Health and Environmental Protective Behaviors Towards Water Pollution Threats in the Pacific Northwest

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Abstract

Water pollutants remain a pertinent public health and environmental issue despite multiple policies to control water pollutants from entering the environment. Community members engaging in both health and environmental protective behaviors can prevent excess pollutants from entering water bodies, protect drinking water and their personal health. Existing social science research has primarily focused on either health protective behaviors or environmental protective behaviors, but rarely considered these behaviors together. As such, little is known about what motivates both types of behaviors within the same environmental issue. This thesis contributes to a broader understanding of factors that encourage both health and environmental protective behaviors in the Pacific Northwest (PNW) using data from an online survey (n = 621). In the first empirical chapter (Chapter 2), I 1) explore threat and coping variables that contribute to both types of behaviors and 2) explore the relationships between subjective knowledge and sociodemographic variables that contribute to both types of behaviors. Results reveal that high self-efficacy significantly predicted both health and environmental protective behavioral intentions for water pollutants, while perceived severity of the threat was only significant in the environmental model. Perceived vulnerability and response efficacy were significant in both models. Education level, political affiliation, and subjective knowledge were significant predictors of environmental protective behavioral intentions, but not health protective behavioral intentions. Overall, the results of this study suggest that when communicating environmental risks of water pollution, highlighting self-efficacy in messaging is particularly important to promote protective environmental and personal health behavior. In the second empirical chapter (Chapter 3), I further investigate motivators of environmental protective behavior through communication frames. There has been little experimental research testing how to effectively communicate information about water pollution to encourage protective behavior. This project used a message framing experiment embedded in an online survey to determine how (a) personal versus impersonal risk frames and (b) self-efficacy versus no self-efficacy frames were effective in encouraging health and environmental protective behavior intentions. We conducted parallel studies with samples from two populations: the Qualtrics panel used in Chapter 2 (n=621) and a university student population (n=173). We found that among the general population, no communication frame was more effective than another to encourage behaviors. Among the student population, we found that the personal risk frame with no self-efficacy message had a significantly higher effect on respondents' intentions to engage in environmental protective behaviors compared to messages with self-efficacy. We found that the average respondent reported high intentions to take protective behaviors toward water pollution, which may suggest that self-efficacy messaging is not necessary when communicating personal risks for a high salience issue. In the Conclusion, I discuss implications for results from both empirical chapters in the context of communication best practices for health and environmental protective behavior change and opportunities for future research.

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Dedication

This thesis is dedicated to my family—Mom, Dad, Carol Rose, and Josie. Thank you for your constant support and guidance.

Table of Contents

List of Tables

List of Figures

Statement of Contribution

Dr. Chloe Wardropper was involved in all steps of the research process, from project inception, funding, and editing of the overall thesis. Dr. Patrice Kohl and Dr. Alan Kolok edited the overall thesis as well and were involved in survey editing. Dr. Patrice Kohl offered guidance on statistical analysis and provided several rounds of edits on Chapter 2.

Chapter 1: Introduction

Water pollutants create concern for both human and environmental health. In the United States Pacific Northwest, the Environmental Protection Agency named mercury, dichloro-diphenyl-trichloroethane (DDT), polychlorinated biphenyls (PCBs), and polybrominated diphenyl ethers (PBDEs) as water pollutants of concern, specifically in the Columbia River Basin. Mercury can damage the human nervous system, kidneys, liver, and immune system (SCDHEC, 2019). DDT is toxic to wildlife, including birds and marine animals, and causes eggshell thinning of certain bird species, leading to population decline (Harada, 2016). PCBs have been shown to cause cancer and affect the immune, reproductive, nervous, and endocrine system in animals (EPA, 2022). PCBs have been in the news recently because they are a part of group of toxic chemicals called persistent organic pollutants (POPs) and are able to travel huge distances around the planet through air and water, affecting communities far away from the source of contamination (Turns, 2022). Because of their mobility and persistence, compounds are still present in human food supplies (fish and dairy being the most contaminated) and can harm people's ability to fight infection, cause increased rates of autoimmunity, and cognitive and behavioral problems (Crinnion, 2011).

Further, studies support evidence that PCBs have carcinogenic and non-carcinogenic effects on human health (EPA, 2022). Finally, studies in rats and mice show that PBDEs cause neurotoxicity, thyroid toxicity, and cancer (Gorini et al., 2018). To help manage these water pollutants, the Environmental Protection Agency utilizes federal policies enabled by the Clean Water Act and Clean Drinking Water Act; however, these laws provide few opportunities to address non-point source water pollution (pollution from diffuse, unregulated landscape sources). Thus, individual behavior change is needed to close the gap where policy and other institutional solutions fall short in protecting environmental and public health.

Individual behaviors to address water pollution can include impersonal risk behaviors, such as environmental protective behaviors. Environmental protective behaviors seek to protect the environment, or in this case, prevent water pollutants from entering water bodies. Behaviors that fall under this category are reducing fertilizer use, disposing of unused medicines safely (i.e., Drug Take Back Programs), reducing the use of plastic, and recycling to prevent plastics from entering water bodies. Individual behaviors can also include personal risk behaviors, such as health protective behaviors that seek to protect the individual performing them directly. For example, health protective behaviors include installing a water filter in the home, flushing pipes in the morning, and reducing fish consumption to limit water pollutants from entering the body.

I use the Protection Motivation Theory (PMT) in the second chapter to understand why individuals behave in health and environmental protective ways. This theory posits that the factors for a person to perform a protective behavior are 1) high perceived severity, or belief that the risk is harmful 2) high perceived vulnerability, or belief that one can be personally impacted by the risk 3) high perceived self-efficacy, or belief in one's capacity and confidence to carry out certain behaviors, and 4) high perceived response-efficacy, or belief that a specific behavior will avoid the threat (Maddux and Rogers, 1983). PMT has historically been used in public health contexts, but more recently has been applied to environmental contexts to understand behaviors that protect the environment. I use one environmental context—water pollutants—to understand how the theory performs with health and environmental protective behaviors.

In Chapter 3, I investigate if and how communication message frames influence the engagement of environmental protective behaviors. Message framing refers to how information is presented to elicit a response from the reader (Wicks, 2011). For example, the environmental issue of water pollutants can be framed as a public health issue by highlighting that the consumption of fish can increase the number of water pollutants a person is exposed to and can potentially harm human health. Thus, in Chapter 3, I seek to understand if framing water pollutants as an environmental issue (or impersonal risk) versus a human health issue (or personal risk) is more effective in stimulating the reader to act in environmentally protective ways. I also test whether a self-efficacy message will be more effective than a message without self-efficacy. As previously mentioned in Chapter 2, PMT posits that an individual tends to have a high self-efficacy to perform a protective behavior. Therefore, I seek to understand if self-efficacy messages effectively instigate environmental protective behaviors.

Using results from an online survey of residents from Idaho, Oregon, and Washington (n= 621), I provide an initial characterization of public perceptions of water pollutants in the Pacific Northwest. The first study, Chapter 2, aims to understand what determines both health and environmental protective behaviors by using the Protection Motivation Theory framework. I examine the role of subjective knowledge about water pollutants from an environmental and human health standpoint as predictors of protective behavior intention. In the second study, Chapter 3, I conduct a communication frame experiment to explore what frame is most effective in inspiring environmental protective behavior intention with two different populations: a Qualtrics panel (n=621) and a university student population (n=173). Using a randomized experiment embedded in a survey, respondents received one of four communication frames: a personal risk message, a personal risk message with a self-efficacy manipulation, an impersonal risk message, and an impersonal risk message with a self-efficacy manipulation. My results provide both public health and environmental officials with essential insights into what the public thinks and knows about water pollutants in the Pacific Northwest that can guide risk communication efforts that encourage protective behavior.

Chapter 2: Health and Environmental Protective Behavioral Intentions for Reducing Harm from Water Pollutants

Abstract

Understanding what motivates people to adopt protective behaviors is important in developing effective risk messaging and may vary depending on the nature of the risk, and whether the risk poses a personal or impersonal risk. Some risks, like water pollution, pose both personal (human health) and impersonal (environmental) threats. Yet few studies have examined people's motivations to protect both personal health and environmental health. Protection Motivation Theory (PMT) uses four key variables to predict what motivates individuals to protect themselves in relation to a perceived threat. Using data from an online survey (n=621), we investigated the relationships between PMT variables health and environmental protective behavioral intentions related to toxic water pollutants among residents in Oregon, Idaho, and Washington, USA. Among PMT variables, high self-efficacy (belief in one's own capacity to carry out certain behaviors) significantly predicted both health and environmental protective behavioral intentions for water pollutants, while perceived severity of the threat was only significant in the environmental behavioral intentions model. Perceived vulnerability and response efficacy (belief that a specific behavior will actually avoid the threat) were significant in both models. Education level, political affiliation, and subjective knowledge of pollutants were significant predictors of environmental protective behavioral intentions, but not health protective behavioral intentions. The results of this study suggest that when communicating environmental risks of water pollution, highlighting self-efficacy in messaging is particularly important to promote protective environmental and personal health behavior.

1. Introduction

There is growing recognition that environmental degradation and human health concerns are connected. The accumulation of pollutants in lakes, streams, and groundwater, for example, not only undermines the health of our environment, but also poses a serious threat to human health (EPA, 2022). Agriculture runoff, wastewater, atmospheric deposition, urban runoff, and many other pollution sources pose a growing contamination issue. Many water resources are no longer safe to use for drinking or recreation (e.g., fishing, swimming) (Denchak, 2022). In 2015, 21 million Americans relied on community water systems that violated the United States (US) Environmental Protection Agency's (EPA) water quality standards (Odetola et al., 2021) and, globally, an estimated 1.8 million people died due to water borne infectious diseases related to pollutants in 2015 (World Health Organization, 2015). Institutions have limited regulatory authority with respect to water pollution and cannot eliminate the environmental and human health threats it poses. The US Clean Water Act, for example, only has authority over point source water pollution (or pollution emitted from a pipe – with a few exceptions) (EPA, 2021, 33 U.S.C. §1251 et seq. (1972)). Individual behavior change is needed to close the gap where policy and other institutional solutions fall short in protecting environmental and public health. In this survey-based study, we examine how well individuals' subjective knowledge about water pollution, and their appraisals of the threat and their ability to cope with it, predict two types of behaviors: behaviors to protect personal health and behaviors aimed at protecting the environment. The pollutants of concern in our study (i.e., mercury, dichloro-diphenyl-trichloroethane (DDT), polychlorinated biphenyls (PCBs), and polybrominated diphenyl ethers (PBDEs)) were chosen because EPA considers them of great concern in our study area, the Pacific Northwest (EPA, 2009). Health protective behaviors refer to any behavior performed by a person to protect, promote, or maintain their health (Harris, 1979). An example of a water-related health protective behavior includes flushing pipes in the morning to sweep out contaminants that may have built up overnight (Katner et al., 2018). Environmental protective behaviors include behaviors that reduce adverse impacts of human activities on the natural environment (Paco et al., 2019), such as reducing one's use of fertilizers and plastics. In this study, we consider health protective behaviors as primarily addressing personal risks and environmental protective behaviors as addressing impersonal risks. To date, these two types of behaviors have largely been explored independently, but there are increasing calls to bring health and environmental perspectives closer together (Bentley, 2014; Graham & White, 2016). We draw on Protection Motivation Theory (PMT)—a theoretical framework widely used to understand protective behaviors—to do a side-by-side examination of what predicts behaviors addressing personal and impersonal risks. PMT (Maddux & Rogers, 1983) uses four key variables to predict protective behaviors—perceived vulnerability and severity (threat appraisal), and response efficacy and self-efficacy (coping appraisal), described in more detail below (Floyd et al., 2000; Maddux & Rogers, 1983).

We also examine the role of subjective (or self-assessed) knowledge in predicting health and environmental protective behaviors. In studies done to understand the public's willingness to get vaccinated, high knowledge surrounding the disease correlated with intention to engage in the protective behavior (Petrie et al., 2016). Similarly, one study that measured knowledge related to COVID-19 found an association between high knowledge and increased health-protective measures surrounding the virus (Faasse et al., 2020). However, there is nuance to this knowledge gap; for example, the deficit model, which says that people need more information from experts to change individuals' attitudes, beliefs, and behaviors, have been criticized as being overly simplistic and not always correlated with behavior change (Suldovsky, 2017). Measuring an individual's level of subjective knowledge of water pollutants may be indicative of their intentions to take health and environmental protective behaviors in response to this threat.

Historically, PMT was developed for public health contexts (Maddux & Rogers, 1983), but more recently the theory has been used in environmental contexts such as determining protective behaviors to prevent wildfires (Bubeck et al., 2012; Floyd et al., 2000; Martin et al., 2007). This chapter builds on this body of literature by testing the utility of PMT in understanding environmental protective behaviors in addition to health protective behaviors in the context of the same environmental issue—water pollutants. In application, PMT can be used as a framework to inform best communication practices to encourage protective behavior (Cismaru et al., 2011). Understanding the relationship between PMT variables and behavioral intention can help inform communication efforts to promote health and environmental protective behavior in relation to water pollutants.

2. Theoretical framework

2.1. Protection motivation theory

Previous studies have found that perceived risk can play an important role in predicting threat reducing behavior (Slovic et al., 1996). The Protection Motivation Theory (PMT) was developed to take this insight into account to help better explain why some people choose health protective behaviors while others do not (Rogers, 1975). According to PMT, the motivation to adopt protective behaviors is explained not only an appraisal of the risk (where a risk is defined as a combination of the perceived severity of the threat and perceived vulnerability to the threat), but also the appraisal of our ability to cope with the threat (Maddux & Rogers, 1983). In turn, coping involves our assessment of self-efficacy (belief in our own capacity to carry out certain behaviors) and response efficacy (belief that a specific behavior will actually avoid the threat).

Perceived severity refers to the negative consequences an individual associates with an event or outcome (Miles, 2020). A meta-analysis conducted on studies of fear-arousing communications found that increases in perceived level of fear and severity resulted in increases in acceptance of proposed adaptive behavior or intention in certain situations, such as messaging on the risks of tobacco smoke (Floyd et al., 2000). Moreover, when researching lead contamination, individuals had higher intentions to practice health protective behaviors when they perceived the risk of lead contamination as severe (Cooper et al., 2020). Thus, the relationship between threat and behavior is an important one to consider, but PMT goes further to look at how other factors interact with perceived severity to induce protective behaviors.

According to PMT, higher perceived vulnerability also stimulates protective behavior. The level of vulnerability experienced by an individual is the perceived susceptibility to the threat, or the likelihood the individual thinks they will be harmed by a risk (Champion and

Skinner, 2008). In a study examining motivations to engage in behaviors to prevent nearsightedness in children, perceived vulnerability was found to directly correlate with motivation to engage in protective behaviors (Lwin et al., 2007). In the study, when parents indicated a greater intention to engage in behaviors to prevent nearsightedness in their children, they also had higher perceptions of their child's vulnerability to becoming nearsighted. Vulnerability to risks posed by environmental problems has also been found to influence actual behavior. In a study on pro-environmental behaviors in the workplace, for example, Janmaimool et al. (2017) found that when people perceived a potential negative impact of environmental pollutants on their personal health and wellbeing, they were more likely to engage in recycling.

Although risk perception and behavioral intention is important to study, in some cases risk researchers have found that elevated perceptions of risk such as the severity of the threat and personal vulnerability sometimes fall short in predicating behavior (Lacroix & Gifford, 2017). The relationship between perceptions of risk and behavior are complex and context specific. For example, if you believe a risk is serious, but you think that there is little you can do to reduce the risk (i.e., you feel low self-efficacy), then your perception of risk might do little to change your behavior. PMT thus includes self-efficacy, response efficacy, and other contextual factors, to try and understand why people may engage in protective behavior.

Self-efficacy refers to belief about one's ability to successfully execute a particular behavior required to produce the desired outcome (Bandura, 1977). Maddux and Rogers found self-efficacy to be the most powerful predictor of behavioral intentions that precede actual behavior (Rogers, 1975). Individuals with a strong sense of self-efficacy are more likely to take protective action, be more receptive to information on the risk, and take effective remedial action (Westcott et al., 2017; Verkoeyen and Nepal, 2019).

Response efficacy is the belief that the adaptive response will work and that taking a specific action will effectively protect the self or others (Floyd et al., 2000). For example, in one study of preventative behaviors towards muscular dystrophy, response efficacy was a significant predictor in parents' intention to comply with recommended medical treatment

(Flynn et al., 1995). Thus, understanding protection motivation is enhanced by including measures of the belief that behavior is effective in reducing the threat.

Rogers originally applied PMT to better understand health behaviors, but researchers have successfully applied the theory to other risk contexts including threats related to internet safety, justice, and the environment (Floyd et al., 2000). In the context of environmental risk, PMT has been used to predict protective behaviors (or behavioral intentions) in the context of risks posed by, for example, floods and wildfires (Martin et al., 2007; Bubeck et al., 2012). For example, in the case of wildfires, Martin et al., found that homeowners are motivated by their perceived vulnerability or the likelihood that a wildfire will harm their property to adopt risk-mitigating behaviors, such as removing yard debris (2007). Further, in understanding factors that influence flood mitigation behavior, Bubeck et al. argue that to encourage a protective response high risk perceptions of an individual need to be accompanied by high coping appraisal, so the individual feels confident in being able to cope with or to avoid the risk (2012). In the present study, by researching environmental protective behavior alongside health protective behavior, we were able to compare the intention to engage in the personal risk behaviors—ones that affect personal health—and impersonal risk behaviors—ones that reduce harm to the environment. For example, a poor environment can pose a direct personal risk to a human of getting sick from drinking polluted water, or an impersonal risk, such as a decline in biodiversity in rivers and lakes due to pollution. The behaviors used in this study target both situations, actions that can enhance human health and actions that can safeguard the environment.

2.2. Hypotheses

Our overall objective is to understand what predicts intention to engage in both health and environmental protective behavior. To test this idea, we developed three hypotheses, based on the above literature review: **Hypothesis 1**: Health and environmental protective behavioral intentions are positively associated with high perceived subjective knowledge of water pollutants. **Hypothesis 2**: Health and environmental protective behavioral intentions are positively associated with a high perceived self-efficacy and response efficacy.

Hypothesis 3: Health and environmental protective behavioral intentions are positively associated with a high perceived severity and vulnerability.

3. Methods and materials

3.1. Data collection

The data used in this study were collected as part of a survey of residents in the Columbia River Basin of the US Pacific Northwest, where water pollutants such as mercury, DDT, PCBs, and PBDEs pose serious risks to both human health and the environment (EPA, 2009). Humans and wildlife exposed to water contaminated with these toxins can suffer nervous system, kidney, liver, immune system and reproductive disorders, and cancer (SCDHEC, 2019; Harada et al., 2016; EPA, 2022; Cooke, 2017). First, we developed a survey instrument using modified existing measures (see below). Three survey experts and environmental risk researchers and a group of seven non-experts pretested the initial survey. The feedback provided from this preliminary review informed several revisions to the survey to improve clarity and reduce measurement error prior to pilot testing. The survey was then pilot tested through Qualtrics to assess the feasibility of the overall study procedures, including sampling, recruitment, data collection, and analysis. Based on results from the 50 respondents in the pilot test sample, no significant changes were made to the survey. We distributed the final survey instrument online from December 2021 to January 2022.

Respondents were recruited using a Qualtrics opt-in panel, a pool of respondents who voluntarily sign up to be solicited for survey participation. Eligible respondents were those at least 18 years of age and residing in Idaho, Oregon, and Washington. We employed equal quotas for age (18-43 (32%), 25-54 (34%), 55+ (35%), gender (male 50%, female 50%), and state (Idaho (20%), Washington (50%), and Oregon (30%). Study procedures were approved and certified exempt by the University of Idaho Institutional Review Board (#19-159). We had an incidence rate of 31%, meaning that out of all the people who entered the survey, 31% of them were eligible respondents who were able to complete it. Our final number of respondents was 621, so we can estimate approximately 2,003 entrants to the survey in total, the majority of which were terminated. It is standard not to calculate a response rate for opt-in panels like ours (Callegro & DiSogra, 2009).

3.2. Measures

The primary study variables were measured using a five-point unipolar scale and response options were tailored to each item. We used unipolar scales to evade forcing respondents to consider between contrasting concepts (i.e., agree and disagree) (Alwin et al., 2018). We used a five-point scale because studies suggest that this number can result in higher response quality than seven- or eleven- point scales, can minimize respondent burden, and is most appropriate for use with unipolar response categories (Krosnick, 2018). Scales for demographic and environmental variables are described below. This analysis included the following survey items.

Perceived severity. Our study included two measures of the perceived severity of the risks posed by toxic water pollutants—one focused on environment and one focused on human health. Participants responded to items used to measure these two variables using a five-point scale(1= Not at all severe; 5= Extremely severe). With respect to the environment, we measured perceived severity by asking participants “How severe do you think the negative consequences of toxic water pollutants are for the health of the environment?” (M=4.17, SD= .93). With respect to human health, we asked participants “How severe do you think the negative consequences of toxic water pollutants are for human health?” (M=4.19, SD= .92).

Perceived vulnerability. Our study included two perceived vulnerability variables—one focused on environment and a second focused on personal health. Participants responded to the items used to measure these two variables using a five-point scale (1 = not at all vulnerable; 5 = extremely vulnerable). With respect to the environment, we measured perceived vulnerability as the averaged response to two items, asking participants “In your opinion, how likely is it that each condition is vulnerable to toxic water pollutants: wildlife on land, wildlife in water (M=4.05, SD=.93, *r2* = .4). With respect to personal health, we measured perceived responsibility as the response to one item, asking participants “When you consider the possibility of toxic water pollutants affecting your physical health, how vulnerable do you feel?” (M=3.56, SD= 1.08). Wording for these measurement items was adapted from Bockarjova and Steg (2014).

Perceived response efficacy. Our study included two perceived response efficacy variables—one focused on environment and a second focused on personal health. Participants responded to the items used to measure these two variables on a five-point scale (1 = not at all effective; 5 = extremely effective). With respect to the environment, we measured perceived response efficacy by asking participants “How effective do you think taking individual action is at reducing toxic water pollutants from entering waterways?” (M=3.6, SD= .99). With respect to personal health, we measured perceived response efficacy by asking participants “How effective do you think taking individual action is at protecting your physical health from exposure to toxic water pollutants?” (M=3.87, SD=.93).

Perceived self-efficacy. Our study included two perceived self-efficacy variables—one focused on environment and a second focused on personal health. Participants responded to the items used to measure these two variables on a five-point scale (1 = not at all confident; 5 = extremely confident). With respect to the environment, we measured perceived response efficacy by asking participants “How confident do you feel in your ability to take any kind of individual action to prevent toxic water pollutants from entering waterways?” (M= 3.9, SD= .99). With respect to personal health, we measured perceived response efficacy by asking participants “How confident do you feel in your ability to take any kind of individual action to protect your health from toxic water pollutants?” (M=3.9, SD= 1.03). Wording for these measurement items was adapted from Bockarjova and Steg (2014).

Subjective knowledge. Respondents were asked to self-assess their water pollutant-related knowledge. We created two knowledge scores, one that reflected a human health knowledge related to water pollutants score and one that was environmental knowledge related to water pollutants. The first items considered the effects of water pollutants on the human body, how water pollutants enter the human body, and how to prevent water pollutant exposure. Respondents answered all items on a response scale from 1 = “not at all knowledgeable” to 5 = “extremely knowledgeable” (M= 2.48, SD=1.16, α= .9). An “I don’t know” option was not offered to respondents. The three items were averaged to create an individual subjective knowledge on human health score used in the health protective behavior model of the regression. The remaining three items asked specifically about several issues related to water pollutants and the environment: effects on the environment, effects on wildlife, sources of water pollutants. Respondents answered all items on a response scale from 1 = "not at all knowledgeable" to 5 = "extremely knowledgeable" (M= 2.6, SD=1.14, α= .93). The three items were averaged to create an individual subjective knowledge on the environment score used in the environmental protective behavior model.

Behavioral intention. Respondents were asked to rank their likelihood in performing behaviors that protect the environment and protect their physical health. For environmental protective behaviors, respondents were asked "Consider the actions listed below related to preventing toxic water pollutants from entering waterways, how likely is it that you will perform these behaviors in the next year? 1) Minimize my use of plastic, 2) Dispose of cleaning products properly based on the label, 3) Encourage people I know to reduce using fertilizer on their lawn, 4) Dispose of medicine properly by taking them to a Drug Take Back Program" Respondents answered all items on a response scale from 1= "not at all likely", 5= "extremely likely" (M= 3.79, SD= .93, α= .8). This environmental protective behavior score was used as the dependent variable in the environmental protective behavior regression model. For health protective behaviors, respondents were asked "Consider the actions listed below related to protecting your physical health toxic water pollutants, how likely is it that you will perform these behaviors in the next year? 1) Install a water filter in your household, 2) Eat fish less frequently, 3) Flush pipes with cold water in the morning and 4) Cook with cool tap water rather than hot. Respondents answered all items on a response scale from 1= "not at all likely", 5= "extremely likely" (M= 3.71, SD= .94, α= .7). This health protective behavior score was used as the dependent variable in the health protective behavior regression model.

Sociodemographic characteristics. Six sociodemographic items were included in the final analysis as controls due to their possible influence on perceived threat and coping appraisal. Survey respondents reported their gender (0 = "male", 1 = "female," age, race and ethnicity (White, Black or African American, American Indian or Alaskan Native, Asian, Native Hawaiian or Pacific Islander, Hispanic or Latino), level of education (less than high school degree, high school graduate, some college but no degree, college degree, and advanced degree), income level (from less than $20,000 to greater than $120,000), and political ideology (ranged from -3 = "strongly liberal" to 3 = "strongly conservative"). Race and ethnicity were recoded such that 0= "White" and 1= "non-White". Education was recoded as high and low education, split at the median such that 0 = low education and 1 = high education. Age was treated as continuous as we used their year of birth to determine exact age after completing the survey. (For a complete set of all sociodemographic variables characterizing our sample see Table 1). To see the complete survey instrument, see Appendix A.

Table 1. Demographics of full sample of respondents (n=621). We removed 37 respondents in our final analysis because they indicated that they were vegetarian, but this table includes all respondents.

Characteristic	Sample
Age	Mean (SD) (% (frequency))
18-34	31.2% (194)
35-54	33.1% (206)
55+	35.5% (221)
Gender	
Female	48.7% (303)
Male	51.1% (318)
Race/ethnicity	
White	74.6% (464)
Black or African American	5.1% (32)
American Indian or Alaskan Native	1.8% (11)
Hispanic or Latino	13.2% (82)
Asian	3.2% (20)
Native Hawaiian or Pacific Islander	1.9% (12)
Highest education	
Advanced degree	11.4% (71)
College degree (2 or 4 year)	32.8% (204)
Some college but no degree	29.6% (184)
High school graduate	22.3% (139)
Less than high school degree	3.7% (23)
Occupational status	
Working full-time	35% (218)
Working part-time	11.3% (70)
Student	4.5% (28)
Unemployed	11.4% (41)
Retired	24.1% (150)
Homemaker	7.6% (47)
Other	5.9% (37)
Approximate household income	
Less than $20,000	18.3% (114)
$20,000-$49,999	34.9% (217)
$50,000-$79,999	22.8% (142)
$80,000-$99,999	8.5% (53)

Table 1. Demographics of full sample continued

$100,000 - $119,999	5.9% (37)
$120,000 or more	9.3% (58)
Region	
Idaho	19.65% (122)
Washington	50.24% (312)
Oregon	30.11% (187)
Political Affiliation	
A strong Democrat	13.2% (77)
A Democrat	20% (117)
Independent, lean toward Democrat	12% (70)
Independent (Close to neither party)	25.9% (151)
Independent, lean toward Republican	9% (53)
A Republican	12.8% (75)
A strong Republican	7% (41)

3.3. Statistical analysis

All analyses were conducted with RStudio (2022.07.1). We analyzed data with two regression models testing our three hypotheses. In the first regression model, we regressed five sociodemographic variables (age, gender, education, political party, and income), the four health-focused PMT variables (perceived severity, perceived vulnerability, perceived self-efficacy, and perceived response efficacy), and human health subjective knowledge of water pollutants on intentions to engage in health protective behaviors. For the second model, we regressed five sociodemographic variables (age, gender, education, political party, and income), the four environmental focused PMT variables (perceived severity, perceived vulnerability, perceived self-efficacy, and perceived response efficacy), and environmental subjective knowledge of water, on intentions to engage in environmental protective behaviors.

We used the lmsupport package to analyze our regression models and retrieve effect sizes (Curtin, 2018). Bivariate correlations for all predictor variables were lower than 0.70, indicating that multicollinearity is likely not a major concern for subsequent model testing (Dorrman et al., 2013). For each regression model, we calculated partial eta-squared (η^2_p) to quantify predictor-variable effect sizes. Effect sizes with η^2_p are considered small at .01, medium at .09, and large at .25 (Tabachinck and Fidell 2007; Watson 2017).

4. Results

Regression analysis

Table 2 reports the results of the health protective behavior and environmental protective behavior intention multiple regression analysis. Model 1 (R^2 = .358) includes human health subjective knowledge of water pollutants, perceived severity, vulnerability, self-efficacy, and response efficacy for health protective behavior intention regarding water pollutants and control variables for sociodemographic and political ideology. Model 2 (R^2 = .377) includes environmental subjective knowledge of water pollutants, perceived severity, vulnerability, self-efficacy, and response efficacy for environmental protective behavior intention regarding water pollutants and control variables for sociodemographic and political ideology. Effect size was calculated for significant variables.

Table 2. Summary of multiple regression models for variables predicting health and environmental protective behavior intention (n=584)

Model	Model 1 Health Protective Behavior Intention			Model 2 Environmental Protective Behavior Intention		
Independent variable	*B* (SE)	*β*	η^2_p	*B* (SE)	*β*	η^2_p
Age	.05	0		.05	0	
Gender	.15 (.02)**	.08	.01	.06	.03	
Education	-.02	-.01		-.09 (.01)*	-.09	.01
Political Party	.00	-.01		-.1 (.005)**	-.1	.01
Income	.04	.02		0	0	
Vulnerability	.21 (<.001)***	.24 (<.001)***	.06	.12 (.01)***	.11	.01
Severity	.07 (.109)	.07	.00	.12 (.01)**	.12	.01
Self-Efficacy	.27 (<.001)***	.3	.09	.29 (<.001)***	.31	.10
Response Efficacy	.2 (<.001)***	.2	.04	.19 (<.001)***	.20	.04
Subjective Knowledge	.02	.03		.10 (.003)**	.12	.01
Adjusted R^2		.36			.37	
F for ΔR^2		33.44***			33.93**	

Only environmental protective behavioral intentions are positively associated with high perceived subjective knowledge of water pollutants in our models (β = .123, p < .001). Whereas health protective behavioral intentions were not associated with perceived subjective knowledge of water pollutants (β = .033, p=0.339). Effect size is considered small for subjective knowledge in the environmental model (η^2_p =.01). Our findings confirmed hypothesis 1 for environmental protective behavior intention and rejected hypothesis 1 for health protective behavior intention.

We assessed coping appraisal for the health and environmental models, with coping appraisal comprised of self-efficacy and response efficacy. A high perceived self-efficacy (β = .270, p < .001) and response efficacy (β = .199, p < .001) were both associated with health protective behavior intention. Similarly, high perceived self-efficacy (β = .293, p < .001) and response efficacy (β = .188, p < .001) were both associated with environmental protective behavior intention. Thus, our findings confirmed hypothesis 2 that health and environmental protective behavior intentions are positively associated with high perceived coping appraisal. Moreover, effect size was considered medium for self-efficacy in both the health (η^2_p =.09) and environmental (η^2_p =.1) model and small for response efficacy.

Threat appraisal is comprised of perceived vulnerability and severity. Only a high perceived vulnerability (β = .207, p < .001) was associated with increased reported health protective behavior intention. Perceived severity (β = .066, p = .109) was not significant in the health protective behavior intention model. Whereas, a high perceived vulnerability (β = .116, p = .008) and severity (β = .117, p = .007) were both associated with increased reported environmental protective behavior intention. Our findings confirmed that high threat appraisal is associated with environmental protective behavior intention but reject that it is associated with health protective behavior intention.

5. Discussion

A polluted environment can negatively affect the health of humans and biodiversity. Environmental protective behaviors can help safeguard the environment and simultaneously bolster public health. Our aim in this study was to assess the strength of the PMT model to predict intentions to perform environmental protective behaviors and health protective behaviors in the context of water pollution. By studying both types of behaviors, we can understand how PMT performs when researching health protective behaviors, or personal risk behaviors, and environmental protective behaviors, or impersonal risk behaviors, in the context of an environmental issue. Our results affirm that PMT can be used for predicting environmental protective behavior intention, and in our analyses, perceived severity and self-efficacy were the most significant variables in predicting environmental protective behavior intention. We found that perceived self-efficacy and severity had higher correlation coefficients with environmental protective behavior intention than health protective behavior. In contrast, perceived vulnerability and response efficacy had higher correlation coefficients with health protective behavior intentions than environmental protective behavior intentions.

Our results revealed that perceived self-efficacy was the strongest predictor of behavioral intention for both health and environmental protective behaviors. A strong sense of self-efficacy is more likely to lead to protective action, influence the degree of receptiveness to information and promote the likelihood of taking effective remedial action (Floyd et al., 2000; Westcott et al., 2017). In an environmental behavior context, Shafiei et al. (2020) applied PMT to understand the motivators behind environmental behaviors and found self-efficacy to be the strongest predictor of behavior. Furthermore, in a study that assessed factors influencing farmers' environmental behavior with respect to non-point source water pollution, self-efficacy was significant in predicting behavior intention (Wang et al., 2019). In our study of water pollutants perceptions, in both the health and environmental protective models, self-efficacy was the strongest predictor of behavioral intention. Fear appeal research suggests that a greater sense of threat could increase persuasiveness to engage in risk-reducing behaviors, but only if the recipient feels capable of avoiding the threat by executing the recommended behavior (Ruiter et al., 2001). Our research and these previous studies suggest that people need to feel confident in their ability to perform behaviors; thus, instilling confidence to take action may be critical when developing communication regarding environmental threats.

Perceived vulnerability had a higher coefficient in our health protective model compared to the environmental protective model but was significant in both models. This finding is similar with both environmental and public health literature that finds higher perceived vulnerability explains engagement in protective behavior (Janmaimool et al., 2017; Lwin et al., 2007). However, these studies' findings could indicate that some environmental issues need to be communicated with specific tailoring about their impact on human health for perceived vulnerability to be stimulated. In fact, many communication campaigns emphasize the public health risks that are associated with environmental issues to incite behavior change (Myers et al., 2012; Sauerborn et al., 2009).

Perceived severity was significant in the environmental protective behavior intention model, but not the health model. This finding could indicate that individuals need to perceive a higher severity to perform environmental protective behaviors compared to health protective behaviors. In other words, people can perceive a lower threat to their personal health—compared with an environmental threat—to be motivated to perform health protective behaviors. Previous literature finds that fear-arousing communications resulted in increased acceptance of proposed adaptive behavior or intention (Floyd et al., 2000). Further, a study on green consumerism in response to species decline due to invasive lionfish found increasing severity messaging was effective in changing consumption behavior (Huth et al., 2018). These findings could be consistent with the engagement of environmental protective behaviors; however, they are not consistent with our results on severity and health protective behaviors. Recent public health literature finds that threat appeals can be unreliable in their efficacy and that a balanced message with severity and self-efficacy is more effective, which may help to explain our findings (Carey & Sarma, 2016). Thus, it may be important to increase the severity of the environmental threat while remaining mindful of self-efficacy messaging to stimulate environmental protective behaviors.

The sociodemographic factors that affected environmental protective behavior intentions were political affiliation and education. Studies consistently find that liberalism is positively and significantly related to environmental concern (e.g., Cruz, 2017). In this study, we found the more liberal the participant, the higher their intention was to participate in environmental behaviors. Previous research has found that more conservative individuals tend to be less sensitive to diffuse threats (or threats spread out over a large area) (Choma et al., 2013). Because the environmental questions regarding water pollutants in our survey instrument focused on how water pollutants harm the environment rather than on how they harm individual health, this could explain why conservatives in our study usually perceived less threat from water pollutants in an environmental context. Consequently, because the health questions were geared to water pollutants directly impacting the respondent's health, this phrasing could explain why political affiliation did not affect health protective behaviors as the water pollutants subject was no longer a diffuse threat, but a direct threat to the respondent.

Finally, we found a negative relationship between education and intent to participate in environmental protective behavior. These findings deviate from previous literature that finds individuals with higher education levels tend to be more environmentally friendly (Meyer, 2015; Wang et al., 2022). 32% of the participants in our survey had a bachelor's degree or higher; compared to 37.9% of individuals in the US, thus, the results could be due to our sample skewed slightly to individuals without a bachelor's degree (U.S. Census Bureau, 2022). Additionally, some researchers find that education effects are mostly driven by different levels of knowledge on environmental issues; for example, having greater knowledge about climate change, perceiving its risks to be higher, and being aware of its causes positively impact green behavior among respondents (Hoffmann & Muttarak, 2015). Because we found that high subjective knowledge on water pollutants correlated with environmental protective behavior, this finding could explain why we see a deviation in education level and behavior intention. To perform environmental protective behavior, an individual's subjective knowledge on the topic may be more important than formal education level.

The sociodemographic characteristic that significantly affected health protective behavior was gender. Women were more likely than men to intent to perform health protective behaviors. This finding is consistent with previous health protection literature; women are often more likely to practice behaviors intended to reduce the consequences of environmental risks that impact their health (Davidson & Freudenburg, 1996; Dömötör et al., 2019). This phenomenon could be related to risk perception and the gender bias that women are socialized to be more concerned about health issues than men (Deeks et al., 2009; Siegrist et al., 2005).

Our study has a few limitations. First, despite efforts to maximize sample representativeness with demographic quotas, the survey did not utilize a random sample, and thus the findings here should not be generalized to the national population. Second, risk researchers have developed an extended PMT model that considers maladaptive response costs (meaning the time, effort, or financial costs of taking protective behaviors) (Floyd et al., 2000). We did not implement the extended PMT model for two reasons. The first was because we were assessing a diverse range of behaviors and the response costs would change dramatically from behavior to behavior. Further, if we were to ask questions for response costs and maladaptive response rewards for each behavior, that would have significantly lengthened the survey. We wanted to be aware of respondent fatigue which could deteriorate the quality of data (Ben-Nun, 2008). Finally, in this study, we tested behavioral intention rather than actual behavior. Many scientists research the intention-behavior gap and have found one variable that influences behavioral intention is actual behavioral control (Nguyen et al., 2019; Wang & Mangmeechai, 2021). We addressed the intention-behavior gap by asking self-efficacy questions to understand the individual's confidence to perform the behavior. Further research should explore actual behavior or past behavior to determine if there are changes between behavioral intention and include the PMT extended model.

6. Conclusion

The PMT was developed primarily in the context of public health behavior; in our study, we compared behavioral intention concerning both behavioral intentions for health (personal) and environmental (impersonal) risks in the context of an environmental issue. Our study found that PMT does not act the same when considering these two different types of intended behaviors; we see that individuals need to perceive a higher severity to stimulate environmental behavior intention versus health behavior intention. Our findings contribute to both health and environmental behavior literature as we found that self-efficacy had the most substantial relationship with behavioral intention across both types of behavioral intentions. These conclusions suggest that instilling confidence in the person performing the suggested behavior is essential when developing communication tools. Future research should explore communication manipulations to understand the effectiveness of self-efficacy messaging to promote behavior with varying levels of threat. Our study was not experimental, and more experimental work needs to be done to understand these findings further. Additionally, we did not assess PMT under varying levels of threat as our study asked about relatively low threat level pollutants, though they can be of great concern at high concentrations. It would be helpful to understand how PMT acts under more acute levels of pollution threats. Finally, we found that perceived severity and self-efficacy were the most important variables in predicting environmental protective behavior intention; thus, future research should explore threat-self-efficacy messaging further as it may be the most effective way to communicate environmental risks to stimulate environmental protective behavior.

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Chapter 3: Comparing personal health risk and environmental risk communication frames on water pollutants to stimulate environmental protective behavior

Abstract

To safeguard water sources from pharmaceutical pollution, individuals can engage in environmental protective behaviors to prevent chemicals in medicines from entering waterways. However, there has been little experimental research testing how to effectively communicate information about water pollution to encourage protective behavior. This project used a message framing experiment embedded in an online survey to determine how (a) personal versus impersonal risk frames and (b) self-efficacy versus no self-efficacy frames performed in encouraging health and environmental protective behavior intentions. We conducted parallel experimental studies with samples from two populations: a general population Qualtrics panel of residents in Washington, Oregon, and Idaho (n=584) and a university student population in the same region (n=168). We found that among the general population, no communication frame was more effective than another to encourage behaviors. Among the student population, the personal risk frame with no self-efficacy message had a significantly higher effect on respondents' intentions to engage in environmental protective behaviors compared to messages with self-efficacy. We found that the average respondent reported high intentions to take protective behaviors towards water pollution, which may suggest that self-efficacy messaging is not necessary when communicating personal risks for a high salience issue.

1. Introduction

Environmental health has a direct impact on public health. The World Health Organization attributes 13 million deaths to preventable environmental causes yearly (WHO, 2015). This statistic reveals that healthy environments prevent premature death and disease. Pollutants such as wastewater discharge and agricultural runoff are highly researched and can impact human health. However, there is growing concern about emerging contaminants, such as pharmaceuticals, that infiltrate water bodies and can have a significant impact on human health and aquatic life (EPA, 2022). Pharmaceutical pollution of the world's rivers is far more extensive than previously thought; in 2022, scientists reported on sampling from 258 rivers in 104 countries, finding that many contained concentrations of medicinal drugs that exceeded safe levels (Wilkinson et al., 2022). Pharmaceuticals get into water bodies through different routes, such as the discharge of treated wastewater, seepage from landfill sites, sewer lines, and runoff from animal wastes (Patneedi & Durga Prasadu, 2015). The presence of pharmaceuticals in drinking water is concerning because exposure to some of these compounds could result in adverse effects on human health, such as endocrine disruption and antibiotic resistance (Bexfield et al., 2019). Further, these contaminants can have negative impacts on aquatic organisms. For example, one study found that oxazepam, an anti-depressant, alters the behavior and feeding rate of wild European perch, individuals exposed to water with dilute drug concentrations exhibited increased activity, reduced sociality, and higher feeding rate (Brodin et al., 2013). The negative consequences of pharmaceutical exposure to fish can alter animal behaviors that can have ecological and evolutionary consequences. To prevent pharmaceuticals from entering waterways, people must engage in environmental protective behaviors, such as avoiding disposal of medicines down the drain and participating in Drug-Take-Back programs to safely dispose of medicines. Because pharmaceutical pollution provides an impersonal ecological risk (danger to the ecosystem) and personal risk (danger to an individual person's health), we designed communication frames on this topic to determine the relative effectiveness of impersonal versus personal risk communication for promoting environmental protective behaviors that reduce pharmaceutical pollution.

To improve environmental health, individuals must engage in environmental protective behaviors, or behaviors that seek to minimize adverse impacts on the natural environment and human health (Kollmuss & Agyeman, 2002). Communication is integral to promoting environmental protective behavior and ensuring that individuals practice behavior change. Message framing, or structuring the presentation of information, is a powerful tool to encourage behavior change (Wicks, 2011). Framing can drastically influence how a problem is perceived and thereby influence the decision-making process (Fitzpatrick-Lewis et al., 2010). For example, a recent communication campaign sought to support wildlife conservation and reduce wildlife-caused injuries to visitors in national parks. A study of the campaign found that communication frames that promoted the visitor's experience as it aligns with wildlife protection, in other words, frames that described a more direct connection to the reader, were more effective in promoting behavior change than information solely about the importance of wildlife protection (Abrams et al., 2020). This example shows that testing communication frames is essential to ensure that the message incites the desired result.

In public health, message design and strategic messaging are widely researched. By contrast, conservation and environmental messaging have been less well studied. In a review of conservation messaging, Kidd et al., (2019) found a lack of information on messaging toward specific audiences, few evaluations of the effectiveness of messaging, and a failure to draw upon behavior theories to guide research. Moreover, conservation research has found that using different communication approaches for each stakeholder can improve responses to communication, pointing to the importance of studying responses to messages by people in specific populations or regions (Kolandai-Matchett & Armoudian, 2020; Nicoll et al., 2016). Our project sought to address this need in environmental communication through two parallel communication experiments with two study populations--people in the Columbia River Basin region of the US Pacific Northwest (PNW) and a university student population—using behavior theory to guide communication measures.

Previous conservation messaging research has focused on the effects of ecological risks, which can be interpreted as impersonal risks. Impersonal risks do not pose a direct personal threat to an individual (Kahlor et al., 2006). For example, one study on communication frames outlined Arctic ice melt from an ecological standpoint, stating that polar bears are at risk of becoming extinct by 2100 due to rising temperatures (Kesenheimer & Greitemeyer, 2020). This frame highlights an impersonal risk because the risk does not directly impact the reader. On the other hand, in health communication, researchers have demonstrated that perceived personal relevance, or personal risk, is a powerful predictor of individuals' use of health-related messages (Liberman and Chaiken, 1992). The same study about messaging on melting Arctic ice was presented as a personal risk by stating that there are diseases in Arctic ice and as it melts these circulate in our air, creating potential harm for human health; this example is a direct impact of how glacial ice melt can affect an individual (Kesenheimer & Greitemeyer, 2020). However, when this experiment was carried out, neither the impersonal-ecological frame nor personal-health risk frame affected pro-environmental behavior (Kesenheimer & Greitemeyer, 2020). The Arctic ice experiment was conducted with participants who were recruited by online advertisements in psychology magazines. To assess whether the context (including the study population and the message content) played a role in the effects of these message manipulations, our project tested ecological (impersonal risk) versus health (personal risk) communication frames regarding pharmaceutical water pollution to measure intention to engage in environmental protective behavior with individuals throughout the Pacific Northwest (PNW) and students at a university in the PNW.

Behavior change theories influence the design and effects of communication frames. For instance, the Protection Motivation Theory and the Health Belief Model posit that individuals with high feelings of self-efficacy are more likely to change behavior (Maddux & Rogers, 1983; LaMorte, 2020). Maddux and Rogers found self-efficacy to be the most powerful predictor of behavioral intentions that precede actual behavior (Maddux and Rogers, 1983). Bandura's social cognitive theory also notes that to successfully achieve a goal, individuals must have high self-efficacy, meaning they believe in their capacity to execute behaviors (Bandura, 2001). To test the extent to which self-efficacy affects behavioral intentions in our context of pharmaceutical water pollutants, we included a frame manipulation with and without a self-efficacy cue.

To verify our results, we conducted two parallel experiments, one with a general population sample and one with university students enrolled in environmentally-themed courses. Thus, this chapter will describe methods and results sections pertaining to each experiments separately. We then review the results of the two experiments together in the discussion section.

2. Literature review and research questions

2.1 Message framing and emphasis framing

Message framing refers to the presentation and structure of information, which affects the amount of persuasion it elicits (Smith and Petty, 1996). Frames can also help simplify complex issues by focusing or placing greater weight on some considerations, showing why an issue might be a problem, who or what might be responsible, and what should be done (Sorensen et al., 2015). For example, the field of public health uses message framing to encourage prevention behaviors, such as skin cancer prevention and smoking prevention (Gallagher & Updegraff, 2012). Similarly, the environmental field has employed message framing to boost environmental protective behavior (Kidd et al., 2019). Specifically, emphasis framing, or giving special prominence to one aspect or feature of an issue, was used in this study (Ding & Pan, 2016). Emphasis framing can tailor the content of a message to enhance its appeal to different individuals. For example, the topic of nuclear energy can be framed as an economic development issue, a safety issue, or an environmental issue (Ding & Pan, 2016). By emphasizing different aspects of an issue, the frame increases those attributes' salience in individuals' minds, prompting individuals to use them as the basis to evaluate the issue. If those attributes resonate with the readers preexisting beliefs, the frame will be more effective and persuasive (Luong et al., 2019). By using different frames, we can determine the most effective frames that incite behavior change within specific populations. This study frames pharmaceutical water pollutants as an ecological issue and a personal health issue respectively to determine whether one frame is more significant in persuading readers to take environmental protective behavior.

2.2 Ecological (impersonal) risk versus health (impersonal) risk frames

A common approach in environmental messaging is an ecological frame. Ecological framing emphasizes distant and/or local environmental impacts of an issue (Badullovich et al., 2020). For example, a study on meat consumption found that framing messaging from the ecological perspective effectively decreased red meat consumption compared to a combined health and environmental message frame condition (Carfora et al., 2019). The ecological frame stated that if the reader avoided red meat, they would protect the environment from releasing harmful greenhouse gases. However, the authors also framed refraining from red meat consumption as a health condition stating that avoiding red meat will prevent colon cancer and heart disease. This example shows how an environmental message can be framed as an ecological/impersonal risk versus a public health/personal risk. This study used an ecological frame as an impersonal risk frame because the ecological message does not directly impact the participant. Perceived personal risk is a powerful predictor of individuals' use of health-related messaging in the field of public health (Kahlor et al., 2006). In their review of risk messaging, they note that AIDS prevention campaigns need to be strategically targeted at their intended audience for the recipient to see the relevance of the message on their own behaviors (Kahlor et al., 2006). This example suggests that risk messaging needs to be relevant to the reader in the context of AIDS. In cyber security research, scientists found that when personal examples are used during risk communication, the user is more likely to make privacy-conscious choices when deciding which applications to install (Harbach et al., 2014). However, in evaluating risk communication about an environmental issue (radon), researchers found that neither personal nor impersonal risk communication had a significant impact on behavior (Golding et al., 1992). Their conclusion suggests that more research needs to be done in the environmental communication field to understand if the conclusion made in other fields applies to environmental concerns.

Q1. Will personal risk communication frames have a greater effect on environmental protective behavior intention than impersonal risk frames?

2.3 Self-efficacy frame

Self-efficacy refers to the belief about one's ability to successfully execute a particular behavior required to produce the desired outcome (Bandura, 1977). Floyd and Rogers found self-efficacy to be the most potent predictor of behavioral intentions that precede actual behavior (Floyd and Rogers, 2000). A strong self-efficacy is more likely to lead to the taking of protective action (Westcott et al., 2017). For example, in Rogers and Maddux's research that sought to find the strongest predictors of quitting smoking, they found that participants who read high self-efficacy communication text indicated greater expectations concerning their ability to give up smoking compared to subjects exposed to a low self-efficacy communication text (Maddux and Rogers, 1983). In a public health communication frame study, researchers found that participants that had higher perceived self-efficacy had higher intentions to perform skin self-examination (van 't Riet et al., 2010). Similarly, in a study promoting volunteerism, the researchers manipulated communication measures to have self-efficacy verbiage (Lindenmeier, 2008). The authors found that self-efficacy frames ("with your help, a child will learn to read!") had a stronger influence on willingness to volunteer than a message without a self-efficacy frame (Lindenmeier, 2008). Both examples found that self-efficacy positively influenced behavioral intention in public health and volunteer settings. In an environmental context, Hart et al. found that efficacy messages concerning climate change increased perceptions of personal self-efficacy in the individual (Hart & Feldman, 2016). The manipulated message said, "as the impacts of climate change are becoming clearer, many Americans find that it is not difficult to make their views on climate change known to legislators," and discussed the ease of sending an email or letter for policy change (Hart & Feldman, 2016). These results may suggest that self-efficacy messaging will have a stronger influence on environmental protective behavior intention than a message without self-efficacy.

Q2. Will self-efficacy messages have a greater effect on environmental protective behavior intentions compared to messages without a self-efficacy frame?

3. Methods

This project conducted a parallel communication frame experiment with two different study populations: an online Qualtrics panel and a university student population. We did an online survey for both, with specific tailoring based on the population. The Qualtrics panel population included more items than we report in this chapter because some items were used for analysis on another study (see Little et al. In Review). To answer the research questions, a factorial design (4 communication frames) was conducted in the form of a survey experiment. Participants were randomly assigned to one of the four frame conditions. The dependent variable was intention to perform environmental protective behaviors.
Below, we describe the specific instruments and procedure for each experiment.

3.1. Survey development for Experiment 1

Study procedures were approved and certified exempt by the University of Idaho Institutional Review Board (#19-159). Three survey experts and environmental risk researchers and a group of seven non-experts pretested the initial survey. The feedback provided from this preliminary review informed several revisions to the survey to improve clarity and reduce measurement error prior to pilot testing. The survey was then pilot tested through Qualtrics to assess the feasibility of the overall study procedures, including sampling, recruitment, data collection, and analysis. Based on results from the 50 respondents in the pilot test sample, no significant changes were made to the survey.

We distributed the final survey instrument online from December 2021 to January 2022. Respondents were recruited using a Qualtrics opt-in panel, a pool of respondents who voluntarily sign up to be solicited for survey participation. Eligible respondents were those at least 18 years of age and residing in Idaho, Oregon, and Washington. We employed equal quotas for age, gender, and state of residence (Idaho, Washington, and Oregon).

3.2. Survey development for Experiment 2

Study procedures were approved and certified exempt by the University of Idaho Institutional Review Board (#19-159). The same development for Experiment 1 was used for Experiment 2.

We started distribution for Experiment 2 in August 2022 and finished in September 2022. Respondents were recruited via voluntary sampling through student list-servs in environment and natural resources programs and 3 environmental-related courses offered in the Fall of 2022. Eligible respondents were those at least 18 years of age and students at University of Idaho.

3.3. Measures for Experiments 1 and 2

Because these were parallel experiments, the measures and analysis are identical. The primary study variables were measured using a five-point unipolar scale and response labels were tailored to each item. We used unipolar scales to avoid forcing respondents to consider between contrasting concepts (i.e., agree and disagree) (Alwin et al., 2018). We used a five-point scale because studies suggest that it can result in higher response quality than seven- or eleven- point scales, can minimize respondent burden, and is most appropriate for use with unipolar response categories (Krosnick, 2018). Scales for demographic and environmental variables are described below.

Communication frames. Each participant was randomly assigned to one of the four communication frames (personal risk, personal risk with self-efficacy messaging, impersonal risk, and impersonal risk with self-efficacy messaging). After the respondent viewed the communication frame text, we asked them questions relative to intention to perform environmental protective behaviors surrounding pharmaceutical water pollutants. The participant was required to stay on the page for 25 seconds before they could continue the survey to ensure they read the frame. They were then asked to confirm that they read the frame. Figure 1 is an image of one of the message frames the participant received during the survey, all frames looked the same, and the text varied.

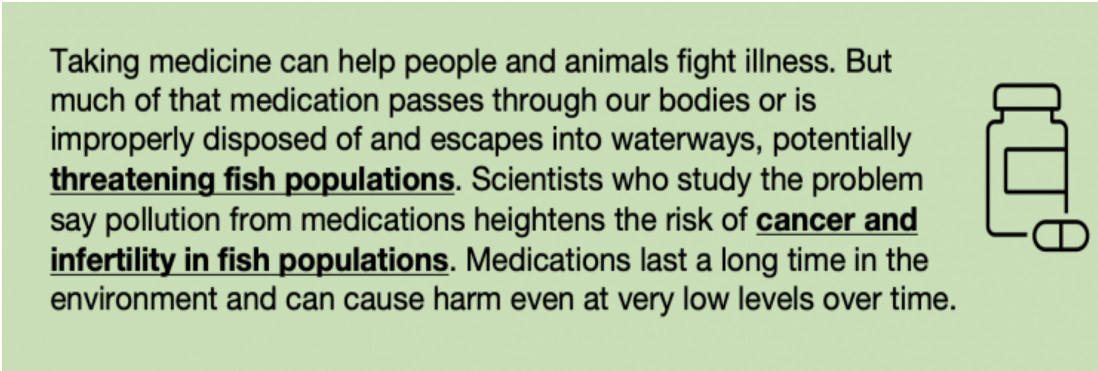

Figure 1. Example of message frame participant received in survey.

The participants received one of the four frames highlighted below:

Personal risk frame: "Taking a round of antibiotics may help people and animals fight infections. But much of that medication actually passes through our bodies, and pharmaceutical residues that escape into waterways may threaten human health. Scientists who study the problem say pharmaceutical pollution heightens the risk of cancer, infertility, and antibiotic resistance for people who drink tap water. Medications last a long time in the environment and can cause harm even at very low levels over time."

Personal risk frame with self-efficacy: "Taking a round of antibiotics may help people and animals fight infections. But much of that medication actually passes through our bodies, and pharmaceutical residues that escape into waterways may threaten human health. Scientists who study the problem say pharmaceutical pollution heightens the risk of cancer, infertility, and antibiotic resistance for people who drink tap water. Medications last a long time in the environment and can cause harm even at very low levels over time. Many people find that it's not difficult to take simple measures preventing medications from entering waterways, which protects human health."

Impersonal risk frame: "Taking a round of antibiotics may help people and animals fight infections. But much of that medication actually passes through our bodies, and pharmaceutical residues that escape into waterways from sewage and agricultural waste may threaten fish populations. Scientists who study the problem say pharmaceutical pollution heightens the risk of cancer and infertility in fish populations. Medications last a long time in the environment and can be taken up by fish and cause harm even at very low levels detected in the environment."

Impersonal risk frame with self-efficacy: "Taking a round of antibiotics may help people and animals fight infections. But much of that medication actually passes through our bodies, and pharmaceutical residues that escape into waterways from sewage and agricultural waste may threaten fish populations. Scientists who study the problem say pharmaceutical pollution heightens the risk of cancer and infertility in fish populations. Medications last a long time in the environment and can be taken up by fish and cause harm even at very low levels detected in the environment. Many people find that it's not difficult to take simple measures preventing medications from entering waterways, which protects fish and the environment."

Behavioral intention. After the respondent received the communication frame, they were asked about behavioral intentions they may perform in the next year that prevent pharmaceutical water pollutants from entering water bodies. To measure this variable, we asked the question "*the following actions are related to pharmaceuticals (or medications). Consider the list below, how likely is it that you perform these actions in the next year?"* The six behaviors we asked about were participating in Drug-Take-Back programs, avoiding disposing of medicines down the drain, supporting stricter regulations to limit medicine flushing, encouraging people the respondent knows to properly dispose of medicines, supporting stricter regulations that limit the use of antibiotics in animal agriculture, and avoiding purchasing animal products that have been treated with antibiotics.

Sociodemographic characteristics. Five sociodemographic items were gender, age, race, level of education for the Qualtrics panel and grade for the university population, and political ideology. Survey respondents reported their gender (0 = "male", 1 = "female," age (1 = "18-34", 2 = "35-54", 3 = "55+"), race and ethnicity (White, Black or African American, American Indian or Alaskan Native, Asian, Native Hawaiian or Pacific Islander, Hispanic or Latino), level of education (less than high school degree, high school graduate, some college but no degree, college degree, and advanced degree for the Qualtrics panel; freshman, sophomore, junior, senior, graduate student for the University population), and political ideology (ranged from -3 = “strongly liberal” to 3 = “strongly conservative”). Race and ethnicity was recoded such that 0= “White” and 1= “non-White”.

3.4. Statistical analysis for Experiment 1 and 2

All analyses were conducted with RStudio (2022.07.02). Descriptive statistics (means, frequencies, and standard deviations) for the independent variables were first calculated to characterize the sample. Using the basic R package, psych, and dplyr in R each scale was analyzed for internal reliability using Cronbach’s alpha with a threshold of ≥.7 (Santos, 1999; Revelle, 2021; R Core Team, 2021). Environmental protective behavior was internally valid for the Qualtrics panel (Cronbach’s alpha for environmental protective behavior = .85). Environmental protective behavior was internally valid for the university student population (Cronbach’s alpha for environmental protective behavior = .81).

We then performed a one-way ANOVA with environmental protective behavior intention as the dependent variable. We used the base R package to analyze this data. Bivariate correlations for all predictor variables were lower than 0.70, indicating that multicollinearity is likely not a major concern for subsequent model testing (Dorman et al., 2013). The same statistical analysis was used for Experiment 1 and 2.

3.5 Participants for Experiment 1

This experiment was fielded to a Qualtrics panel. We had an incidence rate of 31%, meaning that out of all the people who entered the survey, 31% of them were eligible respondents who were able to complete it. Our final number of respondents was 621, so we can estimate approximately 2,003 entrants to the survey, most of which were terminated. It is standard not to calculate a response rate for opt-in panels like ours (Callegro & DiSogra, 2009). We deleted 37 responses for analysis because they indicated they were vegetarian and did not consume fish. Survey respondents from the Qualtrics panel were 51.1% male and 74.6% white. 32.8% of respondents held a bachelor’s degree or higher. Table 3 shows the demographic breakdown of the Qualtrics panel. For T-tests on gender and political affiliation and environmental behavioral intention, see Appendix B.

Table 3. Demographics of full sample of respondents. We removed 37 respondents in our final analysis because they indicated that they were vegetarian, but this table includes all respondents

Characteristic	Sample
Age	Mean (SD) (% (frequency))
18-34	31.2% (194)
35-54	33.1% (206)
55+	35.5% (221)
Gender	
Female	48.7% (303)
Male	51.1% (318)
Highest education	
Advanced degree	11.4% (71)
College degree (2 or 4 year)	32.8% (204)
Some college but no degree	29.6% (184)
High school graduate	22.3% (139)
Less than high school degree	3.7% (23)
Political Affiliation	
A strong Democrat	13.2% (77)
A Democrat	20% (117)
Independent, lean toward Democrat	12% (70)
Independent (Close to neither party)	25.9% (151)
Independent, lean toward Republican	9% (53)
A Republican	12.8% (75)
A strong Republican	7% (41)

3.6 Participants for Study 2

For the university student population, the survey was sent out to two student list-servs and 3 environmental courses, totaling 1252 students. We received 173 responses, making the response rate 13.8%. We deleted 45 responses because they indicated they were vegetarian and did not consume fish. Thus, we had 128 responses that were used in analysis. The student population was 34.7% male and 81.5% white. 34% of respondents were graduate students. Table 4 shows the demographic breakdown of the student population.

Table 4. Demographics of respondents from the full student population for Study 2. We removed 45 responses because they indicated they were vegetarian for the analysis, but this table includes all respondents.

Characteristic	Sample
Age	Count (% (frequency))
18-34	155 (89%)
35-54	13 (7.5%)
55+	4 (2.3%)
Gender	
Female	105 (60%)
Male	60 (34.7%)
Non-Binary	6 (3.5%)
Education Level	
Undergraduate freshman	45 (26%)
Undergraduate sophomore	19 (11%)
Undergraduate junior	20 (11.5%)
Undergraduate senior	29 (16.8%)
Graduate student	59 (34%)
Political Affiliation	
A strong Democrat	24 (14%)
A Democrat	38 (22%)
Independent, lean toward Democrat	32 (18%)
Independent (Close to neither party)	33 (19%)
Independent, lean toward Republican	22 (13%)
A Republican	15 (9%)
A strong Republican	8 (5%)

4. Results

4.1 Results for Experiment 1

The primary dependent variable used in the analysis was environmental protective behavior intention. Participants were asked how likely they would be to perform six actions (see Sec. 3.3) from a scale of 1 to 5, 1 being not at all likely and 5 being extremely likely. The mean response for all six actions was 3.89 (Cronbach's $\alpha = .85$).

4.2 One-way ANOVA Results for Experiment 1

The 137 participants that received the personal risk frame without self-efficacy had an average environmental behavioral intention of 3.8 (SD=.95); the 146 participants who received the personal risk with self-efficacy had an average environment behavioral intention of 3.9 (SD=.95); the 155 participants who received the impersonal risk frame without self-efficacy had an average environmental behavioral intention of 3.9 (SD=.93); the 144 participants who had the impersonal risk frame with self-efficacy message had an average environmental behavioral intention of 3.9 (SD=.95). The communication frames on environmental behavioral intention were not significant $F(3)= .77$, $p=.51$. Our findings for Experiment 1 answer research question one that personal risk communications do not have a greater effect on environmental protective behavior intention compared to impersonal risk frames. Our findings for Experiment 1 answer research question two that self-efficacy messages do not have a greater effect on environmental protective behavior intentions than messages without self-efficacy.

4.3 Results for Experiment 2

The primary dependent variable used in the analysis was environmental protective behavior intention. Participants were asked how likely they would be to perform six actions (see Sec. 3.3) from a scale of 1 to 5, 1 being not at all likely and 5 being extremely likely. The mean response for all six actions was 3.50 (Cronbach's $\alpha = .81$).

4.4 One-way ANOVA Results for Experiment 2

The 33 participants that received the personal risk frame without self-efficacy had an average environmental behavioral intention of 3.7 (SD=.99); the 33 participants who received the personal risk with self-efficacy had an average environment behavioral intention of 3.2 (SD=.99); the 28 participants who received the impersonal risk frame without self-efficacy had an average environmental behavioral intention of 3.5 (SD=.95); the 34 participants who had the impersonal risk frame with self-efficacy message had an average environmental behavioral intention of 3.5 (SD=1.1). The communication frames on environmental behavioral intention were not significant $F(3)= 1.43$, $p=.24$. Our findings for Experiment 2 answer research question one that personal risk communications do not have a greater effect on environmental protective behavior intention compared to impersonal risk frames. Our findings for Experiment 2 answer research question two that self-efficacy messages do not have a greater effect on environmental protective behavior intentions than messages without self-efficacy.

5. Discussion

Pharmaceutical water pollutants can harm both human health and ecological health. Encouraging behaviors such as participating in Drug-Take-Back programs and avoiding the disposal of medicine down drains can help protect humans and animals alike by preventing medicinal pollution. We aimed to test whether specific communication frames were more effective in encouraging environmental protective behavior intentions than others. Our results from both experiments show that neither personal nor impersonal risk frames were more effective in promoting environmental protective behavior intentions. These results could suggest that if the risk is perceived as important, any message will prompt engagement in risk-reducing behaviors. Scholars have cautioned against using fear appeals when the target audience does not possess high levels of efficacy, which is important for people to implement the recommendations a message presents (Floyd et al., 2000; Kok et al., 2018). In addition, self-efficacy can be significant in encouraging behaviors that protect the environment in some instances (Wai et al., 2018). However, there has been a lack of experimental data supporting self-efficacy messaging claims for environmental protective behaviors (Kidd et al., 2019; Kusmanoff, 2017). In our study, we found that self-efficacy did not influence higher environmental protective behavior intentions when communicating about water pollutants. In fact, for the student population, we saw a trend that personal risk messages without self-efficacy were more highly associated with the intention to engage in environmental protective behavior than messages with self-efficacy, though not significant. These results are inconsistent with previous public health literature that recommends a balanced message with severity and self-efficacy encouraging protective behaviors (Carey & Sarma, 2016). One potential explanation for these results is that we may have diminished the fear response to water pollution by portraying it as a manageable threat with self-efficacy messages. Previous studies have found that perceived severity emphasizes the seriousness of an environmental issue, especially if it is considered a remote threat, not a severe and imminent one (Kim et al., 2013). Perhaps, within the student population, the personal risk fear component was necessary for stimulating environmental protective behavior intention. Thus, the self-efficacy messaging decreased the urgency of the threat and caused a decrease in behavioral intention. These results suggest that self-efficacy messaging is context-based and could depend on the topic and the population receiving the messaging. In the case of pharmaceutical water pollutants, self-efficacy messaging was either ineffective, or self-efficacy messages decreased behavioral intentions.

Another possible explanation for the decrease in intention to behave in environmental protective behaviors among students who received the personal risk message with a self-efficacy manipulation is that they experienced reactance. Reactance describes a reaction to an experience when someone feels they are being coerced to do something and react against perceived coercion (Hong et al., 1994). Sometimes when an external stimulus such as a persuasive message is perceived to threaten, hinder, or eliminate an individual's freedom to choose, psychological reactance can occur (Reynolds-Tylus, 2019). For example, in a campaign message regarding climate change, audience members adopted behaviors opposite of recommended action (Hart & Feldman, 2016). Moreover, as age increases, reactance level tends to decrease; thus, because the student population was younger (average age 25), they could have been more susceptible to reactance with the self-efficacy manipulation (Hong et al., 1994; Woller et al., 2007).

Personal risk frames were not more effective in encouraging environmental protective behavior compared to impersonal risk frames. The most significant hypothesized advantage of framing water pollutants as a human health issue is that individuals across the political spectrum generally care about their wellbeing—therefore, by focusing on the impact of environmental issues on human health in science communication efforts, we can take remove some ideological concerns associated with environmental issues (Rossa-Roccor et al., 2021). However, our study did not find evidence that framing environmental issues in a personal-risk frame was more effective in stimulating environmental protective behavior intention than impersonal risk messaging. This finding suggests that both impersonal and personal risk messages can effectively promote environmental protective behavior in the context of pharmaceutical water pollutants. We may also have seen no difference in framing effects due to the specific audience receiving the communication frame; research suggests that messages should be tailored to the different interests and needs of the audience segments (Kusmanoff, 2017). Our student population sample primarily consisted of young and educated women for whom environmental protective behavior intentions tend to be at a higher baseline than for other groups (Vicente-Molina et al., 2018; Meyer, 2015), and thus, might not change significantly in response to a message

Our study has a few limitations. First, while we maximized sample representativeness with demographic quotas, the survey did not utilize a random sample, and thus the findings here should not be generalized to the national population. Second, in the student-population most respondents were in an environment-related class or an environmental list-serv, so that tailored group could have affected their responses to environmental behavioral intentions. Finally, the Qualtrics panel received a survey instrument with more items than the student population received, and their results could have been skewed due to respondent fatigue (Lavrakas, 2011).

It is well established that the way information is framed can influence the resulting judgments, attitudes, and behaviors of those receiving information (Tverskey and Kahneman 1981). However, the present data did not show that personal risk messages were more effective in promoting environmental protective behavior than impersonal risk messages. Moreover, self-efficacy messaging is often be effective in promoting protective behaviors (Floyd et al., 2000; Shafiei & Maleksaeidi, 2020; Westcott et al., 2017). However, our data did not support this effect.

6. Conclusion

We found no difference in the efficacy of personal risk frames over impersonal risk frames in the case of intended protective behavior for water pollution. Scholars have called for reframing environmental issues as public health problems to garner more support and influence protective behaviors, but our study does not support this approach. A takeaway from this study is if the risk is perceived as important enough, any type of message will be more likely to prompt behavioral intention. Moreover, we found that messages with self-efficacy cues were not effective in increasing behavioral intention compared to messages without self-efficacy. Future environmental communication research should test other manipulations of self-efficacy to determine if the phrasing of self-efficacy messages alters responses and should test moderating factors that might explain how risk messages affect behavioral intentions in different populations.

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Chapter 4: Conclusion

Water pollution has deleterious effects on both human and environmental health. Regulations to mitigate water pollutants in the U.S. have significantly reduced many point sources of pollution. However, diffuse non-point pollution sources are the leading cause of water quality problems (EPA, 2022), and remain a contemporary public health concern. Because water pollutants remain in the environment, people must engage in both health and environmental behaviors to protect their local water bodies their health. Past research has focused on studying health and environmental protective behaviors separately. As a result, little is known about how to engage both types of behaviors for one issue. In this thesis, I examined public perceptions of water pollution using Protection Motivation Theory to help characterize the degree to which people perceive water pollutants as a threat and whether they believe they can carry out effective behaviors in protecting their health and the environment. Furthermore, I tested multiple communication frames to determine the most effective way to communicate the issue of water pollutants to encourage behavior change.

This research sought to understand factors that lead people to engage in health and environmental protective behaviors using an online survey of residents living in Idaho, Oregon, and Washington (n = 628). In the first chapter, I aimed to test the PMT model to predict intentions to perform environmental protective behaviors and health protective behaviors. By studying both types of behaviors, we can understand how PMT performs when researching health protective behaviors, or personal risk behaviors, and environmental protective behaviors, or impersonal risk behaviors, in the context of an environmental issue. I also explored the relationships between behavior engagement and subjective knowledge about water pollutants. The study found that PMT does not act the same when considering these two different types of behaviors; we see that individuals may need to perceive a higher severity to stimulate environmental behavior intention versus health behavior intention. Findings contribute to both health and environmental behavior literature as we found that self-efficacy had the most substantial relationship with behavioral intention for both types of protective behaviors. These conclusions could suggest that instilling confidence in the person performing the suggested behavior is essential when developing communication tools.

In my second chapter, I investigated how communication frames influence environmental protective behaviors through 4 different types of frames: personal risk, personal risk with self-efficacy, impersonal risk, and impersonal risk with self-efficacy with two different populations, a Qualtrics panel (n=628) and a university student population (n=168). I found that neither personal nor impersonal risk frames were more effective than the other in promoting environmental protective behavior intentions. These results could suggest that if the risk is perceived as important, any message will prompt engagement in risk-reducing behaviors. In the student population, frames with self-efficacy messaging in the personal-risk group were less effective than frames without self-efficacy messaging in encouraging environmental protective behavior intention. Future research could look at ways to communicate self-efficacy to determine if a variation in self-efficacy messaging would be more effective in encouraging behavior change.

Water pollution is a problem that harms both the environment and public health. Policies are effective to a point; however, people must engage in health and environmental protective behaviors to protect their local water bodies and health. This research offers a unique perspective on both types of behaviors. The results presented here can tailor risk communication strategies that encourage health and environmental protective behaviors. Future research should consider communication experiments to understand the effectiveness of personal versus impersonal risk messages with other environmental topics to understand if the subject matter changes behavioral intentions. Additionally, future research could consider socio-demographic factors that could be affected by personal risk and impersonal risk messaging. For example, research might investigate if personal risk messages are more effective in encouraging environmental protective behaviors across a broad spectrum of political affiliations. Moreover, in Chapter 2 I find that self-efficacy is important for stimulating behavior change intentions, however, in Chapter 3 we see that it has no significant effect on behavior change intentions. More research should be conducted, experimentally, to understand self-efficacy's effectiveness in behavior change. For example, a researcher could adjust how self-efficacy is presented in a communication frame. This research is crucial for ensuring existing policies remain in effect, for communities to participate in risk reducing behaviors.

Appendix A

Survey Instrument for Chapter 3 and 4 (Qualtrics Panel)
Perceptions of Toxic Water Pollutants in the Pacific Northwest *Informed Consent* We are researchers from the College of Natural Resources at the University of Idaho conducting a research study. The purpose of this study is to better understand what the general public thinks and knows about the potential risks of toxic water pollutant exposure. You are being asked to participate in this study because you are at least 18 years of age and live in Idaho, Oregon, or Washington. Your participation will involve answering a series of questions regarding what you think, know, and do about toxic water pollutants. The survey should take about 15 minutes to complete. Your involvement in this study is voluntary, and you may choose not to participate. Please answer the questions to the best of your ability. There are no right or wrong answers, and you have the right to withdraw at any time. There are no names or identifying information associated with your responses. The data generated will describe community members' perceptions and knowledge of toxic water pollutants. If you have any questions about this research project, please contact Grace Little (glittle@uidaho.edu) or Dr. Chloe Wardropper (cwardropper@uidaho.edu). If you have any concerns about your rights as a participant, please feel free to contact the University of Idaho IRB at irb@uidaho.edu or 208-885-6340. Thank you in advance for your participation!

Sincerely,

Dr. Chloe Wardropper Grace Little

By continuing with the survey, you confirm that **<u>you are 18 years old or older</u>** and **<u>consent to participate</u>.**

Thank you for your interest in our study! Before you get started, please answer the following questions to determine if you meet the demographic criteria for our study.

How old are you?

- ◯ Less than 18
- ◯ 18-34
- ◯ 35-54
- ◯ 55+

Which of the following racial or ethnic groups do you most closely identify with?

- ◯ American Indian or Alaskan Native
- ◯ Asian
- ◯ Black or African American
- ◯ Hispanic or Latino
- ◯ Native Hawaiian or Pacific Islander
- ◯ White

What state do you live in?
Oregon, Idaho, Washington

You selected Idaho. What county do you reside in?

You selected Oregon. What county do you reside in?

You selected Washington. What county do you reside in?

You may notice that there is no "I don't know" response to many of the questions in this survey. If you are unsure about how to answer, please respond to the best of your ability. There are no right or wrong answers.
The following questions ask you to report how much you know about toxic water pollutants. We recognize

that you may not know a lot about toxic water pollutants, but we want to understand your baseline knowledge. Later in the survey, we will provide you with more information about toxic water pollutants. How would you rate your own knowledge about the impact of toxic water pollutants on the health of the **human body**?

- ◯ Not at all knowledgeable
- ◯ Slightly knowledgeable
- ◯ Somewhat knowledgeable
- ◯ Moderately knowledgeable
- ◯ Extremely knowledgeable

How knowledgeable are you about the following toxic water pollutants issues?

	Not at all knowledgeable	Slightly knowledgeable	Somewhat knowledgeable	Moderately knowledgeable	Extremely knowledgeable
Effects of water toxics on the environment	◯	◯	◯	◯	◯
Effects of water toxics on wildlife	◯	◯	◯	◯	◯
Sources of water toxics	◯	◯	◯	◯	◯
How water toxics enter the human body	◯	◯	◯	◯	◯
How to prevent water toxic exposure	◯	◯	◯	◯	◯

Below we provide some information on toxic water pollutants. Please read it carefully, we will ask you to confirm that you've read it at the end.

<u>Toxic Water Pollutants</u>

Toxic water pollutants are chemicals that enter water bodies and harm water quality. **Four significant toxic water pollutants** found in the Pacific Northwest region are **mercury**, **PCBs** (polychlorinated biphenyls), **DDT** (dichloro-diphenyl-trichloroethane), and **PBDEs** (polybrominated diphenyl ethers). These toxic water pollutants create human health and environmental risks.

Toxic Water Pollutants Management

Recent efforts have been made by the Environmental Protection Agency and local organizations to lower toxic water pollutants in the Pacific Northwest region. These include encouraging agricultural best practices, monitoring water toxics, and increasing education and awareness about properly disposing of waste to decrease toxic water pollutants exposure and prevent future contamination.

Individual actions, such as
reduce plastic use
avoid the use of fertilizers
dispose of cleaning products properly based on the label
dispose of medicines properly by taking them to a Drug Take Back Program (locations where you can safely dispose of medicines)
help to **prevent contamination in water bodies**.

Individual actions, such as
install a water filter in your home
eat fish less frequently
flush pipes with cold water in the morning
cook with cool tap water rather than hot
can help protect your **physical health** from water toxic pollutant exposure.

The next questions ask you to consider the **severity** (or **seriousness)** of toxic water pollutants. We realize these questions may be challenging, but answer to the best of your ability.
How severe do you think the negative consequences of toxic water pollutants are for the ***health of the environment***?

○ Not at all severe

○ Slightly severe

○ Somewhat severe

○ Moderately severe

○ Extremely severe

How severe do you think the negative consequences of toxic water pollutants are for ***human health***?

- ◯ Not at all severe
- ◯ Slightly severe
- ◯ Somewhat severe
- ◯ Moderately severe
- ◯ Extremely severe

The following questions ask you to consider how **vulnerable** (or **at risk)** you think you and the environment are to the negative impacts of toxic water pollutants.
When you consider the possibility of toxic water pollutants affecting your ***physical health***, how vulnerable do you feel?

- ◯ Not at all vulnerable
- ◯ Slightly vulnerable
- ◯ Somewhat vulnerable
- ◯ Moderately vulnerable
- ◯ Extremely vulnerable

Environmental conditions may be affected by toxic water pollutants. In your opinion, how likely is it that each condition is ***vulnerable*** to toxic water pollutants?

	Not at all vulnerable	Slightly vulnerable	Somewhat vulnerable	Moderately vulnerable	Extremely vulnerable
The health of wildlife in water	◯	◯	◯	◯	◯
The health of wildlife on land	◯	◯	◯	◯	◯

The following questions ask you to consider how **confident** you think you are in performing actions to protect against the negative effects of toxic water pollutants in the next year.
How confident do you feel about your ability to take any kind of individual action to ***protect your health*** from toxic water pollutants? As a reminder, some actions include:
install a water filter, flush pipes with cold water in the morning , cook with cool tap water rather than hot

- ◯ Not at all confident
- ◯ Slightly confident

○ Somewhat confident

○ Moderately confident

○ Extremely confident

How confident do you feel about your ability to take any kind of individual action to prevent toxic water pollutants from ***entering waterways***? As a reminder, some actions include minimize plastic usage avoid the use of fertilizers dispose of cleaning products properly based on the label

○ Not at all confident

○ Slightly confident

○ Somewhat confident

○ Moderately confident

○ Extremely confident

What color is the sky? Please select pink to show you are paying attention.

○ Blue

○ Green

○ Gray

○ Pink

The following questions ask you to consider how **effective** you think actions are at reducing the negative impacts of toxic water pollutants.

How effective do you think taking individual action is at reducing toxic water pollutants from ***entering waterways***?

○ Not at all effective

○ Slightly effective

○ Somewhat effective

○ Moderately effective

○ Extremely effective

How effective do you think taking individual action is at ***protecting your physical health*** from exposure to toxic water pollutants?

- ◯ Not at all effective
- ◯ Slightly effective
- ◯ Somewhat effective
- ◯ Moderately effective
- ◯ Extremely effective

Consider the actions listed below related to protecting your ***physical health*** from toxic water pollutants, how likely is it that you will perform these behaviors in the next year?

	Not at all likely	Slightly likely	Somewhat likely	Moderately likely	Extremely likely
Install a water filter in your household	○	○	○	○	○
Eat fish less frequently	○	○	○	○	○
Flush pipes with cold water in the morning	○	○	○	○	○
Cook with cool tap water rather than hot	○	○	○	○	○

Consider the actions listed below related to preventing toxic water pollutants from ***entering waterways***, how likly is it that you will perform these behaviors in the next year?

	Not at all likely	Slightly likely	Somewhat likely	Moderately likely	Extremely likely
Minimize my use of plastic	○	○	○	○	○
Dispose of cleaning products properly based on the label	○	○	○	○	○
Encourage people I know to reduce using fertilizer on their lawns	○	○	○	○	○
Dispose of medicines properly by taking them to a Drug Take Back Program	○	○	○	○	○

Are there any other actions that you are likely to perform that protect your physical health or the environment from toxic water pollutants in the next year?

The next questions ask about where you get your information on toxic water pollutants.
In the past year, how much information on toxic water pollutants did you get from the following sources?

	No information	A little information	Some information	A moderate amount of information	A great deal of information
Family members	○	○	○	○	○
Friends	○	○	○	○	○
Scientists	○	○	○	○	○
Doctors	○	○	○	○	○

In the past year, how much information on toxic water pollutants did you get from these sources?

	No information	A little information	Some information	A moderate amount of information	A great deal of information
Newspapers	○	○	○	○	○
Magazines	○	○	○	○	○
Social Media	○	○	○	○	○
TV News	○	○	○	○	○
Radio	○	○	○	○	○

If you have read this question carefully, please select "Extremely attentive".

- ○ Not at all attentive
- ○ Slightly attentive
- ○ Somewhat attentive
- ○ Moderately attentive
- ○ Extremely attentive

Below is a short passage about pollution from medications. Please read it carefully, we will ask you to confirm that you've read it at the end.
Taking a round of antibiotics may help people and animals fight infections. But much of that medication actually passes through our bodies, and pharmaceutical residues that escape into waterways may **threaten human health**. Scientists who study the problem say pharmaceutical pollution heightens the risk of **cancer, infertility, and antibiotic resistance for people who drink tap water**. Medications last a long time in the environment and can cause harm even at very low levels over time.

Below is a short passage about pollution from medications. Please read it carefully, we will ask you to confirm that you've read it at the end.
Taking a round of antibiotics may help people and animals fight infections. But much of that medication actually passes through our bodies, and pharmaceutical residues that escape into waterways may **threaten human health**. Scientists who study the problem say pharmaceutical pollution heightens the risk of **cancer, infertility, and antibiotic resistance for people who drink tap water**. Medications last a long time in the environment and can cause harm even at very low levels over time.
Many people find that it's not difficult to take simple measures preventing medications from entering waterways, which protects human health.

Below is a short passage about pollution from medications. Please read it carefully, we will ask you to confirm that you've read it at the end.
Taking a round of antibiotics may help people and animals fight infections. But much of that medication actually passes through our bodies, and pharmaceutical residues that escape into waterways from sewage and agricultural waste may **threaten fish populations**. Scientists who study the problem say pharmaceutical pollution heightens the risk of **cancer and infertility in fish populations**. Medications last a long time in the environment and can be taken up by fish and cause harm even at very low levels detected in the environment.

Below is a short passage about pollution from medications. Please read it carefully, we will ask you to confirm that you've read it at the end.
Taking a round of antibiotics may help people and animals fight infections. But much of that medication actually passes through our bodies, and pharmaceutical residues that escape into waterways from sewage and agricultural waste may **threaten fish populations**. Scientists who study the problem say pharmaceutical pollution heightens the risk of **cancer and infertility in fish populations**. Medications last a long time in the environment and can be taken up by fish and cause harm even at very low levels detected in the environment.

<u>Many people find that it's not difficult to take simple measures preventing medications from entering waterways, which protects fish and the environment.</u>

The next question asks you about your views on pharmaceuticals (or medications) in waterways.
The following actions are related to pharmaceuticals (or medications). Consider the list below, how likely is it that you will perform these actions in the next year?

	Not at all likely	Slightly likely	Somewhat likely	Moderately likely	Extremely likely
Participate in Drug Take Back programs	○	○	○	○	○
Avoid disposing medicine down the drain	○	○	○	○	○
Support stricter regulations to limit medicine flushing	○	○	○	○	○
Encourage people I know to properly dispose of medicines	○	○	○	○	○
Support stricter regulations that limit the use of antibiotics in animal agriculture	○	○	○	○	○
Avoid purchasing animal products that have been treated with antibiotics	○	○	○	○	○

The following questions ask about your views on toxic water pollutants exposure.
How concerned are you (if at all) about the potential negative effects of pharmaceutical pollution exposure to your ***personal health*** through drinking water?

- ◯ Not at all concerned
- ◯ Slightly concerned
- ◯ Somewhat concerned
- ◯ Moderately concerned
- ◯ Extremely concerned

How concerned are you (if at all) about the potential negative effects of pharmaceutical pollution ***on the environment***?

- ◯ Not at all concerned
- ◯ Slightly concerned
- ◯ Somewhat concerned
- ◯ Moderately concerned
- ◯ Extremely concerned

To what extent do you feel worried about your ***personal exposure*** to pharmaceutical pollutants through drinking water?

- ◯ Not at all worried
- ◯ Slightly worried
- ◯ Somewhat worried
- ◯ Moderately worried
- ◯ Extremely worried

To what extent do you feel worried when you think about effects of pharmaceutical pollutants ***on the environment*****?**

- ○ Not at all worried
- ○ Slightly worried
- ○ Somewhat worried
- ○ Moderately worried
- ○ Extremely worried

Finally, we have a few more questions about you and your household. This information will be used only in summary form to compare survey responses across demographic groups.
What is your gender?

- ○ Male
- ○ Female

What year were you born?
(input year)
What is the highest level of school you have completed or the highest degree you have received?

- ○ Less than high school degree
- ○ High school graduate (or equivalent)
- ○ Some college but no degree
- ○ College degree (2 or 4 year)
- ○ Advanced degree (Master's, PhD, JD, MD, etc.)

What is your occupational status?

- ◯ Homemaker
- ◯ Retired
- ◯ Student
- ◯ Unemployed
- ◯ Working part-time
- ◯ Working full-time
- ◯ Other (please specify): ____

Generally speaking, when it comes to political parties in the United States, how would you best describe yourself?

- ◯ A strong Democrat
- ◯ A Democrat
- ◯ Independent, lean toward Democrat
- ◯ Independent (Close to neither party)
- ◯ Independent, lean toward Republican
- ◯ A Republican
- ◯ A strong Republican

Approximately, what is your total annual household income, before taxes?

- ○ Less than $20,000
- ○ $20,000-$49,999
- ○ $50,000-$79,999
- ○ $80,000-$99,999
- ○ $100,000-$119,999
- ○ $120,000 or more

Do you eat...

	Yes	No
Dairy products?	○	○
Eggs?	○	○
Meat?	○	○

Thank you for taking the time to fill out our survey! You have provided us with valuable information that will help researchers, policymakers, and decision makers understand what the general public thinks and knows about toxic water pollutants. We appreciate your participation.

If you have any additional comments about toxic water pollutants in general, please comment below. If you would like to learn more, you can email glittle@uidaho.edu for additional resources.

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Appendix B

Extended T-Tests for Chapter 3
Political affiliation and behavioral intention Welch Two Sample t-test for Experiment 1:
The 264 participants who identified as liberal (M=4.03, SD= .81) compared to the 168 participants who identified as conservative (M= 3.79, SD=.99) demonstrated a higher engagement in environmental behavioral intention, t(321)=-2.67, p=.008.
The 264 participants who identified as liberal (M=4.03, SD= .81) compared to the 150 participants who identified as independent (M= 3.76, SD= 1) demonstrated a higher engagement in environmental behavioral intention, t(271)=-2.79, p=.006.
The 168 participants who identified as conservative (M= 3.79, SD=.99) compared to the 150 participants who identified as independent (M= 3.76, SD= 1) demonstrated no change in environmental behavioral intention, t(310)=0.25, p=.8.

Gender and Behavioral Intention Welch Two Sample t-test for Experiment 1
The 318 participants who identified as male (M= 3.77, SD = .97) compared to the 303 participants who identified as female (M= 4.02, SD= .89) demonstrated a significantly lower environmental behavioral intention, t(580)= -3.34, p=.0009.
Political affiliation and behavioral intention Welch Two Sample t-test for Experiment 2
The 66 participants who identified as liberal (M=3.8, SD= .9) compared to the 38 participants who identified as conservative (M= 3.1, SD=.83) demonstrated a higher engagement in environmental behavioral intention, t(80)=-3.9, p=.0002.
The 66 participants who identified as liberal (M=3.8, SD= .9) compared to the 24 participants who identified as Independent (M= 3.3, SD=1.2) demonstrated no significant change in engagement in environmental behavioral intention, t(33)=-1.93, p=.06.
The 38 participants who identified as conservative (M=3.1, SD=.83) compared to the 24 participants who identified as Independent (M= 3.3 , SD=1.2) demonstrated no significant change in environmental behavioral intention, t(38)=-.63, p=.53.

Gender and Behavioral Intention Welch Two Sample t-test for Experiment 2
The 50 participants who identified as male (M= 3.24, SD = 1.01) compared to the 76 participants who identified as female (M= 3.65, SD= .98) demonstrated a significantly lower environmental behavioral intention, t(102)= 2.25, p=.03.

Survey Instrument for University Student Population used in Chapter 3

Perceptions of Toxic Water Pollutants in the Pacific Northwest *Informed Consent* We are researchers from the College of Natural Resources at the University of Idaho conducting a research study. The purpose of this study is to better understand what students think and know about the potential risks of toxic water pollutant exposure. You are being asked to participate in this study because you are at least 18 years of age and attend the University of Idaho. Your participation will involve answering a series of questions regarding what you think, know, and do about toxic water pollutants. The survey should take about 5 minutes to complete. Your involvement in this study is voluntary, and you may choose not to participate. Please answer the questions to the best of your ability. There are no right or wrong answers, and you have the right to withdraw at any time. There are no names or identifying information associated with your responses. The data generated will describe University of Idaho students' perceptions and knowledge of toxic water pollutants. If you have any questions about this research project, please

contact Grace Little (glittle@uidaho.edu) or Dr. Chloe Wardropper (cwardropper@uidaho.edu). If you have any concerns about your rights as a participant, please feel free to contact the University of Idaho IRB at irb@uidaho.edu or 208-885-6340.
Thank you in advance for your participation!

Sincerely,

Dr. Chloe Wardropper

Grace Little

By continuing with the survey, you confirm that **you are 18 years old or older** and **consent to participate.**

Thank you for your interest in our study! Before you get started, please answer the following questions to determine if you meet the demographic criteria for our study.

How old are you?

- ○ Less than 18
- ○ 18-34
- ○ 35-54
- ○ 55+

Below we provide some information on toxic water pollutants. Please read it carefully, we will ask you to confirm that you've read it at the end.
Toxic Water Pollutants

Toxic water pollutants are chemicals that enter water bodies and harm water quality. **Four significant toxic water pollutants** found in the Pacific Northwest region are **mercury**, **PCBs** (polychlorinated biphenyls), **DDT** (dichloro-diphenyl-trichloroethane), and **PBDEs** (polybrominated diphenyl ethers). These toxic water pollutants create human health and environmental risks.

Toxic Water Pollutants Management

Recent efforts have been made by the Environmental Protection Agency and local organizations to lower toxic water pollutants in the Pacific Northwest region. These include encouraging agricultural best practices, monitoring water toxics, and increasing education and awareness about properly disposing of waste to decrease toxic water pollutants exposure and prevent future contamination.

Individual actions, such as
reduce plastic use
avoid the use of fertilizers
dispose of cleaning products properly based on the label
dispose of medicines properly by taking them to a Drug Take Back Program (locations where you can safely dispose of medicines)
help to **prevent contamination in water bodies**.

Individual actions, such as
install a water filter in your home
eat fish less frequently
flush pipes with cold water in the morning
cook with cool tap water rather than hot
can help protect your **physical health** from water toxic pollutant exposure.

By selecting "yes", I confirm that I have read the above information about toxic water pollutants

○ Yes

The next questions ask about where you get your information on toxic water pollutants.
In the past year, how much information on toxic water pollutants did you get from the following sources?

	No information	A little information	Some information	A moderate amount of information	A great deal of information
Family members	○	○	○	○	○
Friends	○	○	○	○	○
Scientists	○	○	○	○	○
Doctors	○	○	○	○	○

In the past year, how much information on toxic water pollutants did you get from these sources?

	No information	A little information	Some information	A moderate amount of information	A great deal of information
Newspapers	○	○	○	○	○
Magazines	○	○	○	○	○
Social Media	○	○	○	○	○
TV News	○	○	○	○	○
Radio	○	○	○	○	○

Below is a short passage about pollution from medications. Please read it carefully, we will ask you to confirm that you've read it at the end.
Taking a round of antibiotics may help people and animals fight infections. But much of that medication actually passes through our bodies, and pharmaceutical residues that escape into waterways may **threaten human health**. Scientists who study the problem say pharmaceutical pollution heightens the risk of **cancer, infertility, and antibiotic resistance for people who drink tap water**. Medications last a long time in the environment and can cause harm even at very low levels over time.

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Many people find that it’s not difficult to take simple measures preventing medications from entering waterways, which protects human health.

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Many people find that it’s not difficult to take simple measures preventing medications from entering waterways, which protects fish and the environment

The following actions are related to pharmaceuticals (or medications). Consider the list below, how likely is it that you will perform these actions in the next year?

	Not at all likely	Slightly likely	Somewhat likely	Moderately likely	Extremely likely
Participate in Drug Take Back programs	○	○	○	○	○
Avoid disposing medicine down the drain	○	○	○	○	○
Support stricter regulations to limit medicine flushing	○	○	○	○	○
Encourage people I know to properly dispose of medicines	○	○	○	○	○
Support stricter regulations that limit the use of antibiotics in animal agriculture	○	○	○	○	○
Avoid purchasing animal products that have been treated with antibiotics	○	○	○	○	○

How concerned are you (if at all) about the potential negative effects of pharmaceutical pollution exposure to your ***personal health*** through drinking water?

○ Not at all concerned

○ Slightly concerned

○ Somewhat concerned

○ Moderately concerned

○ Extremely concerned

How concerned are you (if at all) about the potential negative effects of pharmaceutical pollution ***on the environment***?

○ Not at all concerned

○ Slightly concerned

○ Somewhat concerned

○ Moderately concerned

○ Extremely concerned

To what extent do you feel worried about your ***personal exposure*** to pharmaceutical pollutants through drinking water?

○ Not at all worried

○ Slightly worried

○ Somewhat worried

○ Moderately worried

○ Extremely worried

To what extent do you feel worried when you think about effects of pharmaceutical pollutants ***on the environment*?**

○ Not at all worried

○ Slightly worried

○ Somewhat worried

○ Moderately worried

○ Extremely worried

Finally, we have a few more questions about you. This information will be used only in summary form to compare survey responses across demographic groups.

Please give the course name or the name of the person/department that sent you this email with the survey link.

____

Which of the following racial or ethnic groups do you most closely identify with?

○ American Indian or Alaskan Native

○ Asian

○ Black or African American

○ Hispanic or Latino

○ Native Hawaiian or Pacific Islander

○ White

○ Other (please state) ____

What is your gender?

○ Male

○ Female

○ Non-binary

○ Other (please state) ____

What is your major at University of Idaho?

____

What year were you born?

____

What year are you at University of Idaho?

- ◯ Undergraduate Freshman
- ◯ Undergraduate Sophomore
- ◯ Undergraduate Junior
- ◯ Undergraduate Senior
- ◯ Graduate Student

Generally speaking, when it comes to political parties in the United States, how would you best describe yourself?

- ◯ A strong Democrat
- ◯ A Democrat
- ◯ Independent, lean toward Democrat
- ◯ Independent (Close to neither party)
- ◯ Independent, lean toward Republican
- ◯ A Republican
- ◯ A strong Republican

Do you eat...

	Yes	No
Dairy products?	◯	◯
Fish?	◯	◯
Meat?	◯	◯

Thank you for taking the time to fill out our survey! We appreciate your participation.

If you have any additional comments about toxic water pollutants in general, please comment below. If you would like to learn more, you can email glittle@uidaho.edu for additional resources.

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