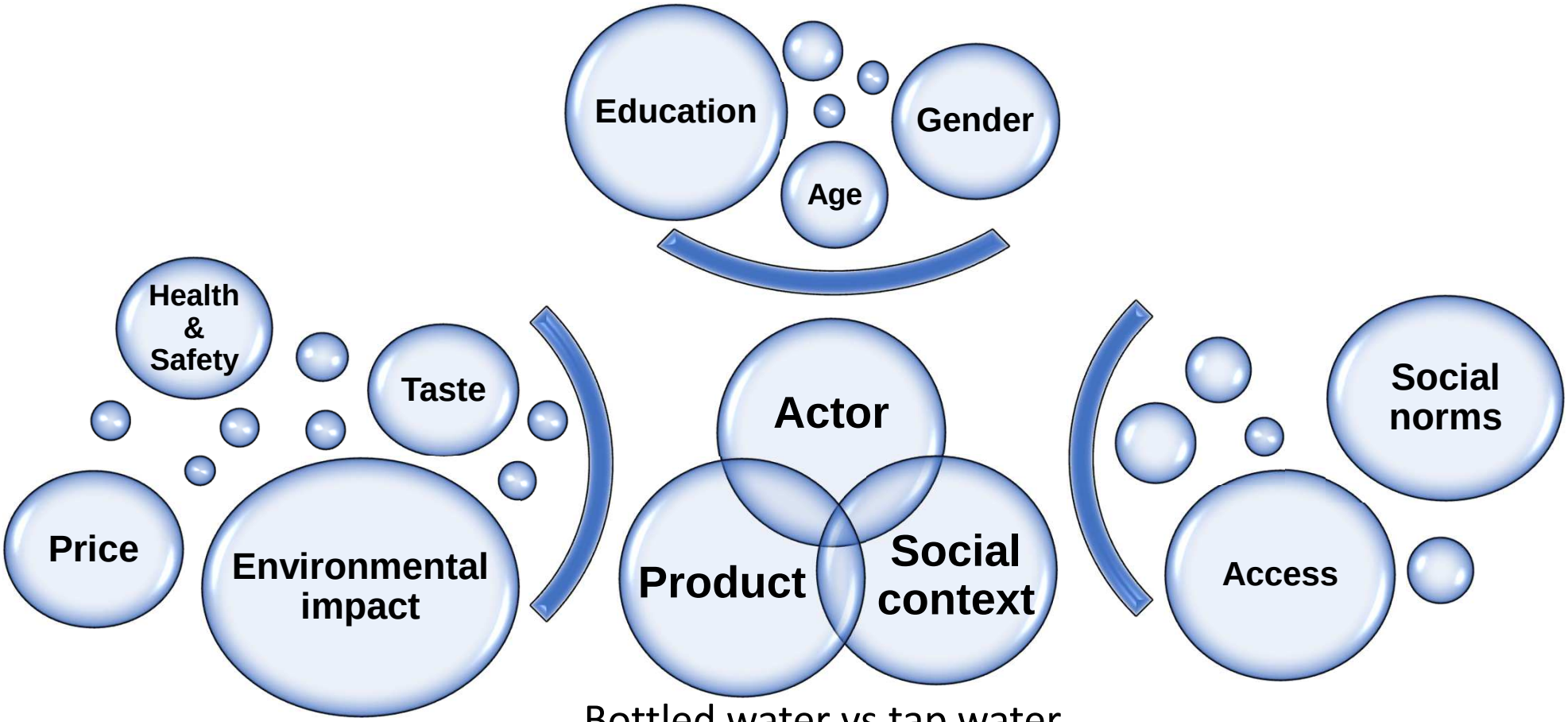
Bottle or tap? Toward an integrated approach to water type consumption




Bottled water vs tap water

# Bottle or tap? Toward an integrated approach to water type consumption

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**Abstract**: While in many countries, people have access to cheap and safe potable tap water, the global consumption of bottled water is rising. Flanders, Belgium, where this study is located, has an exceptionally high consumption of bottled water per capita. However, in the interest of resource efficiency and global environmental challenges, the consumption of tap water is preferable. To our knowledge, an integrated analysis of the main reasons why people consume tap and bottled water is absent in Flanders, Belgium. Using Flemish survey data (N=2309), we first compared tap and bottled water consumers through bivariate correlation analysis. Subsequently, path modelling techniques were used to further investigate these correlations. Our results show that bottled water consumption in Flanders is widespread despite environmental and financial considerations. For a large part, this is caused by negative perceptions about tap water. Many consumers consider it unhealthy, unsafe and prefer the taste of bottled water. Furthermore, we found that the broader social context often inhibits the consumption of tap water. On the one hand, improper infrastructures (e.g. lead piping) can limit access to potable tap water. On the other hand, social norms exist that promote bottled water. Lastly, results suggest that the consumption of bottled water is most common among men, older people and less educated groups. We conclude that future research and policy measures will benefit from an approach that integrates all behavioural aspects

associated with water type consumption. This will enable both governments and tap water companies to devise more effective policies to manage and support tap water supply networks.

**Keywords:** drinking water; sustainability; pro-environmental behaviour; quality perceptions

# 1 Introduction

Environmental challenges such as water scarcity and pollution are increasingly becoming a global concern (du Plessis, 2019). In Flanders, Belgium, respectively 94.1%, 65.8% and 61.9% of the population considers climate change, droughts and water pollution as serious problems (European Commission, 2013, 2017). The production and consumption of bottled water is a contributor to these problems (Cole et al., 2011; Free et al., 2014; United States Government Accountability Office, 2009). One litre of bottled water requires on average three litres of water over its entire lifecycle. Additionally, it requires 1000-2000 times more energy to produce bottled water (5.6 to 10.2 MJ $1^{-1}$) in comparison to tap water (0,005 MJ $1^{-1}$) (Gleick and Cooley, 2009; Pacific Institute, 2007). Therefore, tap water is preferable in the interest of resource efficiency. Bottle manufacturing has a particularly high environmental impact (Horowitz et al., 2018). Most single-use bottles are made of plastic polyethylene terephthalate (PET), which is sourced from fossil fuels (Gleick and Cooley, 2009). Considering that bottled water production reached almost 100 billion gallons in 2017, and considering the worldwide preference for plastic bottles (Rodwan, 2017), bottled water consumption greatly contributes to global plastic pollution. The chemical by-products of plastic such as phthalates pollute the air, water and soil (Olson, 1999). Furthermore, plastic (non-biodegradable) waste often ends up in nature (Barnes et al., 2009; Shaw and Sahni, 2014), vastly accumulating in landfills, water bodies and remote islands (Jambeck et al., 2015; Lavers and Bond, 2017; Olson, 1999). Subsequently, ecosystems are disturbed and wildlife is threatened because animals are entangled in plastic debris or ingest it (Chae and An, 2018; Wabnitz and Nichols, 2010).

While in many countries, people have easy access to cheap and safe potable tap water (Wilk, 2006), bottled water consumption has been increasing on a global scale (Arnold and Larsen, 2006; Rodwan,

2017). In a study of the Flanders Environment Agency (2018b), 66% of the participants indicated that they drink bottled water at least half of the time, averaging 0.4L per day. Flanders has an exceptionally high per capita consumption of bottled water (European Commission, 2013). There appears to be a disconnect between bottled water consumption and its environmental impact (Saylor et al., 2011).

Paradoxically, Flanders has played a pioneering role in the development of tap water supply systems. The region hosted the first (1902) continuous scheme of water disinfection through chlorine for potable purposes (McGuire, 2006; White, 2010). For the consumption of tap water to be the norm, it seems that the development of tap water supply networks is a necessary, but insufficient condition. Extensive insight in water consumption behaviour is critical for the effectiveness of tap water supply networks. This will also help governments develop policies that induce behavioural change (Van Der Linden, 2015).

In recent years, there has been a growing academic interest in the reasons why people consume tap and bottled water. Most studies to date have employed a product-oriented approach where participants are asked to evaluate a product i.e. a type of water (Debbeler et al., 2018). These studies have identified four important considerations. (1) Health and safety concerns about tap water (e.g. Ballantine et al., 2019; Debbeler et al., 2018). People often prefer bottled water because they associate tap water with chemicals, chlorine, sediments, etc. (McLeod et al., 2014; Rahman et al., 2017; Ward et al., 2009). (2) Organoleptic properties (i.e. sensorial information such as taste and odour) play a major role in water type consumption (Ballantine et al., 2019; Doria, 2006). Debbeler et al. (2018) conclude that bottled water consumers indicate taste as a core driver to consume bottled water, given that many consumers prefer its taste over tap water. Moreover, people seem to relate organoleptic properties of beverages to its perceived healthiness and safety (Luckow and Delahunty, 2004; Saylor et al., 2011). The taste of tap water is often associated with the presence of unhealthy substances (Font-Ribera et al., 2017). More recently, (3) environmental concerns have been a

growing consideration in water type consumption. The environmental impact of bottled water might lead people to consume tap water (Qian, 2018; Ward et al., 2009). This behaviour fits within the larger trend of environmentally friendly consumption (Leonidou et al., 2010). Lastly, (4) financial considerations might influence consumers in their choice of water (Van Der Linden, 2015; Ward et al., 2009). Generally, tap water is significantly cheaper than bottled water (Abrahams et al., 2000; Ferrier, 2001). In Flanders, Belgium, tap water cost on average €0.005/L (Flanders Environment Agency, n.d.). In comparison, one litre bottled water costs approximately €0.60.

These product-oriented approaches often led to voluntarist explanations, suggesting that consumers make deliberate choices based on product evaluations (e.g. Ballantine et al., 2019; Ward et al., 2009). Less attention has been paid to socio-contextual explanations, including the broader social context wherein water is consumed and the sociodemographic characteristics of consumers. Firstly, the social context could potentially influence individual water consumption behaviour, given the fact that consumer decisions are made within a broader context (Spaargaren and Van Vliet, 2000). On the one hand, improper infrastructures (e.g. lead pipes) can limit access to potable tap water (Juba and Tanyanyiwa, 2018). In this context, Doria et al. (2009) pointed out the need to combine research on product evaluations with more objective and technical approaches that focus on supply reliability. On the other hand, society installs social norms that define appropriate behaviour, and therefore influence consumer decisions (Higgs, 2015). Etale et al. (2018) show that social norms often promote bottled water, particularly on special occasions (e.g. when visitors are present). Secondly, certain sociodemographic characteristics appear to influence water type preferences. Research indicates that age, gender and educational attainment might be relevant factors, but consistent evidence about the direction and strength of these associations is still lacking (see for example Debbeler et al., 2018; Doria, 2010; Etale et al., 2018; Family et al., 2019; Rosinger et al., 2018; Xu and Lin, 2018).

Sociodemographic influences may also serve as causal antecedents, mediated by other factors associated with water type consumption (Doria, 2010). While previous inquiries into the relationship

between age and environmentalism found a significant association, this relationship is complex (Grønhøj and Thøgersen, 2009). In general, younger people are more concerned about environmental issues. Yet, research also points out that this does not always translate into environmentally friendly consumption. Young people seem less likely to make changes in their consumption behaviour (Kagawa, 2007). In general, environmentally friendly consumers tend to be older (Casalo and Escario, 2018), which might translate into a preference for tap water among older people. Two opposing effects are hypothesised with respect to gender. Woman generally perceive tap water as more hazardous (Anadu and Harding, 2000; Juba and Tanyanyiwa, 2018; Saylor et al., 2011), but are also more concerned about environmental issues (McCright, 2010). In addition, highly educated consumers may favour tap water because they tend to have less health and safety concerns (Ochoo et al., 2017; Park et al., 2019) and possess a greater general environmental concern (Franzen and Meyer, 2009).

Against this background, we analysed the main reasons why people consume tap and bottled water in Flanders, Belgium. Flanders is a particularly noteworthy case because it has both an excellent tap water supply network and relatively high levels of environmental concern among its population (European Commission, 2017). Yet, bottled water consumption is exceptionally high in this region (European Commission, 2013). In order to explain this paradoxical situation, we suggest an integrated analysis of the behavioural aspect associated with water type consumption. To this end, we coupled product-oriented approaches to socio-contextual explanations. In our integrated approach, we considered the product i.e. a type of water, the actor i.e. the sociodemographic characteristics of consumers and the broader social context wherein water is consumed. Extensive insight into the behavioural aspects associated with the consumption of tap and bottled water will enable both governments and tap water companies to device more effective strategies to manage and support tap water supply networks (Van Der Linden, 2015).

## 2 Materials and methods

## 2.1 Data acquisition

The questionnaire for our survey was led by the Flemish Water Knowledge Center (Vlakwa/VITO), an agency facilitating knowledge transfer on water in Flanders, Belgium. In 2018, the online survey *'The Water survey among the citizens'* was launched. Citizens of the Flemish region of Belgium could answer a variety of questions regarding water-related attitudes and behaviours. The questionnaire was carried out through an online application using LimeSurvey, a company specialised in online surveys. The survey was first introduced by the Flemish radio. To augment response rates, the questionnaire was additionally dispersed through social media, advertised by public figures, and distributed with the newsletters of the Federation of Flemish Water- and Sewage Managers (AquaFlanders) and Vlakwa. A total of 2345 individuals participated in the survey. Only participants above the age of 18 were included in the subsequent analysis. Additionally, 24 participants were manually excluded due to incomplete data. Ultimately, the assessment was performed on 2309 participants.

Given that the overall distribution of the participants' sociodemographic characteristics (gender, education, age and residence) did not fully align with the general Flemish demographics (Eurostat, 2018; Statbel, 2019; Statistics Flanders, 2019), a specific set of poststratification weights was introduced to ensure the survey's representativity towards the target population. This weighing was achieved by dividing the population proportion by the sample proportion for each group. Subsequently, weights were multiplied. After weighting, the sample distribution was in line with the general population characteristics (cf. Table 1).

[Table 1. Comparison of sample and population characteristics]

## 2.2 Variables

Water type consumption was measured by inquiring participants about the amount of tap water that they consume at home, relative to bottled water (i.e. *"How frequently do you drink tap water, instead of bottled water, at home"*). Participants could reply to the questions based on a five-point

scale (1. always - 5. seldom or never). The scale was reversed, thus high scores on the scale were associated with increased consumption of tap water, relative to bottled water.

To assess the impact of product evaluations, four questions were used. Health and safety concerns were questioned using a six-point scale (1. totally disagree – 6. totally agree) with the following statement *"Tap water in Flanders is safe and healthy".* This response scale was reversed to construct a variable where high scores indicated high health and safety concerns about tap water. The same, unreversed, response scale was used to identify general environmentally friendly consumers (item: *"It is clear to me what environmentally friendly products and pesticides are, and I am willing to use them"*). High scores were associated with environmentally friendly consumers. Furthermore, respondents were asked why they consume bottled water. Taste preferences was one of the answer categories. Based on this question, a dummy variable was constructed for taste preferences (score 1: the participant preferred the taste of bottled water). Participants were additionally inquired about the amount of money they spend on drinking water. Participants who were able to estimate their spending habits on drinking water were considered to take into account the financial consequences of consumer decisions. This response was translated into a proxy variable with dummy coding (1 denoted an inclination to financial considerations).

To estimate the influence of the broader social context, four questions were used. An improper infrastructure was measured by two items (*"I have lead pipes"* and *"I do not have access to tap water"*). These items were combined into one dummy variable (score 1 indicated limited access to potable tap water). Social norms were measured using two dummies (items*: "Bottled water present better during meals" and "If I have visitors, I prefer bottled water"*). Lastly, sociodemographic characteristics include age (ranging from 18 to 86), gender (score 1: female) and the highest educational attainment of the head of the household i.e. primary provider of the household income (primary education or less, secondary education, tertiary education).

### 2.3 Research setup

The analysis in this study was conducted stepwise. We started with descriptive statistics to evaluate water type consumption in the Flemish context. Secondly, we used spearman correlations to analyse bivariate associations and to compare the characteristics of bottled water consumers with tap water consumers. Thirdly, path modelling techniques were used to further investigate the (interrelation) between the variables associated with water type consumption, resulting in a path model with 12 variables. Such model is comprised of causal chains i.e. direct and indirect relationships between variables (Duncan, 1966). Modelling causal chains has proven to be a valuable approach to research on water type consumption in the past (e.g. Doria et al., 2005; Doria et al., 2009; Levêque and Burns, 2017). In this paper, we were able to investigate the potentially mediated relationship between water type consumption and sociodemographic characteristics. To estimate a causal model that fits well with our data, we used the software package Mplus. Our path model was constructed with both binary and continuous outcome variables. Consequently, the model combined linear regressions when the outcome was continuous with non-linear regressions (i.e. logit or probit regression) when the outcome was binary. Specifically, using a robust weighted least square estimator (WLSMV), linear regression coefficients were estimated when the outcome variable was continuous and probit coefficients were estimated when the outcome was binary (Muthén and Muthén, 1998-2017).

Model fit evaluation was based on multiple fit statistics, as recommended by Kline (2015): $\chi^2$ test, comparative fit index CFI, standardised root mean square residual SRMR, and root mean square error of approximation RMSEA. Cut-off points for fit statistics provide a indicative tool for model evaluation (Lai and Green, 2016). Standards in this analysis were borrowed from Hooper et al. (2007) and Kline (2015). The $\chi^2$ test should be significant ($p < 0.05$), but a large sample size (as is the case in this analysis) may cause the test to be unreliable. SRMR and RMSEA < 0.05 indicate a good fit, while fit values below 0.08 are often seen as acceptable. Whereas initial standards claimed that CFI < 0.9 indicates a bad fit, recent recommendations require CFI > 0.95 for a good fit. Given that fit indices should be evaluated together instead of independently (Kline, 2015), 0.9 < CFI < 0.95 was considered acceptable in combination with SRMR- and RMSEA-scores < 0.05.

# 3 Results

## 3.1 Descriptive statistics

In our data, almost 45% of the participants indicated that they drink bottled water half the time or more (cf. Table 2). Furthermore, 90% agreed when asked whether they are environmentally friendly consumers and almost 60% kept track of their spending habits on drinking water. There appears to be a cognitive disconnect between the consumption of bottled water on the one hand, and environmental and financial considerations on the other hand. Among our participants, only 20% considered tap water completely healthy and safe. Most participants seemed to perceive tap water as relatively healthy and safe, but not entirely. In 15.2% of cases, taste preferences were indicated as drivers to consume bottled water, instead of tap water. Furthermore, 3.1% of our participants had no access to potable tap water at the time of the survey. Lastly, 10% of participants said to consume bottled water because it presents better during meals and more than 25% indicated to prefer bottled water when visitors are present.

[Table 2. Descriptive statistics]

## 3.2 Correlations analysis

A spearman correlation analysis was used to evaluate bivariate correlations between water type consumption on the one hand, and product evaluations and socio-contextual factors on the other hand (cf. Figure 1). Positive correlations indicated a positive correlation with the consumption of tap water, relative to the consumption of bottled water. Results showed that both product evaluations and socio-contextual explanations were significantly correlated with water type consumption. The consumption of tap water seemed negatively correlated with risk perceptions ($\rho$ = -0.408; $p < 0.001$) and taste preferences ($\rho$ = -0.386; $p < 0.001$), suggesting that bottled water consumers may have higher health and safety concerns about tap water and consider its taste inferior to bottled water. Tap water consumers were more likely to be environmentally friendly consumers ($\rho$ = 0.140; $p < 0.001$) and inclined to financial considerations ($\rho$ = 0.071; $p < 0.001$). The negative correlation

between the consumption of tap water and access to potable tap water ($\rho$ = -0.080; p < 0.001) showed that people who do not have access to potable tap water consume significantly more bottled water. Furthermore, social norms played a role in water type consumption. Tap water consumption was negatively correlated with the perception that bottled water presents better during meals ($\rho$ = -0.055; p < 0.01). Moreover, a significant positive correlation was found between the consumption of tap water and the perception that bottled water is preferred when visitors are present ($\rho$ = 0.171; p < 0.001). This suggests the existence of a group that predominantly drinks tap water, but deliberately consumes bottled water when visitors are present. Lastly, all sociodemographic characteristics were significantly correlated with water type consumption. Younger participants ($\rho$ = -0.093; p < 0.001), women ($\rho$ = 0.046; p < 0.05) and families where the head of the household is highly educated ($\rho$ = 0.152; p < 0.001) on average reported a higher consumption of tap water.

[Figure 1. Full correlation matrix]

### 3.3 Path model

To further investigate the bivariate correlations discussed above, we employed path modelling techniques (cf. Duncan, 1966). Given the binary outcome variables in the model, a robust weighted least square estimator (WLSMV) was used to achieve this (Muthén and Muthén, 1998-2017). In total two models were estimated. The model fit of the first model (cf. Figure 2) indicated that improvements could be made ($\chi^2$ = 234.36, p < 0.001; CFI = 0.66; SRMR = 0.079; RMSEA = 0.066).

[Figure 2. First path model]

Using Lagrange Multipliers (or modification indices, as they are often referred to), we were able to find ways in which our model could be improved (Bentler, 2010). In combination with theoretical arguments, some covariance between mediators was accounted for in a secondary model (cf. Figure 3). Firstly, social norms were allowed to covariate. Additionally, covariance between health and safety concerns and taste preferences was included because previous research shows a correlation between the two (Font-Ribera et al., 2017). Finally, the secondary model included covariance

between social norms when visitors are present on the one hand, and the variables on risk perceptions, taste preferences and access to potable tap water on the other hand. Overall, an acceptable fit was reached for the secondary model ($\chi^2$=78.83, p<0.001; CFI=0.90; SRMR=0.049; RMSEA=0.041). Moreover, the secondary model explains more than half of the variance in water type consumption ($R^2 = 0.52$).

[Figure 3. Secondary path model]

The standardized direct and indirect effects discovered in the secondary model are visually represented in figure 4 and figure 5 respectively. This model confirmed that participants with health and safety concerns about tap water consumed more bottled water (std. β = -0.277; p < 0.001). The inferior taste of tap water was another reason to consume bottled water (std. β = -0.444; p < 0.001). Environmental (std. β = 0.131; p < 0.001) and financial considerations (std. β = 0.129; p < 0.001) seemed to be positively associated with the consumption of tap water. Participants without access to potable tap water, consumed significantly more bottled water (std. β = -0.152; p < 0.001). Furthermore, the perception that bottled water present better during meals, was negatively associated with the consumption of tap water (std. β = -0.178; p < 0.01). Additionally, a positive relation was found between the perception that bottled water is preferred in the presence of visitors and the consumption of tap water (std. β = 0.215; p < 0.001). This confirms the existence of a group of predominantly tap water consumers who deliberately serve bottled water to their visitors.

[Figure 4. Path model: direct effects]

Overall, a strong link between the sociodemographic characteristics of consumers and water type consumption was found in the data. The bivariate analysis revealed a negative relationship between age and the consumption of tap water. The path model suggested that environmental (std. β = 0.143; p < 0.001) and financial considerations (std. β = 0.265; p < 0.001) were more common among older participants. In contrast, taste preferences for bottled water (std. β = -0.149; p < 0.001) and the perception that bottled water presents better during meals (std. β = -0.185; p < 0.001) were less

common among the older generations. While the indirect relationship between age and the consumption of tap water was positive, this seemed to be compensated by a negative direct effect (std. $\beta = -0.188$; $p < 0.001$). In other words, older participants consumed more bottled water than younger people, despite the fact that they were more likely to consider the environmental and financial impact of consumer decision; and that they were less likely to indicate 'taste' and 'social norms' as reasons for drinking bottled water. It thus seems that there are reasons external to our model (e.g. generational effects) that drive older people to consume bottled water. With respect to gender, a bivariate positive relationship was found, suggesting that women consume relatively more tap water than men. Whereas women had more health and safety concerns (std. $\beta = 0.104$; $p < 0.001$) and were less inclined to financial considerations (std. $\beta = -0.224$; $p < 0.001$), these positive indirect effects are compensated by a positive direct effect (std. $\beta = 0.076$; $p < 0.01$) and negative indirect effects. Generally, environmentally friendly consumption was more common among women (std. $\beta = 0.062$; $p < 0.05$). The perception that bottles present better during meals seemed less common amongst women (std. $\beta = -0.127$; $p < 0.01$). Put in another way, women consumed more tap water than men, despite health and safety concerns and the fact that they were less inclined to financial considerations. In part, this could be explained by the finding that female participants were more likely to be environmentally friendly consumers and less susceptible to social norms that promote bottled water during meals. Lastly, the level of education was negatively correlated with the consumption of bottled water. This could be explained by the fact that health and safety concerns about tap water were less common among higher educated groups (std. $\beta = -0.188$; $p < 0.001$). Additionally, we found a positive direct relation between higher education and the consumption of tap water (std. $\beta = 0.097$; $p < 0.05$).

[Figure 5. Path model: indirect effects]

Lastly, significant covariances between mediators were observed (cf. Table 3). The results showed a positive association between social norms i.e. the idea that bottles present better during meals and

that they are preferred when visitors are present (std. cov. = 0.384; $p < 0.001$). Furthermore, a positive association between health and safety concerns and taste preferences was found (std. cov. = 0.281; $p < 0.001$), suggesting that people who dislike the taste of tap water perceived tap water as less healthy and safe and visa versa. Lastly, a negative covariance was found between the perception that bottled water is preferred in the presence of visitors on the one hand and taste preferences (std. cov. = -0.221; $p < 0.001$), risk perceptions about tap water (std. cov. = -0.109; $p < 0.01$) and access to potable tap water (std. cov. = -0.190; $p < 0.05$) on the other hand. These findings suggest that 'occasional' bottled water consumers serve bottled water to their visitors due to social norms, yet have no taste preferences for bottled water, less health and safety concerns about bottled water and no limitations in access to potable tap water.

[Table 3. Path model: covariances]

## 4 Discussion

In the interest of resource efficiency and global environmental challenges such as water scarcity and pollution, tap water is preferable to bottled water (Gleick and Cooley, 2009). Tap water is a short-chain product with a minimum footprint, as infrastructures are all in place for other (non-potable) uses of tap water. Despite the fact that many countries provide cheap and safe potable tap water (Wilk, 2006), the consumption of bottled water is rising worldwide (Arnold and Larsen, 2006; Rodwan, 2017). In Flanders, Belgium, the situation is particularly puzzling. This region has an exceptionally high per capita consumptions of bottled water (European Commission, 2013), in combination with an excellent tap water supply network and a population with relatively high environmental concerns (European Commission, 2017). To support (the use of) tap water supply networks and develop more effective policies to induce behavioural change, it is vital to understand water consumption behaviour (Van Der Linden, 2015). In this article, we aimed to provide an integrated analysis of the main reasons why people consume tap and bottled water. To this end, we complemented the product-oriented approach of previous research with a more contextualised

approach. As a testament to the comprehensive nature of our study, we were able to explain more than 50% of the differences in water type consumption.

We found that environmental and financial considerations drive people to consume tap water. Yet, the consumption of bottled water is widespread in Flanders, with almost 45% of our participants drinking bottled water at home at least half the time. This is in stark contrast with the fact that approximately 90% of the participants indicated that they are willing to buy environmentally friendly products and the fact that approximately 60% of the participants kept track of their water spending habits. There appears to be a disconnect between individual water consumption behaviour, environmental consequences and financial consideration. In particular, the disconnect between bottled water consumption and its environmental impact is substantial. Similar findings have been described by Debbeler et al. (2018) as the *water consumption paradox*.

The results show that part of this paradox can be explained by contextual factors that inhibit tap water consumption. Our findings firstly signal social norms in Flanders that promote bottled water. Brei and Tadajewski (2015) argue that these norms are potentially caused by marketing and branding campaigns of bottled water companies. In addition, bottled water has historically been more high status (Wilk, 2006). Social norms are typically augmented on special occasions e.g. in the event that visitors are present. Presenting bottled water to visitors might be a sign of status, appreciation and respect (Etale et al., 2018).

Our survey further suggests that approximately 3% of the Flemish population of Belgium does not have access to potable tap water at home. Similarly, Flemish official statistics indicate that 2% to 3% of Flemish households are not connected to the tap water network (Flanders Environment Agency, 2017). In contrast, Belgium's progress reports on Sustainable Development Goal (SDG) 6.1 [i.e. "Universal and equitable access to safe and affordable drinking water for all" (United Nations, 2019, p. 7/21)] indicate that 100% of the population has access to basic drinking water sources (Sachs et al., 2019). This includes all water sources (tap water, wells, springs, rainwater and packaged water such

as bottled water) that can be reached within a 30-minute round trip (World Health Organisation, 2017). For 1.6% of the populations, these sources are not always available at home (Sachs et al., 2019). Our results suggest that this may be caused by lead piping, which drives people to consume bottled water. Moreover, based on our survey, an estimated 1% to 2% has a privately managed water well at home. Households with these wells seem to consume significantly more bottled water. It appears that water wells are only minimally used for drinking purposes (see also Flanders Environment Agency, 2018b). Although Belgium seems compliant to SDG 6.1, sustainability objectives should focus more on access to tap water supply networks.

Furthermore, our study confirms that the water consumption paradox is also caused by the negative perceptions many consumers have about tap water. The consumption of bottled water is most common among people who perceive tap water as unhealthy and unsafe. Moreover, bottled water consumers often perceive the taste of tap water as inferior. In line with the study Van Der Linden (2015) conducted in the Netherlands, we found that the influence of environmental and financial considerations is less salient than the influence of risk perceptions and taste preferences about tap water. Similar to the findings of Levêque and Burns (2017), we found a strong connection between these risk perceptions and taste preferences. Furthermore, public perceptions about tap water appear to be negatively biased. During blind taste experiments, participants have been unable to differentiate between tap and bottled water (e.g. Debbeler et al., 2018; Wells, 2005). Additionally, many studies fail to prove that tap water is less healthy and safe than bottled water (e.g. Ahmad and Bajahlan, 2009; Lalumandier and Ayers, 2000). Moreover, the legal framework for quality control is more stringent for tap water than for bottled water. Ca. 60 parameters are used for the quality control of tap water and tap water producers screen for additional organics (Vlaamse Overheid, 2002). Furthermore, Belgium reports 99,6% compliance with European and Flemish quality regulations (Flanders Environment Agency, 2018a). In contrast, these regulations do not always apply to bottled water (Flanders Environment Agency, 2018a). Moreover, studies have questioned the quality of bottled water, calling for an improved framework of control (Cidu et al., 2011;

Zamberlan da Silva et al., 2008). Furthermore, the healthiness of plastic bottled water is questioned because microplastics originating from the packaging may infiltrate the drinking water (Mason et al., 2018).

Consequently, perceptions about tap water are often based on subjective judgements, instead of objective differences (Anadu and Harding, 2000; Slovic, 1987). They are augmented by media coverage of drinking water problems and water pollution (Anadu and Harding, 2000; Parag and Roberts, 2009) and by distrust of governments and the tap water industry (Doria et al., 2009; MacGregor and Fleming, 1996). Ironically, this distrust might be partly caused by environmental groups that call attention to water pollution and the government's inactivity (Foltz, 1999). In addition, the impact of bottled water producers should not be neglected, because they are powerful market agents that shape consumer perceptions (Brei and Tadajewski, 2015). They promote their products as healthy and pure, implying that tap water is not (Doria, 2006; Ferrier, 2001; Wilk, 2006).

In terms of sociodemographic differences, the consumption of bottled water appears most common among older people, men and less educated groups. For age, this seems to be explained by a residual direct effect unrelated to any mediator in our model. Given the comprehensive nature of our model, this most likely points to a cohort effect, instead of variables not included in the model. This means that generational differences might be explained by shared temporal life experiences e.g. the growth of the market for bottled water during the 1960s and 1970s and the subsequent marketing campaigns (Brei and Tadajewski, 2015). Furthermore, we confirm that environmentally friendly consumers are mainly woman (McCright, 2010). In additional, women seem less susceptible to social norms that promote bottled water during meals. Pacheco et al. (2018) argue that for women, bottled water consumption is a function of quality and safety, while males may be more driven by its social and cultural functions. In combination with a residual direct effect, these mechanisms outweigh women's health and safety concerns about tap water and the fact that women are less inclined to financial considerations. Less educated groups seem to consume more bottled water because they

have more health and safety concerns about tap water, compared to higher educated groups. Possibly, higher educated people are better in discerning the scientific information that generally supports tap water quality from other information (Dupont et al., 2010). In addition, sociodemographic groups (age, education and gender) seemed to have equal access to tap water. Based on our findings, we cannot conclude that, in a Flemish context, inequality exists in access to tap water services. From an equity point of view, Belgium appears to comply with SDG 6.1. It is especially noteworthy that we did not find educational differences in access to potable tap water, because less educated groups tend to live in areas with inferior infrastructures (Adams et al., 2016). However, future research may specifically include geographical data because spatial inequalities such as a rural/urban divide may still exist (Bain et al., 2014). Lastly, the idea that bottled water is preferred on special occasions such as the presence of visitors seems uniformly accepted.

Given the variety of influential factors, we suggest integrated policy measures that consider the product i.e. the type of water, but also the actor i.e. the consumer, and the social context wherein water is consumed. In order to facilitate tap water consumption, a social marketing campaign that promotes tap water could be beneficial to this cause (see Saylor et al., 2011). Firstly, such a campaign should (1) engage in information dissemination and advertising efforts that tackles the negative perceptions many consumers have about tap water and promote its benefits. Tap water usually receives little or negative publicity (Debbeler et al., 2018). Governments and drinking water companies seem to do little to confront the negative claims made about tap water (Foltz, 1999). In this context, Queiroz et al. (2013) point to the disconnect between public investment in infrastructures and provision of adequate information about water supply systems. Moreover, they argue that the absence of communication channels might cause uncertainty about the quality of public water sources and promote distrust in public water supplies. The lack of public campaigns may be caused by the fact that drinking water only accounts for a marginal percentage of all tap water used, limiting the financial implications of such efforts (Parag and Roberts, 2009). In contrast, the sale of bottled water has been called the greatest advertising and branding campaign in history because

companies package and sell "something that is freely available" (Queiroz et al., 2012, p. 328). Furthermore (2), the social marketing campaign should create a social context that promotes tap water, instead of inhibiting it. On the one hand, policy must endeavour to enable tap water consumption. Governments and tap water companies should optimise tap water supply infrastructures. On the other hand, the activation and manipulation of social norms shows potential in leveraging behavioural change (Van Der Linden, 2015). Social norms that promote tap water might be activated and stimulated through aforementioned advertising and branding (e.g. bottling eco-friendly tap water in reusable bottles). Lastly, (3) knowledge on the sociodemographic characteristics of bottled water consumers allows social marketing campaigns to include and target specific groups i.e. older people, men and less educated groups.

Like all research, our study has its limitations. One of the limitations of this study is that fact that cross-sectional data was used. Consequently, it is hard to draw causal conclusions. While perceptions indeed affect behaviour, the opposite is also true. Perceptions and attitudes are often influenced by past experiences. In our case, the act of drinking a certain type of water potentially influences perceptions about different water sources (Doria, 2010). Future research might employ longitudinal techniques in order to gain a better causal understanding of the relationship between perceptions and behaviour. Additionally, we were mainly interested in the nature of social norms in Flanders i.e. whether they promote bottled or tap water. Future research may further develop these social norms e.g. looking at their quantitative impact such as the frequency of visits, but also differentiating between more occasions. Moreover, social norms are context and culture specific. Studies might compare social norms cross-nationally and cross-culturally. Similarly, cross-national investigations may compare institutional contexts and supply systems. Whereas Flanders has a relatively good supply system, we expect infrastructure issues to play a bigger role in other countries with a less developed system (e.g. Juba and Tanyanyiwa, 2018 in Harare, Zimbabwe). Future research should also investigate the influence of social networks and interpersonal communication. These are important factors that influence perceptions and social norms (Doria, 2010). Lastly, while we aimed

to examine the influence of objective infrastructural issues, other studies by Levêque and Burns (2017) for example include a more subjective measure of tap water infrastructures (i.e. how do people perceive infrastructure quality and maintenance). Theses studies show the interconnectedness between environmental concerns, perceptions on risk, taste and infrastructures. Further research may differentiate between objective and subjective dimensions of infrastructure and how they relate to other perceptions about water types.

## 5 Conclusions

In this study, we found that the consumption of bottled water in Flanders is widespread, despite environmental and financial considerations. In part, this can be explained by negative perceptions about tap water. These product evaluations however are only part of the story. In this study, we have shown the importance of socio-contextual explanations, including the sociodemographic characteristics of consumers and the broader social context wherein water is consumed. Both future research and policy measures will benefit from an integrated approach that considers the product i.e. a type of water, the actor i.e. the consumer, and the broader social context. We suggest three measures that tackle negative perceptions about tap water and create a social context that promotes tap water. (1) Advertising and branding campaigns that provide an answer to the negative perceptions about tap water and activate social norms that promote tap water consumption. (2) Ensuring that everybody has access to potable tap water. (3) Targeted action towards specific groups i.e. older people, males and less educated groups.

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710

# Tables and figures

| | Sample before weights | Sample after weights | Population (Flanders, Belgium) * |
|---|---|---|---|
| **Gender (% female)** | 51.4% | 50.8% | 50.5% |
| **Age (%)** | | | |
| 18-29 | 15.8% | 13.5% | 17.4% |
| 30-49 | 42.1% | 37% | 31.9% |
| 50+ | 42.1% | 49.5% | 50.7% |
| **Education (%)** | | | |
| Primary education or less | 8.8% | 18.9% | 19% |
| Secondary education | 23% | 39.9% | 40% |
| Tertiary education | 68.2% | 41.2% | 41% |
| **Province (%)** | | | |
| Antwerp | 26.9% | 28.2% | 28.2% |
| Limburg | 17.1% | 13.4% | 13.3% |
| East Flanders | 27.5% | 23% | 23% |
| West Flanders | 6.2% | 17.3% | 17.3% |
| Flemish Brabant | 22.4% | 18.1% | 18.2% |

*Based on 'Statistics Flanders': www.statistiekvlaanderen.be; 'Statbel': https://statbel.fgov.be/nl and 'Eurostat': https://ec.europa.eu/eurostat/

Sociodemographic characteristics of the Flemish population, comparing the sample distribution with the population distribution.

**Table 1. Comparison of sample and population characteristics**

| Descriptive (N=2309) | % |
|---|---|
| **Tap water, instead of bottled water** | |
| Seldom or never | 20.8% |
| Less than half of the time | 11.9% |
| Half of the time | 11.4% |
| More than half of the time | 15.1% |
| Always | 40.8% |
| **Tap water is unhealth and unsafe** | |
| Totally disagree | 20.4% |
| Strongly disagree | 41.5% |
| Slightly disagree | 30.2% |
| Slightly agree | 6% |
| Strongly agree | 1.3% |
| Totally agree | 0.6% |
| **Environmental Consideration** | |
| Totally disagree | 0.5% |
| Strongly disagree | 1.3% |
| Slightly disagree | 7.7% |
| Slightly agree | 39.1% |
| Strongly agree | 31.6% |
| Totally agree | 19.8% |
| **Taste (%)** | 15.2% |
| **Financial considerations (%)** | 58.2% |
| **Limited access (%)** | 3.1% |
| **Presentation (%)** | 9.8% |
| **Visitors (%)** | 26.1% |

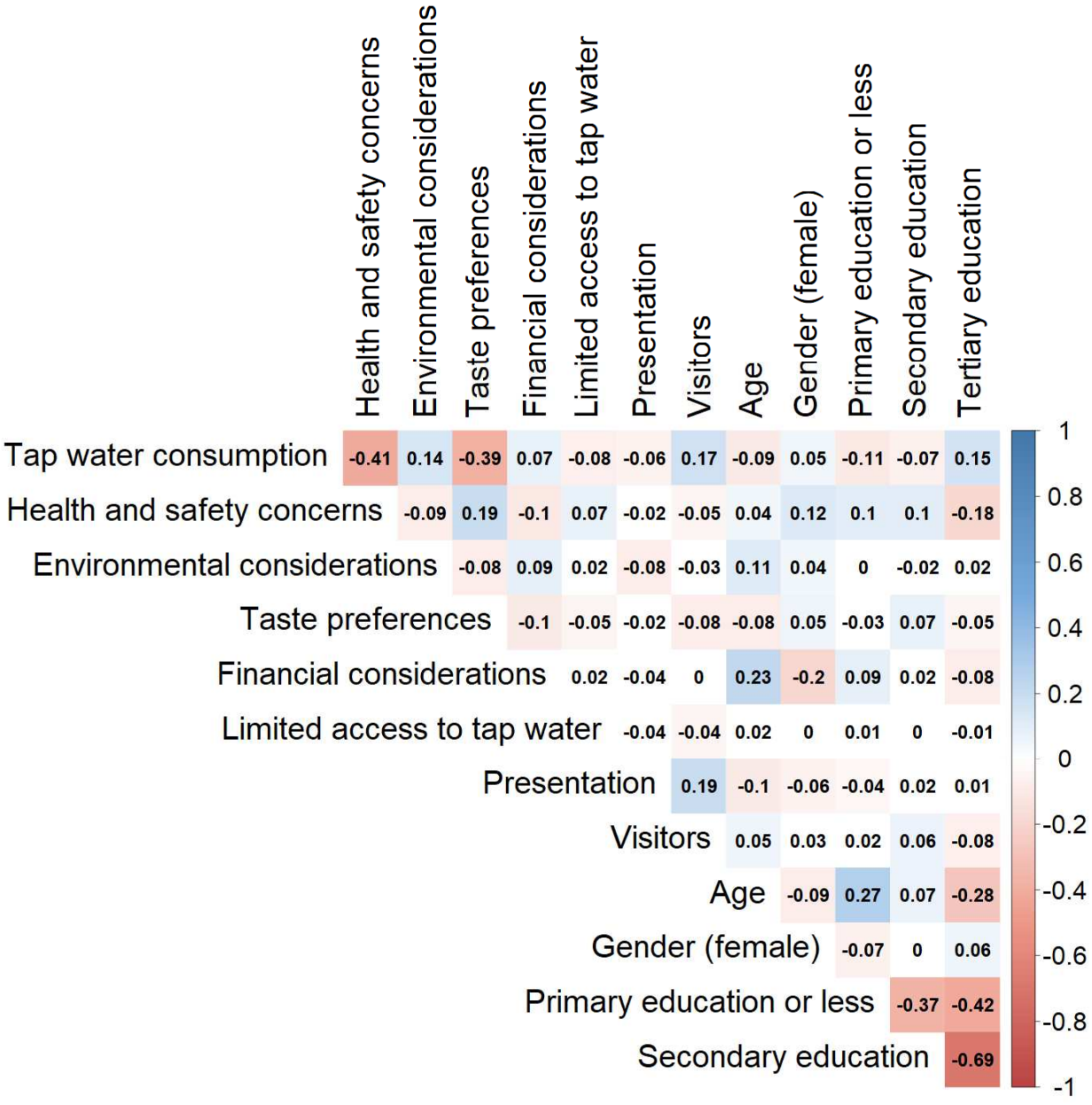
Descriptive statistics for the variables used in the questionnaire, excluding sociodemographic factors (cf. Table 1).

**Table 2. Descriptive statistics**

| Direct effects | Health and safety | Taste | Limited Access | Presentation | Visitors |
|---|---|---|---|---|---|
| **Health and safety** | - | 0.281*** | - | - | -0.109** |
| **Taste** | 0.281*** | - | - | - | -0.221*** |
| **Limited Access** | - | - | - | - | -0.190* |
| **Presentation** | - | - | - | - | 0.384*** |
| **Visitors** | -0.109** | -0.221*** | -0.190* | 0.384*** | - |

Illustration of covariances between the mediating variables in the path model. Empty cells indicate the absence of covariance in the model. For significance, the following standards were applied: *p<0.05; **p<0.01; ***p<0.001

**Table 3. Path model: covariances**




740

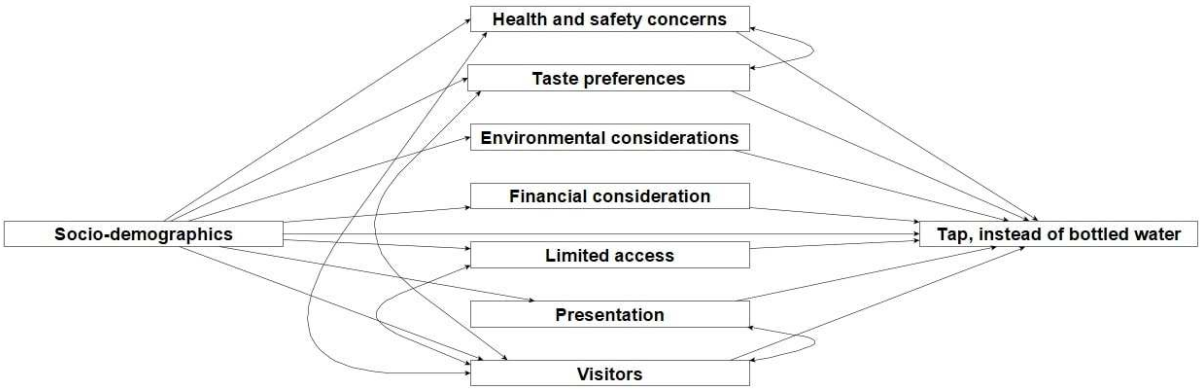
741 Full correlation matrix i.e. spearman correlations between all variables included in the analysis. Darker cells
742 indicate a stronger relationship between two variables. White cells indicate a non-significant relationship (p-value
743 > 0.05).

744 **Figure 1. Full correlation matrix**

745


First path model used. At the dependent level, water type consumption is measured. At the independent level, the explanatory variables are measured, including sociodemographic characteristics that function as fully exogenous factors and mediating factors that explain water type consumption while being explained by sociodemographic characteristics at the same time. Fit statistics: $\chi^2$ = 234.36, p < 0.001; CFI = 0.66; SRMR = 0.079; RMSEA = 0.066).

**Figure 2: First path model**

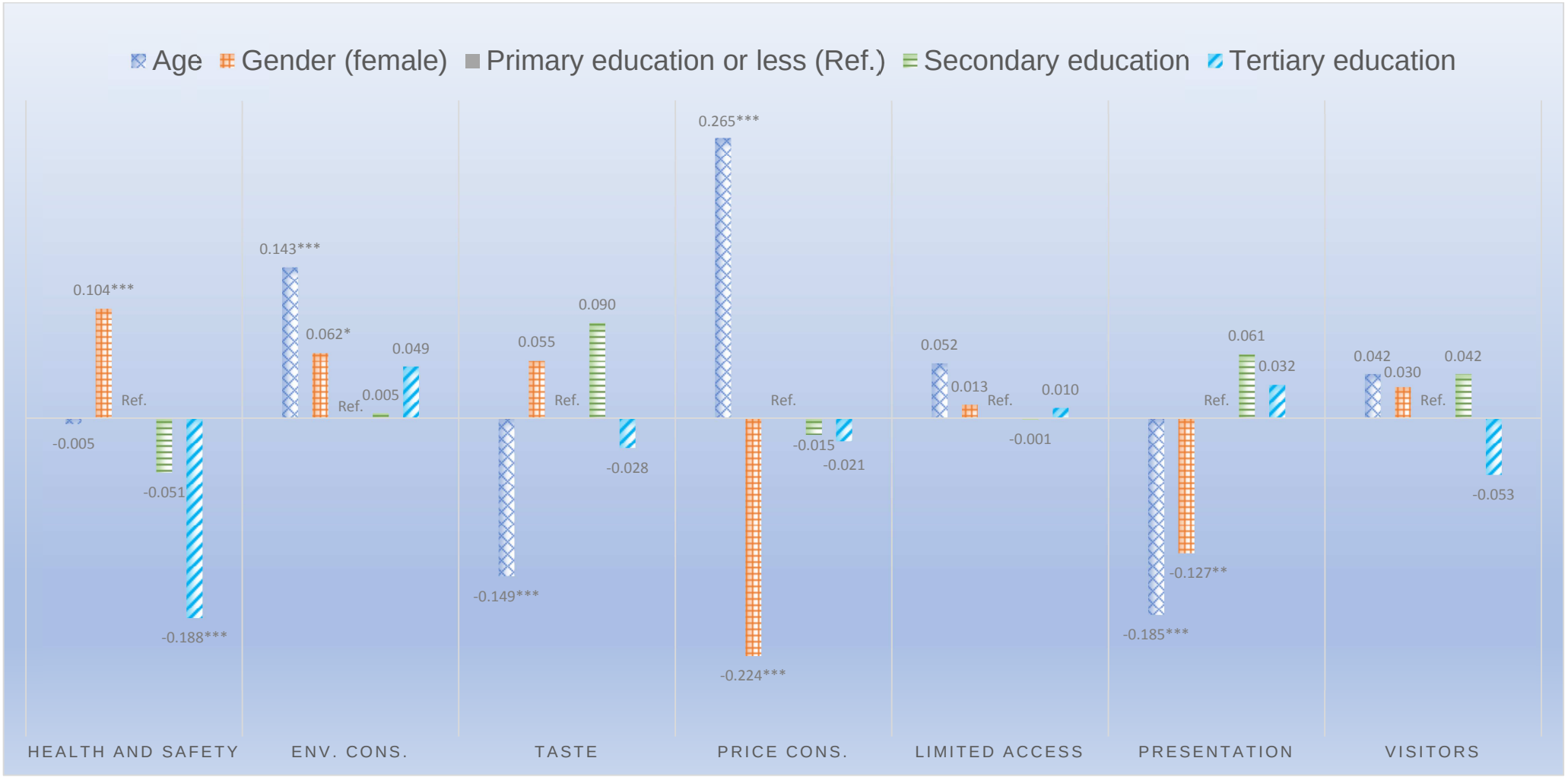



Secondary path model used. At the dependent level, water type consumption is measured. At the independent level, the explanatory variables are measured, including sociodemographic characteristics that function as fully exogenous factors and mediating factors that explain water type consumption while being explained by sociodemographic characteristics at the same time. Additionally, some covariance between mediating variables is included, as depicted by bidirectional arrows. Fit statistics: $\chi^2$=78.83, p<0.001; CFI=0.90; SRMR=0.049; RMSEA=0.041

**Figure 3: Secondary path model**


Direct effects i.e. regression coefficients from the independent variables on water type consumption. For significance, the following standards were applied: *p<0.05; **p<0.01; ***p<0.001

**Figure 4. Path model: direct effects**




Indirect effects i.e. regression coefficients from the sociodemographic variables on the different mediating variables. For significance, the following standards were applied: *p<0.05; **p<0.01; ***p<0.001

**Figure 5. Path model: indirect effect**

## Highlights

- This study addresses the main reasons why people consume bottled or tap water
- Despite environmental and financial considerations, bottled water is popular
- This is partly caused by negative evaluations of the safety and taste of tap water
- The broader social context inhibits the consumption of tap water
- Water type consumption is partly determined by socio-demographics

**Declaration of interests**

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: