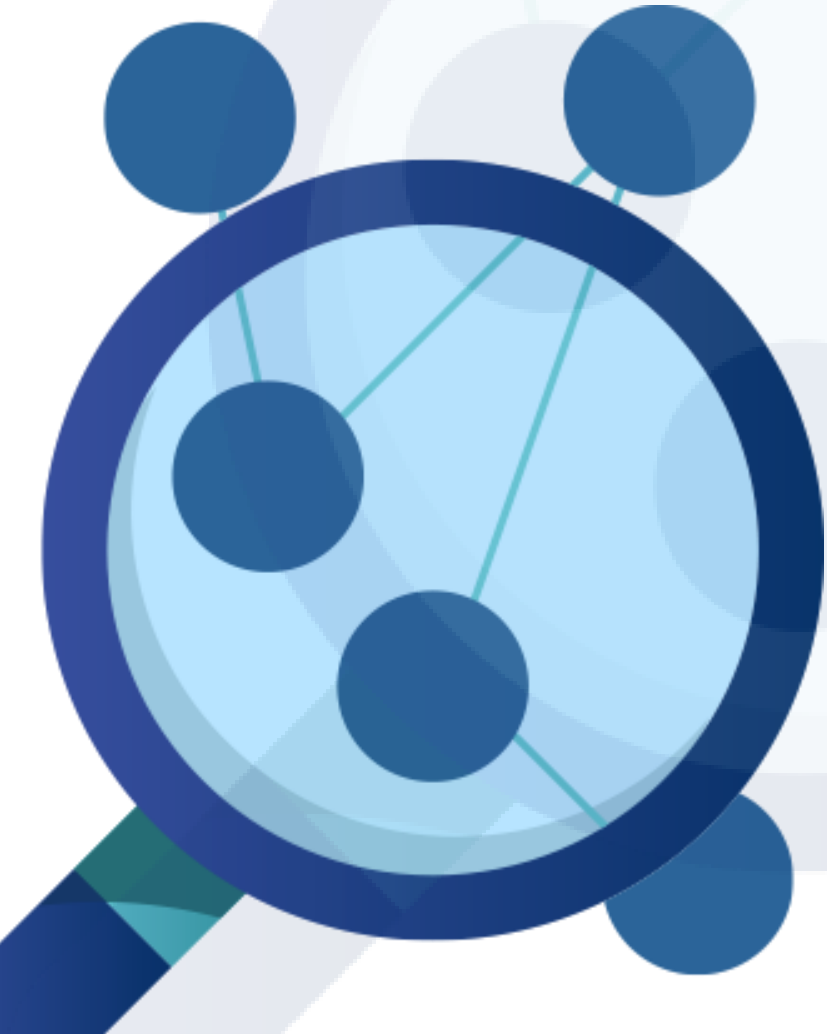
ANNEX 1. Main geolocation of study areas.



intoDBP will create innovative tools and strategies to improve water quality management for safe human use and a healthy environment. It focuses on catchment protection and forecasting, transformative drinking water treatment, and real-time monitoring to combat the effects of climate and global change. In particular, intoDBP focuses on pollution and risks related to disinfection byproducts (DBPs). By developing and applying advanced, integrated, and cost-effective sensors and analytical methods, intoDBP will expand knowledge on water quality and DBP precursors to better understand its formation and human exposure in Europe. intoDBP monitoring results will feed into numerical forecasting tools to predict source water changes and formulate climate change adaptation pathways at catchment and treatment scale. intoDBP also develops transformative options for advanced and cost-effective upgrade of water treatment and disinfection.

In the intoDBP consortium researchers, small and large enterprises, communication experts and public services join forces to generate interdisciplinary solutions, that will generate a renewed perspective of drinking water surveillance, support decision-making and governance, and increase system resilience. intoDBP will implement and validate its cross-cutting products in four complementary case studies from three European countries where compliance with DBP regulation currently is an acknowledged challenge. The direct and visible positive impact of intoDBP in the case studies will foster rapid product adoption at a European and global scale, thus strengthening Europe's position and role in the global water market.

Reaching out beyond the water sector itself, intoDBP will directly engage society through surveys to analyze exposure to DBPs, collect data about catchment protection initiatives, create awareness and promote sustainable consumer behavior such as reducing bottled water consumption.



intoDBP

Funded by
the European Union