

- S1: Current: Currently observed drinking water sources (based on the BHS)
- S2: All tap: 100% of drinking water supplied as tap water without domestic filtration
- S3: All bottle: 100% of drinking water supplied as bottled water
- S4: All filtered tap water: 100% of drinking water supplied as tap water filtered with domestic filters (any type).

Given that THM levels in the public water supply remain the same across scenarios, we assumed the THM exposure patterns from inhalation and dermal absorption did not change across scenarios. We compared health impacts in each scenario (S1–S4) to a reference exposure level in which there was no THM exposure due to ingestion. We included S2 to S4 in which the full population adopted a specific drinking water source in order to explore the full range of modifiable health and environmental impacts linked to drinking water source. Drinking water sources for S1–S4 are described in Table 1.

2.2. Municipal water supply

Barcelona city is supplied by four drinking water treatment plants. The “Abrera” and “Sant Joan Despí” drinking water treatment plants treat, respectively, around 3.5 and 5 m³ s⁻¹ of surface water from the Llobregat river. Both include conventional treatment consisting of pre-treatment, coagulation, flocculation, sedimentation, filtration (sand filters), adsorption (activated carbon filters), and disinfection (chlorine-based, and ozone), in addition to membrane processes such as reverse electrodialysis (Abrera), and reverse osmosis (Sant Joan Despí). The “Cardedeu” drinking water treatment plant treats around 8 m³ s⁻¹ of surface water from reservoirs in the Ter basin, which is less impacted by anthropogenic activity compared to the Llobregat river. Accordingly, this plant only includes conventional treatments (i.e. pretreatment, coagulation, flocculation, sedimentation, and filtration in activated carbon filters). The fourth plant is located in El Prat de Llobregat and produces drinking water through desalination of seawater from the Mediterranean during drought periods, with a treatment capacity up to 2 m³ s⁻¹ of seawater (ACA, 2019; ASPB, 2012).

Barcelona has 3 water supply areas (ASPB, 2012) (Fig. 1): 1) Llobregat area (≈16% of the water supply) receives water from the drinking water treatment plants located in Abrera, Sant Joan Despí, and the desalination plant; 2) Llobregat and Ter area (≈77% of the water supply) receives water from the three drinking water treatment plants in Llobregat and Ter basins, and the desalination plant; and 3) Ter area (≈7% of the water supply) receives water from the Cardedeu drinking water treatment plant. THM levels were measured in 2016 as part of the Barcelona Public Health Agency surveillance programme in the three municipal water supply areas. Median values were: 31.1 µg/L (*n* = 5) in the Llobregat area, 40.1 µg/L (*n* = 5) in the Ter

area, and 46.3 µg/L (*n* = 10) in the Llobregat + Ter area. The different sampling dates, unbalanced Ter/Llobregat proportion, and the THM formation in the distribution system explain the higher levels in the Llobregat + Ter area.

2.3. Estimating trihalomethane exposure

We estimated the population in each water supply area by spatially joining water supply area boundaries provided by the Barcelona Public Health Agency with residential census tract data (Fig. 1). We used adult (≥20 years old) population counts for each census tract in January 2017 (INE, 2018) to estimate the adult population in each water supply area (Table 1). Incidence rates before 20 years of age are very low, and tend to be linked to genetic factors rather than environmental exposures. For Scenario 1, we grouped BHS participants (*N* = 4000) in water supply areas according to their residential census tract and estimated usual water consumption source based on BHS data (Table 1).

We assumed 59.8% of the total water THMs exposure occurred via water ingestion, while dermal contact and inhalation accounted for the remaining 40.2% of the exposure based on a previous study (Jo et al., 1990). We assumed that domestic water filters reduced THM levels by 89%, based on the removal capacity of a 150 L aged activated carbon pitcher type filter (Carrasco-Turigas et al., 2013). We assumed a THM concentration of 0.3 µg/L in bottled mineral water based on a report assessing 15 different popular brands of bottled water consumed in the study area (Font-Ribera et al., 2010). We derived total THM exposure levels by computing a weighted mean of exposure pathways. THM exposure levels for drinking water (ingestion) and all exposure routes (ingestion, dermal absorption, and inhalation) according to water supply area and drinking water consumption source are described in Table 2.

2.4. Health impact assessment

HIA provides a framework and procedure for estimating the impact of an intervention on a selected environmental health issue for a defined population. In this study, we obtained years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life years (DALYs) for bladder cancer in Spain from the Global Burden of Disease (GBD) 2017 estimates (IHME, 2018), for 5-year age groups. We scaled YLLs, YLDs, and DALYs from Spain to Barcelona proportional to the adult population by 5-year age groups, leading to 3070 YLLs, 324.7 YLDs, and 3394.8 DALYs in the city of Barcelona for both sexes (Table 5).

We used published exposure-response functions for the association between total THM levels (encompassing all exposure pathways) and bladder cancer (Costet et al., 2011). Based on a pooled database including data from 6 case-control studies (Costet et al., 2011), Evlampidou and colleagues estimated an odds ratio (OR) of 1.004 (95% CI 1.002, 1.006) for a unit increase in the continuous THM exposure expressed

Table 1

Proportion of tap, filtered and bottled water consumption (mean, 95% confidence interval) and adult population and by water supply area in the city of Barcelona for each drinking water consumption scenario.

Water supply area		Llobregat	Llobregat + Ter	Ter	Barcelona City
Scenario 1 (Current)	Tap (%)	13.2 (9.1, 17.3)	24.8 (23.1, 26.4)	46.3 (40.9, 51.6)	26.1 (24.6, 27.6)
	Filtered (%)	15.3 (11.0, 19.7)	16.7 (15.3, 18.1)	10.9 (7.5, 14.2)	16 (14.7, 17.3)
	Bottled (%)	71.4 (66.0, 76.9)	58.5 (56.6, 60.4)	42.9 (37.6, 48.1)	57.9 (56.2, 59.6)
Scenario 2 (All tap water)	Tap (%)	100	100	100	100
	Filtered (%)	0	0	0	0
	Bottled (%)	0	0	0	0
Scenario 3 (All bottled water)	Tap (%)	0	0	0	0
	Filtered (%)	0	0	0	0
	Bottled (%)	100	100	100	100
Scenario 4 (All filtered tap water)	Tap (%)	0	0	0	0
	Filtered (%)	100	100	100	100
	Bottled (%)	0	0	0	0
Adult population		112,495	1,096,627	140,448	1,349,570