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The Relative Weights of Direct and Indirect Experiences in the Formation of Environmental Risk Beliefs

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Direct experiences, we find, influence environmental risk beliefs more than the indirect experiences derived from outcomes to others. This disparity could have a rational basis. Or it could be based on behavioral proclivities in accord with the well-established availability heuristic or the vested-interest heuristic, which we introduce in this article. Using original data from a large, nationally representative sample, this article examines the perception of, and responses to, morbidity risks from tap water. Direct experiences have a stronger and more consistent effect on different measures of risk belief. Direct experiences also boost the precautionary response of drinking bottled water and drinking filtered water, while indirect experiences do not. These results are consistent with the hypothesized neglect of indirect experiences in other risk contexts, such as climate change.

KEY WORDS: Experience; perception; risk beliefs; tap water

1. INTRODUCTION

Individuals often make personal decisions—should they install a water purifier, should they move to a more convenient apartment where the air pollution is worse—that require that they assess risks. Rarely do they conduct careful research, though that might be desirable. They usually simply decide on the basis of their own experiences and the experiences of others.

This article considers perception of risks from drinking tap water and asks: "When making risk assessments, how much do individuals rely on their own experiences and how much on the experiences of others?" In most instances, we would expect the latter to be much more extensive, hence much more informative.

A substantial literature has assessed the effect on risk beliefs of warnings, labels, and a wide variety of public information efforts. These studies examine chemical labeling for workers,[1] labels for household chemicals and pesticides,[2,3] organic product labels,[4] radon risk information from a variety of sources,[5–8] well water test results,[9] reports on drinking water quality and standards,[10,11] general and household-specific information on nitrate risks in water,[12] incorporation of scientific information about arsenic risks in water in risk beliefs,[13] and product recall publicity for pet food and lead-painted toys.[14] These studies, like those here, focus on people's ability to acquire and utilize information to update their risk beliefs. That personal experience affects risk beliefs is well-established. Workers who have been injured at work view their jobs as more hazardous;[15] earthquake survivors assess future earthquakes as more likely,[16] as do those who have incurred losses from hurricanes[17] and red tides.[18] Personal health shocks affect smokers' beliefs about the effects of smoking.[19]

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Others' experiences may alter risk beliefs as well, but the extent of influence is unclear and may vary depending on the context.[20] Both own and others' experience influence perceptions of product risks.[21] For floods, direct experience weighs much more heavily than community or vicarious experience.[22] Similarly, direct flood losses rather than generic experience of a disaster promote behavior to mitigate flood losses.[23] If people do rely disproportionately on own experiences relative to others' experiences, broad policy consequences follow. For example, such a bias could contribute to a failure of citizens to adequately assess the risks of climate change.[24]

Placing greater weight on one's own tap water illness experiences as compared to the experiences of others could be quite rational. The age of the water pipes into or feeding one's house and/or the quality of the water supplied may differ from that of others. If one's friends experienced their illnesses in a distant locale, or even overseas, their information should be strongly discounted.

A variety of behavioral tendencies also might lead one to undervalue others' experiences, or even disregard them completely, when forming risk assessments. People may overestimate the extent to which their experiences indicate general risks. If so, they would overvalue their own experiences relative to those of others when assessing risks to the overall population. These and related factors contribute to an "empathy gap."[25] Behavioral propensities—such as relying on one's own information much more heavily than that of others—may override sensible approaches to risk assessment. To illustrate, the availability heuristic reveals that, when instances can easily be brought to mind, a phenomenon is viewed as more common. One's own experiences are much more available and, therefore, more influential in determining risk assessments.

There is disturbing evidence that physicians, in making decisions, primarily rely upon their own experiences, secondarily upon the experiences of colleagues, and only third upon the literature. Hertwig *et al.*[20] draw a useful distinction between decisions where individuals draw on external information sources, such as newspapers or mutual fund brochures, and those where their own past experiences likely predominate, such as whether to back up their hard drive or whether to accept a blind date. They identify a number of biases in own-experience decisions, notably underweighting rare events, a bias that is potentially important for assessing many environmental risks.

This article examines the assessments and decisions made by a nationally representative cross-section of American adults estimating their risks of getting sick from the tap water in their homes. This risk is consequential. There are somewhere between 12 million and 20 million cases of waterborne disease in the United States annually.[26] Though most illnesses are brief, and full recovery is normal (except in particularly vulnerable groups), their common occurrence makes them a significant health-policy concern. Their frequency also creates a splendid opportunity for determining how individuals, drawing upon their own personal experiences and upon reports from others about their experiences, assess a risk.

Consider the classic situation of observing trials from a Bernoulli urn. Our formulation, which utilizes a Bernoulli urn model as the reference point and a beta distribution to analyze risk beliefs, parallels that in many previous studies.[1,2,5,19,27] To draw inferences about the color composition in the urn, risk beliefs should be the same whether draws from the urn are made by the individual or by another person who then reports to the individual.

In life, however, experiences with risk are far from the crisp draws of balls from that Bernoulli urn. One's own experience may be processed quite differently from an experience reported by others. Our minds work as though each participant has a different urn. This article assesses how individuals, in evaluating and responding to the risk of illness from home tap water, weigh their own experiences relative to those reported by others. More specifically, it examines whether individuals adequately weigh reports from others. This class of concerns is related to the recent literature on social influences and decisions involving risk.[28]

A standard Bayesian learning framework serves as our benchmark. We invoke Bernoulli trials, and a beta distribution for prior beliefs characterized by two parameters, b and c. Binary chances yield a success or failure, but in our context the "success" event is getting a water-related illness. The prior probability of success in this urn model is b/c, equivalent to observing b successes in c trials. After making n draws from the Bernoulli urn and observing m successes, the posterior probability based on this information becomes $(b + m)/(c + n)$. Of course, if flipping a coin, the prior weights would be much more substantial; b might be 5,000 and c 10,000. Just a few trials would produce virtually no updating of the probability.

We address the perceived probability of getting sick from drinking tap water; for with it experience would change the probability significantly. People who had never gotten sick from tap water would have a much lower estimate than those who had. Posit that someone starts with a prior with $b = 3$ and $c = 10$, implying a prior probability of 0.3 from getting sick from tap water. (This is roughly the proportion of those in our sample who report having been sick from drinking water.) Let one experience be either $m = 0$ (not sick) or $m = 1$ (sick) in a single trial where $n = 1$. Thus, one past illness experience would boost the posterior probability to 4/11; its nonoccurrence would reduce the probability to 3/11. Note, 3/10, the initial probability, equals (3/10)(4/11) + (7/10)(3/11); the expected posterior probability must equal the prior probability. Of course, if prior beliefs more definitively determined the posterior probability, c would be much larger relative to n. If one's own experience weighed more heavily in the posterior assessment, personal sickness would represent a much larger m value, with n proportionately larger as well.

Our survey question asks whether the individual has ever gotten sick from drinking his or her own home's tap water. It tracks neither the number of illnesses nor the number of trials (as reflected in the total number of times the person has drunk tap water). It thus combines reports from individuals who have gotten sick only once with those who have gotten sick many times. The same is true of reports from others. Thus, we implicitly treat personal sickness and reports of sickness from others as comprising the same number of both trials and illnesses. If anything, experiences from others would contain more information, given that most people would have heard of sickness (or the lack thereof) from many people. One's own experiences are called *direct*; experiences reported by others are *indirect.*

Do individuals treat these two types of experiences as equivalent? Let m_1 and n_1 be the values of illness events and total trials for oneself. Posit that reports from others, as indicated by m_2 and n_2, are informative in the same way, but are given a weight w that is greater or less. This is a simplification. Thus, after "observing" m_2 illnesses in n_2 trials for others, the person applies a weight w to these values when forming the posterior assessment. Then, drawing on both sources, an individual's posterior probability of illness is $(b + m_1 + wm_2)/(c + n_1 + wn_2)$. If the weight $w = 0$, others' experiences play no role in forming risk beliefs. If the weight w [< 1][$= 1$][>1], others' experiences count [less than][equal to][more than] one's own. For both the individual respondent and others there are thousands of experiences, so that the values of n_1 and n_2 should be quite large and not restricted to only those instances in which there are memorable adverse events. Our empirical analysis seeks to determine the implicit value taken by w, where individuals look solely at the aggregate "yes sick" or "no not sick" and do not seek to factor in the number of trials.

Section 2 outlines our hypotheses. Section 3 describes our sample illness-related questions. Section 4 analyzes how risk beliefs relate to personal and indirect experiences. Section 5 considers the behavioral responses to illness experiences. Our results, as elaborated in concluding Section 6, show that people know substantial amounts about the risk-related experiences of others. Nevertheless, their direct experiences are the overwhelming contributors to people's risk beliefs and risk-averting behaviors; indirect knowledge weighs much less.

2. HYPOTHESES

Indirect experiences of others might well weigh much more heavily in aggregate in an individual's risk assessment than direct experiences. Most people have at least several friends, which gives them access to a much more extensive data set. Additionally, illness from tap water is likely to be discussed among friends. Indeed, we find that many more subjects report friends' tap-water illnesses (58.8%) than their own (28.8%). This result suggests that there is more information about sickness from indirect than from direct experiences.

We hypothesize, however, that individuals give less weight to indirect knowledge than to direct knowledge of tap-water-related illness. There are three reasons, the first fully rational, the latter two behavioral.

2.1. Different Exposure and Vulnerability

Individuals should think, correctly, that a personal occurrence of illness predicts their future risk more than a similar occurrence to another. Others may have tap water from a different source, different residential plumbing, or different susceptibility to waterborne illness.

2.2. Availability Heuristic

The availability heuristic, one of the most thoroughly documented phenomena in behavioral decision, finds that people tend to judge the frequency of an event by how easily they recall specific instances.[29] It surely applies here. In contemplating gastrointestinal (GI) illness from tap water, a past victim can readily bring to mind graphic memories of visceral misery. By contrast, the experiences of others are much harder to summon. The "empathy gap" reinforces this disparity; events that happen to oneself have greater emotional weight than the same events happening to others.[25] There is also evidence that people may have difficulty in predicting the personal impact of sicknesses that they have not experienced. Siegrist and Gutscher have documented this role of the severity of personal experiences in flood-related contexts, as people who have experienced floods rate many consequences of flooding as being worse than those who have not experienced floods, including matters such as uncertainty; insecurity; evacuation problems; debris, mud, and dust; effort for cleaning up; fear; shock; helplessness; and perplexity.[30] Living in an area with a history of hurricanes does not affect risk beliefs, though it should, but individual hurricane experience and losses from Hurricanes Katrina and Rita do boost risk beliefs.[17] Given the pivotal role of individual experience, suffering no water-related illnesses or only mild losses from water-related illnesses may lead to risk underestimation.

2.3. Vested-Interest Heuristic

People regularly provide information that we factor into our decisions. In many situations, those others also have an interest in the decisions that we make. They might be job applicants hoping to impress us, friends trying to persuade us to their political views, or salesmen trying to sell us an item. In such situations, we expect others to exaggerate or selectively reveal information favorable to the choices they prefer us to make. Alert to others' potential vested interests, we discount the information they provide. Individuals in dyads underutilize information from collaborators, even though their interests are fully aligned.[31]

The vested-interest heuristic would operate because, as with other heuristics, sensible behavior in a wide variety of contexts carries over to situations where that behavior is inappropriate. Thus, we might devalue information from others in situations where the other individual was indifferent to one's decision, or had completely compatible interests. For example, a friend recounting an illness from tap water is unlikely to have other than a purely altruistic interest in raising one's assessment of the risk from tap water. However, one might inappropriately employ this heuristic, and devalue or ignore entirely the friend's information. These three explanations lead to our two major hypotheses:

> **HYPOTHESIS 1**: In assessing risk levels from tap water, individuals will attach much less weight to indirect experiences than to their own direct experiences.

Thus, any single adverse event will have greater weight if based on one's own experiences. If Hypothesis 1 is supported, we would expect direct experience also to have a stronger influence on actual choices in relation to tap water, such as whether to use bottled water. This leads to a subsidiary hypothesis:

> **HYPOTHESIS 2**: In making choices to reduce exposure to tap water, individuals will attach much less weight to indirect experiences than to direct experiences.

Our empirical study focuses on the relative weights assigned to direct and indirect information regarding risks of illness. We make no attempt to determine comparative contributions of our three possible explanations for why indirect information is discounted in determining risk beliefs or risk-related behaviors. Such a comparison would be a fruitful subject for future research.

3. DATA DESCRIPTION

Our data set comes from an original survey the authors commissioned from and conducted by Knowledge Networks in 2009. The survey questions were a subset of the authors' larger national study regarding hazards from drinking home tap water. This Internet-based sample is a nationally representative adult (18 years and over) sample, generated using a probability-based sampling approach. The survey firm ensured representativeness by providing Internet access to enable households to participate if they otherwise lacked computers or Internet services. The sample's characteristics closely matched those of the adult U.S. population (see Table AI).

The survey elicited measures of the subjects' direct and indirect experiences with their homes' tap

Table I. Summary Statistics of Variables

	Percentage
Water-related illness:	
Respondent ever sick from tap water (Yes)	3.94
Respondent ever sick from tap water (Not Sure)	24.85
Respondent ever sick from tap water (Yes or Not Sure)	28.80
Respondent ever sick from tap water (No)	71.20
Friend ever sick from tap water (Yes)	5.42
Friend ever sick from tap water (Not Sure)	53.35
Friend ever sick from tap water (Yes or Not Sure)	58.78
Friend ever sick from tap water (No)	41.22
Tap-water-related GI risk beliefs:	
Believe own GI risk is above average national risk	6.71
Believe own GI risk is average national risk	32.25
Believe own GI risk is below average national risk	61.05
Ever afraid to drink tap water	24.95
Believe bottled water is safer than tap water	32.05
Water-related precautions:	
Drink bottled water	66.77
Drink filtered water	37.87
Demographic characteristics:	
Gender: female	51.28
Race: white	80.57
Race: black	12.43
Race: not white or black	6.21
Race data missing	0.79
Hispanic	13.51
Top income category ($175,000 or more)	2.37
Northeast	18.44
South	32.25
West	23.67
	Mean (*SD*)
Other demographic characteristics:	
Age	49.63 (16.10)
Income/$10,000	6.13 (4.26)
Years of education	13.80 (2.58)

Note: Sample size is 1,014.

water, as well as several measures of risk beliefs. While some survey questions used the term "drinking water," the text made clear that all such questions pertained to tap water in their homes. "In this survey we will ask you questions about how you value drinking water. When we say drinking water in this survey, we mean water from the tap in your home."

Table I summarizes the means and standard deviations of the variables employed. The survey included detailed demographic information on each respondent's income, years of education, age, gender, and race (black, not white or black, or white, which is the omitted category) and, ethnicity (Hispanic or the omitted category of not Hispanic). Dividing the race and ethnicity categories into a series of mutually exclusive categories creates groups for which the effects are too small to be distinguished in the empirical analysis. Of the 137 respondents who reported Hispanic ethnicity, 111 indicated white race. Only six Hispanic respondents reported being black, while 20 reported other racial groupings, with the most common being multiple races, which 17 respondents indicated. The breakdowns by race and by ethnicity without indicating all mutually exclusive groups are comparable to those in government statistics on water quality, cited below, which also report overlapping categories. There were regional variables for Northeast, South, and West, with Midwest being the omitted category. The sample size throughout all analyses in the article was 1,014.

The survey, which was broader in scope than this analysis, focused on the valuation and perception of the morbidity risks of home tap water. The primary questions of interest dealt with respondents' direct and indirect experiences with tap-water illnesses, their perceptions of tap-water risks, and the precautions they had taken to avoid them. The survey informed respondents of the different morbidity risks associated with drinking contaminated tap water, and described the characteristics of these ailments. The survey introduced the illness risk as follows: "The most common sickness caused by drinking water contamination is called gastrointestinal illness. Contaminants in water can cause nausea and vomiting, diarrhea, stomach pain, and sometimes a fever. Such illnesses last from 2 days to 14 days, but average about a week before all symptoms end."

The focus was on GI risks. After providing information on GI illnesses and their prevalence in the United States, the survey asked respondents whether they had ever become ill from drinking contaminated tap water in their homes, and if so, which particular symptoms they had experienced. It then asked them whether any of their friends had ever become sick from drinking contaminated tap water at home. The survey also included questions asking whether other family members had become sick from tap water. This variable related strongly to the respondent's own experiences and served no additional role in the analysis. In particular, for the 290 cases in which the respondent's family had gotten sick from tap water, the respondent also reported a tap water illness in 242 instances, or 83% of the time. This high percentage may have stemmed in part from the survey's instructions to respondents to answer questions on behalf of their households: "For the rest of the survey, when a question refers to you, think of it as referring to you and the members of your family who currently live in your home." Also, families would be much more likely to be drinking from the same tap, and more likely to suffer together from undiagnosed food poisoning or a contagious illness.

The responses to the personal illness question were Yes (3.9%), Not Sure (24.9%), and No (71.2%). To the friends question, they were Yes (5.4%), Not Sure (53.4%), and No (41.2%). As expected, respondents were more often "Not Sure" about water-related illnesses for their friends than for themselves. Since GI illness is not a signature disease, causality is often difficult to ascertain, even for oneself. Given the low frequency of definite Yes responses, and the fact that Not Sure should create some concern about waterborne illness, our analysis pools the Yes and Not Sure responses.

Pooling the Yes and Not Sure responses leads to similar results with respect to the key behaviors of interest but provides much more power for the statistical tests. Consider the relationship of personal illness experiences to whether the respondent is afraid to drink tap water. The corresponding percentages for Yes (40.0%) are similar to Not Sure (35.3%), and well above No (20.5%). The percentages for own illness experiences in relation to whether the respondent believes bottled water is safer than tap water are Yes (35.0%), Not Sure (41.7%), and No (28.5%), lowest, as expected.

The Table I statistics summarize the breakdown of responses for the two tap water illness-experience variables. As noted earlier, the No answer was given less often for friends than for self. Indeed, including Not Sure, subjects reported other persons' (indirect) previous adverse tap-water experiences 30% more frequently than direct adverse experiences, slightly more than twice as often. Presumably, given multiple friends and relatives on average, others' experiences provide a much larger sample of potential illness experiences. If individual risk beliefs about tap-water hazards prove to be less responsive to the experiences of others, this cannot be due to a failure to be aware of others' experiences.

Before eliciting information on risk beliefs, the survey gave respondents detailed information regarding the frequency of GI illnesses due to tap water. The survey presented this information in multiple forms to help the subjects process the baseline risk information. The risk ranges provided were consistent with acute GI illness statistics.[26,32,33] Subjects were told that 15 million Americans became sick annually due to contaminated home tap water, and that children and the elderly were the most susceptible age groups. They were also informed that the average annual 0.05 risk probability of GI illness produced 50 cases annually out of a population of 1,000. That survey text was as follows: "Overall, about 50 out of every 1,000 Americans become sick in this way from drinking water each year." To help respondents conceptualize the probability information, the survey showed a 1,000-square grid with 50 squares colored red, indicating the proportion of people who got sick from drinking water in the previous year. To put the risk probability in perspective, the survey also included a risk ladder relating tap-water GI risk to the frequency of other hazards, such as dog bites, traffic accidents, and the flu.

After receiving this information, respondents were asked: "Compared to the 50 out of 1,000 average risk for the country overall, do you think that the GI risk of your tap water is: Much Lower Risk, Lower Risk, About the Same Risk, Higher Risk, or Much Higher Risk?" Our empirical analysis collapsed these five categories into three by pooling the two above-average risk categories and then the two below-average risk categories. Subjects' perceived risks were above average (6.7%), approximately average (32.2%), and below average (61.0%).

Note the preponderant belief that personal risks were average or below. There are two plausible explanations for this pattern of results, which might superficially suggest that respondents were understating their relative risk levels. First, tap-water risks are distributed highly unevenly across the country.[3] The concentration of risks skews outcomes so the mean risk exceeds the median risk. Moreover, some population groups—particularly the elderly, people with compromised immune systems, minorities, apartment dwellers, and residents whose homes or local utilities have ancient pipes and plumbing—are at greater risk. The concentration of minorities in rental housing elevates their risks. Supporting

[3]Statistics on the substantial heterogeneity of water quality violations are summarized by the Environmental Working Group at http://www.ewg.org/tap-water/reportfindings.php.

data are from the U.S. Department of Housing and Urban Development,[34] Tables 3-4 and 4-4. Minorities are more likely to perceive bottled water as safer than tap water.[35] Given such concentrations within the risk distribution, a characteristic of many classes of risks, accurate perceptions by respondents would have most in the below average category. Second, a framing effect could combine with optimism-bias-type effects to contribute to the observed pattern of results: people do not want to be viewed as worse off than their neighbors.[2,36]

The two other measures of risk belief examined were 0–1 indicator variables asking respondents whether they had ever been afraid to drink their home's tap water, "Have you ever gotten water from your tap that you were afraid to drink due to concerns about its safety?" and whether they believed bottled water to be safer than their tap water. About one-third of the sample had, at some time, been afraid to drink their home's tap water due to safety concerns. The question asking respondents to compare their tap-water risk to the bottled-water risk established a different reference point for assessing the riskiness of tap water rather than asking them if their risk was above, below, or the same as the national average. The safety of bottled water is less tightly regulated than that from tap water, so there is little firm data on its riskiness, implying little data on the comparative risks of bottled and tap water. To the extent that bottled water is viewed as being "safe," the risks will be perceived as equal for tap water from facilities known to comply with government standards.[37] However, average risks from bottled water will be thought to be lower for many water districts, since many spend time out of compliance with regulatory standards, standards that are not always tightly enforced.[38] Moreover, such violations often get public attention.[4] Therefore, one would expect the percentage of the sample who believed that their risk from tap water exceeded a zero-risk bottled-water reference point to be greater than the percentage who believed that their risk level was higher than the national average tap-water risk. Consistent with our posited relationship, 32.1% of the sample viewed bottled water as safer than their tap water, even though only 6.7% of the sample considered their risk levels to be above the national average risk.

Finally, the survey elicited information related to risk-reducing behaviors; whether the respondent used bottled water and whether the respondent used water filters. The answers to those two questions should be positively related to adverse direct and indirect illness experiences, and to greater risk beliefs based on such experiences, controlling for income and other pertinent factors.

4. ILLNESS EXPERIENCES AND RISK BELIEFS

We examine how tap-water experiences affect three risk-belief variables. We first focus on raw proportions, and then conduct regression analyses to provide additional statistical tests that control for demographic characteristics. In each case, two positive relationships emerge: the first is between the subjects' direct experiences and the subjects' risk beliefs, and the second is between the subjects' indirect experiences and those beliefs. In accord with Hypothesis 1, indirect experiences affect fewer risk-belief variables, and their effects are also of lesser magnitude than direct experiences.

Table II shows how various experience groups perceived their risks compared to the national tap-water morbidity risk. The reported χ^2 statistic of 28.63, $p = 0.000$ ($df = 2$), for the respondent's own risk experiences indicate that risk beliefs are not independent of own experiences with tap-water illnesses. However, one cannot reject the hypothesis that the respondents' risk beliefs are independent of their friends' tap-water illness experiences, based on the χ^2 value of 4.25, $p = 0.12$ ($df = 2$). Of the Yes/Not Sure direct-experience group, 49% believed that they faced GI risks below the national average, compared with 66% of their No counterparts. Such possible underestimation of the risk may also persist when additional information is provided in experimental contexts.[39] Of the Yes/Not Sure group for indirect experiences, the percentage with below-average risk beliefs is 59%, as compared to 49% for those with direct sickness experiences, and to 64% for those who had never had friends sick from water.

The patterns across the columns are consistent. The percentage of the sample in each of the

[4]Few citizens are well informed about violations in their own district. Hence, our focus is on perceived risks. We thank a referee who pointed out that smaller, non-community water systems are mostly those that violate microbial standards. Corporate and large municipal systems rarely exceed standards. This implies, for example, that inner-city dwellers are actually not likely to be at high risk.

Table II. Tap-Water Illness Experiences and Relative GI Risk Beliefs

		Tap-Water GI Risk Beliefs Relative to the Average National Risk for Different Tap-Water Illness Experiences		
Respondent's Tap-Water Illness Experience	*N*	Believe Own GI Risk Is Above Average National Risk	Believe Own GI Risk Is Average National Risk	Believe Own GI Risk Is Below Average National Risk
Ever sick from tap water				
Yes or Not Sure	292	11.0%	40.1%	49.0%
No	722	5.0%	29.1%	65.9%
Friend ever sick from tap water				
Yes or Not Sure	596	7.7%	33.6%	58.7%
No	418	5.3%	30.4%	64.4%
Total	1,014	6.7%	32.2%	61.0%

Note: For the Ever Sick results, the pertinent χ^2 statistic is 28.63, with a critical p value of 0.000 ($df = 2$), a γ value of 0.327, and an asymptotic standard error of 0.058. For the Friend Ever Sick results, the pertinent χ^2 statistic is 4.25, with a critical p value of 0.12 ($df = 2$), a γ value of 0.120, and an asymptotic standard error of 0.061.

risk-belief categories rises as one moves across columns of Table II. The differences between the values in the lower-risk belief column and the higher-risk belief column is less for those indicating either direct or indirect adverse experiences, as one would expect if risk experiences shift risk beliefs toward a higher risk category.

Table III considers the two binary risk-belief variables: afraid to drink tap water and believing that bottled water is safer. It separates the possible responses into four mutually exclusive groups—whether the respondent is afraid to drink tap water but does not believe bottled water is safer, whether the respondent believes bottled water is safer but is not afraid to drink tap water, whether the respondent is both afraid to drink tap water and believes bottled water is safer, and whether the respondent is not afraid to drink tap water and does not believe bottled water is safer. The χ^2 tests reject the null hypothesis that a person's fears and beliefs are independent of own tap-water illness experiences as the χ^2 is 31.87, $p = 0.000$ ($df = 3$). A person's fears of tap water are also not independent of knowledge of friends' tap-water illness experiences, as the $\chi^2 = 22.54, p = 0.000$ ($df = 3$). Those with direct adverse experiences were 10.8 percentage points more likely both to be afraid of tap water and to believe bottled water is safer. For indirect experience, the difference was 7.8 percentage points.

Tables II and III show results consistent with Hypothesis 1: among individuals who think their tap water poses an above-average risk, personal experience produces higher values than indirect experience. Three regressions in Table IV enable us to isolate the influence of either experience variable specifically, and to assess the incremental effect of experience controlling for other personal attributes. Each regression tests for the effects of direct and indirect experiences on risk beliefs. Regression results omitting the demographic variables yield very similar effects in terms of their magnitude and statistical significance. Indirect experiences never produce a statistically significant effect. The dependent variables are whether the respondents believe themselves to be exposed to average or above-average tap-water risks relative to the rest of the country (column 1), have ever been afraid to drink their tap water (column 2), and believe that bottled water is safer than tap water (column 3). Table IV reports probit regression estimates. Its coefficients have been transformed to correspond to the marginal effect each variable exerts on the pertinent probability. Direct experiences consistently significantly increase risk beliefs. Indirect experiences only do so for ever afraid to drink tap water. There the marginal effects are large—0.11 (direct) and 0.08 (indirect)—relative to the 25% of the population expressing this fear. Direct experiences boost by 0.09 the probability that the respondent believes that bottled water is safer, which is substantial relative to the 0.32 probability for the population. Indirect experiences have no significant effect, so most of the people who believe bottled water is safer have had no adverse direct or indirect experiences—a striking result given that bottled water is not safer than tap water that complies with government regulatory standards.[37]

The other explanatory variables included in the risk-belief equations reflect expected patterns. On average, black respondents and poorer respondents hold higher risk beliefs, consistent with their greater

Table III. The Relationship of Tap-Water Illness Experiences to Fears of Tap Water and Beliefs in the Relative Safety of Bottled Water

Respondent's Tap-Water Illness Experience	N	Ever Afraid to Drink Tap Water Only	Believes Bottled Water Is Safer than Tap Water Only	Both Ever Afraid to Drink Tap Water and Believe Bottled Water Is Safer than Tap Water	Not Ever Afraid to Drink Tap Water and Do Not Believe Bottled Water Is Safer than Tap Water
Ever sick from tap water					
Yes or Not Sure	292	14.0%	18.8%	21.9%	45.2%
No	722	9.4%	17.5%	11.1%	62.0%
Friend ever sick from tap water					
Yes or Not Sure	596	12.8%	17.6%	17.4%	52.2%
No	418	7.9%	18.2%	9.6%	64.4%
Total	1,014	10.7%	17.9%	14.2%	57.2%

Note: For the Ever Sick results, the pertinent χ^2 statistic is 31.87, with a critical p value of 0.000 ($df = 3$). For the Friend Ever Sick results, the pertinent χ^2 statistic is 22.54, with a critical p value of 0.000 ($df = 3$).

Table IV. Probit Regressions for Different Tap-Water Risk-Belief Variables

Variable	Believe Own GI Risk Is Average or Above Average National Risk	Ever Afraid to Drink Tap Water	Believe Bottled Water Is Safer than Tap Water
Ever sick from tap water, Yes or Not Sure	0.1612***	0.1126***	0.0931**
	(0.0392)	(0.0351)	(0.0374)
Friend ever sick from tap water, Yes or Not Sure	0.0007	0.0792***	0.0434
	(0.0360)	(0.0302)	(0.0337)
Income/$10,000	−0.0144***	−0.0073*	0.0017
	(0.0045)	(0.0039)	(0.0042)
Years of education	−0.0160**	−0.0025	−0.0116*
	(0.0067)	(0.0057)	(0.0062)
Age	−0.0054***	0.0002	−0.0028***
	(0.0010)	(0.0009)	(0.0010)
Gender: female	0.0363	−0.0186	0.0012
	(0.0317)	(0.0275)	(0.0301)
Race: black	0.1348***	0.1190**	0.2210***
	(0.0500)	(0.0465)	(0.0495)
Race: not white or black	0.0039	0.1359**	0.1315**
	(0.0653)	(0.0651)	(0.0655)
Hispanic	0.0672	0.0354	0.1439***
	(0.0492)	(0.0431)	(0.0479)
Pseudo-R^2	0.073	0.063	0.058
Log likelihood	−628.161	−533.902	−599.380
Prob > χ^2	0.000	0.000	0.000

Note: Significance levels: *0.10, **0.05, and ***0.01, two-sided test. Standard errors are in parentheses. The regressions also include three regional indicator variables, a top income code variable for those with incomes of $175,000 or more, and a variable identifying eight respondents with missing race data. Coefficients are transformed to correspond to marginal effects.

levels of exposure to unsafe tap water. There is a documented negative relationship between income and health risks from tap water.[40]

The results of Table IV strongly support Hypothesis 1. "In assessing risk levels from their homes' tap water, individuals will attach much less weight to indirect experiences than to their own direct experiences." We now test Hypothesis 2, examining how direct and indirect experiences affect individuals' efforts to reduce their exposure to tap water.

5. ILLNESS EXPERIENCES AND PRECAUTIONARY EFFORTS TO REDUCE EXPOSURE

The best way to reduce one's risks from tap water is to reduce one's exposure. Precautionary actions reveal how tap-water experiences affect actual choices, such as drinking bottled water from small bottles, gallon jugs, or water coolers, as does 67% of the sample. Water filters geared to the whole house, the tap, or

Table V. The Relationship of Tap-Water Illness Experiences to Different Precautionary Behaviors

Respondent's Tap-Water Illness Experience	*N*	Drink Bottled Water Only	Drink Filtered Water Only	Both Drink Bottled Water and Drink Filtered Water	Neither Drink Bottled Water Nor Drink Filtered Water
Ever sick from tap water					
Yes or Not Sure	292	40.4%	11.3%	31.8%	16.4%
Not ever sick	722	41.3%	12.5%	23.3%	23.0%
Friend ever sick from tap water					
Yes or Not Sure	596	40.6%	11.99%	28.0%	19.5%
Friend not ever sick	418	41.6%	12.4%	22.5%	23.4%
Total	1,014	41.0%	12.1%	25.7%	21.0%

Note: For the Ever Sick results, the pertinent χ^2 statistic is 10.45, with a critical p value of 0.015 ($df = 3$), a γ value of 0.170, and an asymptotic standard error of 0.053. For the Friend Ever Sick results, the pertinent χ^2 statistic is 4.89, with a critical p value of 0.180 ($df = 3$), a γ value of 0.105, and an asymptotic standard error of 0.049.

Table VI. Probit Regressions for Precautionary Behavior and Tap-Water Illness Experiences

Variable	Drink Bottled Water	Drink Filtered Water	Drink Bottled Water	Drink Filtered Water
Ever sick from tap water, Yes or Not Sure	0.0694**	0.0620*	0.0546	0.0578
	(0.0353)	(0.0377)	(0.0363)	(0.0384)
Friend sick from tap water, Yes or Not Sure	0.0170	0.0254	0.0425	0.0313
	(0.0334)	(0.0344)	(0.0343)	(0.0351)
Income/$10,000			0.0225***	0.0107**
			(0.0044)	(0.0043)
Years of education			−0.0045	0.0189***
			(0.0063)	(0.0065)
Age			−0.0031***	0.0003
			(0.0010)	(0.0010)
Gender: female			0.0926***	−0.0318
			(0.0303)	(0.0311)
Race: black			0.2028***	−0.0150
			(0.0358)	(0.0483)
Race: not white or black			0.0023	0.0624
			(0.0629)	(0.0669)
Hispanic			0.0905**	0.0765
			(0.0427)	(0.0484)
Pseudo-R^2	0.005	0.004	0.066	0.029
Log likelihood	−641.755	−670.030	−602.180	−653.289
Prob > χ^2	0.051	0.069	0.000	0.000

Note: Significance levels: *0.10, **0.05, and ***0.01, two-sided test. Standard errors are in parentheses. The detailed regression also includes three regional indicator variables, a top income code variable for those with incomes of $175,000 or more, and a variable identifying eight respondents with missing race data. Coefficients are transformed to correspond to marginal effects.

a pitcher represent safety measures used by 38% of the sample.

Table V explores how illness experiences influence precautionary behaviors of drinking only bottled water but not using filters, using water filters but not drinking bottled water, both drinking bottled water and using water filters, and neither drinking bottled water nor using water filters. The χ^2 statistic leads to rejection of the null hypothesis that a person's own risk experiences are independent of precautionary behaviors ($\chi^2 = 10.45$, $p = 0.015$, $df = 3$), but not in the case of friends' tap-water illness experiences ($\chi^2 = 4.89$, $p = 0.180$, $df = 3$). For the decision to both drink bottled water and use water filters, the difference in the values between those with and without adverse experiences is 8.5 percentage points (direct) and 5.5 percentage points (indirect).

The first two columns of Table VI employ regressions to test Hypothesis 2. The probit regression results show that direct experiences significantly increase the use of precautionary behaviors—bottled water by 0.07 and water filters by 0.06—whereas indirect experiences do not. Note, however, that

Table VII. Probit Regressions for Different Precautionary Behavior and the Role of Risk Beliefs

	Drink Bottled Water	Drink Filtered Water	Drink Bottled Water	Drink Filtered Water
Believes own GI risk is average or above average national risk	0.0550* (0.0317)	0.0046 (0.0325)	0.0649** (0.0328)	0.0291 (0.0339)
Ever afraid to drink tap water	0.1115*** (0.0351)	0.0247 (0.0374)	0.1341*** (0.0346)	0.0384 (0.0385)
Believe bottled water is safer than tap water	0.2941*** (0.0281)	0.0051 (0.0350)	0.2813*** (0.0287)	0.0038 (0.0360)
Income/$10,000			0.0253*** (0.0045)	0.0108** (0.0044)
Years of education			−0.0002 (0.0063)	0.0199*** (0.0065)
Age			−0.0020** (0.0010)	0.0004 (0.0010)
Gender: female			0.0989*** (0.0306)	−0.0330 (0.0311)
Race: black			0.1568*** (0.0398)	−0.0210 (0.0486)
Race: not white or black			−0.0637 (0.0699)	0.0585 (0.0671)
Hispanic			0.0558 (0.0455)	0.0759 (0.0486)
Pseudo-R^2	0.103	0.001	0.157	0.027
Log likelihood	−578.408	−672.385	−543.226	−654.787
Prob > χ^2	0.000	0.884	0.000	0.002

Note: Significance levels: *0.10, **0.05, and ***0.01, two-sided test. Standard errors are in parentheses. The detailed regression also includes three regional indicator variables, a top income code variable for those with incomes of $175,000 or more, and a variable identifying eight respondents with missing race data. Coefficients are transformed to correspond to marginal effects.

while the direct experience variable is statistically significant, these overall regressions are marginally significant. After controlling for demographic variables, the effect of direct experiences loses statistical significance. This loss of significance after controlling for demographics is not surprising, as these characteristics are predictive of illness experiences. Posit the extreme case, where direct adverse experiences were the true causal variable, but were fully concentrated in some demographic groups. A regression would show zero effect for direct experiences.

These results support Hypothesis 2. "In arriving at behavioral choices to reduce exposure to tap water, individuals will attach much less weight to indirect experiences than to their own direct experiences, even accounting for risk levels."

The regressions in Table VII examine whether risk beliefs predict precautionary behaviors. Table IV showed that direct water illness experiences raise risk beliefs, hence the potential for a two-step explanation, where raised beliefs promote precautionary behavior. The results are similar both with and without demographic controls. Those who either believe that their tap-water risks are above average, or have ever been afraid to drink their tap water, or think bottled water is safer, use bottled water significantly more often. Water filter use does not show a comparable effect, and the equation is not statistically significant, perhaps due to the less frequent use of water filters, hence a less powerful test. As expected, people at higher income levels are greater users of bottled water and filters, other factors equal.

6. CONCLUSIONS

Individuals learning about drinking water risks give significantly more weight to their personal experiences than they do to the experiences of others. This imbalance arises though others collectively have far more experience. We suggest three possible explanations for such behavior. The first is rational, as individual experiences may better reflect particular individual circumstances. The other two explanations have strong behavioral underpinnings. The well-established availability heuristic is pertinent as the salience of own experiences brings them readily to mind. Thus, they are given excess weight in probabilistic assessment. The vested-interest heuristic, presented here, leads individuals to underweight information from others, because those others often have interests that differ from our own. Our survey data cannot separate the relative contributions of these three explanations.

Fortunately, other modes of future investigation could disentangle these effects. Thus, well-controlled experimental studies, where individuals and counterparts took ambiguous financial risks in the lab, for example, losing part of their payment, and then sharing information before deciding on subsequent risk taking, could be instructive. Similarly, as has been shown in other contexts,[41] detailed longitudinal data also might illuminate the role of rational and behavioral determinants of the greater weight placed on one's own experiences.

Two hypotheses flow from our explanations. They posit that individuals will underweight information from others relative to their own when assessing the risks of drinking tap water, and when making choices—such as purchasing bottled water—that reduce their tap-water risks. Our data support both hypotheses.

The health risks of tap water are important for the health losses they impose, and for the costs individuals incur to avoid such losses. It seems likely that many individuals substantially misestimate those risks. Presumably, more accurate assessments across individuals and locales could reduce both health losses and protective expenditures.

Tap water served as our case study because it causes illness reasonably often, and we could design a survey with well-specified questions that could elicit risk outcomes and risk beliefs. Presumably, our findings would apply in other contexts. If so, people who have not had direct experiences with the adverse effects of floods, hurricanes, or climate change would assess these risks below those who have had direct experiences. Outside the environmental risk area, doctors will employ the wrong treatments, and spouses and business partners will remain at odds though their shared information should lead to agreement. The problem is compounded, of course, when interests diverge. For example, international agreements will not be reached, and labor disputes will fester, because the parties cannot agree on facts.

Decisions made about tap water are simple and straightforward. Yet strong behavioral biases afflict them. Presumably, those biases will also afflict an array of decisions individuals must make where the risks are far more consequential.

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APPENDIX: SAMPLE COMPARISON

Table A1. Comparison of 2009 Sample to the National Adult Population

Demographic Variable	U.S. Adult Population Percent	2009 Survey Participants Percent
Gender		
Male	48.7	48.7
Female	51.3	51.3
Age		
18–24 years old	13.1	7.5
25–34 years old	17.9	11.9
35–44 years old	17.9	17.8
45–54 years old	19.2	21.0
55–64 years old	15.0	23.0
65–74 years old	8.9	13.2
75 years old or older	8.1	5.6
Educational attainment (25 and older)		
Less than HS	13.3	11.4
HS diploma or higher	57.2	57.4
Bachelor's degree or higher	29.5	31.2
Race/ethnicity		
White Black/	80.9	80.6
African American	12.2	12.4
Other	6.9	6.2
Hispanic	13.6	13.5
Household income		
Less than $15,000	12.9	12.3
$15,000–$24,999	11.8	8.4
$25,000–$34,999	10.9	10.7
$35,000–$49,999	14.0	16.4
$50,000–$74,999	17.9	20.9
$75,000–$99,999	11.9	14.3
$100,000 or more	20.5	17.0

Note: Sample size is 1,014.

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