PERCEPTIONS AND EXPECTED RESPONSES TO A WATER CONTAMINATION EMERGENCY

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15 June, 2010

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ABSTRACT

Local authorities who believe their water systems are contaminated need to warn those at risk to take protective actions. In the past, such efforts have often achieved only partial success in preventing consumption of contaminated drinking water. To examine the possible causal antecedents of compliance with water consumption advisories, this study examined perceptions of the likelihood of getting sick through 11 exposure paths. In addition, the study collected people's ratings of five protective actions on six attributes, their behavioral expectations of using each protective action, their ratings of eight information sources on three attributes, and their experience and demographic characteristics. The results indicated that the perceived difference between most and least dangerous exposure paths was surprisingly small—only about 40% of the response scale. The profiles of the protective actions on the six hazard-related and resource-related attributes explained why people expected to use bottled water rather than other options. Perceived effectiveness in protecting health was the most important correlate of behavioral expectations. Profiles of possible information sources showed that water utility personnel, public health officials, and emergency managers were high in protection responsibility, expertise, and trustworthiness. The congruence of these three attributes indicates protective action recommendations from these sources are likely to be accepted. However, protective action recommendations will be useless if people lack bottled water, heat sources to boil water, or bleach to chlorinate it.

Key words: hazard adjustment attributes, protective action, stakeholder perceptions, water contamination

1.0 INTRODUCTION

In normal circumstances, Americans can reasonably assume that their tap water is safe for drinking, cooking, and washing. Occasionally, however, water distribution systems become contaminated by unusually high levels of chemicals or biological parasites. Historically, such incidents have been accidental, but some are concerned that future cases might result from intentional acts by malicious agents (Berry et al., 2005).

When local authorities have reason to believe that such contamination exists, they need to warn those at risk to take precautions to prevent exposure. Unfortunately, such efforts often achieve only partial success in preventing consumption of potentially contaminated drinking water. Recent research on water consumption advisories provides some insight into the magnitude of the warning noncompliance problem, as well as some explanations why noncompliance occurs. The broader research literature on disaster warnings provides a more complete picture of reasons for noncompliance. Most of the research on warning response has studied people's response to evacuation warnings. The decision processes involved in responses to evacuation warnings are likely to be similar to those involved in responses to water consumption advisories, but they cannot be assumed to be identical. Thus, research is needed to test the applicability of research on evacuation warnings to water consumption advisories.

The following sections begin to address this issue. A section on water consumption advisories is followed by a review of relevant research on evacuation warnings that concludes with a set of specific research questions about people's perceptions of some important aspects of water consumption advisories. The *Results* section describes respondents' perceptions of 11 exposure paths, their ratings of five protective actions on six attributes and behavioral expectations, their ratings of eight information sources on three attributes, and their experience and demographic characteristics. Finally, the *Discussion* section identifies the study's theoretical and practical implications, methodological limitations, and research recommendations.

1.1 Research on Water Consumption Advisories

Until a water system can be decontaminated, people must protect their health and safety by taking protective actions to minimize, if not completely prevent, exposure. This means that water system managers must work with public health authorities, environmental protection officials, and emergency managers to respond to the event. They must identify the contaminating agent and the geographical areas in which contamination is present, select the most appropriate protective action recommendations for different population segments, warn those at risk in a timely and effective manner, and provide any support needed to implement those protective actions (Lindell, Prater & Perry, 2007; Perry & Lindell, 2007). The success of any population protection strategies depends substantially on the timeliness of the warning and compliance of the population at risk, as well as the response of those who actually are safe but *think* they are at risk.

There are a number of publications providing recommendations about water contamination advisories (e.g., Hoffman & Meyer, 2007; Parkin, Embry. & Hunter, 2003; Pontius, 1996; Sly, 2000) but only a few studies that demonstrate the range and levels of compliance during water system emergencies. In their study of two counties stricken by Hurricane Rita, Ram et al. (2007) found that only 39% of their respondents were aware of a boil water order. Many of those who received a warning did boil water (46%), but almost as many who were able to boil water did not (39%) and 15% reported being unable to boil water. Even though the leaflet announcing the water consumption advisory stated that water should be brought to a rolling boil for one full minute, most respondents remained misinformed about the boiling procedure. A majority (52%) gave answers that were over five minutes, 11% of the answers were between one and five minutes, 7% gave the correct answer of one minute, 4% gave an answer less than one minute, and 26% did not answer. Angulo et al. (1997) showed that in response to a salmonellosis outbreak, only 10% of the households at risk heard about the event before 10 days had passed and, of those who were aware, 31% did not comply—in large part due to forgetfulness (44%). Similar findings emerged in a town that experienced *E. coli* contamination in its water system after a flood (Harding & Anadu, 2000). There, 10% of the residents took no action and only 57% of those who received a warning boiled tap water as advised by the water utility, while 77% drank bottled water. Residents regarded the local newspaper and mail from the water utility as equally reliable sources of information (23% apiece) and the county health department and personal physician as only slightly less reliable (15% apiece). Conversations with family/friends, flyers from the water utility, radio broadcasts, phone calls from the local utility, and television broadcasts were less frequently rated as reliable but none was rated as unreliable.

In a sewage contamination incident in Greater Manchester, England, 56% of the survey respondents reported drinking unboiled water, after the incident had occurred but before receiving the boil water notice (O'Donnell, Platt, & Aston, 2000). During the time the notice was in place, 64% of households took some form of risk as defined by the boil water notice they had been sent. Members of 20% of the households at some stage forgot to boil the water before drinking it. Members of 54% of the households brushed their teeth with unboiled water. Members of 17% of the households used unboiled water to prepare foods that were not to be cooked before eating, such as washing a salad. In a study of residents living in an area in the North Thames region, United Kingdom, where 300,000 households were advised to boil tap water before consumption during a large outbreak of cryptosporidiosis, Willocks et al. (2000) reported that 85% of respondents said that they used boiled water while the notice was in place, 72% used bottled water, and 12% did not continue to boil water for the entire 16 days during which the boil water order was in effect. Although 88% believed that they were following the advice contained in the order, 20% washed food that would be eaten raw in unboiled tap water and 57% used it to clean their teeth. Similarly, Kargiannis et al. (2009) found that in an incident in which e. coli was found in the tap water supplied by a company in North Holland, 81.8% of respondents reported replying with the boil water advisory, while at the same time the majority of the respondents continued to use tap water for brushing their teeth, washing salads, and washing fruits.

1.2 Research on Natural Hazard Warnings

Studies on warning consumption advisories are somewhat helpful, but provide only limited guidance on how people respond to a water contamination. Research on evacuation warning response has led to the development of the *Protective Action Decision Model* (PADM, Lindell & Perry 1992, 2004), which provides a framework for systematically studying this problem. The PADM, which is based on five decades of disaster research, describes the sequence of stages in the warning response process and the progression of events that can prevent people from taking appropriate protective actions. Specifically, people receive warnings from a variety of social (news media, authorities, and peers) and environmental (sights, sounds, smells) sources. The social sources include authorities, the news media, and peers (friends, relatives, neighbors, and coworkers). Sources communicate their warnings by means of a number of different channels including face-to-face conversations, telephones, loudspeakers, and the print and electronic (television, radio, and internet) media (see Lindell & Perry, 1992, pp. 103-113). Authorities can control the timing of warning dissemination over some information channels (e.g., face-to-face, telephone, and loudspeaker warnings), but population segments vary in the frequency with which they are accessible by other channels—especially radio, television, and newspapers.

Perceptions of stakeholders. The way people process the information they receive during an emergency is influenced by their perceptions of the sources of that information. Information sources are evaluated in terms of a variety of characteristics, but their perceived expertise, trustworthiness, and protection responsibility are especially relevant in hazard warnings (Arlikatti, Lindell & Prater, 2008). In addition to the influence of information source perceptions, the amount of time that people spend in contact with those sources—especially the news media—influences people's protective actions (Lindell, Lu &Prater 2005).

Perceptions of risk. Information from environmental cues and social warnings, together with prior beliefs about the hazard agent, produces a situational perception of personal risk that is characterized by beliefs about the ways in which environmental conditions will produce specific personal consequences. In hurricanes, for example, risk perceptions can be characterized by people's beliefs about the degree to which storm surge, inland flooding, and storm wind will cause their death or injury, kill or injure their loved ones, destroy their property, or disrupt their jobs or basic services such as electric power and water (Baker, 1991; Dash & Gladwin, 2007; Lindell & Prater 2008). In water contamination incidents, the risk is highly likely to arise from some exposure paths, such as drinking contaminated tap water, and not others, such as using contaminated water to wash clothes.

Perceptions of hazard adjustments The expectation of personal consequences motivates people to search for actions that they can take to protect themselves. These might be actions that they already know, ones that were mentioned in a warning, or ones that they improvise when the situation arises. When multiple protective actions are available, the alternatives are evaluated in terms of hazard-related attributes such as efficacy in protecting persons and utility for other purposes, as well as resource-related attributes such as requirements for money, knowledge and skill, time and effort, and cooperation from others (Lindell & Perry, 1992; Lindell & Prater, 2002; Lindell et al., 2009). The alternatives that are highest on the hazard-related attributes and lowest on the resource-related attributes are the ones that people would prefer to implement. Even though people might prefer a protective action, they cannot implement it if they lack critical resources. As became quite obvious during Hurricane Katrina, people cannot evacuate themselves if they do not have reliable personal transportation. Similarly, they cannot switch to bottled water if they don't have some in stock, disinfect tap water if they lack household bleach, or use a filter pitcher is they don't have one. Nor can they boil water if the electric power is out unless they have camp stoves or other sources of heat (Ram et al. 2007).

Finally, there is evidence that adoption of protective actions is related to people's demographic characteristics, including female gender (Fothergill, 1996) and ethnic minority status (Fothergill et al., 1999). Gender is a relevant variable because previous research has shown women tend to differ from men in their perceptions of information sources (Arlikatti, Lindell, & Prater, 2008; Major, 1999), environmental risks (Fothergill, 1996) and protective actions (Lindell, Arlikatti & Prater, 2009).

1.3 Research on Pseudo-attitudes

Unfortunately, asking people to rate objects such as protective actions or information sources on a number of attributes will not necessarily yield reliable data. A major concern when asking respondents to rate objects with which they might not be familiar on attributes that they might not have previously thought about is that the ratings might reflect only pseudo-attitudes (Converse, 1970; Schuman & Kalton, 1985) that are constructed when people are asked for their opinions about issues for which they have no prior information. Although test-retest procedures can sometimes be used to test for the presence of pseudo-attitudes (Lindell & Perry, 1990), cross-sectional surveys require the use of other procedures (Lindell et al., 2009; Terpstra & Lindell, 2009). Thus, it is necessary to confirm that respondents' ratings cannot be attributed to central tendency (Cascio and Aguinis, 2004) and that the respondents differentiate among the alternatives with respect to each of the attributes (Lindell 1994a; Lindell et al., 2009; Terpstra, Lindell & Gutteling, 2009). Such assessments are particularly important when there is reason to believe that the respondents might be unfamiliar with the objects to be rated and, thus, are most likely to generate pseudo-attitudes.

It is also important to assess the degree of agreement among people in their perceptions of protective action attributes because this information is essential for determining the strategy to be followed in risk communication programs. If people agree in their perceptions of the protective actions but these differ from those of local officials, the latter can initiate a single risk communication program to correct any inaccuracies. However, if people vary significantly in their perceptions of the protective actions, local officials should use audience segmentation strategies to identify homogeneous subgroups and target individualized messages to each segment (Expert Review Committee, 1987; Hance, Chess & Sandman, 1988; Nelson & Perry, 1991). The limited research on people's perceptions of protective actions indicates there will be greater agreement on resource-related attributes than on hazard-related attributes (Lindell et al., 2009). Moreover, expectancy-valence models of attitudes (Fishbein and Ajzen (1975) propose that an individual's protective action behavioral expectations are influenced by both the perceived attributes of each hazard adjustment (expectancies) and the importance of these attributes (valences). Thus, even if people have high levels of agreement on the protective action attributes, they are likely to differ in their valences for those attributes. Consequently, as Lindell, et al. (2009) have found, they would be expected to have lower levels of agreement in their ratings of their behavioral expectations than in their ratings of the protective action attributes.

1.4 Research Needs

Although the research on which the PADM is based does not include water consumption advisories, the PADM seems to be compatible with the findings of behavioral studies in this area (Angulo et al., 1997; Griffin, Dunwoody & Zabala, 1998; Harding and Anadu, 2000; Pontius, 1998; Ram et al., 2007; Seydlitz, Spencer & Lundskow, 1994). However, more research is needed to determine how the PADM applies to water contamination threats. First, information is needed on people's perceptions of their vulnerability to different ingestion, inhalation, and absorption exposure pathways such as drinking tap water, washing hands, washing vegetables, using ice from automatic ice makers, bathing, showering, washing dishes, washing kitchen/bathroom counters, washing clothes, and watering and eating vegetables from home gardens and local farms (Fox & Lytle, 1996). Second, more information is needed about people's perceptions of protective action recommendations such as using bottled water, filtering water at home (e.g., filter pitchers), boiling water, and chemically disinfecting water (EPA, 2006). Third, more information is needed on people's perceptions of information sources (e.g., water system managers, public health authorities, environmental protection officials, emergency managers, and news media personnel)—especially how these sources vary in their perceived expertise, trustworthiness, and protection responsibility (Arlikatti et al., 2007).

In addition to assessing people's perceptions of alternative protective actions, we also need to determine how these perceptions affect people's behavior. Although there has been considerable debate in the past about the validity of behavioral intentions as predictors of the actual likelihood of compliance, extensive research has identified conditions under which there is a significant degree of correspondence between intentions and behavior (Glasman & Albarracin, 2006; Sheeran, 2001). However, intention-behavior correspondence is strongest when people have formed intention to perform specific behaviors in near future that are similar to ones that they have performed in the past. For example, Kang, Lindell and Prater (2007) found that the behavioral *expectations*, which are less specific than behavioral *intentions*, that are most congruent with later behaviors are the ones that have been performed in the past.

The literature reviewed above leads to the following hypotheses.

H1: Respondents' mean ratings of exposure paths, protective actions, and information sources will rule out pseudo-attitudes by being significantly different from the midpoints of the rating scales.

H2: Respondents' mean ratings will differentiate among exposure paths, as indicated by significant differences in respondents' mean ratings of the perceived risk of becoming sick from contaminated water through the exposure paths.

H3: Respondents' mean ratings of hazard-related and resource-related attributes will differentiate among protective actions, as indicated by significant differences among the protective actions in respondents' mean ratings on each attribute.

H4: Respondents will have higher agreement on the resource-related attributes than on hazard-related attributes of protective actions which, in turn, will have higher agreement than on behavioral expectations.

H5: Each of the three attributes (expertise, trustworthiness, and protection responsibility) will differentiate among the information sources, as indicated by significant differences among the information sources in respondents' mean ratings on each attribute.

H6: Female gender will be positively correlated with perceived risk from the exposure paths, the hazard-related and resource-related attributes of the protective actions, the perceptions of the information sources, and media monitoring.

H7: Past experience (previous warnings and previous illnesses) and facilitating conditions (availability of bottled water, chlorine, and filter pitchers) will be positively correlated with expectations of taking the protective actions.

H8: Hazard-related attributes will be strongly positively correlated with each other, as will the resource-related attributes, but the hazard-related attributes will be minimally correlated with the resource-related attributes.

RQ1: Are there systematic patterns in access to the news media (television, radio, and newspapers)?

2.0 METHOD

2.1 Instrument

Hazard perception was measured by asking respondents to judge on a scale of *Not at all likely* (= 1) to *Almost certain* (= 5), the likelihood that they could get sick by having a glass of water to drink, rinsing fresh vegetables such as lettuce, cooking some spaghetti noodles, brewing a pot of coffee, making ice for cold drinks, rinsing their mouths after brushing their teeth, washing their hands after using the toilet, taking a shower, washing their dishes, washing kitchen/bathroom counters, and washing clothes. Total risk perception was the average rating on all 11 exposure paths.

Following the procedures in Lindell and Prater (2002) and Lindell et al. (2009), respondents reported their perceptions of protective actions by asking respondents to rate five different protective actions (buying and using only bottled water to drink, boiling all the water they drink, using chlorine bleach to disinfect all the water they drink, using water from a filter pitcher, using water from the hot water heater). Each protective action was rated on seven attributes (protect my health very effectively, cost a lot of money, require specialized knowledge and skill, require a lot of effort, require a lot of cooperation from others, also be useful for purposes other than water contamination, be something I am likely to do) using a scale of *Not at all* (= 1) to *Very great extent* (= 5). Total protective action expectation was the average rating on all six behavioral expectations items.

Following Arlikatti et al. (2007), perceptions of information sources were measured by asking respondents to rate eight different sources (local water utility personnel, local public health personnel, local emergency management personnel, local elected officials, local news media, your personal physician, friends, relatives, neighbors and coworkers, and yourself and your immediate family). Each source was rated on three attributes (*expertise*—"knowledgeable about water contamination hazard", *trustworthiness*—"willing to provide you with accurate information about water contamination hazard", and *protection responsibility*—"responsible for protecting you from water contamination") using a scale of *Not at all* (= 1) to *Very great extent* (= 5).

Channel access was measured by asking respondents to report the times of day they usually (four or more times per week) monitored the news. Respondents were given a 24 hour timeline and asked to circle all relevant hours at which they watch local television news, listen to local radio news, and read local newspapers. Resource access was measured by asking respondents to report how many quarts of bottled water they had in their homes (ranging from 0 to 10 or more), whether they had at least one cup of chlorine bleach (*No* = 0, *Yes* = 1), and whether they had a filter pitcher (*No* = 0, *Yes* = 1). Experience was measured by asking respondents to report they had ever been told by public officials not to drink tap water in their homes (*No* = 0, *Yes* = 1), and whether they or a family member had ever gotten sick from drinking tap water in their homes (*No* = 0, *Yes* = 1). Finally, media access was measured by three items that asked respondents to check each hour on a 24 hour timeline that they usually (four or more times per week) monitored that news media channel (TV, radio, or newspaper). The total number of hours of access to each of the individual channels was calculated by summing the number of hours that the respondent reported monitoring that channel.

2.2 Participants

Forty eight undergraduates enrolled in an introductory psychology class completed the questionnaire as part of a course requirement. The sample was 52% female, with an average age of 18.7 (ranging from 18 to 21), and all were single. The members of the sample identified themselves as African American (4.2%), Asian/Pacific Islander (2.1%), Caucasian (68.8%), Hispanic (8.3%), Native American (2.1%), and Mixed (14.6%). Although undergraduates are not representative of the population as a whole, we expect to be able to obtain meaningful results from these respondents because many of them live in apartments where they have facilities for boiling or disinfecting water and have enough disposable income to purchase bottled water if there were a water contamination incident in their community. Moreover, findings from a preliminary study of college students' perceptions of seismic hazard, hazard adjustments, and information sources (Lindell & Whitney, 2000) were substantially replicated in a later study of households in six cities (Lindell & Prater, 2000, 2002; Arlikatti et al., 2007).

3.0 RESULTS

3.1 Tests for Pseudo-attitudes

To determine if the ratings are based on systematic responses, as proposed by H1, we conducted single sample *t*-tests to determine the significance of the difference of the mean rating of each hazard adjustment on each attribute from the scale midpoint (3 on the 1-5 scale). These tests can be used to determine if there is evidence of *central tendency*, which is a response bias that is commonly encountered when people are asked to rate objects on dimensions about which they feel they have insufficient information (Cascio & Aguinis, 2004). These tests revealed that 22/24 (91.7%) of the stakeholder ratings, 23/35 (65.7%) of the protective action ratings and 4/11 (36.4%) of the exposure path ratings were significantly different from their scale midpoints. This provides substantial confidence in the reliability of the stakeholder ratings and, to a lesser extent, the protective action ratings, but raises questions about the reliability of the exposure path ratings.

3.2. Exposure Paths

Because the exposure path data had a very high percentage of ratings that were not significantly different from the scale midpoint, we conducted further analyses to determine if they displayed evidence of *halo error* which is another rating tendency that occurs when people are asked to rate objects on dimensions about which they feel they have insufficient information (Cascio & Aguinis, 2004). Halo error refers to the tendency for ratings of separate dimensions to be consistent with a global evaluation or judgment (for discussion, see Nisbett & Wilson, 1977). Halo error would be expected to produce highly correlated ratings among the exposure path ratings and, in the extreme, a single factor. Table I displays the matrix of means, standard deviations, r_{wg} values (a measure of interrater agreement; see below for further discussion), and correlations among the exposure paths. The correlation matrix was subjected to a principal axis factor analysis with varimax rotation, which produced three factors with eigenvalues greater than one. A scree plot confirmed the three factor solution, which accounted for 68.5% of the variance. As the correlation matrix clearly indicates, Items 1-3 (having a glass of water to drink, rinsing fresh vegetables such as lettuce, and making ice for cold drinks) form one factor; Items 4 and 5 (brewing a pot of coffee and cooking some spaghetti noodles) form a second factor; and Items 6-11 (rinsing the mouth after brushing teeth, washing hands after using the toilet, taking a shower, washing dishes, washing kitchen/bathroom counters, and washing clothes) form the third factor. The construct validity of this solution is indicated by the fact that there are high average intercorrelations within factors (mean r_{ij} = .54 for Factor 1, .74 for Factor 2, and .65 for Factor 3) indicating convergent validity and low average intercorrelations between factors (mean r_{ij} = .24) indicating discriminant validity (Nunnally & Bernstein 1994). It is noteworthy that there was a much higher average level of interrater agreement that drinking water was hazardous and a much lower level of agreement that brewing coffee was hazardous.

Table I about here

Consistent with H2, a MANOVA revealed that there was a significant effect for exposure path (Wilks Λ = 0.21, $F_{11, 36}$ = 155.20, p < .05). As Figure 1 indicates, the respondents discriminated significantly among the exposure routes in terms of their likelihood of getting sick. Moreover, the rank ordering of the exposure routes is reasonable, with drinking water from a glass having the highest hazard rating, washing clothes having the lowest hazard rating, and other exposure routes having intermediate ratings. However, it is somewhat surprising that there was not more differentiation between the highest and lowest rated exposure routes. Specifically, one would expect the ratings of drinking tap water from a glass and using ice made to have higher ratings than they did because both involve direct ingestion of significant amounts of contaminated tap water. Conversely, one would expect that brewing coffee, cooking spaghetti, and washing clothes would have lower ratings than they did because the first two involve boiled water and the third involves only a very indirect exposure. In fact, the most noticeable pattern in the results is that drinking from a glass and making ice (which were similar to each other) were significantly different from the next four exposure paths (t_{47} = 5.90, p < .001) which, in turn, were significantly different from the last five exposure paths (t_{47} = 3.41, p < .001).

Figure 1 about here

3.3. Protective Actions

Consistent with H3, a MANOVA revealed that significant effects for protective action (Wilks Λ = 0.29, $F_{4, 42}$ = 25.41, p < .001), attribute (Wilks Λ = 0.31, $F_{6, 40}$ = 14.71, p < .001), and interaction (Wilks Λ = 0.07, $F_{24, 22}$ = 11.56, p < .001). As Figure 2 indicates, respondents gave the highest intention ratings to bottled water, followed by boiled water, filtered water, chlorinated water, and heater water. Bottled and boiled water tended to receive relatively similar ratings on all attributes except money, where they were at opposite ends of the rating scale. Chlorinated water and heater water also tended to receive similar ratings but were lower than bottled or boiled water on protecting health and other purposes (where high ratings are desirable) and were higher than bottled or boiled water on knowledge and skill, effort, and social cooperation. Chlorinated water and heater water were rated lower in cost than bottled water but, curiously, higher in cost than boiled water. Filtered water received intermediate ratings on all attributes except effort and social cooperation, where it received the lowest (most desirable) ratings.

Figure 2 about here

Post-tests indicated that there were statistically significant differences between the ratings of the lowest rated and highest rated protective actions on each attribute. Table II indicates that the differences between the lowest and highest rated protective actions ranged from 20.8 to 60.4 per cent of the rating scale, indicating that these attributes had practical significance in distinguishing among the protective actions. Heater water was a defining alternative (either the highest or lowest rated) on six of the seven attributes whereas bottled water was a defining alternative on five of the seven attributes. Filtered water was a defining alternative on two attributes and boiled water was a defining alternative on one attribute. The differences among alternatives were greater on financial cost and knowledge/skill than on effort and required cooperation (the other two resource-related attributes) or protect health and other uses (the two hazard-related attributes).

Table II about here

H4 was tested by comparing the observed variances in the ratings of the hazard adjustments on each attribute against a uniform distribution (equal numbers of responses in each of the five response categories) using the index $r_{WG} = 1 - (s_X^2 / \sigma_{EU}^2)$, where s_X^2 is the observed variance in the responses on a specific rating dimension and σ_{EU}^2 is the variance of a uniform distribution. The latter term equals $(c^2 - 1)/12$, where c is the number of response categories, so σ_{EU}^2 = 2 when using a five point scale (Lindell & Brandt, 1999; Tinsley & Weiss, 1975). An approximate test of r_{WG} can be accomplished by using the statistic, $\chi_{K-1}^2 = (K-1)(s_X^2 / \sigma_{EU}^2)$, where K is the number of raters. As Table III indicates, the null hypothesis that $r_{WG} = 0$ was rejected at the $p < .05$ (two-tailed) level for 33 (94%) of 35 items (5 protective actions x 7 attributes), indicating that the ratings were not uniformly distributed. This finding, together with fact that the r_{WG} values were generally positive, supports the conclusion that there was a significant level of agreement in the respondents' ratings (see Le Breton, James & Lindell, 2005; Lindell & Brandt, 2000; Lindell, et al., 1999, for further discussion of tests of interrater agreement). Contrary to H4, the level of interrater agreement for the resource-related attributes (median r_{WG} = .46) was no different from the value for the hazard-related attributes (median r_{WG} = .46) but, consistent with H4, agreement on the resource-related and hazard-related attributes was greater than on the behavioral intentions (r_{WG} = .39) but the difference was small. Moreover, one of the hazard-related attributes (other uses) actually had a lower level of interrater agreement than did behavioral expectations. Thus, support for H4 was weak. Although not hypothesized, agreement on bottled and boiled water was higher than on filtered, heater, or bleached water.

Table III about here

3.4. Information Sources

Consistent with H5, a MANOVA revealed significant effects for information source (Wilks Λ = 0.16, $F_{7, 40} = 31.14$, $p < .001$), attribute (Wilks Λ = 0.33, $F_{2, 45} = 11.26$, $p < .001$), and interaction (Wilks Λ = 0.25, $F_{14, 32} = 7.20$, $p < .001$). As Figure 3 indicates, respondents gave the highest ratings on all three attributes (expertise, trustworthiness, and protection responsibility) to the water utility, public health officials, and emergency managers. They gave somewhat lower, but generally similar, ratings, of trustworthiness to all other information sources. The results were somewhat more complex for ratings of expertise because personal physicians received ratings of expertise that were relatively similar to their ratings of trustworthiness (as was the case for the water utility, public health officials, and emergency managers. However, the news media, elected officials, peers, and self and family received expertise ratings that were similar to each other but significantly lower than their trustworthiness ratings. Ratings of protection responsibility yielded the most complex results, with personal physicians receiving much lower ratings of protection responsibility than expertise and trustworthiness, whereas news media and peers received much lower ratings of expertise and protection responsibility than trustworthiness. Further, elected officials and self/family received much lower ratings of expertise than trustworthiness and protection responsibility.

Figure 3 about here

Consistent with H5, post-tests indicated that there were statistically significant differences between the ratings of the lowest rated and highest rated information sources on each of the attributes. Table IV indicates that the differences between the lowest and highest rated information sources ranged from 33.9 to 54.2 per cent of the rating scale, indicating that these attributes had practical significance in distinguishing among the information sources. Peers were the lowest rated information sources on two of the three attributes whereas public health officials were the highest rated information sources on those two attributes. Personal physicians were lowest on one attribute (personal responsibility) whereas water utility personnel were highest on that attribute.

Table IV about here

Although there was no hypothesis about the level of interrater agreement on the stakeholder attributes, Table V shows there was generally a higher level of agreement about expertise (mean r_{WG} = .53) than about trustworthiness (mean r_{WG} = .45) or protection responsibility (mean r_{WG} = .44). Conversely, there was generally a higher level of agreement about water utility personnel (mean r_{WG} = .55), public health officials (mean r_{WG} = .57), and emergency management officials (mean r_{WG} = .52) than about the remaining information sources, especially the news media (mean r_{WG} = .37).

Table V about here

To assess RQ1, a MANOVA revealed that there was not an overall significant effect for media channel (Wilks $\Lambda = 0.91$, $F_{2, 46} = 2.82$, *ns*). Nonetheless, Figure 4 indicates that respondents had a tendency to view TV at 7-8am and again from 5-10pm. They tended to read the newspaper from 8am to 1pm and listen to the radio from 7-8am and 4-5pm. These patterns leave noticeable gaps from 1-5pm and 11pm to 6am when news media access is at a very low level.

Figure 4 about here

3.4. Prediction of Protective Action Expectations

The respondents reported a generally high ability to implement three of the protective actions, with a median of 5.00 quarts of bottled water in a nearly symmetric distribution ranging from 1-10 quarts, 75% having at least one cup of chlorine bleach, and 56% having a filter pitcher. Moreover, 23% reported having been told by public officials not to drink tap water in their homes but only 4% had gotten sick from drinking tap water in their homes. Thus, with the exception of experience with water-related illness, there was little potential for variance restriction to reduce the correlations predicted by H6 and H7. Moreover, as noted earlier, 52% of the respondents were female and 31% were minorities so there was little potential for variance restriction on these variables either. Nonetheless, Table VI indicates there were only marginally significant correlations of minority ethnicity with perceived risk from the exposure paths and female gender with possession of water filters. Whites tended to rate the protective actions higher in effort and required cooperation but neither of the demographic variables was significantly correlated with behavioral expectations of the protective actions.

Table VI about here

There were also significant correlations of past experience with access to water filters (counter-intuitively negative) and previous illnesses with lower ratings of effort and negative expectations about using water filters. However, none of these variables was significantly correlated with behavioral expectations for any of the protective actions. In fact, there were only two of the 50 (10 demographic, experience, media exposure, protective action facilitation, and risk perception variables x 5 protective actions) correlations that were statistically significant—which is less than the 5% that would be expected by chance. In summary, neither H6 or H7 was confirmed.

However, there was support for H8, which predicted that the two hazard-related attributes (protect health and other uses) would be positively correlated, as would the resource-related attributes (cost, knowledge/skill, effort, and required cooperation). As Table VI indicates, the hazard-related attributes were not significantly correlated with the resource-related attributes. Moreover, the two hazard-related attributes were significantly related with total expectations of implementing the five protective actions. More specifically, protecting health was significantly correlated with each of the protective actions except bottled water and other uses was significantly correlated with boil water and heater water.

Although not hypothesized, it is noteworthy that the media access variables were significantly positively intercorrelated (mean r_{ij} = .50), indicating that respondents tended to either monitor no channels or all channels. Moreover, the protective action behavioral expectations variables had generally low intercorrelations (mean r_{ij} = .22), indicating that respondents did not consider the protective actions to be intersubstitutable.

4.0 DISCUSSION

The tests for pseudo-attitudes associated with H1 suggested that there is substantial reliability of the stakeholder ratings and, to a lesser extent, the protective action ratings, but raises questions about the reliability of the exposure path ratings. Nonetheless, consistent with H2, there are statistically significant differences among the exposure paths. Moreover, Figure 1 shows that the rank ordering of the exposure routes is reasonable, with drinking tap water from a glass having the highest hazard rating, washing clothes having the lowest hazard rating, and other exposure routes having intermediate ratings. However, it is somewhat surprising that there was not more differentiation between the highest and lowest rated exposure routes. Specifically, one would expect the ratings of drinking tap water from a glass and using ice made with contaminated water to have higher ratings than they did because both involve direct ingestion of significant amounts of water. Conversely, one would expect that brewing coffee, cooking spaghetti, and washing clothes would have lower ratings than they did because the first two involve boiled water (which, in the case of spaghetti, is not ingested) and the last one involves only a very indirect exposure even though the water isn't boiled. These results call attention to the need to develop a more comprehensive understanding of people's interpretations of exposure because the data in Figure 1 suggest that the respondents' *intuitive toxicology* (MacGregor, Slovic & Malmfors, 1999; Owen, Colbourne, Clayton, & Fife-Shaw, 1999) could account for the differences in the ratings of risk associated with the different exposure paths. Specifically, they seemed to be heeding differences in the amount of water consumed (drinking a glass of tap water vs. rinsing one's mouth with tap water) and distinguishing between ingestion (drinking a glass of tap water) and skin contact (taking a shower). It also seems that differences in risk judgments were influenced by whether boiling water was implied (drinking a glass of tap water vs. making coffee). Further research is needed to test these possible explanations for the observed differences.

The finding that H3 was supported by statistically significant differences among the protective actions on all of the hazard-related and resource-related attributes is important because it replicates the findings of previous studies using a different set of respondents and different protective actions for a different hazard. Specifically, Lindell and Whitney (2000) used a student sample and Lindell, et al. (2009) used a broader population sample to judge earthquake mitigation and preparedness actions whereas this study used a student sample to judge water contamination emergency response actions The similarity of these findings suggests that these hazard-related and resource-related attributes are meaningful ways to describe a wide range of protective actions for to a diverse set of hazards. However, it is important to note that the magnitudes of the differences among the water contamination protective actions were much smaller (an average of 39.3% of the rating scale) than among the earthquake hazard adjustments studied by Lindell et al. (2009), which was an average of 55.2% of the rating scale. Further research is needed to determine if this difference is attributable to the nature of the protective actions (water contamination vs. earthquake) or the samples (student vs. general population).

The finding that H4 (there will be higher agreement on the resource-related attributes than on hazard-related attributes of protective actions which, in turn, will have higher agreement than on behavioral expectations) was only partially confirmed. This is because there was no difference in the levels of interrater agreement on the resource-related (median r_{WG} = .46) and hazard-related (median r_{WG} = .46) attributes but both of these were slightly higher than the levels of interrater agreement on the behavioral expectations (r_{WG} = .39). This pattern is rather different from that found in a study of earthquake hazard adjustments (Lindell, et al. 2009). In that study, the level of interrater agreement on the resource-related attributes (median r_{WG} = .49) was noticeably higher than on the hazard-related attributes (median r_{WG} = .31) which, in turn, was much higher than the level of interrater agreement on behavioral expectations (r_{WG} = .18). As was the case with the magnitudes of the differences among the water contamination protective actions (H3), further research is needed to determine if this difference in findings is attributable to the nature of the protective actions (water contamination vs. earthquake) or the samples (student vs. general population). If, in fact, there is more agreement about water contamination protective actions than about earthquake hazard adjustments, it will be important to determine if the public consensus is accurate. Specifically, if there were a strong public consensus that boiled water is ineffective in protecting health, then public officials could focus on correcting this misconception. However, if there is a low level of interrater agreement then it will be important to find out which population segments hold this misconception and then focus risk communication efforts on these population segments.

The fact that H5 (there will be differences among the information sources in their perceived expertise, trustworthiness, and protection responsibility) was confirmed is important because it shows that water utility personnel, public health authorities, and emergency managers are all considered to be responsible for providing public protection but also knowledgeable about water contamination hazard and trustworthy in providing information. The congruence of these three attributes is important because a source that was perceived as responsible for protection but lacking in either expertise or trustworthiness would have a very difficult time getting those at risk to accept his or her protective action recommendations. To some extent, Figure 3 shows that this is a potential problem for local elected officials, who are perceived to be high in protection responsibility and trustworthiness but lacking in expertise. Thus, their credibility in an incident will depend on the degree to which their protective action recommendations are perceived to be consistent with those of water utility personnel, public health authorities, and emergency managers—all of whom are perceived to have the required expertise.

The finding that neither H6 (female gender will be positively correlated with perceived risk, hazard-related and resource-related attributes, perceptions of information sources, and media monitoring) nor H7 (past experience and facilitating conditions will be positively correlated with expectations of behavioral expectations) was confirmed is somewhat surprising, given that some previous research has found demographic characteristics—especially gender (Fothergill, 1999)—and previous experience (Weinstein, 1989) to be significantly correlated with protective actions. One methodological explanation for the nonsignificant findings is variance restriction. However, as noted earlier, 52% of the respondents were female and 31% were minorities so variance restriction on these two variables is not an explanation for the absence of significant correlations involving these variables. In addition, the respondents reported a generally high—but variable—ability to implement three of the protective actions, with a median of 5.00 quarts of bottled water in a nearly symmetric distribution ranging from 1-10 quarts, 75% having at least one cup of chlorine bleach, and 56% having a filter pitcher. Moreover, 23% reported having been told by public officials not to drink tap water in their homes but only 4% had gotten sick from drinking tap water in their homes. Thus, with the exception of experience with water-related illness, there was little potential for variance restriction to reduce the correlations predicted by H6 and H7.

The non-significance of these variables is not completely surprising because, as Baker (1991) noted, there is conflicting evidence regarding the correlations of demographic characteristics and previous experience with protective actions and this is probably because these variables exert their influence early in the causal chain from hazard exposure through hazard experience and risk perception to protective action (Lindell & Hwang, 2008). On the other hand, college students—whether female or male, minority or majority—are not necessarily representative of their demographic groups, so further research is needed on broader population samples. If future research replicates the non-significant correlations of demographic variables with perceived risk, hazard-related and resource-related attributes, perceptions of information sources, and media monitoring, then local officials will have little need for audience segmentation strategies during water contamination incidents.

However, there was support for H8, which predicted that the two hazard-related attributes (protect health and other uses) would be positively correlated, as would the resource-related attributes (cost, knowledge/skill, effort, and required cooperation). The finding that the two hazard-related attributes, but not the four resource-related attributes, were significantly related with total expectations of implementing the five protective actions is also consistent with previous findings (Lindell & Whitney, 2000; Lindell & Prater, 2002). This means that local officials should emphasize the effectiveness of the recommended protective actions in providing protection from waterborne illnesses.

It is important to acknowledge that this study has its limitations. First, the sample was small and demographically homogeneous. The small sample size means it had adequate power to detect only moderate sized correlations ($r \geq .28$) as statistically significant. Moreover, the sample's homogeneity precluded examination of possible demographic differences in the ratings of exposure path hazards, protective action attributes, information source attributes, and media monitoring.

Second, this study—like all cross-sectional designs—has limited ability to draw conclusive causal inferences. In particular, longitudinal studies are needed to assess the test-retest reliability (stability) of participants' perceptions. If such studies show high stability in the perceptions of exposure path hazards and protective action attributes, local officials could have greater confidence in the usefulness of these results for designing water contamination warnings. Moreover, longitudinal data would clarify whether the hazard-related attributes caused the behavioral expectations or vice-versa

Notwithstanding the sample's limitations, this study does have some theoretical and practical implications. First, these results provide further empirical support for the distinction between hazard-related and resource-related dimensions of hazard adjustments. Moreover, just as lay people's conceptions of risk have been found to be broader than those of technologists (Fishchhoff, Slovic, Lichtenstein, Read & Combs, 1978; Slovic, 1987), the present results show that hazard adjustment attributes are broader than the simple conception of benefits (reduction in risk to lives and property) and economic costs. Benefits also include usefulness for other purposes, which effectively distribute the resource requirements of a protective action over other risks. Costs also include knowledge/skill, effort, and required cooperation.

Second, some protective actions had high levels of adoption intentions even though they had poor ratings on one or more attributes. For example, bottled water—which had the highest ratings on behavioral expectations—had high ratings on cost (a negative attribute) and was indistinguishable from the other protective actions on other uses (a positive attribute). Thus, a protective action does not need to be perfect (i.e., high on the hazard-related attributes and low on all resource-related attributes) to have high rates of adoption expectations.

Third, when providing information about protective actions, it is likely that there will be differences among the attributes in people's acceptance of data from even the most credible public officials. Specifically, information about hazard-related attributes such as a protective action's effectiveness in protecting health is more likely to be accepted because it would be difficult for people to verify this information independently. Consequently, these hazard-related attributes are likely to be influenced by experts' authoritative appeals. However, information about resource-related attributes such as a protective action's cost, skill, time, effort, and cooperation requirements may be more difficult to change because they can be independently verified by people' personal experience. Persuasive appeals from a similar source (e.g., friends and family) might be more effective than appeals from an expert source regarding these attributes, an argument similar to that made regarding adjustments to occupational hazards (Lindell, 1994b). It might seem from Figure 3 that persuasive appeals from peers might be offset by people's perceptions that such sources have lower levels of hazard knowledge than they have themselves but perceptions of peers are significantly related to behavioral expectations (see also Arlikatti, et al., 2007; Lindell and Whitney, 2000).

Ultimately, public officials who are able to increase the adoption of protective actions could significantly reduce waterborne illnesses in their communities. However, even if they can disseminate warnings to all households within their communities, get people to heed all information in those warnings, and ensure that warnings are stated in language that all population segments can understand, the warning messages will be useless if people lack bottled water, heat sources to boil water, or bleach to chlorinate it (Ram et al., 2007). Thus, preimpact emergency preparedness is needed just as much as postimpact warning message construction and dissemination.

5.0 ACKNOWLEDGEMENT

This work was supported by the National Science Foundation under Grant CMM-0826401. Any opinions, findings, and conclusions and recommendations expressed in this work are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Figure 1. Perceived likelihood of getting sick from different types of exposure.

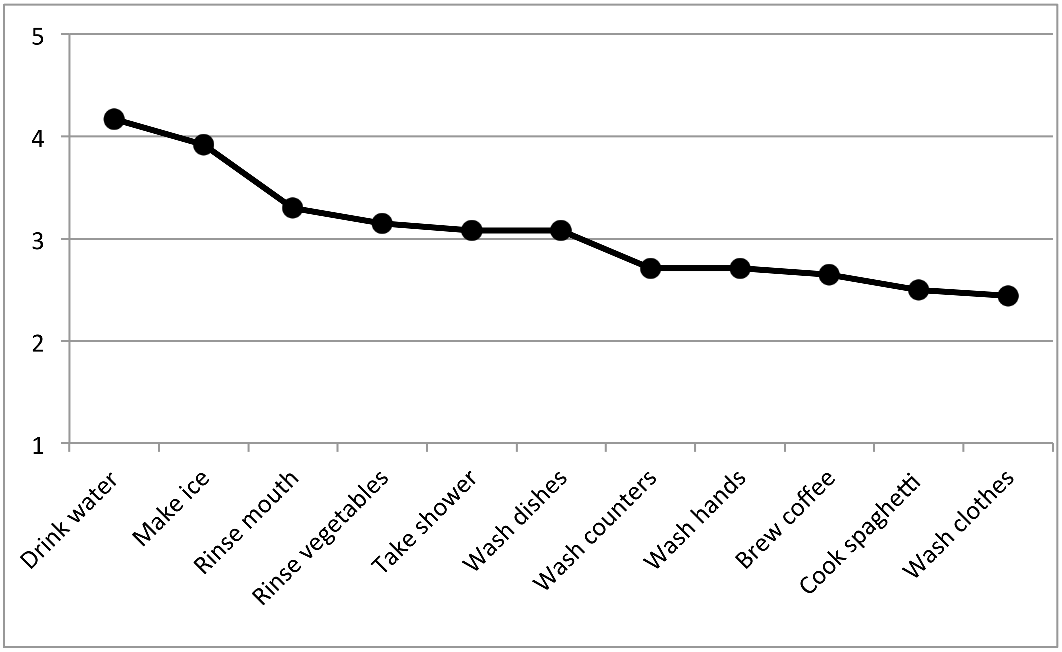

Figure 2. Perceptions of drinking water protective actions, by attribute.

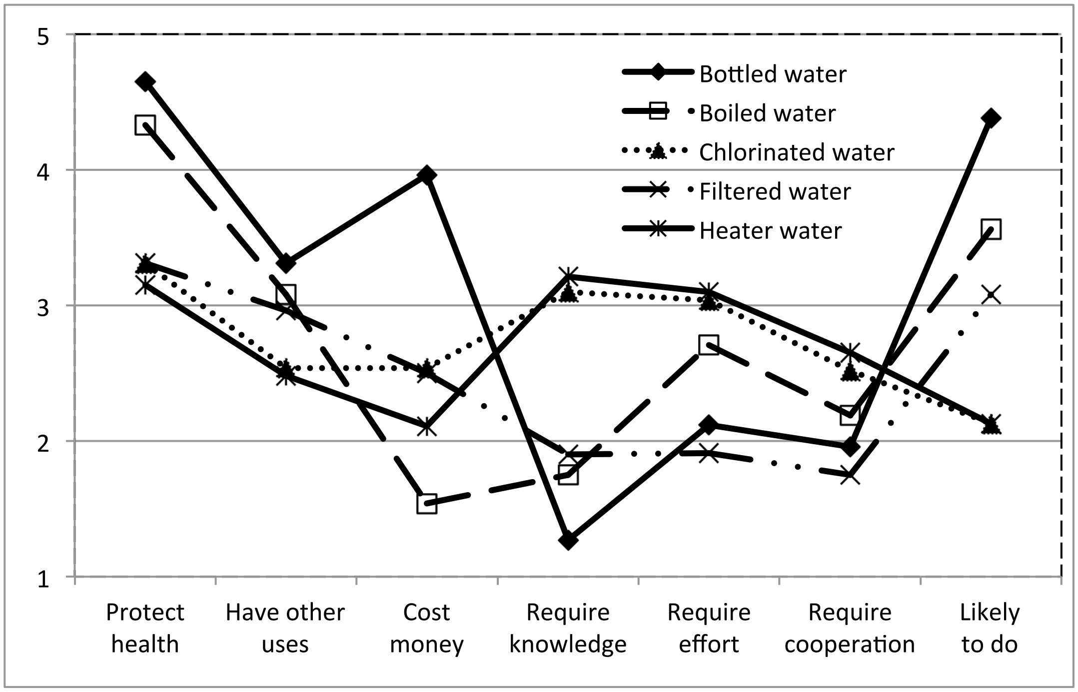

Figure 3. Perceptions of stakeholder characteristics, by stakeholder.

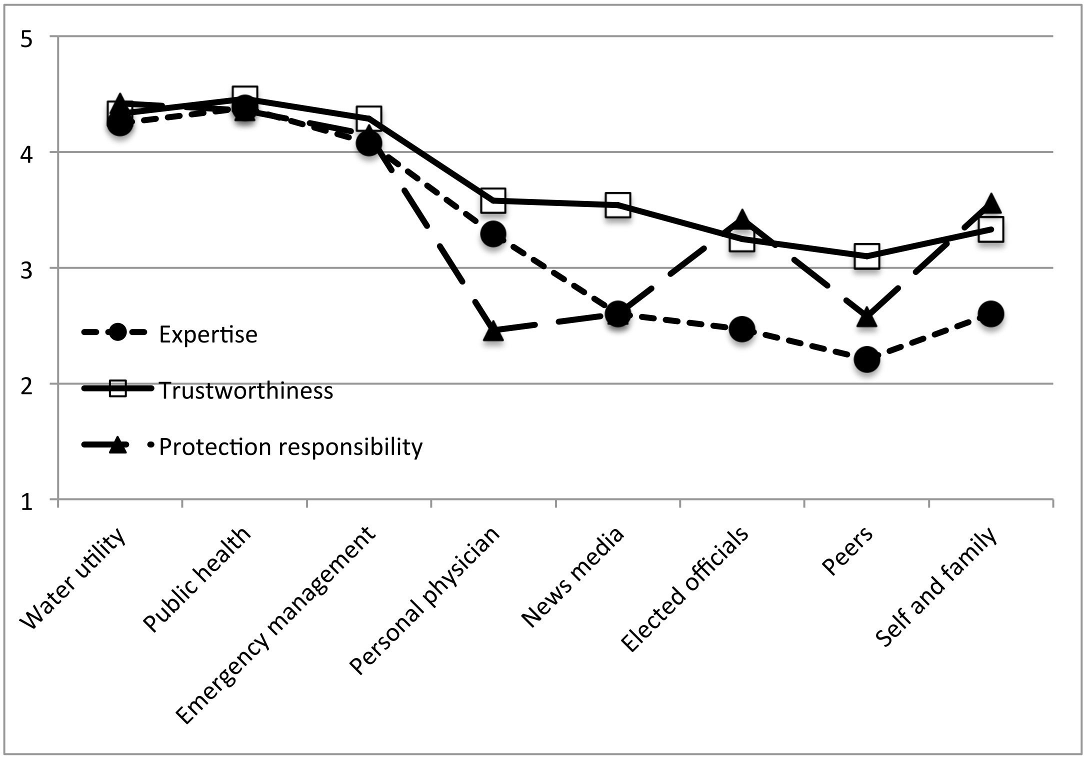

Figure 4. Time of day for news media monitoring

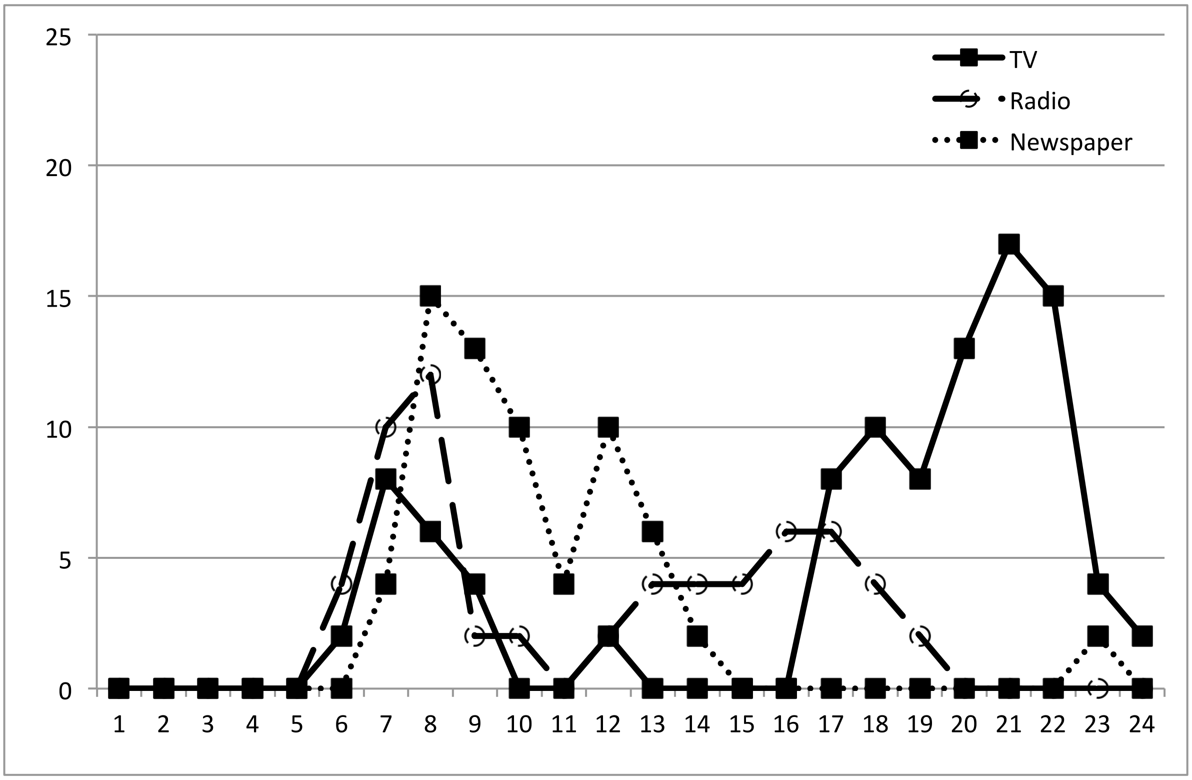

Table I. Intercorrelations among exposure path ratings

	M	SD	r_{WG}	1	2	3	4	5	6	7	8	9	10	11
1. Drink water	4.17	.81	.67	1.00										
2. Rinse vegetables	3.15	1.01	.49	.54	1.00									
3. Cook spaghetti	2.50	1.17	.32	.00	.21	1.00								
4. Brew coffee	2.65	1.31	.14	.04	.39	.74	1.00							
5. Make ice	3.92	.94	.56	.52	.57	.33	.23	1.00						
6. Rinse mouth	3.30	1.16	.33	.27	.49	.17	.17	.61	1.00					
7. Wash hands	2.71	1.13	.36	.12	.28	.16	.16	.47	.70	1.00				
8. Take shower	3.08	1.05	.45	.11	.24	-.07	-.07	.31	.58	.74	1.00			
9. Wash dishes	3.08	1.07	.43	.13	.39	.14	.14	.42	.60	.58	.58	1.00		
10. Wash counters	2.71	1.13	.36	.15	.38	-.08	-.08	.39	.58	.62	.72	.76	1.00	
11. Wash clothes	2.44	1.13	.36	-.06	.24	.09	.09	.32	.48	.59	.65	.71	.85	1.00

Table II. Profile analysis results for protective actions

Attribute	Low	Mean	High	Mean	Difference	% of scale
1. Protect health	Heater water	3.15	Bottled water	4.65	1.50	37.5
2. Have other uses	Heater water	2.48	Bottled water	3.31	0.83	20.8
3. Cost money	Boiled water	1.54	Bottled water	4.18	2.42	60.4
4. Require knowledge	Bottled water	1.27	Heater water	3.21	1.94	48.4
5. Require effort	Filter water	1.91	Heater water	3.10	1.19	29.7
6. Require cooperation	Filter water	1.75	Heater water	2.65	0.90	22.4
7. Likely to do	Heater water	2.13	Bottled water	4.38	2.25	56.3

Table III. Values of interrater agreement (r_{WG}), by protective action and attribute.

	Bottle	Boil	Bleach	Filter	Heater	Row Mean
Protect health	0.80	0.70	0.49	0.32	0.47	0.56
Have other uses	0.32	0.02	0.23	0.15	0.26	0.20
Cost money	0.26	0.68	0.38	0.34	0.34	0.40
Require knowledge	0.86	0.71	0.12	0.44	0.30	0.49
Require effort	0.48	0.21	0.09	0.55	0.19	0.30
Require cooperation	0.47	0.35	0.17	0.67	0.24	0.38
Likely to do	0.45	0.30	0.24	-0.10	0.28	0.23
Column Mean	0.52	0.42	0.25	0.34	0.30	0.37

$r_{WG} > .31$ is statistically significant at $p < .05$

Table IV. Profile analysis results for stakeholders

Attribute	Low	Mean	High	Mean	Difference	% of scale
1. Expertise	Peers	2.21	Public health	4.38	1.50	54.2
2. Trustworthiness	Peers	3.10	Public health	4.46	0.83	33.9
3. Protection responsibility	Physician	2.46	Water utility	4.42	2.42	49.0

Table V. Values of interrater agreement (r_{WG}), by information source and attribute.

	Expertise	Trustworthiness	Protection Responsibility	Row Mean
Water utility	.56	.55	.66	.59
Public health	.65	.62	.65	.64
Emergency management	.62	.55	.43	.53
Personal physician	.60	.39	.30	.43
News media	.35	.11	.13	.20
Elected officials	.42	.31	.15	.29
Peers	.75	.31	.34	.47
Self and family	.43	.25	.19	.29
Column Mean	.55	.39	.36	.42

$r_{WG} > .31$ is statistically significant at $p < .05$

Table VI. Intercorrelations among demographic, experience, media exposure, response resources, and protective action expectations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. White																						
2. Female	.07																					
3. WatWarn	.05	-.07																				
4. WatSick	-.09	-.01	-.12																			
5. TotTV	-.03	-.21	-.07	.23																		
6. TotRadio	-.45	.23	-.14	.42	.39																	
7. TotNews	-.21	-.18	-.02	.07	.64	.47																
8. BotWater	.02	-.21	-.05	.22	.09	.09	.13															
9. Chlorine	-.18	-.26	.20	.12	.34	.23	.32	.39														
10. Filter	-.05	.33	-.32	.19	-.06	.25	-.04	.06	-.02													
11. TotRisk	-.28	.14	-.27	.04	.15	.28	.17	.07	-.12	.02												
12. ProtHlth	.16	.08	.01	-.13	.13	-.17	.04	-.02	-.03	-.17	-.16											
13. OtherUse	-.11	.13	-.05	-.05	.22	.11	.18	.11	.19	-.07	.18	.31										
14. Cost	-.03	-.17	-.18	-.16	.17	.07	.15	.10	-.11	-.10	.23	-.09	.11									
15. Know/Skill	.15	-.08	-.09	-.09	.19	.09	.23	.14	-.02	-.03	.18	-.20	.17	.60								
16. Effort	.29	.06	.09	-.30	.03	.01	.16	-.17	-.14	.01	.03	-.04	.04	.52	.73							
17. Cooperate	.28	.04	.03	-.16	.14	.10	.23	-.01	.04	.08	-.08	-.08	.03	.40	.67	.79						
18. ExBottle	.11	.27	.19	.12	.13	.16	.08	.06	.16	-.13	.06	.21	.12	-.12	.09	-.01	.06					
19. ExBoil	.02	.18	-.05	-.20	.10	.01	.12	-.01	-.13	-.08	.15	.32	.46	.08	.05	.16	.10	.12				
20. ExBleach	.03	-.07	-.02	.15	.07	-.11	-.05	-.03	.10	-.05	-.35	.52	.20	-.34	-.33	-.36	-.32	.16	.30			
21. ExFilter	-.05	.22	.07	-.29	.11	.09	.02	-.14	.16	.22	-.20	.48	.24	.01	-.07	.08	.09	.24	.14	.34		
22. ExHeater	.07	-.22	-.23	.16	.26	-.08	.03	.10	.14	-.12	.08	.35	.35	-.06	-.03	-.14	-.21	.05	.33	.51	.05	
23. TotExpect	.05	.12	-.01	-.04	.22	.02	.06	-.02	.14	-.03	-.11	.62	.44	-.13	-.10	-.08	-.09	.47	.60	.76	.63	.61

N = 48, $r \geq .28$ significant at $p < .05$, 2 tailed. WatWarn = received a water contamination warning, WatSick = gotten sick from contaminated water, TotTV = total hours watching TV, TotRadio = total hours listening to radio, TotNews = total hours reading newspapers, BotWater = total rating of bottled water, Chlorine = total rating of chlorinated water, Filter = total rating of filtered water, TotRisk = total rating of risk from all exposure paths, ProtHlth= total rating of protect health, OtherUse = total rating of have other uses, Cost = total rating of cost money, Know/Skill = total rating of require knowledge, Effort = total rating of require effort, Cooperate = total rating of require cooperation, ExBottle = expectation of using bottled water, ,ExBoil = expectation of boiling water, ExBleach = expectation of bleaching water, ExFilter = expectation of using filtered water, ExHeater = expectation of using heater water, TotExpect = expectation of using all alternative water sources.