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APPLICATION OF A MODIFIED HEALTH BELIEF MODEL TO THE PRO-ENVIRONMENTAL BEHAVIOR OF PRIVATE WELL WATER TESTING[1]

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ABSTRACT: A social cognition model of health behavior, the health belief model, was applied to the pro-environmental behavior of private well water testing. Conceptualizing environmental behaviors as health behaviors may provide new insight into pro-environmental behavior change. A groundwater education program was provided to K-12 children throughout New England. Both child participants and their parents completed surveys pertaining to private well water behavior. Results indicate that perceived barriers and socioeconomic status significantly influenced past well water testing of parent participants. Perceived barriers included: participants' concern related to the cost of treating their water, and how a well water problem would influence their property value. Parent participants also indicated that they would perform future well water testing if they received a reminder cue to action that might include: getting a discount or reminder in the mail, if a well testing program was available, and state or local requirement. Our findings reinforce the need for continued private well water research and parallels to additional environmental behaviors.

(KEY TERMS: health belief model; well water; water quality testing; pro-environmental behavior.)

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INTRODUCTION

Although homeowners are responsible for the quality of their private well water, very few actually test the water. If homeowners do perform private well water testing, they may not correctly interpret the results. In fact, studies have shown that individuals using private well water often believed their water was very good, and even if they were concerned about contaminants, they still did not test their private well water (Jones *et al.*, 2005, 2006; Walker *et al.*, 2006). Based on 2005 estimates, approximately 14% of the United States (U.S.) population (42.9 million people) supplied their own water for domestic use. Water that individuals supply themselves is called "self-supplied" *vs.* "public-supplied" water, and the majority of those withdrawals are from groundwater via private or domestic wells.

Several New England states have a large percentage of the population that is self-supplied and acquires drinking water from household wells. This includes 44, 42, 30, and 24% of all households in Maine, New Hampshire, Vermont, and Connecticut, respectively (Kenny *et al.*, 2009). Water quality in private wells used for household drinking water is not regulated under federal law. There are some limited regulations by state and local governments such

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as water quality testing during sale of property or following installation of a new well. In general, maintenance and water quality monitoring must be completed by the homeowner (DeSimone, 2009). Regular water quality testing is necessary to determine potential exposure to contaminants before consuming water from private wells (USEPA, 2004).

There are numerous and widespread potential sources of private well water contaminants (DeSimone, 2009), and many homeowners are not aware of the risk to their drinking water (USEPA, 2004). Some examples of potential pollutants include naturally occurring sources of pollution such as microorganisms, radionuclides, radon, nitrates and nitrites, heavy metals, fluoride, and anthropogenic sources such as bacteria and nitrates, concentrated animal feeding operations, heavy metals, fertilizers and pesticides, industrial products and waste, household wastes, lead and copper, and water treatment chemicals (USEPA, 2004). Regular water quality testing is essential to determine the safety of private water since many contaminants cannot be identified by taste, color, or odor.

Recently, a comprehensive, long-term study (DeSimone, 2009) was completed that helped define groundwater contamination in private wells across the U.S. As part of the National Water Quality Survey of the U.S. Geological Survey, water samples were collected from approximately 2,000 domestic wells across the U.S. during 1991-2004. Approximately 23% of wells had at least one contaminant at concentrations greater than human health benchmarks. Contaminants most frequently found at high concentrations were arsenic, radon, nitrate, fluoride, and several other trace elements. Each of these contaminants was greater than its benchmark in about 1-7% of sampled wells. In addition, microbial contaminants were detected in as many as one-third of sampled wells. These values indicate a substantial potential for adverse effects on human health (DeSimone, 2009) especially when many homeowners are not aware of the potential risk (USEPA, 2004).

Health psychologists research factors that are integral in understanding how people adopt and change health behaviors (Rosenstock, 1974; Rosenstock *et al.*, 1988; Albery and Munafo, 2008). Health behavior is often defined as promotion and preventative action(s) taken by an individual that believes he/she is healthy or asymptomatic (Kasl and Cobb, 1966; Rosenstock, 1974; Becker *et al.*, 1977). The factors that impact health behavior may be cognitively based such as beliefs and attitudes, and relate to the processes used when an individual makes action decisions (Maiman and Becker, 1974; Rosenstock, 1974; Albery and Munafo, 2008). One example of a social cognition model of health behavior is the health belief model (HBM). The HBM specifies how individuals cognitively represent health behaviors, and identifies which components are important for predicting health behavior (Maiman and Becker, 1974; Rosenstock, 1974; Albery and Munafo, 2008).

The HBM is based on four components: the likelihood of a negative event (vulnerable to a health threat), the severity of the event (significant consequences), the benefits associated with a certain preventive action (action will prevent/reduce risk), and the costs (or barriers) associated with performing that action (low cost and barriers). The first two beliefs form perceived threat, defined as an assessment of the likelihood of an event combined with the severity of the event. The other two beliefs make up outcome expectancy, which is defined as the benefits associated with a certain action minus the costs or barriers associated with performing the action. Self-efficacy and cues to action are also included in many recent applications of the HBM. For self-efficacy — individuals must feel competent to take action and maintain behavior. For cues to action, some trigger, either internal (e.g., the individual feels sick) or external (e.g., media message), is required to ensure actual behavior ensues. The type of cue and its effects tends to vary with differences in susceptibility and severity. For example, less perceived vulnerability or severity (or in combination) would require a more significant cue to trigger action, whereas greater perceived threat would mean a less significant cue would have an effect (Rosenstock, 1966, 1974; Becker *et al.*, 1977; Janz and Becker, 1984; Lindsay and Strathman, 1997; Heimlich and Ardoin, 2008). This study is an exploratory study using the HBM to investigate private well water testing. On the basis of guidance from local stakeholders (i.e., water quality specialists), selected variables were investigated to develop a foundation for further research.

Understanding why people act in an environmentally responsible manner is of great value to many individuals such as Cooperative Extension researchers, policy makers, scientists, and health professionals. Investigating private well water behavior is of particular value to Cooperative Extension researchers who work closely with the public. Cooperative Extension researchers engage in “reaching out” and “extend” their resources, solving public needs with college or university resources through non-formal, non-credit programs. However, certain HBM variables, such as risk and threat perception (subjective assessment on likelihood of negative event), have received little attention in environmental behavior literature — particularly related to well water issues.

Despite the applicability of the HBM to environmental behavior, only two studies employed the HBM in the environmental domain, even though both studies indicate a significant influence on pro-environmental action due to health behavior risk assessment (Lindsay and Strathman, 1997; Walker *et al.*, 2006). This study expands on the essential yet limited literature by investigating the HBM variables and their influence on the pro-environmental behavior of private well water testing. Specifically, our objectives were to: (1) investigate participants' perception and level of concern about health risk factors including water quality, and (2) determine if health risk factors influence past well water testing and the intention to test well water in the future. We expect participants who perceive water quality to be a greater health threat will be more likely to report regularly testing their well water.

CONCEPTUAL FRAMEWORK

Behavior motivation theory, which underlies the HBM, originates from the social-psychological theory of Kurt Lewin, which describes behavior or decision making under conditions of uncertainty (Maiman and Becker, 1974; Rosenstock, 1974; Janz and Becker, 1984). Lewin's (1951) approach to predicting behavior, called value-expectancy or "expectancy × value" theory, proposed that events were positively or negatively evaluated based on two variables. The variables included the following: whether the individual believed the event to be more or less likely to happen (Lewin, 1951), or the individual's estimate of the likelihood that a given action will result in that outcome (Rosenstock, 1974; Janz and Becker, 1984), if the event was more or less attractive to the individual (Lewin, 1951; Janz and Becker, 1984), or the value placed by an individual on a particular outcome (Rosenstock, 1974; Janz and Becker, 1984).

The HBM was originally created to expand the use of socio-psychological variables to determine what factors influence preventive health behavior including the subjective views of individuals (Maiman and Becker, 1974; Janz and Becker, 1984; Carpenter, 2010), and enhance effectiveness of health education programs (Rosenstock, 1966; Lorig, 2000; Albery and Munafo, 2008; Steckler *et al.*, 2010). The model analyzes whether or not an individual will modify their behavior, which is influenced by an expected health benefit. The HBM was conceptualized by a group of social psychologists (Hochbaum, Leventhal, Kegeles, and Rosenstock) working for the U.S. Public Health Service during the 1950s (Albery and Munafo, 2008).

Historically, demographic variables such as socioeconomic status, gender, ethnicity, and age were thought to be related to preventive health behaviors and the use of health services (Rosenstock, 1966, 1974; Janz and Becker, 1984). However, there seemed to be no effect on behavior from health education, and certain demographic variables (i.e., age) could not be modified. These early studies supported the need to research additional variables that might influence behavior change since particular demographic variables are innate. Previous studies indicated that when funding was available, the impact from socioeconomic variables was still significant (Abraham and Sheeran, 2005; Albery and Munafo, 2008). Researchers searched for factors that could be modified through health education including factors that would provide a causal relationship between specific variables and preventive health behavior and the use of health services (Abraham and Sheeran, 2005). Essential components of the HBM included factors that would predict health behavior action, and could be influenced through health education and communication (Abraham and Sheeran, 2005).

The modification of the HBM in this study is fundamentally about "nudging" better behavior related to private well water testing. Nudging is anything that influences our choices — persuading, producing, and evolving sufficient reasons for individuals to change behaviors — in this instance, private well water testing (Thaler and Sunstein, 2009). It is important to note the difference between a causal relationship — an action or occurrence can cause another (such as smoking causes lung cancer) — and a correlational relationship (such as smoking is correlated with alcoholism). A correlational relationship indicates that two things perform in a corresponding manner.

Models of health behavior change, including the HBM, have been applied with great success to health behaviors such as smoking, screening exams, diet, etc. (Becker, 1974; Janz and Becker, 1984; Abraham and Sheeran, 2005; Carpenter, 2010). Even though some environmental behaviors significantly influence personal health and well-being, little has been done to implement health promotion and prevention strategies with environmental behaviors (Nisbet and Gick, 2008). There are numerous behavioral change theories that could provide potential frameworks for research on environmental behavior: theories of reasoned action and planned behavior, transtheoretical model, protection motivation theory, social cognitive theory, etc. (Armitage and Conner, 2000; Heimlich and Ardoin, 2008; Nisbet and Gick, 2008).

On the basis of Lindsay and Strathman's (1997) approach with recycling behavior, this study focused on the HBM due to the similarities between behavior performed to maintain good health and behavior undertaken to maintain water quality — in combination with health. Taking action to maintain health and water quality are behaviors that prevent poor health and poor natural resources. Both environmental and health behaviors are usually only taken when the consequences are perceived to be severe and likely. One striking overlap is the negative sacrifices required for the eventual positive result such as time involved, inconvenience, and financial constraints (Lindsay and Strathman, 1997). This is especially true for private well water testing, which requires significant time and the somewhat confusing nature of professional well water testing, busy schedules, and financial concerns with not only testing but possible treatments, remediation, etc. Because of these factors, we investigated the potential use of the HBM in determining private well water testing behavior. It should be noted that many of the behavioral change theories are rooted in subjective expected utility and expectancy-value theories and, therefore, have significant overlap (Edwards, 1954). Based on our research, there are limited studies that implement the HBM to influence pro-environmental behavior especially related to water quality and private well water concerns.

Although numerous theoretical frameworks (social learning, theories of reasoned action and planned behavior, locus of control, etc.) have been developed to understand the determinants of pro-environmental behaviors, limited theoretical research has investigated the parallels between behaviors performed when making both health and environmental decisions (Kollmuss and Agyeman, 2002; Heimlich and Ardoin, 2008). The two studies found during our search indicate a significant influence on pro-environmental action due to health behavior risk assessment, and suggest a connection between health and environmental behaviors. Lindsay and Strathman (1997) found perceived seriousness, perceived benefits, and self-efficacy predicted recycling behavior of their participants. Walker *et al.* (2006) indicated that participants in their study were influenced by threat perception. In other words, level of concern about arsenic levels influenced water consumption. Although results from these studies indicate that health risk factors from the HBM have a significant influence on environmental change, additional studies are needed.

This study not only increases the small number of studies (studies that have investigated the parallels between behaviors performed when making both health and environmental decisions) available but also incorporates a more thorough approach to well water testing. To provide comprehensive results, we employed a more complete set of factors (when compared to the limited environmental studies available) within the HBM when investigating environmental behavior. For example, Walker *et al.* (2006) investigated threat perception, which we included in addition to behavioral evaluation, self-efficacy, cues to action, and socioeconomic status. This is an exploratory study to determine the appropriateness of the HBM in well water testing behavior driven by landowners' lack of concern with potential well water contamination. This study applied the HBM to determine whether or not health factors would have an impact on well water testing. Due to the limited literature on well water issues and individuals' behaviors in addition to the novel approach of framing a health behavior as an environmental behavior, future investigations are needed to test and modify the variables used in this study. Investigations are needed to broaden not only the baseline data but to incorporate additional HBM variables when determining predictors of private well water testing and pro-environmental behaviors.

METHODS

Groundwater Education Program

A groundwater education program — Groundwater Education Through Water Evaluation & Testing (GET WET!) was used to not only create a long-term private well water quality database but to also invite students, parents, teachers, and community members to participate as citizen scientists. GET WET! instruction was done by one of two trained personnel that traveled to each school. There were six main components of GET WET! including the following: training day, pre-visit lecture, testing day, post-visit lecture, research day, and a community presentation.

Middle and high schools were randomly selected within targeted watersheds, and then were contacted to determine teacher availability and whether or not the majority of the students' households used private well water. Recruitment criteria included finding the following: schools needed to provide at least 60 students on well water with approximately 50% of the students that participated in the program on well water, allowed student surveys, and had teachers willing to provide extended class time for completion of GET WET! objectives.

Students were recruited from schools located throughout the Northeastern region of the U.S. The number of participating schools per state is identified in parentheses after each state name: Connecticut (1), Rhode Island (1), Maine (2), New Hampshire (4), and Vermont (1). A total of 776 students from grades 6th-12th were recruited to participate in the groundwater education program, GET WET!. The pre-GET WET! participation response rate of children was 513 of 776, or 66%. There were 264 male participants and 249 female participants ranging from 10 to 18 years of age with a mean age of 15 (SD = 2.4). The post-GET WET! participation response rate of children was 262 of 513, or 51%.

A total of 776 parents or guardians (henceforth "parents") were invited to participate in the study. This number corresponds to one parent per child that was requested to complete the research questionnaires. The pre-survey response rate of parents was 452 of 776, or 58%. There were 131 male parents and 321 female parents ranging from 25 to 83 years of age with a mean age of 45 (SD = 7.5).

Survey questionnaires were provided to the teachers for both the child and parent pre-surveys. Child participants were asked to complete the surveys during their classroom period before the GET WET! pre-visit lecture day. The parent survey was sent home with the child and turned back in to the teachers after the parent completed the survey. The student post-surveys were completed in the classroom after participation in the full GET WET! program. Parent surveys were again sent home with the child and were returned to the teacher when they finished. Although post-survey information was collected, the data are not used in this study. Our objective was to determine the effectiveness of using the HBM in predicting well water testing behavior and we did not want to investigate an intervention — only risk perception. In addition, we were not able to address direct correlations between each parent and child (for both pre- and post-survey). We were limited in the information (including names of child participants) because we were working with minors in schools. Although some school districts allowed us to collect and complete full datasets, some of the schools had strict restrictions.

Survey Questions

Variables were developed based on the HBM literature (used for health behavior) (Janz and Becker, 1984; Carpenter, 2010) and the recent studies on pro-environmental behavior (Lindsay and Strathman, 1997; Walker *et al.*, 2006; Nisbet and Gick, 2008), and the factors used were based on what were thought to be the best selection for the exploratory nature of the study. The modified questions that were developed to investigate the variables in this study were based on previous HBM studies related to health issues and the few HBM studies available related to environmental issues (without development and validation of an instrument to assess latent constructs). Question modification could be improved by incorporating questions focused more explicitly on specific behaviors. However, this study creates a solid baseline for future research questions.

The HBM is rooted in the expectancy-valence theory, yet it is different. Our integrated approach incorporates root theory, but also includes model modifications for health and environmental behavior and well water issues. Our approach is a novel investigation into the usefulness of the HBM in an environmental context, and several modifications were made due to the limited theoretical literature on well water issues. The developed HBM variables (and corresponding survey questions) were used to measure well water user behavior: threat perception (factor pattern = 0.832, eigenvalue = 2.712), behavioral evaluation (factor pattern = 0.709, eigenvalue = 2.055), self-efficacy (factor pattern = 0.641, eigenvalue = 1.225), water quality cue to action (factor pattern = 0.855, eigenvalue = 3.566), and reminder cue to action (factor pattern = 0.868, eigenvalue = 3.948).

Threat Perception. The next four items ($\alpha = 0.66$) assessed the perceived severity and susceptibility associated with their well water. On the basis of a 5-point agreement scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) respondents were asked a set of questions. Examples include "Compounds in my well water may cause health problems" and "I believe my well water is safe."

Behavioral Evaluation. Three items ($\alpha = 0.70$) were used to assess the perceived barriers to testing and treating well water, based on a 5-point Likert scale measuring level of agreement. Questions asked if respondents agreed with statements that testing or treating their well water took too much time or cost too much (e.g., "I am not sure I have the money to treat my well water if it had a problem").

Three items ($\alpha = 0.68$) were asked to explore perceived benefits of testing and treating well water using a five-point agreement scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Respondents were asked if they agreed with the statements "Testing my well water is good for my health," "Testing my well water is good for my family's health," and "Treating my well water is good for my health."

Self-Efficacy. The next four items ($\alpha = 0.65$) asked respondents their level of agreement with statements regarding their capability to safely and effectively test and treat their well water (e.g., "I have enough information to manage the safety of my well water" and "I know how to treat my well water" and "I know a lot about private well water testing"). Responses ranged from 1 (Strongly Disagree) to 5 (Strongly Agree).

Water Quality Cues to Action. The next four items ($\alpha = 0.74$) asked respondents a dichotomous question with statements regarding the stimuli necessary to initiate or trigger engagement in the desired action — private well water testing. Examples include: "Would the following prompt you to do a well water test — change in taste of your well water, change in color of your water, neighbors well is contaminated, etc."

Reminder Cues to Action. The next six items ($\alpha = 0.72$) asked respondents a dichotomous question with statements regarding the stimuli necessary to initiate or trigger engagement in the desired action — private well water testing. Examples include: "Would the following prompt you to do a well water test — getting a reminder, if a well testing program was available, getting a discount, etc."

Socioeconomic Status. The final set of questions asked participants about their level of education, income, and gender.

Model

To determine if health risk factors influence past well water testing and future well water testing, several statistical methods were used in this study, including factor analysis with principal component analysis to reduce dimensionality and to generate factors. The factor analysis using maximum likelihood estimation and Varimax rotation yielded a six-factor solution that explained 88.0% of the variation across the measurement items. All statement items intended to measure the potential behaviors held together within the freely estimated factors and loaded highly on each extracted factor. The scores for each factor group were summated to combine multiple items into a single index, rather than analyzing the items separately. Survey question responses were reverse scored when needed before summation. Summated scores have been shown to possess good psychometric properties, meaning a good scale has reliability, validity, and precision. Scale reliability was assessed using Cronbach's alpha. Additional statistical methods included descriptive statistics and logistic regression modeling. Independent variables selected for analysis were chosen based on previous literature.

Logit models were used to estimate the likelihood of private well water testing and examine the contribution that a suite of explanatory variables has on individual private well water testing behavior. Tables 1 and 2 contain definitions and descriptive

TABLE 1. Description and Hypothesized Influence of the Explanatory Variables on an Individual's Decision to Test Their Private Well Water.

Variable	Description	Hypothesized Effect on Behavior
Threat perception		
Family	Importance of family's health[1]	Positive
Personal	Importance of personal health[1]	Positive
Behavioral evaluation		
Money	Not have the money to treat problem[1]	Negative
Property	Worried about property values with problem[1]	Negative
Self-efficacy		
Well water	Private well water knowledge[1]	Positive
Groundwater	Groundwater contamination knowledge[1]	Positive
Water quality cue to action		
Taste	Change in private well water taste[2]	Positive
Color	Change in private well water color[2]	Positive
Odor	Change in private well water odor[2]	Positive
Contaminant	Contamination in the area[2]	Positive
Neighbor	Neighbor's well is contaminated[2]	Positive
Health	Unexplained health problems[2]	Positive
Reminder cue to action		
Reminder	Getting a reminder[2]	Positive
Program	Available well testing program[2]	Positive
Discount	Getting a discount[2]	Positive
Socioeconomic status		
Education	Education[3]	Positive
Income	Income[4]	Positive
Gender	Gender[5]	Positive
Age	Age[2]	Positive

[1]Scale items (1 = Strongly Disagree, 5 = Strongly Agree).
[2]Continuous.
[3]Dichotomous (0 = Some College or Less, 1 = Bachelors Degree or More).
[4]Dichotomous (0 = ≤$60,000, 1 = >$60,000).
[5]Dichotomous (1 = Male, 0 = Female).

TABLE 2. Descriptive Statistics of Explanatory Variables.

Variable	Mean (SD)	Minimum	Maximum
Threat perception			
Family	4.900 (0.540)	1	5
Personal	4.880 (0.556)	1	5
Behavioral evaluation			
Money	3.020 (1.353)	1	5
Property	3.500 (1.259)	1	5
Self-efficacy			
Well water	2.490 (1.124)	1	5
Groundwater	2.440 (1.025)	1	5
Water quality cue to action			
Taste	0.890 (0.330)	0	2
Color	0.880 (0.340)	0	2
Odor	0.890 (0.322)	0	2
Contaminant	0.900 (0.310)	0	2
Neighbor	0.870 (0.338)	0	2
Health	0.840 (0.379)	0	2
Reminder cue to action			
Reminder	0.640 (0.502)	0	2
Program	0.860 (0.346)	0	2
Discount	0.740 (0.453)	0	2
Socioeconomic status			
Education	0.397 (0.146)	0	1
Income	0.602 (0.299)	0	1
Gender	0.710 (0.490)	0	1
Age	44.530 (7.515)	17	83

statistics of the explanatory variables developed from the survey.

RESULTS

The first objective for this study was to assess levels of concern and perceptions of New England residents about groundwater issues to develop a reference point for guiding future health risk factor research. The questionnaire administered to child and parent GET WET! participants requested information about levels of concern for the following: health risks from untreated water (Figure 1) and compounds in their water causing health problems (Figure 2). We also determined safety perceptions of water (Figure 3).

For levels of concern about health risks from untreated water, 58% of parents and 40% of children were concerned with health risks (Figure 1). Although the majority of parents either somewhat agreed or strongly agreed that they were worried about health risks from untreated water, there was still a high percentage (25%) of respondents that either somewhat disagreed or strongly disagreed that they were concerned about health risks from untreated water. The "Somewhat Disagree" and "Strongly Disagree"

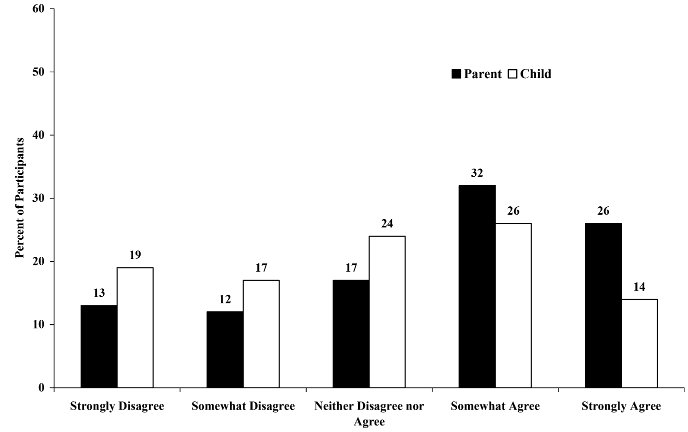

FIGURE 1. Parent (n = 437) and Child (n = 480) Percent Response to the Following Survey Question: I Am Worried about Health Risks from Untreated Water.

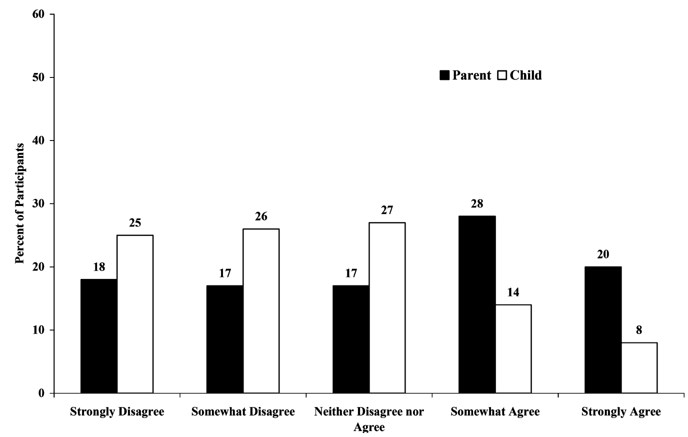

FIGURE 2. Parent (n = 385) and Child (n = 385) Percent Response to the Following Survey Question: Compounds in My Water May Cause Health Problems.

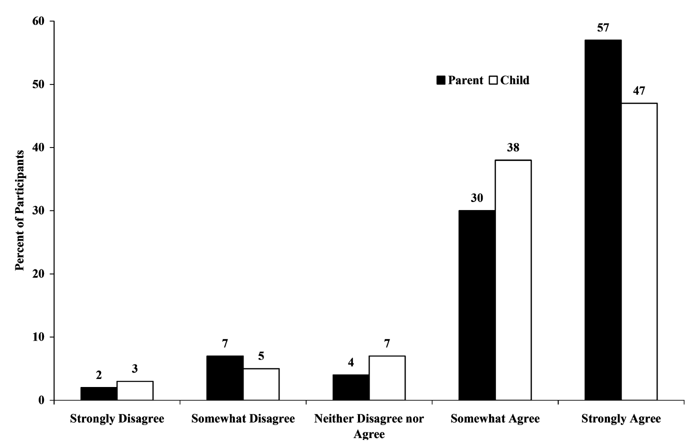

FIGURE 3. Parent (n = 438) and Child (n = 475) Percent Response to the Following Survey Question: I Believe My Water Is Safe.

response categories had an even higher response rate (36%) in child participants (Figure 1).

Parents' responses for the survey question — compounds in my water may cause health problems — have similar proportions for all disagreement/agreement categories (Figure 2). In fact, the responses were fairly consistent in each category — "Strongly Disagree/Somewhat Disagree" (35%), "Neither Disagree nor Agree" (17%), and "Somewhat Agree/Strongly Agree" (48%). The "Somewhat Agree" response category had the highest percentage (28%), and indicated that parents were concerned about compounds in their water causing health problems. Child participants, on the other hand, reported the lowest percentages in the "Somewhat Agree/Strongly Agree" (22%) categories. These percentages suggested a difference in child and parent perceptions pertaining to risk from compounds in their water, with little concern from the child participants.

The final survey question provided to both child and parent participants indicated a strong response from both participant groups when asked about their perception on the safety of their water (Figure 3). Child (85%) and parent (87%) respondents had the highest response rates in the "Strongly Agree/Somewhat Agree" response categories. The "Strongly Disagree" and "Somewhat Disagree" categories had low percentages ranging between 2 and 7% for both participant groups. These response rates indicated that both child and parent participants agreed that they perceive their water to be safe.

The next two survey questions were specific to parent participants and pertained to barriers to well water testing (Figure 4). The first question determined levels of agreement for the following — I am not sure I have the money to treat my well water if it had a problem. Approximately even response rates (40%) were reported in the "Strongly Disagree/Somewhat Disagree" categories when compared to 43% in the "Strongly Agree/Somewhat Agree" response categories. These percentages indicate a fairly even divide between participants that were not sure they have money to treat their well water *vs.* those participants that think they did have money to treat their well water. The second question determined levels of concern for the following — I am worried about property values if I found a problem. The response rates for this question varied more between the agreement and disagreement categories. Parent respondents had the highest percent responses (54%) in the "Strongly Agree/Somewhat Agree" categories. In contrast, only 23% of participants responded in the disagreement response categories. These percentages indicated that parents would be worried about property values if they found a problem with their well water.

Our second research objective was to determine if health risk factors influence past well water testing and future well water testing. Maximum likelihood estimation was used to fit binary logistic regression models of reported past well water testing (Table 3). Maximum likelihood estimation was also used to fit ordered logistic regression models of future well water testing (Tables 4 and 5). Past well water testing was significantly influenced by behavioral evaluation and socioeconomic status (Table 3, LL_U = −158.557, LL_R = −182.493, LR χ^2 statistic = 12.589). These results indicated that perceived barriers, income, and education significantly influenced past well water testing. Future well water testing was significantly influenced by reminder cues to action (Tables 4 and 5, LL_U = −238.557, LL_R = −249.840, LR χ^2 statistic = 22.525). These results indicate that participants would perform future well water testing if they received specific cues to action such as a reminder to test their private well water. It should be noted that past barriers may also influence future actions. Some of the cues to actions are potential incentives that might impact barriers and overlap between variables must be considered. All behavior related to well water testing was self-reported.

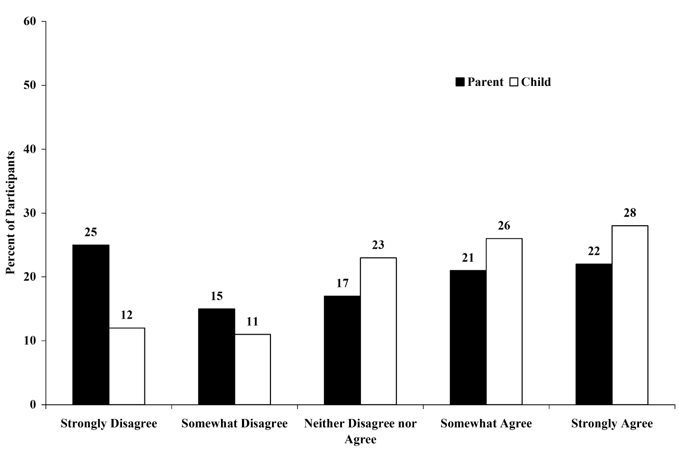

FIGURE 4. Parent Percent Response to the Following Survey Questions: I Am Not Sure I Have the Money to Treat My Well Water If It Had a Problem (n = 386). I am worried about property values if I found a problem (n = 418).

DISCUSSION

There are obvious parallels between behaviors performed when making both health and environmental decisions. However, there is limited research that investigates the theoretical underpinnings of these parallels. In this study, we broaden pro-environmental behavior research by investigating a new avenue

TABLE 3. Logistic Regression Predicting Parent Decision Making of Previous Well Water Testing from HBM Factors of: Cues to Action, Behavioral Evaluation, Threat Perception, Self-Efficacy, and Demographic Variables.

Variable	*b* (SE)	Wald χ^2 Score	*p*-Value	Marginal Effect
Threat perception	0.173 (0.234)	0.547	0.460	0.410
Behavioral evaluation	**−0.481 (0.158)**	**9.268**	**0.002**	**−0.114**
Self-efficacy	0.193 (0.141)	1.874	0.172	0.046
Water quality cue to action	0.552 (0.493)	1.254	0.263	0.131
Reminder cue to action	0.148 (0.430)	0.118	0.732	0.035
Socioeconomic status	**1.380 (0.325)**	**18.030**	**0.000**	**0.328**
Gender	−0.251 (0.317)	0.627	0.429	−0.059
Age	0.030 (0.018)	2.778	0.088	0.007

Note: $n = 270$ (155 no, 115 yes — past well water testing). AIC = 1.249. $LL_U = -158.557$; $LL_R = -182.493$; LR χ^2 statistic = 12.589, 8 df. Missing values set to sample mean. Values significant at $p < 0.05$ are in bold. HBM, health belief model.

TABLE 4. Ordered Logistic Regression Predicting Parent Decision Making of Future Well Water Testing from HBM Factors of: Cues to Action, Behavioral Evaluation, Threat Perception, Self-Efficacy, and Demographic Variables.

Variable	*b* (SE)	Wald χ^2 Score	*p*-Value
Threat perception	−0.169 (0.222)	0.580	0.445
Behavioral evaluation	0.214 (0.142)	2.271	0.133
Self-efficacy	0.113 (0.130)	0.756	0.931
Water quality cue to action	0.028 (0.477)	0.003	0.953
Reminder cue to action	**1.257 (0.407)**	**9.539**	**0.002**
Socioeconomic status	0.151 (0.515)	0.856	0.607
Gender	−0.543 (0.293)	3.435	0.056
Age	−0.029 (0.016)	3.285	0.069

Note: $n = 264$ (137 no, 92 maybe, 35 yes — future well water testing). AIC = 1.883. $LL_U = -238.557$; $LL_R = -249.840$; LR χ^2 statistic = 22.525, 8 df. Missing values set to sample mean. Values significant at $p < 0.05$ are in bold. HBM, health belief model.

in environmental behavior change — applying the HBM to investigate factors related to private well water testing.

Our first objective was to identify participants' perception and level of concern about health risk factors. There were some key drivers in implementing the first objective including the following: the need to determine baseline data for perceptions about and levels of concern for water quality in New England, and to pinpoint some potential factors in well water testing behavior.

In general, parent participants were worried about health risks from untreated water, but the minority of child participants indicated that they were not worried about health risks from untreated water. When questioned about whether or not parents thought compounds in their water may cause health problems, parents did not have a strong response. Although more respondents than not thought compounds may cause health problems, responses were fairly consistent across all agreement levels. In contrast, child participants did not think compounds in their well water may cause health problems. These results indicated inconsistent views from parent participants while most of the child participants were not concerned about compounds in their water. Some potential factors that may influence the child participants' lack of concern include levels of knowledge, limited understanding of the potential risks, influence from parents related to water safety, and lack of interest. The final survey question showed that both participant groups thought that their water was safe.

In general, there was inconsistency among parent participants' beliefs about untreated water and compounds in their water. However, they did agree that

TABLE 5. Marginal Effects for Ordered Logistic Regression Model of Parent Participants' Intention to Test Their Private Well Water in the Next Six Months.

Variable	No — I Do Not Intend to Test My Well in the Next Six Months	Maybe — I Might Test My Well in the Next Six Months	Yes — I Intend to Test My Well in the Next Six Months
Threat perception	−0.007	0.004	0.003
Behavioral evaluation	−0.053	0.034	0.192
Self-efficacy	−0.311	0.198	0.113
Water quality cue to action	0.042	−0.027	−0.015
Reminder cue to action	−0.003	0.002	0.001
Socioeconomic status	−0.037	−0.024	0.014
Gender	0.135	−0.081	−0.054
Age	0.007	−0.005	−0.003

their water was safe. There was less variation among child participants' perceptions about untreated water and compounds in their water with most children viewing less risk from these factors than parents. Similarly, child participants believed that their water was safe. Interestingly, Walker *et al.* (2006) found levels of concern about water quality and arsenic in water were not uniformly high among their participants. In fact, Walker *et al.* (2006) found the majority of responses to their survey question pertaining to level of concern about arsenic in drinking water were distributed at the extremes of the Likert disagree/agree scale. The same trend was true for levels of concern about water quality in general. In addition, Walker *et al.* (2006) found interesting results when investigating concern about arsenic and consumption of tap water. Although they had respondents that indicated a high level of concern about arsenic in water, there was a significant gap in understanding and knowledge about water quality. This is similar to our findings where there seems to be some concern about water quality, although not with all participants, but parents still report their water as safe. In asking participants to report on their levels of concern related to untreated water, a potential factor is knowledge levels. Differences in how aware people are of water quality issues and potential contaminants may influence their levels of concern. This disconnect may contribute to the discrepancy between health concerns and lack of safety concerns in this study.

Furthermore, we determined baseline data on participants' perception about barriers to well water testing, and found a range of responses from parent participants with some parents having high levels of concern about the cost of well water treatment while others indicating less concern for monetary issues. In contrast, a higher percentage of parents did seem to be worried about property values if they found a problem with their well water. Although the HBM has not previously been applied to risk perception and well water testing behavior, the model has been used in health behavior research that indicates significant influences in behavior due to perceived barriers (Carpenter, 2010). Similarly, a high percentage of our participants reported concern for perceived barriers, which indicates an important area of study for future research.

Our second objective was to determine if health risk factors influence past well water testing and future well water testing. Results indicate that perceived barriers and socioeconomic status significantly influenced past well water testing, and participants would perform future well water testing if they received specific cues to action such as a reminder cue to action. Lindsay and Strathman (1997) also used the HBM to investigate environmental behavior — recycling behavior — and reported significant influence from several HBM factors including self-efficacy and perceived seriousness and benefits. Walker *et al.* (2006) researched threat perception and found a significant influence on water consumption. These studies combined with our results indicate promising opportunities for developing a reliable theoretical approach to pro-environmental behaviors.

There is limited research that provides information about parent/child perception and level of concern related to private well water. What landowners are thinking in relation to their well water and water quality in general is especially important with recent research testing arsenic (and other pollutant) levels in Maine and New England. The baseline descriptive data provided in this manuscript as well as the potential theoretical applications of the HBM and well water testing behavior are necessary in providing a starting point in trying to influence landowner behavior.

There are several limitations in this study. First, the well water testing behavior was a self-reported behavior, not observed. Depending on survey participants' accuracy, behavior results may be skewed. Second, due to limited literature on well water issues and individuals' behaviors in addition to the novel approach of framing a health behavior as an environmental behavior, additional investigations are needed to test and modify the variables used in this study. Third, we were not able to address direct correlations between each parent and child. We were limited in the information (including names of child participants) because we were working with minors in schools. Although some school districts allowed us to collect and complete full datasets, some of the schools had strict restrictions.

CONCLUSIONS

Although this study provides insight into perceptions of and levels of concern for groundwater in New England, it also indicates a need for further research. Investigations are needed to broaden not only the baseline data but to incorporate additional HBM variables when determining predictors of private well water testing and pro-environmental behaviors. Since there are limited studies available, future research is needed to replicate and broaden this study to test the generalizability of the findings. Research is needed to determine if HBM factors can be applied to other pro-environmental behaviors. It would be helpful to provide a dynamic element to future research. For example, how do perceptions of risk and well water testing behaviors change as external or internal factors fluctuate? What are the "tipping points" for behavior change? In this study, we have no knowledge of participants' decision-making behaviors when change is introduced into an individual's life such as a change in his/her health, new advertisement campaigns are developed and viewed by him/her, the cost of testing increases or decreases, etc. Further studies are needed to investigate the link between behavioral intention and actual behavior.

In a broader sense, there are a few important queries that must be considered when applying the HBM in future environmental studies. One is that the HBM might be limited in the way of explanatory power for determining well water testing behavior. In fact, theory with a greater focus on behavioral economic elements may provide a more productive, potential framework to approach well water testing behavior. Our approach is a novel investigation into the usefulness of the HBM in an environmental context. Since there are limited studies using the HBM to investigate well water testing behavior and environmental issues in general, further research is needed to see if the economic variables are consistently significant factors across studies. It is important to discuss the potential of a more focused behavioral economic approach. Second, perhaps the HBM does have great potential, but on the basis of this study further modifications are needed. Potential modifications are outlined in the discussion including modifying questions used in this study, adding additional questions, collecting more data, applying the HBM to supplementary environmental issues to determine generalizability, etc. Third, the HBM holds the potential to be a powerful theory and approach in environmental situations because it determines which variables are important, economic or otherwise. When using the HBM, researchers can investigate both economic and noneconomic variables, and determine their relative importance.

The scenarios listed above are important to discuss and should be thought about carefully before continuing future studies. We do believe that the HBM holds the potential to be a powerful theory especially related to many of our current and future environmental issues that also impact human health such as well water contaminants (i.e., arsenic) — and have the potential to cause cancer, delay development, etc. However, this is one of the few studies that applied the HBM to an environmental/health issue. Therefore, additional studies that go beyond this exploratory research are needed to determine the extent of the potential that the HBM actually has in addressing these issues, additional factors and questions needed for analysis, and testing of further environmental issues to determine generalizability across environmental problems.

Achieving a more complete understanding of why people act in an environmentally responsible manner is of great value to many individuals such as Cooperative Extension specialists, policy makers, researchers, and health professionals. Our results not only provide a baseline dataset including perceptions of and concern for private well water quality in New England but also potential predictors of water quality behaviors related to well water testing. The significant factors reported in this article can be implemented in future water quality campaigns and research investigations. Even though there are parallels between health and environmental decision making, there are limited environmental HBM studies from which to understand how well an HBM approach fits into environmental decision making. Our recent discoveries, in combination with those studies, provide a potential avenue for developing a reliable theoretical approach to pro-environmental behavior modification.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Data S1. The questionnaire provided to participants, which comprises the survey questions used in the health belief model analysis.

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