Drinking water in West Virginia (USA): tap water or bottled water – what is the right choice for college students?

Jonas Germain Levêque and Robert Clyde Burns

ABSTRACT

West Virginia has had a history of water quality issues. In parallel, the world is facing a plastic pollution crisis. In order to better understand behavioral responses to perceived water quality, a survey was conducted at a major research university to ask participants about water quality perceptions and drinking water behaviors. A total of 4,188 students completed the survey during the Spring 2017 semester. Logistic regression analyses were used to predict behaviors. Results indicated that a third of the student population primarily used bottled water for drinking purposes at home, while 39% used a filter at home and 26% drank water directly from the tap. On campus, bottled water use was reported by 36% of the students, water fountain use represented 31%, and 29% of the students brought their own water with reusable cups/bottles. Health risk perceptions, organoleptic perceptions (i.e., taste, odor, color), and environmental concern were predictors of the different behaviors. Students originally from West Virginia had a higher propensity of using bottled water. We argue that bottled water consumption should be reduced in areas where water quality is not an issue. In this sense, there is a need for education among the student population in West Virginia.

Key words | bottled water, environment, health risks, perceptions, water quality, West Virginia

Jonas Germain Levêque (corresponding author)
Robert Clyde Burns
School of Natural Resources,
West Virginia University,
Morgantown, WV 26505,
USA
E-mail: *jonas.leveque@gmail.com*

INTRODUCTION

Pollution from plastics is receiving worldwide attention, as plastics are accumulating at an alarming rate on lands and in oceans. Recent research suggests limited mitigation taking place (Eriksen *et al.* 2014; Lavers & Bond 2017; Lebreton *et al.* 2017). While promising developments exist in polymer research, there is still uncertainty on biodegradable plastics and not enough recycling capabilities (Albertsson & Hakkarainen 2017; Garcia & Robertson 2017). According to Garcia & Robertson (2017: p. 870), about 'half of the annual global production of solid plastics, or 150 million tons, is thrown away worldwide each year', with the USA being responsible for one-fifth of this waste. Despite this, bottled water consumption has increased globally in the past decade, especially in western countries (Qian 2018). This may be considered a paradox since western countries have some of the best water treatment technologies and subsequent tap water quality in the world (Qian 2018). As a consequence, researchers have sought to understand the factors that explain people's drinking behaviors and especially the use of bottled water (Doria 2010; Hu *et al.* 2011; Proulx *et al.* 2012; Levêque & Burns 2017a).

One of the explanations for this rise in bottled water consumption is a strong emphasis on marketing (Wilk 2006; Doria 2010; Saylor *et al.* 2011; Espinosa-García *et al.* 2015). In their very recent study in the USA, Huang & Liu (2017) found evidence that marketing messages promoting the health benefits of bottled water influenced consumers' perceptions of bottled water quality. Interestingly, these

doi: 10.2166/wh.2018.129

authors noted that companies such as PepsiCo and Coca-Cola are already adapting their marketing strategies for this market (Huang & Liu 2017). As a result, they explained that an increase in health-related marketing efforts would drastically expand the demand for bottled water (Huang & Liu 2017).

Another explanation for a larger demand of bottled water is consumers' perceptions about their tap water quality (for a larger discussion, see Doria *et al.* 2009; Doria 2010; Hu *et al.* 2011; Levêque & Burns 2017a). Drinking behaviors are strongly associated with organoleptic perceptions (i.e., taste, odor, and color), and/or perceived health risks with drinking from the tap (Doria *et al.* 2009; Zivin *et al.* 2011; Proulx *et al.* 2012; Levêque & Burns 2017a). For example, tap water fluoridation is a common practice in the USA, with recognized benefits for cavity prevention (Slade *et al.* 2018). Nonetheless, there have been risk perceptions associated with fluoridation (Chubaka *et al.* 2017). Although drinking bottled water does not have the same strict standards as tap water in the USA, it is often perceived to be safer than tap water (Raj 2005; Levêque & Burns 2017a). This perception can be partially attributed to events of water pollution in recent years in the USA (e.g., Flint, MI; Charleston, WV). Not surprisingly, some fears exist about drinking tap water because of exposure to media and information (Means 2002). In truth, a new study by Allaire *et al.* (2018) demonstrated large tap water quality violations across the USA for the past 34 years. As a result, some of the consumption of bottled water can be explained in some cases to avoid health risks from known polluted tap water.

In West Virginia, one of the most rural states in the eastern USA, water quality has faced many challenges, from a history of natural resource extraction and with non-existent or aging water infrastructure (Falco & Webb 2015; Allaire *et al.* 2018). Hendryx *et al.* (2010) showed that air and water pollution were linked to higher cancer and mortality rates in rural West Virginia. The most recent study from Allaire *et al.* (2018) suggests that low-income rural populations are at more risk of water quality violations than urban areas. All these factors may influence the behaviors of West Virginians.

Although plastic pollution is increasing globally, there are still gaps in understanding people's perceptions of water quality, environmental concern and how these affect drinking water behaviors. For instance, there is only limited literature focusing on young adults and college students. This is important as college students are the next generation that needs to tackle the plastic problem. The aim of our study was to understand students' drinking water behaviors at home and on the university campus. While there are only a few studies relating to water perceptions and drinking behaviors (Doria *et al.* 2009; Levêque & Burns 2017a), this is the first study to assess the influence of 'at home' behaviors on behaviors of students who are on-campus. We made this inference as there is a precedence in the behavior: students are first at home and then come to college. This study not only depicts bottled water use but also filter use, water fountain use, and unfiltered tap water use, while most studies study bottled water use only. We utilized an online questionnaire in order to describe the factors that influence students' drinking water behaviors. The following research questions were established:

- R1: What are the specific drinking water behaviors of the student population at home in West Virginia and on-campus?
- R2: How do perceived health risks, environmental concern, and organoleptic perceptions affect their behaviors?
- R3: What is the influence of drinking water behaviors at-home on the drinking behaviors that occur on-campus?
- R4: How do demographic variables (gender, age, being from the state of West Virginia, and being a freshman) affect drinking water behaviors?

METHODS

Survey implementation

An online questionnaire was administered to the students of the university, using the Qualtrics software. After being granted access to the complete email database of on-campus students enrolled in the Spring 2017, we followed Dillman *et al.*'s (2014) strategy to survey the students. A first invitation email was sent in early March 2017, followed by four reminders (3, 13, 30, and 45 days after the first invitation). We did not use incentives to participate in the survey. Only students who were above 18 years old could participate in the research. From the 23,800 students who received the email, 5,536 students started the survey. After cleaning the data (we deleted cases with more than 60% incomplete answers), responses from 4,188 students were used for analyses, achieving an effective response rate of 17.6%. While the response rate may seem low, it is not surprising as response rates have been continuously decreasing for online surveys (Sax *et al.* 2003; Levêque & Burns 2017a, 2017b). Non-response bias was conducted with first and last respondents, proving no significant differences (Israel 2001). As we proceeded to multivariate analyses, non-response bias was shown to be of low magnitude compared with univariate analyses (Blair & Zinkhan 2006). In terms of sample size, the 4,188 responses were well above the 385 needed responses to estimate the whole student population (Dillman *et al.* 2014).

Questionnaire design

The questionnaire contained 50 questions and took approximately 20 minutes to complete. It was developed based on previous research (see Levêque & Burns 2017a) with the addition of questions related to the university environment. Several items related to drinking water behaviors on campus were added: drinking primarily from the water fountain on campus, drinking primarily bottled water, bringing primarily water from home, or drinking primarily sodas. The answers to these behavioral questions were mutually exclusive (only one possible choice). These were later recoded into binary items for analyses: 0: no, 1: yes.

Regarding the water quality perceptions, we asked about perceived health risks with drinking from the tap (based on Doria *et al.* 2009), and satisfaction with the taste, odor, and color of the water (organoleptic perceptions) (Doria *et al.* 2009). We also asked students about items related to environmental concern (Dutcher *et al.* 2007). These items were measured with a five-point Likert scale: (1) 'strongly disagree', (2) 'disagree', (3) 'neutral', (4) 'agree', and (5) 'strongly agree' (see Levêque & Burns 2017a). Scales were developed based on Vaske (2008). A higher score on perceived health risks implied a person believed they could get sick from drinking from the tap (At home: Cronbach's $\alpha = 0.834$; On-campus: Cronbach's $\alpha = 0.828$). A higher score in organoleptic perceptions represented a person who was highly satisfied with the quality of the tap water (At home: Cronbach's $\alpha = 0.823$; On-campus: Cronbach's $\alpha = 0.848$). A higher score in environmental concern implied that a person was more concerned about the environment (Cronbach's $\alpha = 0.871$). Using the same five-point Likert scale, we asked students whether they trusted the US Environmental Protection Agency (EPA) and the US government: 'I trust the US EPA' and 'I trust the US government.'

Finally, we collected general demographic information and asked students if they were freshmen, sophomores, juniors, seniors, or graduate/professional students and whether they were from West Virginia. If the students were from West Virginia, they were asked to answer the questions related to their behaviors at their home of record or parents' home, not their student housing location. Students who were not from West Virginia reported on their student housing in West Virginia. People who were commuting from a neighboring state ($n = 36$) were asked to report on their house in their state and were included with the students who were not from West Virginia (t-tests and chi-squares did not show any significant differences between the two groups).

Data analysis

We analyzed the data with Statistical Package for the Social Sciences (SPSS) version 24, using descriptive statistics and logistic regressions. Six logistic regression models were analyzed in order to describe: (1) bottled water use at home, (2) filtered tap water use at home, (3) unfiltered tap water use at home, (4) bottled water use on-campus, (5) drinking home water on-campus, (6) using water fountain on-campus. Demographics variables and the described water quality perceptions scales were used to build these models. We included whether students used tap water at home as a predictor for the on-campus models in order to test the link between home and on-campus behaviors. Some respondents did not finish the survey or chose not to answer the demographic questions at the end of the survey. As a consequence, sample sizes for the logistic regression were reduced, but were still well beyond the 385 responses required for inferences (Dillman *et al.* 2014). Multicollinearity indicators did not prove significant (also see Levêque & Burns 2017b). In order to test model fit, we used the Hosmer-Lemeshow test of poor fit. In order to test the assumption of linearity, we used the Box-Tidwell test. Although both of these tests are sensitive to large sample sizes and may increase the type II error, we did not encounter any aberrations in our analyses (Hosmer *et al.* 2013; Wuensch 2016). Remedies to the violation of the Box-Tidwell test include the insertion of a polynomial term (the square or the cube of a variable), which we applied in several cases (Wuensch 2016).

RESULTS

Descriptive statistics

More than half of the students who answered the survey were from West Virginia (58.5%). In terms of student type, respondents were: freshmen (15.9%), sophomores (14.3%), juniors (16.1%), seniors (20.1%), and graduate and professional students (33.6%). More females answered the survey (54%) than males. The mean age of the respondents was 24 years old, however 60% of the respondents were 22 years old or younger.

In terms of drinking water behaviors at home, 39% of respondents primarily used filtered tap water, 31.5% of respondents primarily drank bottled water, 26% used unfiltered tap water, and 3.5% drank sodas or other drinks.

On-campus, 36% of respondents primarily used bottled water, 31% used the university water fountains, 29% used water from home, and 3.9% drank sodas or other drinks. Less than half of the students (46%) disagreed or strongly disagreed with items related to perceived health risks at home (mean = 2.93). About half of them (49%) agreed or strongly agreed with organoleptic perceptions at home (mean = 3.19). On-campus, less than half of the students (44%) disagreed or strongly disagreed with items associated with health risks' perceptions (mean = 2.89), while more than half (52%) agreed or strongly agreed with items pertaining to on-campus organoleptic perceptions (mean = 3.25). In terms of environmental concern, almost three-quarters of the students agreed or strongly agreed with the items (mean = 3.82).

Logistic regressions

Predicting unfiltered tap water use at home

The assumptions of independence of observations and the linearity of independent variables with the log of the dependent variable were met, except for the item, 'Trust in US government', which was squared to meet the linearity assumption. The Hosmer-Lemeshow test indicated that the model did not have a poor fit ($\chi^2 = 6.80$, df = 8, $p = 0.558$).

Considered together, the nine variables significantly predicted the use of unfiltered tap water at home ($\chi^2 = 326.15$, df = 12, $p < 0.001$). The Nagelkerke pseudo R^2 indicated a moderate strength of the model in predicting unfiltered tap water use at home. Table 1 presents the odds ratios for each variable. Specifically, the odds for a student to drink unfiltered tap water at home increased by 1.50 if the student was a junior, by 1.85 if a senior and by 1.96 if a graduate student; increased by 1.69 per unit increase of organoleptic perceptions and by 1.29 per unit increase of environmental concern. In contrast, the odds of using unfiltered tap water at home deteriorated by 0.73 if the student was a female, by 0.64 if the student was from West Virginia, and by 0.68 per unit increase in perceived health risk. Sophomore students did not have a different behavior than freshmen. The two trust items and age did not prove to be significant in predicting the use of unfiltered tap water at home.

Predicting bottled water use at home

The assumptions of independence of observations and the linearity of independent variables with the log of the dependent variable were met, with the exception of the environmental concern scale. For this variable we used the square of the scale, which met the linearity assumption. The Hosmer-Lemeshow test indicated that the model did not have a poor fit ($\chi^2 = 5.65$, df = 8, $p = 0.687$).

The nine variables significantly predicted the use of bottled water at home ($\chi^2 = 352.17$, df = 12, $p < 0.001$). The Nagelkerke pseudo R^2 indicated a modest strength of the model in predicting bottled water use at home. Table 2 presents the odds ratios for each variable. Specifically, the odds for a student to drink bottled water at home increased by 1.20 if the student was a female, by 1.44 if the student was

Table 1 | Logistic regression summary for predicting unfiltered tap water use at home ($n = 3,256$)

Predictor	Beta	Standard errors	Odd ratios	95% Confidence interval	Wald statistic	p
Female	−0.32	0.09	0.73	[0.61, 0.86]	13.80	<0.001
Age	−0.01	0.01	0.99	[0.98, 1.01]	0.37	0.544
Origin from West Virginia	−0.45	0.09	0.64	[0.54, 0.76]	26.45	<0.001
Student type (control Freshmen)					24.26	<0.001
Sophomore	0.25	0.16	1.23	[0.93, 1.75]	2.32	0.127
Junior	0.41	0.16	1.50	[1.10, 2.04]	6.65	0.010
Senior	0.61	0.15	1.85	[1.38, 2.49]	16.54	<0.001
Graduate or professional	0.67	0.15	1.96	[1.46, 2.64]	19.73	<0.001
Organoleptic perceptions	0.52	0.06	1.69	[1.50, 1.90]	75.53	<0.001
Perceived health risks	−0.38	0.07	0.68	[0.60, 0.78]	32.72	<0.001
Environmental concern	0.25	0.05	1.29	[1.16, 1.42]	24.17	<0.001
Trust in EPA	−0.01	0.01	0.99	[0.98, 1.01]	0.43	0.512
Trust in US government (squared)	0.00	0.00	1.00	[0.99, 1.00]	0.41	0.521
Pseudo R^2 (Nagelkerke)	0.274					

from West Virginia, and by 1.45 per unit increase in perceived health risk. In contrast, the odds of drinking bottled water at home decreased by 0.66 if the student was a sophomore (by 0.52 if junior, 0.43 if senior, and 0.44 if graduate student), by 0.64 per unit increase of organoleptic perceptions, and by 0.93 per unit of squared environmental concern. The two trust items and age did not prove to be significant in predicting the use of bottled water at home.

Predicting filter use at home

Although the assumptions of independence were met for most variables, there were issues with the linearity assumption for the organoleptic and environmental scales. We used the squares of these two scales. The Hosmer-Lemeshow test indicated a poor model fit ($\chi^2 = 19.94$, $df = 8$, $p = 0.011$), which could be suspected from the Nagelkerke pseudo R^2

Table 2 | Logistic regression summary for predicting bottled water use at home ($n = 3,256$)

Predictor	Beta	Standard errors	Odd ratios	95% Confidence interval	Wald statistic	p
Female	0.18	0.08	1.20	[1.02, 1.41]	4.58	0.032
Age	0.01	0.01	1.01	[0.99, 1.02]	1.17	0.280
Origin from West Virginia	0.37	0.08	1.44	[1.22, 1.70]	18.81	<0.001
Student type (control Freshmen)					47.26	<0.001
Sophomore	−0.42	0.14	0.66	[0.50, 0.87]	8.91	0.003
Junior	−0.65	0.14	0.52	[0.40, 0.68]	21.94	<0.001
Senior	−0.85	0.14	0.43	[0.33, 0.56]	38.19	<0.001
Graduate or professional	−0.82	0.14	0.44	[0.34, 0.58]	34.37	<0.001
Organoleptic perceptions	−0.45	0.05	0.64	[0.58, 0.71]	71.42	<0.001
Perceived health risks	0.37	0.06	1.45	[1.28, 1.64]	34.73	<0.001
Environmental concern (squared)	−0.07	0.01	0.93	[0.92, 0.95]	93.77	<0.001
Trust in EPA	−0.01	0.01	0.99	[0.98, 1.01]	0.31	0.579
Trust in US government	0.01	0.01	1.01	[0.99, 1.02]	0.65	0.420
Pseudo R^2 (Nagelkerke)	0.145					

of 1.8%. The squared environmental concern (OR = 1.03, $p < 0.001$) and being a female (OR = 1.16, $p = 0.040$) were the only significant predictors of using a filter at home.

Predicting bottled water use on-campus

The assumptions of independence of observations and the linearity of independent variables with the log of the dependent variable were met, except for environmental concern. We used its squared form. The Hosmer-Lemeshow test did not indicate poor model fit ($\chi^2 = 15.20$, df = 8, $p = 0.055$).

Considered together, the ten variables significantly predicted the use of bottled water on-campus ($\chi^2 = 531.47$, df = 13, $p < 0.001$). The Nagelkerke pseudo R^2 (21%) indicated a moderate model strength. Table 3 presents the odds ratios for each variable. The odds for a student to drink bottled water on-campus increased by 1.02 per unit increase of age (i.e., per year), by 1.70 if the student was from West Virginia, and by 1.26 per unit increase of perceived health risks. These odds decreased by 0.57 if the student was a sophomore, by 0.53 if the student was a junior, by 0.47 if a senior, and by 0.33 if a graduate student; by 0.64 per unit increase of organoleptic perceptions, by 0.95 per unit increase of squared environmental concern, and by 0.23 if the student primarily drank unfiltered tap water at home. The two trust items, and gender were not significant in predicting the use of bottled water on-campus.

Predicting own water use on-campus

The assumptions of independence of observations and the linearity of independent variables with the log of the dependent variable were met. The Hosmer-Lemeshow test did not indicate poor model fit ($\chi^2 = 5.39$, df = 8, $p = 0.715$).

Considered together, the ten variables significantly predicted the use of own water on-campus ($\chi^2 = 175.80$, df = 13, $p < 0.001$). The Nagelkerke pseudo R^2 (8%) indicated a weak model strength. Table 4 presents the odds ratios for each variable. The odds for a student to drink his/her own water on-campus increased by 1.32 if the student was a female, by 2.17 if the student was a sophomore, by 2.29 if the student was a junior, by 2.72 if a senior and by 1.63 if a graduate student; by 2.15 if the student primarily drank unfiltered tap water at home. The odds for a student to bring his/her own water deteriorated by 0.97 per unit increase of age (i.e., per year). The other variables were

Table 3 | Logistic regression summary for predicting bottled water use on-campus ($n = 3{,}177$)

Predictor	Beta	Standard errors	Odd ratios	95% Confidence interval	Wald statistic	p
Female	0.15	0.08	1.16	[0.99, 1.37]	3.16	0.075
Age	0.02	0.01	1.02	[1.01, 1.04]	8.52	0.004
Origin from West Virginia	0.53	0.09	1.70	[1.44, 2.00]	38.88	<0.001
Student type (control Freshmen)					61.66	<0.001
Sophomore	−0.57	0.14	0.57	[0.43, 0.75]	16.26	<0.001
Junior	−0.63	0.14	0.53	[0.41, 0.70]	20.50	<0.001
Senior	−0.76	0.14	0.47	[0.36, 0.62]	30.38	<0.001
Graduate or professional	−1.12	0.14	0.33	[0.25, 0.43]	60.68	<0.001
Organoleptic perceptions	−0.34	0.06	0.64	[0.63, 0.80]	33.82	<0.001
Perceived health risks	0.23	0.07	1.26	[1.09, 1.45]	9.81	0.002
Environmental concern (squared)	−0.05	0.01	0.95	[0.94, 0.97]	49.71	<0.001
Trust in EPA	−0.01	0.01	1.00	[0.99, 1.02]	0.19	0.667
Trust in US government	0.01	0.01	1.00	[0.99, 1.02]	0.06	0.811
Unfiltered tap water use at home	−1.49	0.12	0.23	[0.18, 0.29]	159.30	<0.001
Pseudo R^2 (Nagelkerke)	0.213					

Table 4 | Logistic regression summary for predicting own water use on-campus ($n = 3,177$)

Predictor	Beta	Standard errors	Odd ratios	95% Confidence interval	Wald statistic	p
Female	0.28	0.08	1.32	[1.16, 1.56]	11.35	0.001
Age	−0.03	0.01	0.97	[0.96, 0.99]	12.27	<0.001
Origin from West Virginia	0.10	0.08	1.10	[0.94, 1.30]	1.44	0.230
Student type (control Freshmen)					59.52	<0.001
Sophomore	0.77	0.15	2.17	[1.61, 2.93]	25.70	<0.001
Junior	0.83	0.15	2.29	[1.71, 3.08]	30.39	<0.001
Senior	1.00	0.14	2.72	[2.04, 3.62]	46.29	<0.001
Graduate or professional	0.49	0.16	1.63	[1.20, 2.21]	9.69	0.002
Organoleptic perceptions	0.08	0.06	1.09	[0.97, 1.22]	2.04	0.154
Perceived health risks	0.00	0.07	1.00	[0.87, 1.15]	0.00	0.973
Environmental concern	0.06	0.05	1.06	[0.97, 1.17]	1.57	0.211
Trust in EPA	0.00	0.01	1.00	[0.99, 1.02]	0.08	0.776
Trust in US government	0.00	0.01	1.00	[0.98, 1.02]	0.00	0.998
Unfiltered tap water use at home	0.77	0.09	2.15	[1.81, 2.57]	74.05	<0.001
Pseudo R^2 (Nagelkerke)	0.077					

not significant in predicting the use of a student's own water on-campus.

Predicting water fountain use on-campus

The assumptions of independence of observations and the linearity of independent variables with the log of the dependent variable were met. The Hosmer-Lemeshow test did not prove poor model fit ($\chi^2 = 5.54$, df = 8, $p = 0.699$).

Considered together, the ten variables significantly predicted the use of water fountains across campus ($\chi^2 = 350.44$, df = 13, $p < 0.001$). The Nagelkerke pseudo R^2 (14%) indicated a modest model strength. Table 5 presents the odds ratios for each variable. The odds for a student to use water fountains on-campus increased by 2.23 if the student was a graduate student, by 1.32 per unit increase of organoleptic perceptions, by 1.33 per unit increase of environmental concern, and by 1.52 if the student primarily drank unfiltered tap water at home. In contrast, the odds decreased by 0.67 if the student was a female, by 0.53 if the student was from West Virginia, and by 0.85 per unit increase of perceived health risks. Age, trust in the EPA, trust in the US government, as well as being a sophomore, a junior, or a senior were not significant in predicting the use of water fountains on-campus.

DISCUSSION

Comparison with previous studies

Our results confirm previous studies on drinking water behaviors, linking perceived health risks and organoleptic perceptions to bottled water use (Hu *et al.* 2011; Saylor *et al.* 2011; Levêque & Burns 2017a). The use of bottled water (at home or on campus) by a third of the student population at this major research university is rather striking, but does not differ from the general population (Levêque & Burns 2017a). The fact that students who were from West Virginia were more likely to drink bottled water is probably one of the most important results of this study. This finding suggests the water quality perceptions in West Virginia lead students originally from West Virginia to drink more bottled water.

Similar to earlier studies, female students were more likely to drink bottled water (at home) than male students (Hu *et al.* 2011; Saylor *et al.* 2011), contrasting with Xu &

Table 5 | Logistic regression summary for predicting water fountain use on-campus ($n = 3,177$)

Predictor	Beta	Standard errors	Odd ratios	95% Confidence interval	Wald statistic	p
Female	−0.40	0.08	0.67	[0.57, 0.79]	22.99	0.001
Age	−0.01	0.01	0.99	[0.97, 1.00]	2.76	0.097
Origin from West Virginia	−0.63	0.08	0.53	[0.45, 0.62]	60.29	<0.001
Student type (control Freshmen)					79.43	<0.001
Sophomore	−0.13	0.15	0.88	[0.65, 1.18]	0.76	0.383
Junior	−0.04	0.15	0.96	[0.72, 1.23]	0.09	0.769
Senior	−0.13	0.15	0.88	[0.66, 1.17]	0.75	0.387
Graduate or professional	0.80	0.14	2.23	[1.68, 2.95]	31.15	<0.001
Organoleptic perceptions	0.28	0.06	1.32	[1.18, 1.49]	21.75	<0.001
Perceived health risks	−0.17	0.07	0.85	[0.74, 0.97]	5.64	0.018
Environmental concern	0.29	0.05	1.33	[1.21, 1.47]	33.71	<0.001
Trust in EPA	−0.00	0.01	1.00	[0.98, 1.02]	0.04	0.839
Trust in US government	−0.00	0.01	1.00	[0.98, 1.02]	0.01	0.933
Unfiltered tap water use at home	0.42	0.09	1.52	[1.27, 1.81]	21.61	<0.001
Pseudo R^2 (Nagelkerke)	0.146					

Lin (2018). Nonetheless, this relationship was no longer significant on-campus: there were no differences between male and female students. Further analyses of the data could look at potential interactions between gender, origins, and behaviors to explain this difference.

Students who had a higher environmental concern were significantly less likely to drink bottled water, both on-campus and at home. This result supports previous studies (Saylor *et al.* 2011; Merkel *et al.* 2012; Levêque & Burns 2017a; Janicki *et al.* 2018) but differs from Hu *et al.* (2011). Students who drank unfiltered tap water at home were less likely to drink bottled water on campus. This may be the result of drinking habits at home and/or a combination with the water quality scales and environmental concern.

The number of students who used a filter to treat tap water at home was relatively high (39%). However, the prediction of filter use at home did differ from earlier results, as the model did not perform well with a very low variance explained (Levêque & Burns 2017a). This means that there were limited differences of student profiles and in the perceptions of water quality across the students who used a filter and those who did not use a filter. While higher environmental concern and being female were significant in increasing the odds of using the filter, these results were contradictory to our earlier study (Levêque & Burns 2017a). Income was not included in these analyses because students are not necessarily employed and most have student loans, which could explain the lack of fit of our model for filter use.

Students who primarily drank straight from the tap at home without using a filter had higher levels of environmental concern and higher organoleptic perceptions of water quality, and they were less likely to be from West Virginia. Higher perceived health risks led students not to drink from the tap. These results are consistent with the literature (Doria 2010; Hu *et al.* 2011; Saylor *et al.* 2011; Xu & Lin 2018). It is also worth noting that students who were freshmen and sophomores were less likely to drink from the tap than other students. Two explanations can be proposed here: (1) a large majority of freshmen and sophomores are staying in dorms at US universities, and may not have the ability to filter water; (2) people who have more education may drink more from the tap (Levêque & Burns 2017a). Female students were less likely to drink from the tap at home than male students, which made sense since they were more likely to drink bottled water at home or use a filter.

Regarding on-campus water, female students who were not freshmen and who were drinking unfiltered tap water at home were more likely to bring water from home to drink on campus (in a cup or a reusable bottle). Female students might have been concerned with the quality of the water at home, yet none of the perceived health risks, organoleptic perceptions, or environmental concern scales were significant in predicting this behavior. As noted earlier, the difference in behavior with the type of student might be explained by freshmen having to live in dorms and being less educated. Also, students who were older were less likely to bring water from home. The variance explained by this model was rather small, and more factors could be at play here, such as the distance between the house and the campus, the number of hours on campus, etc.

When looking at water fountain use, the pattern was similar to drinking unfiltered tap water at home. Female students and students from West Virginia were less likely to use the water fountains across campus. There were no differences between freshmen, sophomores, juniors, and seniors. However, graduate students were more likely to use the water fountains. An interpretation of this result can be that graduate students tend to spend more time on-campus than the other categories of students (assistantships require at least 20 hours of work per week on-campus). In accordance with drinking unfiltered water at home, students who had higher organoleptic perceptions, lower perceived health risks, and higher environmental concern were more likely to use these fountains. Students who drank unfiltered tap water at home were more likely to use the fountains as well. Another factor (not tested) that could potentially explain this use is the perception of cleanliness of the water fountains.

Although trust in the US government and the US EPA were tested for each of the models, they were not significant. This finding somewhat supports the previous study from Saylor *et al.* (2011) who found no differences with political association. The data collection took place four months after the 2016 US elections, which may have affected this result (i.e., lack of variance).

Management implications

This study highlights the role of health risk perceptions and organoleptic perceptions about tap water and how these affect behaviors. Although a large proportion of students are drinking primarily from plastic bottled water, these results have to be put into perspective within the context of West Virginia and its water infrastructure (Falco & Webb 2015). The fact that students originally from West Virginia are more susceptible to drinking bottled water delivers a clear message to water managers and decision-makers in the state of West Virginia. There is need for more funding targeted towards water treatment, water distribution networks, and sewage systems as well as a need for education on tap water quality. Perceived health risks were a strong explanatory factor to predict the use of bottled water. When infrastructures are not adequate, there may be health risks, which would lead West Virginians to use alternatives. In instances where the water infrastructure is not adequate, people may find bottled water to be the safe alternative. This behavior may also be a result of the 2014 Elk River Spill that affected West Virginia's state capital (Whelton *et al.* 2015). Our results highlight the need for water quality improvements and education in places like West Virginia in order to reduce health risks' perceptions associated with drinking from the tap. Nonetheless, in places where tap water quality is known to be adequate (e.g., at the university and in Morgantown), tap water is the safest alternative (Morgantown Utility Board 2017). Syme & Williams (1993) described a similar discrepancy between perceptions and actual water quality in Australia.

Simultaneously, since organoleptic perceptions have been presented as being important factors to explain students' behaviors, water providers could perhaps find ways to reduce chlorine taste in the water and test other treatment options (Doria *et al.* 2009; Doria 2010; Levêque & Burns 2017a). For instance, studies have shown that ozonation leads to less dangerous byproducts than chlorine, which often leaves a strong taste (Doria 2010; Massalha *et al.* 2018). While bottled water may seem like a good alternative, Raj (2005) demonstrated higher health risks from drinking bottled water than tap water. In addition, a new study from Mason *et al.* (2018) discovered the presence of plastic particles in bottled water, across many brands. These results have been presented as a shockwave in the media, which might affect the sales of bottled water. The effects of these plastics on health are not precise, and more studies will be needed to evaluate the risks for humans (Mason *et al.*

2018). This announcement might create confusion for the public. However, this might be an opportunity for some bottled water users to switch to tap water and to use water treatments such as filters.

As stated earlier, bottled water consumption contributes to global plastic pollution that represents an environmental disaster (Lebreton *et al.* 2017). A most recent example is the brand Evian (owned by the group Danone) stating they will use 100% of recycled plastic bottles by 2025 (Reuters 2018). Nevertheless, bottled water contributes to environmental degradation such as CO_2 emissions, use of limited natural resources (transport, production), and plastic pollution (Saylor *et al.* 2011; Van der Linden 2015; Levêque & Burns 2017a). In actuality, the recycling rate of used plastic bottles in the USA in 2016 was 29.7%, implying that 70% of plastic bottles ended up in landfills or rivers and oceans (American Chemistry Council and Association of Plastic Recyclers 2017). Our results suggest that environmental concern decreases the likelihood of using bottled water. In that sense, there is need for educational emphasis on the issue at the university level to decrease the amount of bottled water used. Previous experiences at other universities have suggested that the ban of plastic bottled water did not result in the expected outcome (Berman & Johnson 2015). An experiment to remove bottled water from the University of Vermont led researchers to find that students substituted bottled water by other types of bottled drinks, undermining the efforts to reduce plastic pollution (Berman & Johnson 2015). Nonetheless, there were limitations to this particular study and more research is needed (Bohme *et al.* 2016).

Van der Linden (2015) showed that normative-induced messages would work best to discourage students from drinking bottled water. This could be an opportunity for universities to campaign against the use of bottled water. As Saylor *et al.* (2011) proposed, there could be more use of water fountains with filter use. Another solution for universities could be to offer incentives to recycle plastic bottled water. For example, the American Chemistry Council and Association of Plastic Recyclers (2017: p. 10) stated that 'municipalities also need to understand that they can benefit from the sale of bales of bottles, including revenue sharing to fund educational programs and other costs of collection'. Universities across the USA and in other countries in the world could partner with bottled water companies and recycle the water bottles. Promoting behavior change towards tap water and towards recycling promotion could decrease the environmental footprint of students.

CONCLUSIONS

Our study aimed at understanding drinking water behaviors at a major research university. While there are issues with the water quality in this region, about 30% of the respondents indicated drinking bottled water as their primary source, both at home and on-campus. Perceived health risks, organoleptic perceptions, and environmental concern were significantly predicting the different behaviors. We argue that in areas where the water quality is known to be adequate, there should be campaigns focused on reducing bottled water use, and on increasing recycling rates. In contrast, using bottled water may sound reasonable in areas where water infrastructures are lacking and where drinking water quality may pose a threat to human health. Both more infrastructure improvements and education are critically needed in these locations.

ACKNOWLEDGEMENTS

This work was supported by the National Science Foundation under Award Number OIA-1458952, the USDA National Institute of Food and Agriculture (NIFA), and the West Virginia Agricultural and Forestry Experiment Station. Results presented may not reflect the views of the funding agencies and no official endorsement should be inferred. The funding source had no involvement in the study design; in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the article for publication. Free and informed consent was asked from participants or their legal representatives and was obtained. Our study protocol was approved by West Virginia University Institutional Review Board IRB, by West Virginia University, West Virginia, United States, protocol No.161237001, February 2017.

REFERENCES

Albertsson, A. C. & Hakkarainen, M. 2017 Designed to degrade. *Science* **358** (6365), 872–873.

Allaire, M., Wu, H. & Lall, U. 2018 National trends in drinking water quality violations. *Proceedings of the National Academy of Sciences* **115**, 2078–2083.

American Chemistry Council and Association of Plastic Recyclers 2017 *2016 United States National Postconsumer Plastic Bottle Recycling Report*. https://plastics.americanchemistry.com/2016-US-National-Postconsumer-Plastic-Bottle-Recycling-Report.pdf (accessed 12 January 2018).

Berman, E. R. & Johnson, R. K. 2015 The unintended consequences of changes in beverage options and the removal of bottled water on a university campus. *American Journal of Public Health* **105** (7), 1404–1408.

Blair, E. & Zinkhan, G. M. 2006 Nonresponse and generalizability in academic research. *Journal of the Academy of Marketing Science* **34** (1), 4–7.

Bohme, S. R., Berman, E. R. & Johnson, R. K. 2016 Beverage policy article too limited to show consequences/Berman and Johnson respond. *American Journal of Public Health* **106** (7), E9.

Chubaka, C. E., Ross, K. E. & Edwards, J. W. 2017 Rainwater for drinking water: a study of household attitudes. *WIT Transactions on Ecology and the Environment* **216**, 299–311.

Dillman, D. A., Smyth, J. D. & Christian, L. M. 2014 *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. John Wiley & Sons, Hoboken, NJ, USA.

Doria, M. F. 2010 Factors influencing public perception of drinking water quality. *Water Policy* **12** (1), 1–19.

Doria, M. F., Pidgeon, N. & Hunter, P. R. 2009 Perceptions of drinking water quality and risk and its effect on behaviour: a cross-national study. *Science of the Total Environment* **407** (21), 5455–5464.

Dutcher, D. D., Finley, J. C., Luloff, A. E. & Johnson, J. B. 2007 Connectivity with nature as a measure of environmental values. *Environment and Behavior* **39** (4), 474–493.

Eriksen, M., Lebreton, L. C. M., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., Galgani, F., Ryan, P. G. & Reisser, J. 2014 Plastic pollution in the world's oceans: more than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. *PloS One* **9** (12), e111913.

Espinosa-García, A. C., Díaz-Ávalos, C., González-Villarreal, F. J., Val-Segura, R., Malvaez-Orozco, V. & Mazari-Hiriart, M. 2015 Drinking water quality in a Mexico City University community: perception and preferences. *Eco Health* **12** (1), 88–97.

Falco, G. J. & Webb, W. R. 2015 Water microgrids: the future of water infrastructure resilience. *Procedia Engineering* **118**, 50–57.

Garcia, J. M. & Robertson, M. L. 2017 The future of plastics recycling chemical advances are increasing the proportion of polymer waste that can be recycled. *Science* **358** (6365), 870–872.

Hendryx, M., Fedorko, E. & Halverson, J. 2010 Pollution sources and mortality rates across rural-urban areas in the United States. *The Journal of Rural Health* **26** (4), 383–391.

Hosmer Jr., D., Lemeshow, S. & Sturdivant, R. 2013 *Applied Logistic Regression*, 3rd edn. John Wiley & Sons, Hoboken, NJ, USA.

Hu, Z., Morton, L. W. & Mahler, R. L. 2011 Bottled water: United States consumers and their perceptions of water quality. *International Journal of Environmental Research and Public Health* **8** (2), 565–578.

Huang, L. & Liu, Y. 2017 Health information and consumer learning in the bottled water market. *International Journal of Industrial Organization* **55**, 1–24.

Israel, G. D. 2001 *Sampling Issues: Nonresponse*. Program Evaluation and Organizational Development, IFAS, University of Florida. PEOD9.

Janicki, R., Thomas, M. K., Pintar, K., Fleury, M. & Nesbitt, A. 2018 Foodbook study drinking and recreational water exposures among Canadians: foodbook study 2014–2015. *Journal of Water and Health* **16** (2), 197–211.

Lavers, J. L. & Bond, A. L. 2017 Exceptional and rapid accumulation of anthropogenic debris on one of the world's most remote and pristine islands. *Proceedings of the National Academy of Sciences of the United States of America* **114** (23), 6052–6055.

Lebreton, L. C., Van der Zwet, J., Damsteeg, J. W., Slat, B., Andrady, A. & Reisser, J. 2017 River plastic emissions to the world's oceans. *Nature Communications* **8**, 15611.

Levêque, J. G. & Burns, R. C. 2017a Predicting water filter and bottled water use in Appalachia: a community-scale case study. *Journal of Water and Health* **15** (3), 451–461.

Levêque, J. G. & Burns, R. C. 2017b A Structural Equation Modeling approach to water quality perceptions. *Journal of Environmental Management* **197**, 440–447.

Mason, S. A., Welch, V. & Neratko, J. 2018 *Synthetic Polymer Contamination in Bottled Water*. State University of New York at Fredonia. http://news.bbc.co.uk/2/shared/bsp/hi/pdfs/14_03_13_finalbottled.pdf (accessed 16 March 2018).

Massalha, N., Dong, S., Plewa, M. J., Borisover, M. & Nguyen, T. H. 2018 Spectroscopic indicators for cytotoxicity of chlorinated and ozonated effluents from wastewater stabilization ponds and activated sludge. *Environmental Science & Technology* **52** (5), 3167–3174.

Means, E. G. 2002 Drinking water quality in the new millennium: the risk of underestimating public perception. *American Water Works Association Journal* **94** (8), 28.

Merkel, L., Bicking, C. & Sekhar, D. 2012 Parents' perceptions of water safety and quality. *Journal of Community Health* **37** (1), 195–201.

Morgantown Utility Board 2017 *2017 Consumer Confidence Report*. http://mub.org/sites/default/files/2017%20CCR%20Print_0.pdf (accessed 3 April 2018).

Proulx, F., Rodriguez, M. J., Sérodes, J. B. & Bouchard, C. 2012 Spatio-temporal variability of tastes and odors of drinking water within a distribution system. *Journal of Environmental Management* **105**, 12–20.

Qian, N. 2018 Bottled water or tap water? A comparative study of drinking water choices on university campuses. *Water* **10** (1), 59.

Raj, S. D. 2005 Bottled water: how safe is it? *Water Environment Research* **77** (7), 3013–3018.

Reuters 2018 *Danone's Evian Vows to use 100 Percent Recycled Plastic in Bottles by 2025*. January 18. https://www.reuters.com/article/us-danone-evian-plastic/danones-evian-vows-to-use-100-percent-recycled-plastic-in-bottles-by-2025-idUSKBN1F70RZ (accessed 7 February 2018).

Sax, L. J., Gilmartin, S. K. & Bryant, A. N. 2003 Assessing response rates and nonresponse bias in web and paper surveys. *Research in Higher Education* **44** (4), 409–432.

Saylor, A., Prokopy, L. S. & Amberg, S. 2011 What's wrong with the tap? Examining perceptions of tap water and bottled water at Purdue University. *Environmental Management* **48** (3), 588–601.

Slade, G. D., Grider, W. B., Maas, W. R. & Sanders, A. E. 2018 Water fluoridation and dental caries in US children and adolescents. *Journal of Dental Research* **97** (10), 1122–1128.

Syme, G. J. & Williams, K. D. 1993 The psychology of drinking water quality: an exploratory study. *Water Resources Research* **29** (12), 4003–4010.

Van der Linden, S. 2015 Exploring beliefs about bottled water and intentions to reduce consumption: the dual-effect of social norm activation and persuasive information. *Environment and Behavior* **47** (5), 526–550.

Vaske, J. J. 2008 *Survey Research and Analysis: Applications in Parks, Recreation and Human Dimensions*. Venture Publishing, State College, PA.

Whelton, A. J., McMillan, L., Connell, M., Kelley, K. M., Gill, J. P., White, K. D., Gupta, R., Dey, R. & Novy, C. 2015 Residential tap water contamination following the Freedom Industries chemical spill: perceptions, water quality, and health impacts. *Environmental Science & Technology* **49** (2), 813–823.

Wilk, R. 2006 Bottled water: the pure commodity in the age of branding. *Journal of Consumer Culture* **6** (3), 303–325.

Wuensch, K. L. 2016 *Binary Logistic Regression with SPSS*. http://core.ecu.edu/psyc/wuenschk/MV/Multreg/Logistic-SPSS.PDF (accessed 20 February 2018).

Xu, X. & Lin, C. A. 2018 Effects of cognitive, affective, and behavioral factors on college students' bottled water purchase intentions. *Communication Research Reports* **35** (3), 245–255.

Zivin, J. G., Neidell, M. & Schlenker, W. 2011 Water quality violations and avoidance behavior: evidence from bottled water consumption. *American Economic Review* **101** (3), 448–453.

First received 21 May 2018; accepted in revised form 20 July 2018. Available online 21 August 2018