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Differences in water consumption choices in Canada: the role of socio-demographics, experiences, and perceptions of health risks

Diane Dupont, W. L. (Vic) Adamowicz and Alan Krupnick

ABSTRACT

In 2000 and 2001 Canadians were shocked by water contamination events that took place in two provinces. In 2004 we undertook an internet-based survey across Canada that asked respondents to identify in percentage terms their total drinking water consumption according to one of three sources: tap water, bottled water, and home-filtered water (either some type of container or an in-tap filter device). In this paper we investigate the factors that influence these choices and whether choosing to either filter or purchase water is linked to perceptions of health concerns with respect to tap water. A series of one-way analysis of variance (ANOVA) tests suggest that the presence of children in a household and self-reported concern that tap water causes health problems lead to significantly greater consumption of bottled water or filtered water and significantly less tap water consumption. In order to examine these choices in a multivariate framework, we estimate a multinomial logit model. Factors yielding higher probabilities of a respondent being primarily a bottled water drinker (relative to the choice of tap water) include: higher income, unpleasant taste experiences with tap water, non-French-speaking, and being a male with children in one's household. Similar factors yield higher probabilities of a respondent being primarily a filtered tap water drinker. An important finding is that two key variables linking a person's health perceptions regarding tap water quality are significant factors leading to the choice of either filtered tap water or bottled water over tap water. They are: a variable showing the degree of health concerns a respondent has with respect to tap water and a second variable indicating whether the respondent believes bottled water is safer than tap water.

Key words | bottled water, consumption choices, health concerns, home water treatment, public perceptions, tap water

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INTRODUCTION

After many years of being taken for granted by the general public in Canada, the quality of municipally supplied drinking water came to the forefront of both public and government awareness as a result of the outbreaks of waterborne diseases in Walkerton, Ontario, (2000) and North Battleford, Saskatchewan (2001): *E. coli* O157:H7 contamination in Walkerton, Ontario in 2000 caused seven deaths, close to 100 hospitalizations, and many people experienced less severe symptoms. The North Battleford, Saskatchewan event in 2001 was caused by an outbreak of cryptosporidiosis which infected 6,500 but did not cause any deaths.

Events in these communities served to highlight the importance of understanding the link between the environment, human health, and water quality. One outcome was the development of a position paper in 2002 by the Canadian Council of Ministers of the Environment (CCME) advocating the employment of an integrated multi-barrier

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approach to ensure water quality from "source to tap". The report urged involvement from multiple stakeholders, including all levels of government (federal, provincial and municipal), as well as industry, non-governmental agencies and the general public.

What these events also underscored is the necessity of undertaking research into public concerns, particularly those pertaining to health, as they relate to the public's tap and bottled water preferences and determinants (Doria 2006). There have been only a few efforts in the past to shed light on these matters. What these studies have revealed, however, is that large (and growing) numbers of the public have chosen to consume substitutes for their tap water: in the form of either home-filtered tap water or as purchased bottled water (Health and Welfare Canada 1983; Auslander & Langlois 1993; Levallois *et al.* 1999; Abrahams *et al.* 2000). This is confirmed by a Statistics Canada (2002) report showing that bottled water sales rose at an annual rate of about 9% over the period 1995–2000. Over the more recent period of 2000–2003, Zenith International and Beverage Marketing Corporation has published statistics showing that the total value of bottled water sales in Canada have almost doubled (from 310 to 650 (USD) million) with volume up from 820 to 1,490 million litres (International Council of Bottled Water Associations 2004).

Two recent papers in this journal (Jones *et al.* 2006; Pintar *et al.* 2009) surveyed consumers in two different medium sized communities in Ontario, Canada–Hamilton and Kitchener-Waterloo–and found that between 27 and 34% of respondents could be classified as primarily bottled water users (75% or more of total daily consumption) and 49% reported using some form of home filtration device. A cross-Canada survey undertaken by Statistics Canada in 2007 (Statistics Canada 2009) found similar results: almost 3 out of every 10 households drank bottled water predominantly and around 50% of Canadian households treated their tap water with some type of home filtration device. Many factors might help to explain the choices made by these households (Dietz *et al.* 1998). For example, heterogeneity of preferences arising from socio-demographic characteristics is likely to be an important determining factor. Jones *et al.* (2006) found evidence of age differences associated with consumption of bottled water but did not find support for income or education factors. They speculated that other considerations - such as perceptions, views, beliefs, and experience - might dictate choices and argued that it would be important to examine the roles played by these factors. While Statistics Canada (2009) did not examine the relationship between these types of perception and experience motivations and bottled water purchases, the report noted that removal of chlorine, metals and minerals, as well as concerns about possible bacterial contamination, e.g. from *E. coli*, *Cryptosporidium*, or *Giardia*, appeared to be important factors in the decision to filter one's home tap water. Previous research suggests that aesthetics (taste and smell) and convenience might be just as important to consumers as the perception that bottled water is somehow safer than tap water (Grondin *et al.* 1996; Jardine *et al.* 1999; Levallois *et al.* 1999; Abrahams *et al.* 2000; Doria 2006; Jones *et al.* 2007). Statistics Canada (2009), for example, asked respondents to categorize their motivations for filtering or treating tap water at home. Approximately 43% of respondents indicated that they did so to remove possible bacterial contamination, while 58% indicated that they preferred the taste/smell of home-filtered water.

This paper provides a response to Doria's (2006) call for more research on bottled and tap water preferences and determinants and contributes to the literature in a number of ways. First, it reports on the drinking water choices of a representative national sample of Canadian households. Survey respondents were asked about three sources for home drinking water consumption: tap water, home filtered tap water and bottled water. In addition to providing information for Canada, as a whole, the data allow us to identify similarities/differences in these choices across four main geographic regions: West, Ontario, Quebec, and Atlantic. This yields an overall picture of water consumption in Canada that expands beyond the work of Jones *et al.* (2006) and Pintar *et al.* (2009). Second, the paper examines the association between these three drinking water choices and demographic characteristics of the respondents in each of these regions. Third, the paper integrates socio-demographic factors with additional information on self-reported experiences of common "problems" of tap water (such as unpleasant smell and taste), beliefs about the risks of bacterial contamination for tap water, and perceptions of tap water quality, in a multinomial logit

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model to explain the probabilities of a respondent choosing to be either a filtered or bottled water drinker rather than a tap water drinker.

The next section gives a brief description of the survey from which these data are taken. The following section discusses methods used to examine factors that are associated with respondents' water consumption from the three sources: tap, filtered tap water, and bottled water. In the fourth section we report our empirical results and in the fifth section we discuss key findings. The paper concludes with some implications arising from the results that can inform a water and health policy dialogue. Specifically, our results show that a majority of survey respondents believe that bottled water is safer than tap water and that health concerns are a key component to better understanding water consumption choices made by the public. Ironically, this is occurring at the same time as a number of municipalities are enacting legislation to ban the sale of bottled water in public places. Insofar as these government efforts lead to much needed and publicised reinvestment in public water infrastructure, perceptions may change and the public interest may be served.

SURVEY DATA

Survey administration

During the summer of 2004 we conducted an internet-based survey using a secure on-line website administered by Ipsos-Reid, a marketing and public research firm. The survey was developed after extensive focus group testing in various Canadian cities during 2002 and a pre-test in December 2003, and employed the current best practices of internet survey design (Dillman 1999). In order to meet our request to have approximately 1,600 completed responses with cross-Canada representation, Ipsos-Reid sent out 4,563 email invitations to a random sample of its panel of internet users. The panel consists of over 100,000 members who have been recruited to the panel primarily over the telephone using random digit dialling. After initial contact, the Internet panel is constantly maintained and updated. Non-active members are removed from the panel and membership is continuously refreshed through a double opt-in process. Incentives for survey completion are points that can be exchanged for vouchers. Panel members are not told the topic until they enter the survey site and pass the screening questions. (For our survey, this was whether the respondent was on a municipal water supply system). The composition of the panel reflects an accurate, balanced representation of internet-enabled Canadians. Nevertheless, we make no claim that the survey is representative of all Canadians as it is estimated that for 2005 32% do not have access to an internet connection from any location (Statistics Canada 2008). To the extent income and education drive whether a given household has such a connection and these factors tend to favor drinking bottled or treated water, our results probably overestimate the use of these options for the general public.

An individual 18 or older in the household with the next upcoming birthday was requested to complete the survey. Respondents answered surveys in their choice of either French or English. Free and informed consent of the participants was obtained and the study protocol was approved by the Research Ethics Boards at the University of Alberta, Edmonton, Alberta, Canada, and Brock University, St. Catharines, Ontario, Canada, File No. 02.330, July 2003. We had 2,520 respondents begin the survey and 1,633 completed it. Four hundred and nineteen individuals quit the survey before completion. In addition, 466 responses were deemed ineligible since we did not include respondents on septic systems. Two responses were deleted due to errors caused when the Ipsos-Reid server went down. It is reasonable to assume that ineligibles are found in the same proportions to those contacted as to those responding ($466/2{,}520 = 18.5\%$). The survey response rate of 35.8% is similar to other Canadian surveys on water consumption and health (Pintar *et al.* 2009).

A number of alternative approaches for undertaking surveys exist including telephone, mail, and in-person methods. While in-person surveys may be seen as providing the most accurate and complete responses, they are very costly to administer. Telephone surveys must be very short and simple in order to maintain interest. Mail surveys tend to generate the same response rates as Internet surveys (Dillman 1999), however, mail surveys may be subject to self-selection bias if the respondent chooses not to answer the survey after viewing it. The internet approach was chosen for the following advantages: visual presentation

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of questions, the ability of the researcher to control the order in which respondents answer the survey, and the speed of data retrieval.

Data collected

The questionnaire elicited information from respondents about their consumption of water from three sources described to them as: water direct from the tap, home treated tap water (either filtered or boiled in the home), and purchased water (either bottled or from home delivery). Respondents were asked to indicate the percentage of water that they personally consume at home from each of the three sources. In addition, the survey asked respondents to indicate the type of water filtration or treatment systems that they use in their homes. A second set of questions told respondents to consider only their tap water and to indicate whether they had experienced rusty water, sedimentation, unpleasant tastes and smells in their tap water (these factors were identified by respondents who participated in our focus groups as important ones). Next, respondents were asked to indicate whether they had heard about the presence of certain items in their tap water and separately whether any of these had been of special concern in their community (the questions read as follows: "For each of the following items that may be present in a household's tap water, please indicate if you have heard about it as a concern with drinking tap water and if any of these items have been a special concern in your community." The list of items included: *E. coli.*, *Cryptosporidium*, *Giardia*, Trihalomethanes, fluoride, pesticides, and metals). They were also asked to indicate which of four different statements best reflected their personal opinion about health concerns relating to their tap water: drinking tap water does not pose a problem for my health or my family's health; drinking tap water poses a minor problem for my health or my family's health; drinking tap water poses a moderate problem for my health of my family's health; and drinking tap water poses a serious problem for my health or my family's health. Finally, we queried whether they thought their tap water had made anyone in their household sick and whether they had health conditions (e.g. food allergies and/or stomach ulcers) that might give rise to concerns about tap water quality.

Information about a number of socio-demographic variables was requested of respondents. This information included: gender, age (in years), highest level of education attained, household income, province, and whether there were children in the household. Since survey respondents were drawn from an internet-panel across Canada, we were able to obtain a proportional sample of responses from the provinces. Table 1 shows the percentage of respondents in our dataset in each socio-demographic category both across Canada and in each of four regions: West (combining British Columbia, Alberta, Saskatchewan, and Manitoba), province of Ontario, province of Quebec, and Atlantic (combining Nova Scotia, New Brunswick, Newfoundland, and Prince Edward Island).

Since the data are proportional to the actual population in Canada the majority of observations come from the two central provinces. The table shows that socio-demographic characteristics were very similar across the four regions, with the exception of slightly lower income levels and slightly lower completed education levels for respondents in the Atlantic region.

METHOD

Our goal in this paper is to determine the factors that are important for the drinking water choices of our representative sample of Canadian households. We use our survey data in an empirical model to examine the factors that either increase or decrease the probability of respondents choosing to use filtered tap water and bottled water over tap water. These factors include socio-demographic variables, as well as self-reported water quality experience variables and a number of variables pertaining to perceptions of water quality as they relate to health considerations. Our empirical analysis proceeds in two stages. First, we examine the independent associations between water consumption choices and a number of explanatory factors as noted above through a series of univariate ANOVA tests. In each case the hypothesis is that for each of the three types of water the mean percentage chosen is the same for all Canadians, regardless of socio-economic variables, experiences, health concerns, and perceptions. This approach has two challenges. The first is that water

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Table 1 | Percentages of survey respondents (compared to population percentages in parentheses) by socio-demographic characteristics and region

	Canada	West	Ontario	Quebec	Atlantic
Age					
19–29	14 (18)	14 (19)	13 (18)	16 (18)	16 (16)
30–39	18 (18)	18 (18)	20 (18)	17 (16)	12 (16)
40–64	53 (47)	52 (46)	51 (46)	54 (48)	57 (49)
65 and over	15 (18)	16 (17)	16 (18)	13 (18)	16 (19)
Highest level of education					
High school or less	28 (25)	29 (26)	25 (26)	30 (21)	37 (23)
University/college	72 (75)	71 (74)	75 (74)	70 (79)	63 (77)
Household income ($CAN 2004)					
Under 29,999	27 (26)	26 (25)	28 (22)	25 (30)	30 (31)
30,000–54,999	27 (25)	30 (25)	24 (23)	26 (28)	36 (34)
55,000–99,999	31 (30)	28 (30)	33 (31)	34 (28)	34 (23)
Over 100,000	15 (19)	16 (20)	15 (24)	15 (14)	0
Gender					
Female	48 (52)	48 (51)	47 (52)	48 (52)	51 (52)
Male	52 (48)	52 (49)	53 (48)	52 (48)	49 (48)

consumption choices are likely to arise from combinations of a number of individual factors. ANOVA analysis that focuses upon individual univariate measures may be confounded by the presence of other important factors. The second is that our water consumption variables are percentages whose total sums to 100. A univariate analysis does not allow for jointness in choices. For these reasons, in the second stage we analyze water consumption choices by employing a multinomial logit model.

The multinomial logit model is used in situations where an individual (i) can make a choice (j) from more than two mutually exclusive alternatives (where J is the set of alternatives; this is three in our case). Conditional upon an individual's socio-demographic characteristics, perceptions, experiences, etc., we define in Equation (1) the probability (π_{ij}) of individual i choosing a particular water type alternative j. In this equation the explanatory variables are represented by the vector, X, and the coefficients to be estimated are the βs. The price of bottled water is an important explanatory variable; however, our survey did not collect information on this variable. It is difficult to ascertain the actual cost of a bottle of water to an individual given that bottles can be purchased individually, as well as by the case. *A priori*, we expect income levels to be positively correlated with increasing bottled water consumption given the high costs of purchasing this source of water; in some areas, the cost per cubic metre for bottled water is 1,000 times that of municipally supplied water. For the United States, this number might be even higher. The Natural Resources Defense Council (1999) report to the FDA shows research indicating that the price per gallon for bottled water (relative to tap water) could reach from 240 to 10,000 times greater.

$$\pi_{ij} = \frac{e^{\beta_j' X_i}}{\sum_{j=0}^{J} e^{\beta_j' X_i}} \tag{1}$$

In our case, we are interested in the choices respondents make between consuming primarily tap water, primarily bottled water or primarily filtered water. We classify a respondent as choosing to be primarily a tap, filtered or bottled water drinker if he/she consumes 75% or more of that type of water. This corresponds to the definition used in Jones *et al.* (2006). This gives us 552 respondents who fall into the primarily tap category, 562 who fall into the primarily filtered category, and 223 who fall into the primarily bottled water category with

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the remainder 296 having no particular or predominant preferences over their water choice. They represent 18% of the sample of respondents, which is similar to the finding of Pintar *et al.* (2009) that 14% of their sample drank both tap and bottled water.

Given the observed choices of the N respondents in our sample, we define in Equation (2) the log of the likelihood function. This is the joint probability distribution of the data, expressed as a function of the parameters (the βs). Estimation proceeds by maximizing Equation (2) through choice of the βs. The econometrics package NLOGIT is used (Greene 2008).

$$\mathrm{LLF} = \sum_{i=1}^{N} \sum_{j=0}^{J} d_{ij} \ln \pi_{ij} \tag{2}$$

where $d_{ij} = 1$ if individual i chooses alternative j and 0 otherwise.

RESULTS

We present three sets of results in this section: information on water consumption choices for the respondents in our sample, information on self-reported water quality experience and perception variables and how these are related to water consumption choices, and estimated coefficients from the multinomial logit model that incorporates all factors simultaneously.

Water consumption choices

Table 2 presents data on the self-reported percentage of total drinking water consumption from each of the three sources (tap water, home treated (filtered or boiled) tap water, and bottled water). This information is presented in a number of ways: for the average respondent in Canada and for the average respondent in each of the four regions. As well, the table presents these consumption percentages

Table 2 | Percentage water consumption choices across Canada and by region for overall sample and by two selected socio-demographic characteristics

	Canada		West		Ontario		Quebec		Atlantic	
	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)
Tap consumption	1,633	38 (42)	515	38 (42)	624	34 (40)	411	46 (43)	83	37 (44)
Filtered consumption	1,633	40 (41)	515	42 (42)	624	41 (40)	411	36 (41)	83	43 (42)
Bottled consumption	1,633	22 (31)	515	20 (32)	624	25 (32)	411	19 (27)	83	20 (30)
Tap consumption by education level										
High school or less	459	33 (41)	147	33 (40)	158	29 (38)	123	40 (44)	31	30 (41)
University/college	1,163	41 (42)	364	41 (43)	463	36 (40)	284	49 (43)	52	42 (46)
Filtered consumption by education level										
High school or less	459	46 (42)	147	45 (43)	158	47 (41)	123	43 (42)	31	54 (40)
University/college	1,163	38 (41)	364	40 (42)	463	39 (40)	284	32 (40)	52	36 (42)
Bottled consumption by education level										
High school or less	459	21 (30)	147	23 (33)	158	24 (32)	123	16 (24)	31	16 (25)
University/college	1,163	22 (31)	364	19 (31)	463	25 (32)	284	20 (29)	52	23 (33)
Tap consumption by presence of children										
No	1,096	39 (42)	338	38 (43)	408	36 (40)	286	46 (43)	64	42 (45)
Yes	537	36 (41)	177	39(42)	16	30 (38)	125	46 (44)	19	21 (38)
Filtered consumption by presence of children										
No	1,096	42 (42)	338	45 (43)	408	43 (41)	286	36 (41)	64	38 (41)
Yes	537	37 (40)	177	35 (40)	216	38 (39)	125	34 (41)	19	59 (41)
Bottled consumption by presence of children										
No	1,096	19 (29)	338	17 (29)	408	21 (30)	286	18 (27)	64	20 (31)
Yes	537	27 (34)	177	26 (35)	216	32 (35)	125	20 (29)	19	19 (27)

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when we break the sample down according to two selected socio-demographic characteristics: highest level of education (high school or less versus university/college) and the presence/absence of children in a household. These two factors are chosen for presentation of results because they illustrate the range of values observed for mean percentage consumption of tap water and bottled water in the sample. Consumption percentages according to a number of other socio-demographic variables including a respondent's age, income, and health circumstances (as defined by the presence/absence of stomach ulcers and/or food allergies) are available upon request from the authors but are not presented here in the interests of space. They show some differences such as higher tap water consumption among older people in Ontario and the West but lower tap water consumption for the same group for residents of Quebec. In addition, increases in household income and being female are associated with increasing bottled water consumption. However, these consumption percentages are not significantly different from the overall sample averages presented in Table 2.

A comparison of the first three rows shows that, for the average respondent in our sample, mean tap water consumption is 38% of total drinking water consumption, while filtered is 40% and bottled is 22%. We conduct a number of one-way ANOVA tests for the null hypotheses that mean percentages for each type of water are equal across the four regions. Statistical Package for the Social Sciences (SPSS) was used for these tests. Accuracy of the test statistics assumes a normal distribution. The p-values are adjusted by the number of tests undertaken for a given dependent variable. The use of ANOVA in this context may give rise to concerns about the lack of independence in choices in the sense that the percentages of water consumption choices add up to 100 (the multinomial logit model, on the other hand, accounts for jointness and is, therefore, preferred). The only significant differences in the mean percentage of tap water consumed for the sample as a whole are for Ontario and Quebec ($p = 0.000$) and the West and Quebec ($p = 0.046$). Thus, our data show, for example, that 46% of water consumed at home by a Quebec resident is tap, while the comparable number for an Ontario resident is only 34%. There are no significant differences in filtered water consumption by region across the whole sample. However, there is a significant difference in the percentage of bottled water consumption between Ontario and Quebec. Bottled water consumption at 25% in Ontario is significantly greater than Quebec's 19% ($p = 0.012$).

It is difficult to compare the results from these data with that of Statistics Canada (where 1 in 3 people reported drinking bottled water and 50% claimed to treat their water by either filtering or boiling) since in the latter less informative questions were asked. For example, the Statistics Canada survey asked "what type of water does your household primarily drink at home" and gave respondents the following choices: tap, bottled or both tap and bottled. Unfortunately, respondents were not asked to specify the extent to which the tap water was home filtered. Moreover, respondents were not given a specific number intended to represent "primarily". Respondents obviously could interpret this as being a number from 51 to 100%. Our data collection process required respondents to state the percentages of home water consumption from each of the three sources (unfiltered tap, filtered tap, and bottled). It further required the answers to sum to 100% before allowing respondents to proceed to the next question.

As noted above, we also present data in Table 2 on percentage consumption choices broken down according to two selected socio-demographic variables. First, to the extent that parents are concerned for the health of their children and perceive higher health risks from tap water, then we would expect increasing reliance upon the two alternatives to tap water (Teal & Loomis 2000; Dupont 2004). We find support for this hypothesis. The presence of children in a household appears to be a significant factor for decreasing tap water consumption for residents in Ontario relative to Quebec ($p = 0.005$) and for Maritimes residents relative to Quebec ($p = 0.067$). Moreover, the data also suggest that the presence of at least one child in a household is a significant factor in encouraging a greater reliance on bottled water in Ontario relative to Quebec ($p = 0.000$) and in the West relative to Quebec ($p = 0.046$). The gap is the biggest in Ontario, with households where there are children consuming 32% of total water in the form of bottled water while childless households consume only 21% ($p = 0.001$) of their total as bottled water.

The second breakdown presented in Table 2 looks at water consumption according to educational attainment.

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Table 3 | Percentage of respondents with poor water quality experiences and health/safety concerns regarding tap water

	Canada (*N* = 1,633)	West (*N* = 515)	Ontario (*N* = 624)	Quebec (*N* = 411)	Atlantic (*N* = 83)
Rusty colour in water	14	13	13	15	22
Sediment in water	14	19	13	7	22
Unpleasant smell	33	36	38	22	34
Unpleasant taste	31	35	32	23	33
E. coli is specific concern in my community	16	8	13	29	22
Cryptospordium is specific concern in my community	6	7	4	10	6
Giardia is specific concern in my community	6	7	3	9	6
Someone has become sick from drinking home tap water	5	4	3	9	4
Overall degree of health concern for tap water					
Tap water poses no problem for health	62	61	56	72	61
Tap water poses minor problem for health	23	24	26	19	19
Tap water poses moderate problem for health	12	11	15	9	16
Tap water poses serious problem for health	3	4	4	1	4
Belief that bottled water is safer than tap water (entire sample)					
Women in sample	59	60	59	55	65
Men in sample	48	46	49	48	43

Respondents with lower levels of formal education have much higher filtered water consumption levels. This may arise because less educated individuals are older, although we find limited support for increasing age being related to using filtered tap water (Quebec alone). Alternatively, individuals with a lower level of education may be less able to independently assess health risks and, therefore, may be more influenced by health claims made about home water filtration devices. These differences appear to be substantial (e.g. for the Atlantic region, respondents whose highest level of education is high school consume on average 54% filtered water compared with 36% for a respondent who has achieved a higher level of education); however, given the small sample size, these differences are not significant ($p = 0.540$).

Experiences with tap water and role of perceptions for water choices

In addition to querying survey respondents on their water consumption choices, we asked them to provide answers to a number of questions designed to examine the extent to which they have experienced water quality problems and their perceptions about the relationship between water quality and health. Table 3 presents this information for Canada, as a whole, and for each of the four regions. We note first the percentages of respondents in our survey who report having experienced rusty water and sediment. Such occurrences appear relatively frequently across Canada, particularly for the Atlantic region. Unpleasant taste and smell problems occur for 1 in 3 respondents in the survey in all areas with the exception of Quebec (1 in either 4 or 5), which it may be recalled, had the highest rate of tap water use.

The rest of Table 3 reports on answers that respondents gave to a number of questions designed to help us understand the linkage that may exist between perceptions regarding water and self-reported health concerns. Given the much publicized outbreak of *E. coli* in tap water in Walkerton, it is not surprising in this study that many Canadians (15%) indicate that they believe this contaminant to be a problem for their community; however, fewer recognize *Cryptosporidium* and *Giardia*. Almost 5% of respondents (particularly those in Quebec) answered yes to the question: "To the best of your knowledge, have you or has anyone in your household ever become sick from drinking the tap water in your home?". Using responses to

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our 4-point Likert scale question on tap water and health concerns, Table 3 shows that 38% of respondents indicated that they perceived some degree of problem, and 15% of respondents indicate it to be a moderate to serious problem. Residents of Ontario and the Atlantic provinces are more inclined to express a greater degree of concern for their health from drinking tap water than do residents elsewhere. Quebecers, on the other hand, in spite of their past self-reported negative experiences with tap water do not appear to have translated these experiences into an elevated degree of concern about health.

Previous literature suggests women may be more aware of the connection between the environment and health than men (Stern *et al.* 1993; Bord & O'Connor 1997). In order to examine this further, we split our sample by gender to see whether there was any difference in views about the safety of bottled water versus tap water. The responses by gender are included in Table 3. For Canada, as a whole, 59% of the women said bottled water was safer compared with 48% of the males and this difference was significant ($p = 0.000$). The scale of this difference was repeated in every region with the biggest difference arising in the Atlantic Provinces where 65% of women felt bottled water was safer while 43% of men agreed with this ($p = 0.044$). These female–male differences were significant in every region but Quebec ($p = 0.115$).

Tables 4 and 5 are designed to illustrate how selected variables pertaining to water quality experiences and degrees of concern may give rise to differences in mean percentages of consumption for each of the three types of water. We have correlated these consumption choices against a large number of factors that might contribute to differences but do not report them in this paper in the interests of space. They are available from the authors. The items chosen for reporting are the ones exhibiting the biggest ranges of differences in percentage choices. Table 4 reveals that the mean percentage of tap water consumption for a respondent who experienced rusty water varies from 23% (for an individual in the Western provinces) to 35% (for an individual living in Quebec), although this is not a significant difference. Similarly, mean tap water consumption as a percentage for individuals reporting sediment, unpleasant taste and smell events varies across the entire sample of respondents, with the values for people

Table 4 | Percentage water consumption choices according to selected poor water quality experiences

	Canada (N = 1,633)		West (N = 515)		Ontario (N = 624)		Quebec (N = 411)		Atlantic (N = 83)	
	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)	# obs.	Mean (st. dev.)	# obs.	Mean (st. dev.)
Tap water consumption when experience rusty water	225	29 (38)	66	23 (36)	78	29 (38)	63	35 (41)	18	25 (36)
Filtered water consumption when experience rusty water	225	43 (40)	66	46 (42)	78	40 (39)	63	40 (39)	18	51 (38)
Bottled water consumption when experience rusty water	225	28 (34)	66	30 (39)	78	31 (36)	63	24 (28)	18	23 (26)
Tap water consumption if *E. coli* is specific concern in community	258	35 (41)	42	24 (37)	79	27 (38)	119	43 (43)	18	43 (47)
Filtered water consumption if *E. coli* is specific concern in community	258	39 (40)	42	53 (43)	79	37 (38)	119	36 (39)	18	33 (43)
Bottled water consumption if *E. Coli* is specific concern in community	258	26 (34)	42	23 (35)	79	36 (38)	119	22 (28)	18	24 (36)
Tap water consumption if believe someone became sick from tap water	76	25 (36)	18	25 (34)	17	11 (24)	38	32 (40)	3	10 (17)
Filtered water consumption if believe someone became sick from tap water	76	37 (38)	18	29 (38)	17	45 (40)	38	36 (38)	3	52 (22)
Bottled water consumption if believe someone became sick from tap water	76	39 (36)	18	46 (43)	17	44 (39)	38	32 (32)	3	38 (28)

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Table 5 | Percentage tap and bottled water consumption choices according to gender and health concerns

	Canada (*N* = 1,633)		West (*N* = 515)		Ontario (*N* = 624)		Quebec (*N* = 411)		Atlantic (*N* = 83)	
	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)	# Obs.	Mean (st. dev.)
Tap water consumption if believe bottled water is safer than tap water										
Males in sample	401	27 (36)	123	22 (32)	159	26 (36)	102	32 (39)	17	39 (46)
Females in sample	464	28 (36)	150	31 (38)	176	20 (31)	110	37 (38)	28	28 (38)
Bottled water consumption if believe bottled water is safer than tap water										
Males in sample	401	29 (34)	123	32 (37)	159	30 (34)	102	26 (31)	17	27 (38)
Females in sample	464	35 (35)	150	33 (37)	176	39 (36)	110	30 (30)	28	32 (34)
Tap water consumption if believe:										
Tap water poses no problem for health	1,008	47 (44)	315	47 (44)	347	43 (42)	295	52 (45)	51	46 (46)
Tap water poses serious problem for health	51	12 (28)	19	15 (34)	27	7 (21)	2	45 (64)	3	10 (17)
Bottled water consumption if believe:										
Tap water poses minor problem for health	1,008	15 (25)	315	14 (26)	347	17 (26)	295	15 (25)	51	7 (14)
Tap water poses serious problem for health	51	52 (42)	19	51 (45)	27	55 (42)	2	38 (53)	3	43 (25)

having taste problems showing the widest range in percentages of tap water consumption. Specifically, for those individuals having experienced unpleasant taste events, mean consumption of tap water in the Atlantic Provinces is only 16%, while it is 34% in Quebec. The *p*-value is 0.430.

When compared to the sample averages presented in Table 2, we see that tap water consumption is lower than the sample average of 38% and that bottled water consumption is higher than its sample average counterpart. Specifically, bottled water consumption for the average Canadian in Table 2 is 22% but this rises to 28% for an average Canadian who says she/he has experienced rusty water. However, these differences are not significant ($p > 0.250$). Similarly, the belief that someone in the family has become sick from drinking tap water acts as one might expect. Unfiltered tap water consumption falls to a low of 11% in Ontario and 10% in the Atlantic Provinces compared to a high of 32% in Quebec. In this case, the differences in mean percentage tap consumption are significant for the comparison between Ontario and Quebec only ($p = 0.086$). Finally, if respondents believe that *E. coli* is a specific concern in their community, then bottled water consumption in Ontario increases significantly more than for Quebec ($p = 0.023$) while tap water consumption decreases significantly for Ontario and the Western region relative to Quebec ($p = 0.046$ and $p = 0.043$, respectively). Interestingly, there are no significant differences across region and by experience in mean percentage of filtered tap water consumed.

Turning to the relationship between a respondent's expressed degree of health concerns from consumption of tap water and water drinking choices, we find across Canada and the regions that the greater the degree of concern ("tap water poses moderate or serious problems for health versus tap water poses no or minor problems"), the lower the percentage of tap water consumed and the higher the percentage of bottled water consumed. This is shown very clearly in Table 5 which shows the extent of the differences by presenting data for two extremes of respondents: those indicating that tap water poses no problem for health and those indicating that tap water poses a serious problem for health. For the sample as a whole the percentage of tap water consumed by someone who has no health concern is 47%. This falls to 12% for someone who indicates that tap water poses a serious problem for health. The *p*-value for this test for Canada and each region is $p = 0.000$. Corresponding to this fall in tap water consumption is an increase in bottled water consumption

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(to 52% for Canadians who believe tap water poses a serious health problem). Again, the p-values for tests of differences in mean bottled water consumption according to health concern are significant ($p = 0.000$) for Canada as a whole and by region. In the interests of space, we do not include the filtered tap water percentages. They show little variation across region and by expressed health concern and there are no significant differences in their values.

Table 5 also presents information on tap and bottled water consumption by gender from the subset of individuals who expressed the view that bottled water is safer than tap water. While Table 4 shows us that women tend to be more likely to believe that bottled water is safer, Table 5 shows that this translates into only small differences in mean consumption percentages but these are not significant ($p > 0.330$).

In summary, our data exhibit some regional differences in consumption patterns that may be tied not only to factors such as income, education, and gender but also to past experiences, beliefs and risk perceptions. However, the analysis to this point has used one-way ANOVA that focuses only on one factor at a time and does not control for other factors that may be influencing choices at the same time. We turn next to the results from the multinomial logit model that allows us to simultaneously examine all of the disparate influences that help to determine water consumption choices.

Multinomial logit analysis of drinking water choices

Each survey respondent is classified as being primarily either a tap, filtered or bottled water drinker if he/she consumes 75% or more of that type of water. We estimate the multinomial logit model described by Equations (1) and (2) to predict the probability of a respondent being in one of these three categories – we do not include the group of respondents who show no particular preference over one of the three types of water – using the econometric package NLOGIT (Greene 2008). The explanatory variables fall into several categories: socio-demographic characteristics, previous tap water experiences, and expressed concern regarding one's health and the quality of one's tap water. Our socio-demographic variables are: a binary variable to identify males, age, a binary variable to indicate that the respondent is educated beyond high school, household income, a binary variable to indicate whether there are children present in the household, the number of individuals in the household, a binary variable to indicate that the respondent is French speaking, and three binary variables to indicate whether the respondent lives in the province of Quebec, a Western province, or an Atlantic province, as well as two binary variables to indicate whether the respondent has food allergies and/or the respondent has stomach ulcers. In addition, we include a binary variable that interacts the binary variable indicating a male respondent with the binary variable indicating the presence of children in the household. The previous tap water experience variables are: a binary variable to indicate whether the respondent has experienced unpleasant tap water smells, another one for unpleasant tap water tastes, and a third for experience with rusty water. In addition, we have a binary variable to indicate that the respondent believes that someone in the household has become sick from drinking tap water. The variables that represent a respondent's health concerns with respect to tap water are: a binary variable to indicate whether the respondent has heard of *E. coli* (given the high profile of the Walkerton incident), the 4-point Likert scale variable designed to identify the degree of health concern, and a binary variable if a respondent has indicated that she/he thinks that bottled water is safer than tap water.

Results from the estimated model are presented in Table 6. The reference group is a tap water drinker and the reference individual lives in Ontario. The overall fit of the model is reasonable for cross-sectional data. The McFadden Psuedo R squared is 0.133 and the chi-squared statistic for the likelihood ratio test is 364.348 ($p = 0.000$). In addition, a number of the estimated coefficients are significantly different from zero at the 1% significance level or less.

An examination of the results shows that a number of socio-economic variables are important factors associated with either a decrease or an increase in the probability of a respondent choosing to be primarily a bottled water drinker or a filtered water drinker relative to the baseline of being a tap water drinker. A positive sign on the coefficient for a variable indicates that an increase in the value of the variable increases the probability of the respondent

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Table 6 | Multinomial logit model results (Ontario is referent respondent)

	Probability of being a filtered water user (compared to tap water)		Probability of being a bottled water user (compared to tap water)	
Explanatory variable	**Estimated coefficient**	**Estimated standard error (*p*-value)**	**Estimated coefficient**	**Estimated standard error (*p*-value)**
Number of people in household	−0.023	0.072 (0.750)	−0.094	0.099 (0.346)
Household income	0.471×10^{-6}	0.195×10^{-5} (0.809)	0.100×10^{-4}*	0.272×10^{-5} (0.000)
Educated beyond high school	−0.596*	0.165 (0.000)	−0.429	0.240 (0.073)
Age	0.002	0.005 (0.700)	−0.002	0.007 (0.776)
Quebec resident	0.172	0.259 (0.506)	0.296	0.366 (0.419)
Western Provinces resident	−0.060	0.153 (0.694)	−0.371	0.216 (0.087)
Atlantic Provinces resident	−0.041	0.290 (0.887)	−0.192	0.428 (0.654)
French speaking	−0.740*	0.250 (0.003)	−1.400*	0.380 (0.000)
Male	0.039	0.156 (0.805)	−0.392	0.243 (0.106)
Children in the household	−0.410	0.234 (0.080)	−0.085	0.316 (0.788)
Male × children in the household	0.651†	0.278 (0.019)	1.097*	0.381 (0.004)
Experienced unpleasant smell	−0.058	0.162 (0.723)	0.130	0.218 (0.551)
Experienced unpleasant taste	0.228	0.173 (0.188)	1.065*	0.222 (0.000)
Experienced rusty water	0.232	0.199 (0.245)	0.189	0.267 (0.479)
Someone in household sick from water	−0.043	0.229 (0.851)	0.037	0.276 (0.894)
Stomach ulcers	0.183	0.324 (0.573)	0.659	0.408 (0.106)
Have food allergies	0.077	0.195 (0.692)	−0.463	0.285 (0.104)
Heard of *E. coli*	0.014	0.143 (0.922)	−0.013	0.223 (0.953)
Health concern about tap water	0.506*	0.105 (0.000)	0.901*	0.126 (0.000)
Bottled water safer	0.455*	0.136 (0.001)	1.464*	0.214 (0.000)
Constant	−0.275	0.609 (0.651)	−3.244*	0.810 (0.000)

*Significant at 1% or less.
†Significant at 5% or less.

choosing one of the alternatives to tap water while a negative sign suggests a decrease in the probability. First, higher household income is significantly positively associated with an increased probability of being primarily a bottled water drinker but it does not have a significant impact upon the probability of being primarily a filtered water drinker. Our results also show that age, the number of people in a household, the existence of food allergies and/or stomach ulcers, and geographic location are not significant factors in the probability of choosing either bottled or filtered water over tap water. Second, individuals with a high school level of education or less are significantly more likely to be primarily filtered water drinkers. Third, French-speaking respondents are significantly less likely to be primarily either a filtered water drinker or a bottled water drinker than English-speaking respondents. Fourth, while there are no significant differences in the probabilities of being a filtered or bottled water drinker relative to being a tap water drinker amongst men and women without children, the presence of a child in a household significantly raises the probability of a man being primarily either a filtered water drinker or a bottled water drinker. Fifth, the previous experience variables are generally not significant factors with the exception of experience with unpleasant tap water tastes leading to a significantly higher probability of being primarily a bottled water drinker. Interestingly, there is no significant difference in choices amongst those who have heard about *E. coli* and those who have not.

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Finally, the two factors that stand out as being associated with significant increases in the probabilities of being either a filtered/bottled water user as compared to being a tap water user are the two health/water safety perception variables: the first asking respondents to state their personal opinion about health concerns with the tap water in their home and the second being the dichotomous choice variable identifying respondents who believe bottled water to be safer than tap. Individuals who express greater concerns about detrimental health impacts of tap water are significantly more likely to be either primarily a filtered water drinker or a bottled water drinker with p-values of 0.000. Similarly, individuals who believe that bottled water is safer than tap water have much higher probabilities ($p = 0.001$) of being either filtered or bottled water drinker. It is interesting to note that our results echo a finding by Doria *et al.* (2005) who estimate a model to explain the use of tap water to drink at home and find that the presence of bottled water as an alternative is the most important (and negative) factor.

DISCUSSION

Our national survey reveals geographic and socio-demographic differences and similarities across Canada with respect to water consumption choices, as well as past experiences with tap water problems. The data show, for example, that 1 in 5 residents of Ontario believes that tap water poses either a moderate or a serious problem for their own health and/or their family's health. Water consumption choices reveal that these residents on average consume greater proportions of tap water substitutes than residents in other regions.

In addition to presenting information on consumption choices, our paper reports on the results from a multivariate regression analysis. This reveals that a number of socio-demographic and health perception variables are important factors in either raising or lowering the probability of choosing filtered and/or bottled water compared to choosing tap water; our results are consistent with those found by other researchers using different methodologies. We find, for example, that, after controlling for all other factors, income is a significant factor in a respondent being primarily a bottled water drinker. Jones *et al.* (2006) observe a positive association between income and bottled water consumption but do not find it to be significant, possibly because other factors may be confounding the association. They do find support for age to be a significant factor in water choices in their sample, with younger people more likely to consume bottled water. In our results, after controlling for other influences, age is not a significant factor in changing the probability of consumption choices. Our findings with respect to the role of education mirror those of Janmaat (2007)'s survey of 319 respondents in Nova Scotia's Annapolis Valley. He notes that education is a significant factor in whether individuals undertook to filter their tap water at home with less educated individuals placing more reliance on filtration than more educated people. We find the same result but note, as well, that more highly educated individuals have a smaller probability of being primarily bottled water drinkers. These are potentially important findings from a public policy perspective. Individuals who are educated beyond high school are more likely to drink their municipal tap water than are less educated individuals. Perhaps, this reflects the fact that more highly educated people are better able to assess the scientific information that presents arguments in favor of the excellence of a utility's water quality. There may be a role for government to provide independent and more easily digested information on the benefits and costs of water filtration systems and/or bottled water.

We also report on three interesting new results. First, French-speaking respondents are significantly less likely to be either filtered tap or bottled water drinkers than English-speaking respondents. They were also less likely to report having taste and smell problems with their tap water. Second, we note (similar to Jones *et al.* (2006)) that, while there are no significant differences in the probabilities of being a filtered or bottled water drinker amongst men and women without children, the presence of a child in a household significantly raises the probability of a man being primarily either a filtered water drinker or a bottled water drinker. This may represent a "father effect". This may be similar to the "mother effect"–that women with children might express more concern for local environmental problems–proposed by Blocker & Eckberg (1989). Third, while these socio-demographic factors play an important role, our results show that those respondents who have

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developed a concern for the safety of their tap water as expressed by two variables (belief that bottled water is safer than tap water and health concerns about tap water) are significantly less likely to be tap water drinkers. Given the overall quality and safety of municipally supplied water in Canada and the degree to which it is regulated and monitored for the presence of contaminants, this finding also has public policy implications. There appears to be a quality perception gap in the general public that may be driving these tap water substitute choices. This suggests that there is a need for greater communication and information dissemination by municipal water suppliers and their government regulators.

It should be noted, however, that our sample size of 1633 is designed in such a way as to obtain a representative sample of Canadians from Ipsos-Reid's panel of internet-enabled individuals, recognizing that this does not necessarily mean that the panel is representative of all Canadians. In particular, our survey was directed only to individuals who are supplied by a municipal water utility. To the extent that there are systematic differences in any of the explanatory factors pertaining to these individuals when compared to those individuals who obtain their water from wells, for example, then our results may either overstate or understate the degree to which Canadians in different geographic regions choose to consume water that is either filtered or bottled in preference to tap water. This also illustrates a disadvantage of undertaking a cross-Canada survey; namely, that cost factors dictate relatively small sample sizes for any particular region. This reduces the ability to uncover heterogeneity of responses within each of the smaller regions in Canada.

When designing methods for obtaining information from the public, there are tradeoffs between sampling and survey administration methods. Sampling from an internet panel provides information from a group that is reasonably representative in terms of observable characteristics (age, income, education, etc.). However, there are concerns regarding the sampling properties of volunteer panels relative to panels where individuals are recruited systematically to maintain representativeness. Also, non-response bias in internet panels is a concern as respondents are probably more computer literate or comfortable with technology. There are also concerns about the coverage of the population with internet panels as individuals without access to computers are difficult to recruit and may be missed in the sampling frame. Overall response rates to internet panels may also be low, relative to other survey modes, although mail and telephone response rates appear to be falling. Taylor *et al.* (2009) review issues surrounding mail, telephone and internet panel survey methods and conclude that there is no preferred method. Each mode generates different forms of response bias or self selection bias. The internet panel, however, appears best when administering information that requires graphics or more complex content.

CONCLUSIONS

In Canada, a large number of households on municipally supplied water systems choose to filter their tap water at home or to purchase bottled water rather than drink their tap water - actions that appear to be seen as improving the quality of the water and/or reducing the health risks from the water that they ingest. Our cross-sectional data on water consumption choices of a representative sample of Canadians who consume municipally supplied water provide a response to Doria's (2006) call for more research on bottled and tap water preferences and determinants. Our analysis of these choices provides insight into which factors are most influential. While we find a fair degree of similarity in the percentage choices of tap water/filtered water/bottled water made by Canadians, we note that residents of Quebec consume somewhat greater percentages of tap water and somewhat smaller percentages of bottled water than residents of other provinces. In addition, socio-demographic factors appear to influence behavior in ways predicted by the literature. The most important finding is that consumers in Canada appear to have translated their expressed health and safety concerns and perceptions about the quality and safety of their municipally supplied tap water into their drinking water choices. Two variables (Health Concern about Tap Water and Bottled Water Safer) are the most significant ones in the multinomial logit model. They have strong roles in terms of determining the probability that a given respondent will choose to be either a filtered water drinker or a bottled water drinker over being a tap water drinker.

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Means wrote in 2002 that water utility managers in the United States have ignored the public's concern about potential health risks in their tap water and urged them to determine exactly what their customers think about water quality. In this paper, the message from Canadians is that they are willing to undertake additional expenditures (defensive expenditures) in order to obtain what they perceive as safer water. Whether these choices alter a person's risk of exposure to waterborne contaminants, however, depends not only upon the share of different water consumption choices but also the total volume of water consumed (Pintar *et al.* 2009). Such baseline information is crucial to a better understanding and management of waterborne microbial risks to the general population and to individuals in different regions and with different socio-demographic characteristics.

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REFERENCES

Abrahams, N., Hubbell, B. & Jordan, J. 2000 Joint production and averting expenditure measures of willingness to pay: do water expenditures really measure avoidance costs? *Am. J. Agric. Econ.* **82**(2), 427–437.

Auslander, B. A. & Langlois, P. H. 1993 Toronto tap water: perception of its quality and use of alternatives. *Can. J. Public Health.* **84**(2), 99–102.

Blocker, T. J. & Eckberg, D. L. 1989 Environmental issues as women's issues: general concerns and local hazards. *Social Sci. Q.* **70**, 586–593.

Bord, R. J. & O'Connor, R. E. 1997 The gender gap in environmental attitudes: the case of perceived vulnerability to risk. *Social Sci. Q.* **78**(4), 830–840.

Canadian Council of Ministers of the Environment (CCME) 2002 *From source to tap: the multi-barrier approach to safe drinking water*. http://www.ccme.ca/assets/pdf/mba_eng.pdf

Dietz, T., Stern, P. & Guangnano, G. 1998 Social structures and social psychological bases of environmental concern. *Environ. Behav.* **30**(4), 450–471.

Dillman, D. 1999 *Mail and Internet Surveys: The Tailored Design Method*. Wiley, New York.

Doria, M. F. 2006 Bottled water versus tap water: understanding consumers' preferences. *J. Water Health.* **4**(2), 271–276.

Doria, M. F., Pidgeon, N. & Hunter, P. 2005 Perception of tap water risks and quality: a structural equation model approach. *Water Sci. Technol.* **52**(8), 143–149.

Dupont, D. P. 2004 Do children matter? An examination of gender differences in environmental valuation. *Ecol. Econ.* **49**(3), 273–286.

Greene, W. 2008 *Econometric Analysis*, 6th edition. Prentice Hall, New York.

Grondin, J., Levallois, P., Moret, S. & Gingras, S. 1996 The Influence of Demographics, Risk Perception, Knowledge, and Organoleptics on Water Consumption Patterns. *Proceedings of the AWWA Annual Conference: Management and Regulations*. AWWA, Denver. pp. 537–546.

Health and Welfare Canada 1983 *Tapwater Consumption in Canada*. Cat #H46-2/82-80E. Environmental Health Directorate.

International Council of Bottled Water Associations 2004 *Global Bottled Water Statistics*. http://www.icbwa.org/2000-2003_Zenith_and_Beverage_Marketing_Stats.pdf

Janmaat, J. 2007 A little knowledge …: household water quality investment in the Annapolis Valley. *Can. J. Agric. Econ.* **55**(2), 233–253.

Jardine, C. G., Gibson, N. & Hrudey, S. 1999 Detection of odour and health risk perception of drinking water. *Water Sci. Technol.* **40**(6), 91–98.

Jones, A. Q., Dewey, C. E., Doré, K., Majowicz, S. E., McEwen, S. A. & Waltner-Toews, D. 2006 Drinking water consumption patterns of residents in a Canadian community. *J. Water Health.* **4**(1), 125–138.

Jones, A. Q., Dewey, C. E., Doré, K., Majowicz, S. E., McEwen, S. A., Waltner-Toews, D., Henson, S. & Mathews, E. 2007 A qualitative exploration of the public perception of municipal drinking water. *Water Policy* **9**(4), 425–438.

Levallois, P., Grondin, J. & Gingras, S. 1999 Evaluation of consumer attitudes on taste and tap water alternatives in Quebec. *Water Sci. Technol.* **40**(6), 135–140.

Means, E. G. 2002 Drinking water quality in the new millennium: the risk of underestimating public perception. *J. Am. Water Works Assoc.* **94**, 28–34.

National Resources Defense Council 1999 *Bottled Water. Pure Drink or Pure Hype?* http://www.nrdc.org/water/drinking/bw/bwinx.asp

Pintar, K., Waltner-Toews, D., Charron, D., Pollari, F., Fazil, A., McEwan, S., Nesbitt, A. & Majowicz, S. 2009 Water consumption habits of a south-western Ontario community. *J. Water Health* **7**(2), 332–343.

Statistics Canada 2008 *Cansim Table 3580122–Canadian Internet Use Survey, Internet Use, by location of access, Canada,*

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provinces and selected census metropolitan area. Data for 01-Jan-2005 to 01-Jan-2007.

Statistics Canada 2009 *Households and the Environment Survey (HES) 11-526-X*. February 2009.

Stern, P., Dietz, T. & Kalof, L. 1993 Value orientations, gender, and environmental concern. *Environ. Behav.* **25**(3), 322–348.

Taylor, P., Nelson, N., Grandjean, B., Anatchkova, B. & Aadland, D. 2009 *Mode Effects and Other Potential Biases in Panel-based Internet Surveys: Final Report. WYSAC Technical Report No. SRC-905*. Wyoming Survey & Analysis Center, University of Wyoming, Laramie, WY. http://yosemite.epa.gov/ee/epa/eerm.nsf/Author/A62D95F235503D03852575A800674D75

Teal, G. & Loomis, J. B. 2000 Effects of gender and parental status on the economic valuation of increasing wetlands, reducing wildlife contamination and increasing salmon populations. *Soc. Nat. Resour.* **13**(1), 1–14.

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