Behavioral Intentions, Risk Perception, and Issue Framing: Exploring Perspectives in a Mining-Impacted Region of Northern Idaho, USA

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Authorization to Submit Dissertation

This dissertation of Courtney M. Cooper, submitted for the degree of Doctor of Philosophy with a Major in Water Resources and titled "Behavioral Intentions, Risk Perception, and Issue Framing: Exploring Perspectives in a Mining-Impacted Region of Northern Idaho, USA" has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

Initiatives to remove and contain hazardous waste are complex, requiring collaboration across stakeholder groups. In the United States, the Environmental Protection Agency leads efforts to remediate and restore sites with hazardous waste through the Superfund program. Despite reductions in risk, complete removal of hazardous waste is often infeasible. Decisions about how to manage remaining hazards are influenced by how stakeholders frame economic development, public health, and environmental issues. In cases where contaminants such as lead [Pb] are present, risk communicators must also encourage people to practice health protective behaviors to reduce exposure risks. Risk perceptions influence how people receive and act on this risk communication information. The overall goal of my dissertation was to understand issue framing, behavioral intentions, and risk perceptions at a Superfund site with widespread lead contamination in a mining-impacted region of northern Idaho, USA. I conducted my research in partnership with the Panhandle Health District, an agency responsible for enforcing regulations and policies related to the Superfund program and public health. The dissertation includes four primary chapters. The first assesses associations between residents' perceived health risk and their behavioral intentions to avoid Pb contamination. The second explores how economic, public health, and environmental priorities influences primary issue frames related to stakeholder perspectives about site remediation and restoration. The third offers perspectives about best practices for integrating participatory research when studying issues related to water and society. The final chapter presents a case study analysis of challenges and opportunities for risk communication. Implications from my research inform future risk communication strategies and collaborative planning processes in mining-impacted regions.

Acknowledgements

The opportunity to partner with the Panhandle Health District in developing this dissertation provided me with an avenue to explore research questions based on applied issues and community goals focused on improving livelihoods. Thank you, Valerie Wade and Andy Helkey, for your support over the past four years. Thank you, Alta Engineering and Science, Susan Spalinger, Erin Radford, Bea Radford, Ben Bailey, for the technical support and guidance. I am also grateful to the community members and leaders in the Silver Valley and greater Coeur d'Alene region for openly sharing your perspectives and experiences with me. In reflecting on my experiences, I have deep respect to those who work to make the Silver Valley an eccentric and vibrant place to live.

To my community at University of Idaho, thank you for making this challenging pursuit of knowledge a collaborative endeavor. To my co-advisors: Dr. Chloe Wardropper, thank you for providing steadfast dedication to mentoring and advising over the past three years. You have nurtured my curiosity and inspired me to continue developing into an independent scholar. Dr. J.D. Wulfhorst, thank you for your guidance, especially in encouraging me to explore the complexities of rural sociology and interdisciplinary lenses. My gratitude extends to my committee Drs. Jeff Langman, Dilshani Sarathchandra, and Chantal Vella. Thank you all for providing reassuring feedback and guidance. To Prof. Barbara Cosens and Dr. Jan Boll for early feedback on proposal development. To Dr. Tim Link for his dedication to the NSF-IGERT Fellowship Program and Water Resources Program and support for interdisciplinary research. Additional thanks are extended to my IGERT colleague Dr. Kathleen Torso, for her collaboration and dedication to participatory research; Dr. Julia Piaskowski, for her expertise and guidance in statistical analysis. Thank you to Mary Schierman and Elise Kokenge for their administrative assistance. Finally, thank you to the supportive graduate student community of the Water Resources Program and the Wardropper Research Lab.

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Dedication

I dedicate this dissertation to my friends and family for their encouragement and support. For the friends and colleagues who challenge me to remain self-reflective and grateful for the opportunity to engage in academic pursuits. To my parents for instilling the value of service and education. To my husband for listening, encouraging, and helping me to stay positive.

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Statement of Contribution

The research studies presented in this dissertation were conducted in collaboration with the Panhandle Health District through a community-university partnership. Chapter 2 included several co-authors including Drs. Chloe Wardropper, Jeff Langman, Dilshani Sarathchandra, and Chantal Vella. As co-authors, they provided feedback on the manuscript and helped to develop the funding proposal for the research. Dr. Julia Piaskowski, a statistician for the University of Idaho, also contributed to Chapter 2 by providing guidance for the statistical analysis. Chapter 3 was written in collaboration with Chloe Wardropper. Chapter 4 represents a required collaborative chapter. As a graduate student in the IGERT Program, I was asked to collaborate with a colleague in the development of one dissertation chapter. To fulfill this requirement, Chapter 4 was co-written with my IGERT colleague, Dr. Kathleen Torso. Contributions for this chapter also extended to Dr. Anne Kern, Chloe Wardropper, Dr. Chris Meyer, and Andy Helkey. Kathleen and I co-wrote the paper and the remaining authorship team provided feedback and approval. Chapter 5 was written in collaboration with Valerie Wade, Madeline Goebel, and Chloe Wardropper. The ideas for Chapter 5 were developed at a workshop about teaching environmental case studies supported by the National Science Foundation's Socio-Environmental Synthesis Center (NSF-SESYNC). The contribution acknowledged in chapters 2-5 reflects the ethical and participatory nature of collaborative, interdisciplinary research and strengthens the authenticity of this dissertation.

Chapter 1: Introduction

Introduction

Mining-impacted regions worldwide face multifaceted public health and ecological risks (Entwistle et al., 2019). Since 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which enables the Superfund program, has guided United States Environmental Protection Agency (USEPA) site objectives aimed at reducing public health risks across many of the nation's most mining-impacted regions (USEPA, 2020). Lead [Pb] contamination, which is present at 50% of Superfund sites in the United States (US), is a primary contaminant of concern in many mining-impacted regions (Klemick et al. 2020). People are exposed to Pb by ingesting or inhaling particles contaminated with Pb. In 2012, the Centers for Disease Control (CDC) declared that there is no safe level of Pb for children (Vorvolakos et al. 2016). Primary prevention of Pb contamination, or the complete removal of a hazard, is a priority (Sullivan and Green 2016). However, the complete removal of Pb is often infeasible, and primary prevention must be complemented by secondary prevention.

Health protective behaviors in the context of Pb contamination include handwashing and avoiding contaminated areas. Whether people practice health protective behaviors is informed by many factors, including their risk perception. While there are many definitions of risk perception, Aven & Renn (2009) define it as a two-dimensional judgement that a person holds towards how severe the consequences of an activity or event might be, and how uncertain those consequences are. For Pb exposure, the perceived severity of consequences includes beliefs that exposure to Pb poses a severe health threat, and that one could experience health effects. People may have different perceptions of how certain it is they are being exposed to Pb. Understanding the associations between risk perceptions and behaviors informs risk communication strategies. While risk perception is influenced by many factors, beliefs about the health risks of environmental contamination are important to understand when designing risk communication strategies. The Health Belief Model provides a theoretical framework for studying how beliefs about health risks influence an individuals' motivation to practice health protective behaviors (Rosenstock 1974).

In rural areas with a long history of mining, social and cultural factors likely influence risk perception. Rural residents tend to be older and poorer and report more risky health behaviors, worse health status, and greater barriers to accessing health care relative to their urban and suburban counterparts (Egen et al., 2017). Rural regions are less likely to pass public health policies and are more likely to have underfunded health departments relative to urban areas (Harris et al., 2016). Rural health districts rely on partnerships to expand capacity but have limited organizations available to partner (Barnes et al., 2013; Harris et al., 2016). Limiting the health effects of exposure to Pb in mining-impacted rural communities can help to address other social and economic disparities.

Remediation and restoration efforts at contaminated sites are complex and require significant collaboration and trust between experts and non-experts (Virapongse et al., 2016; Metcalf et al., 2015). Understanding stakeholder priorities is often a challenge for collaboration. Recent efforts to conduct more inclusive and collaborative planning processes offer a range of innovative techniques for facilitating collaboration (e.g., Apitz et al., 2018; Virapongse et al., 2016). Collaborative processes are often characterized by conflict (Ramirez-Andreotta et al., 2016; Hoover et al. 2017).

My dissertation focuses on three related but overlapping topics about Superfund sites and risk communication in a rural and mining-impacted region of northern Idaho. First, there is a need to understand the factors that motivate people to practice health protective behaviors in mining-impacted communities. Second, collaborative planning processes at Superfund sites must build understanding of stakeholder values and priorities, especially when diverse groups participate in collaborative planning processes. The final topic addresses a call for inclusive approaches to conducting research that promote community capacity building.

In this dissertation, I take a participatory approach to analyzing individual- and community-level behavioral intentions, risk perceptions, and issue framing in a mining-impacted region of northern Idaho, USA. The region includes a Superfund site resulting from mine waste hazards left behind by over a century of mining activities. I conducted my research in partnership with the Panhandle Health District (District). The District leads risk communication efforts related to promoting the health protective behaviors need to avoid Pb exposure. Guidance from participatory research helped me to design and carry out research that advanced community goals towards reducing the ecological and public health risk of Pb contamination in northern Idaho. My motivation to conduct this research is based on the personal values I hold for conducting research with practical implications and an effort to acknowledge the growing social and ecological disparities posed by industrial hazards and related environmental contamination.

Dissertation Organization

My dissertation includes four primary manuscripts (Table 1.1) and a conclusion. The first assesses associations between risk perception and their health behavioral intentions to avoid Pb contamination. The second explores how economic, public health, and environmental priorities influence stakeholder perspectives about Superfund remediation and restoration activities. The third offers perspectives about best practices for integrating participatory research approaches when studying issues about water and society. The last is a case study analysis, intended for an undergraduate audience, reviewing risk communication strategies and the risk perception normalization effect in the context of Idaho's Silver Valley. The conclusion includes a reflection on three primary lessons learned and may be of interest for graduate students in early phases of their programs. The Institutional Review Board's approval letters along with other content needed to develop the primary studies are in the appendices. The next few sections provide a brief overview of key highlights from each chapter.

Chapter 2

Chapter 2, prepared for the journal *Environment and Behavior*, informs the District's risk communication strategies. The District recommends behavioral practices for avoiding exposure. Risk communication is challenging because even areas that appear pristine can have high levels of Pb contamination. The objective for this chapter was to model associations between perceived risk and health behavioral intentions. To do this, we conducted a survey of residents in Idaho's Silver Valley (n=306). Analysis of the survey included developing a statistical model of the associations between perceived health risks and behavioral intentions based on the Health Belief Model, factor analysis and structural regression modeling. Model results indicate that perceived benefits to action, perceived severity, and cues to action were associated with behavioral intentions. In the discussion, we draw from risk perception literature to demonstrate how our data is situated within the growing literature about environmental health risks.

Highlights

- Behavioral intentions are significantly associated with the variables perceived severity and perceived benefits.
- Residents reported low to medium levels of perceived risk and moderately high behavioral intentions.

Chapter 3

In Chapter 3, which we have submitted to a special issue about remediation and society in the *Journal of Environmental Management*, we evaluated how stakeholders in the Coeur d'Alene Region prioritize issues related to public health, the economy, and the Superfund program. The chapter uses Q-methodology and issue framing to explore differences in how stakeholders prioritize public health, economic, and environmental issues. Twenty-eight people representing seven primary stakeholder affiliations participated in the study. Q-methodology is a method for holistically understanding relative stakeholder perspectives across an issue area. In this chapter we identified four primary issue frames that stakeholders use to communicate their priorities: 1) government intervention, 2) Superfund remediation, 3) local concern, and 4) public-private partnerships. Study results inform future environmental decision-making at Superfund sites by illustrating areas where different stakeholders are likely to agree and disagree. In the Coeur d'Alene region, a site-specific framework for collaboration is needed to encourage more local involvement in collaborative planning processes.

Highlights

- Differing stakeholder priorities about the environment, economic development, and public health create barriers and opportunities for collaborative planning processes.
- Economic development and environmental remediation and restoration can happen side-by-side, but there are differing views about how.
- Views about local government and economic development distinguished perspectives across the four issue frames.

Chapter 4

Chapter 4 is a collaborative chapter that I co-wrote with my IGERT colleague, Dr. Kathleen Torso and our respective advisors and community partners. Kathleen and I both developed our dissertation research through community-university partnerships in the Coeur d'Alene region. This manuscript has been accepted from publication in a special issue in the *Hydrological Sciences Journal* about sociohydrology and hydro-social research, a divide in water resources research that has recently open debate between the bio-physical and social sciences. Given power imbalances and cultural differences, inquiry about how to design equitable and inclusive interdisciplinary research about issues related to water and society must address complex questions about hydrosocial relations. Participatory research addresses power imbalances and cultural differences by focusing on capacity building, promoting data accessibility, and attention to community goals.

In this chapter, we demonstrate challenges and opportunities for participatory research, by describing hydrosocial dynamics experienced by Tribal and non-Tribal rural communities residing in a mining-impact region in northern Idaho and comparing between the participatory processes that we developed in conducting our research. We conclude that future participatory research should continue to develop methods that include clear, flexible, and minimally intrusive methods for monitoring and evaluating project outcomes. Recognition of the diversity of approaches for participatory research is necessary for evaluating, funding, and advancing the processes that lead to more equitable approaches. In the concluding chapter of this dissertation, I share some of my ideas for providing graduate students with opportunities to formally conduct research through community-university partnerships.

Highlights

- Community-university partnerships led to research projects that address community goals.
- Participatory research approaches, while necessarily diverse, could benefit from more systematic process to monitor and evaluate outcomes from participatory research.

- Synthesis of participatory research about hydrosocial relations could benefit from a greater emphasis on synthesizing methods and approaches.

Chapter 5

Chapter 5 includes the final deliverable that we developed after attending a workshop at the National Science Foundation's Socio-Environmental Synthesis Center (SESYNC). We have submitted and completed an initial round of revisions for the manuscript with the journal, *Case Studies in the Environment.* The journal publishes peer-reviewed case study articles and case study pedagogy articles. The article concludes with questions that encourage critical thought about the case. This chapter describes risk communication in the Silver Valley. My advisor and I have used the case analysis as a teaching unit in a course titled *Social-Ecological Systems.* The chapter draws from the survey data described in Chapter 2 to evaluate whether the risk perception normalization effect influences how people perceive risk and their intentions to undertake health protective behaviors. We review how differences in risk perception by residency time may affect the District's risk communication strategies. We then evaluate future risk communication challenges and opportunities, urging readers to consider the complexities of communicating the negative health consequences of metal contaminants. Lessons learned from this examination apply to other Superfund sites and communities impacted by metal contaminants. Refer to the Supplementary materials to view the teaching guide that we developed in parallel with this chapter.

Highlights

- Risk communication strategies shift over time at Superfund sites as the visual evidence of contamination decreases and observations of people not practicing recommended health protective behaviors increase.
- Variations in risk perception are not heavily influences by the amount of time a person lives in an impacted region.

Conclusion

Risk communicators face the challenging task of ensuring that the public is aware and prepared to respond to risk under dynamic circumstances. The growing global population and climate change further exacerbate human health and ecological risks at Superfund sites (Odell et al., 2018), creating new challenges for risk communication. For instance, in June of 2020, in Midland County Michigan, a historic flood, which surpassed a 1986 flood by two feet, caused concern that a Superfund site was disturbed and that remedial work done to contain the toxic waste at the site might be destroyed (Murdock 2020). It is increasingly important that risk communication scholars and practitioners consider how to communicate the compounding risks of multiple hazards and stressors. Interdisciplinary and transdisciplinary are needed to ensure that non-experts are adequately informed about risk and the actions they can take to reduce the risk.

The conclusion of the dissertation summarizes three primary lessons learned: (1) co-develop a plan to apply research findings prior to beginning research; (2) primary issue frames include views that balance economic development and public health goals; and (3) community-university partnerships teach graduate students critical skills needed to bridge gaps between science and practice. These lessons are based on my experiences both in participants in University of Idaho's NSF-IGERT program and on the primary studies of my dissertation. One way to encourage more transdisciplinary approaches to research is by making clearer and more structured requirements for students conducting research with community members and community partners.

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Tables

Table 1.1 Primary dissertation deliverables

Chapter Titles	Summary	Manuscript
Risk perception, behavioral intentions, and lead contamination in mining-impacted communities	Community survey of resident's perceptions and behavioral intentions to practice health protective behaviors related to lead contamination. Supported by pilot grant program.	*Environment and Behavior*
Environmental, public health, and economic development framing at a Superfund site: A Q methodology approach	A Q methodology approach to understanding how stakeholder perspectives inform framing of priorities about environmental, public health and economic development issues.	*Journal of Environmental Management* (Submitted)
Participatory research approaches in mining-impacted hydrosocial systems	Describes the hydrosocial dynamics experienced by Tribal and non-Tribal rural communities residing in a mining-impact region in northern Idaho. We compare two community-university partnerships in the region.	*Hydrological Science Journal* (Accepted)
Challenges and opportunities for communicating lead exposure risk in Idaho's Silver Valley	Case about risk perception and the Panhandle Health District's risk communication strategy.	*Case Studies in the Environment* (Revised and Resubmitted)

Chapter 2: Perceived risk, behavioral intentions, and lead contamination in mining-impacted communities

Abstract

Understanding the strength of the associations between perceived risk and individuals' behavioral intentions to protect their health is an important step in determining appropriate risk communication strategies in communities impacted by lead contamination. We conducted a drop-off, pick-up survey within communities of northern Idaho, USA (n = 306) near a Superfund megasite with legacy mine contamination. We use the survey data to empirically test a theoretical model of perceived risk and behavioral intentions based on the Health Belief Model. Survey results indicate that people who perceive the threat of lead contamination as severe, perceive benefits to health protective behaviors, and regularly consider risks of lead contamination had high intentions for practicing protective behaviors. We find that women report higher behavioral intentions than men, but age and mining affiliation do not influence behavioral intentions. Understanding risk perceptions and behavioral intentions aid public health agencies in tailoring risk communication for increasing protective behavior in such impacted communities.

Introduction

Lead [Pb] contamination, a consequence of industrialization, is a widely publicized environmental health risk (Gleason et al., 2019). Sources of and exposures to Pb declined in the US following the enforcement of new regulations and the removal of Pb from gasoline (Levin et al., 2008; Schoof et al., 2016), but Pb remains a widely dispersed contaminant, especially in and around mining communities (Maxwell et al., 2018). Primary prevention actions, such as removal of mine waste, is the preferred method for containing and managing hazardous substances (Kegler et al. 2010). However, it is challenging to fully eliminate metal contamination and exposure pathways in mining communities where legacy practices allowed the contaminants to be widely dispersed in the environment (Entwistle et al., 2019). For instance, Pb contaminated topsoil remains a leading source of elevated blood lead levels in children in the US because of the wide distribution of the contaminant in the environment from industrial processes such as mining (Laidlaw et al., 2017; Levin et al., 2008; Mielke et al., 2019). While high levels of exposure can lead to acute Pb poisoning, negative health consequences are more often linked to long-term chronic diseases and health consequences (Vorvolakos et al., 2016). When Pb is widespread in a community, primary prevention activities must be complemented by secondary prevention such as the practice of health protective behaviors (US EPA, 2000)

The Health Belief Model (HBM) is one of many possible health behavior frameworks that facilitate an understanding of associations between perceived risk and behavioral intentions (e.g., Fishbein & Ajzen, 1977; Prochaska & Velicer, 1997). The model is often favored for empirical studies about environmental and health related topics (Andrade et al., 2019; Kim & Cooke, 2020; Lindsay & Strathman, 1997; Nisbet & Gick, 2008). Identifying the associations between environmental risk perceptions and behavioral intentions with the HBM can aid responsible agencies in developing or modifying communicating risk strategies (Hoover, 2017; Janmaimool & Watanabe, 2014; Straub & Leahy, 2014; Sullivan & Green, 2016).

The objective of this study was to examine the strength of associations between perceived risk and health protective behavioral intentions (behavioral intentions) in mining-impacted communities of the Silver Valley in northern Idaho, United States (US) (Figure 2.1). Communities of the Silver Valley are located in a designated Superfund site, where widespread Pb contamination has been present for over 140 years (Gustavson et al., 2007; Mix, 2016). In 1983, the several residential areas were included in the initial boundaries of the Bunker Hill Mining and Metallurgical Complex or Bunker Hill Superfund site. In 2002, the Superfund site boundaries were expanded to include all communities along the floodplains of the Silver Valley (Gustavson et al., 2007). Staff with the Panhandle Health District (District) are concerned that people are not protecting their health by partaking in activities such as recreating at old mine sites, because of the continued presence of the contamination even after 40 years of remediation (Helkey, 2018). To assist in identifying perceived risks for improving the District's risk communication strategy, we used the HBM to develop a community survey (n=306) for examining perceived health risks and behavioral intentions given possible exposure to Pb contamination.

Background

The Health Belief Model (HBM)

The HBM describes six primary constructs that influence perceptions of health risks and a decision framework for choosing health protective behaviors (Janz & Becker 1984). These constructs—perceived susceptibility, perceived severity, perceived barriers, perceived benefits, cues to action, and self-efficacy—are hypothesized to predict whether a person will choose to employ protective behavior (Janz & Becker, 1984; Rosenstock, 1974). Perceived susceptibility and severity make up threat perception, while perceived barriers and benefits relate to individuals' outcome expectancy (Rosenstock, 1974), or an individual's subjective estimates of how likely it is that a specific behavior will be followed by particular consequences (Lippke, 2017). Self-efficacy was included because a disbelief in one's ability to practice a health behavior is also believed to influence behavior (Bandura, 1977). Similarly, cues to action—internal and external triggers that prompt a health behavior—were added to the model because of the importance of reminders in facilitating behavior change (Glanz, 2015; Harrison et al., 1992). The HBM is also influenced by demographic and psychosocial factors that presumably affect an individual's risk perception (Janz & Becker, 1984). Behavioral intentions are widely considered the most immediate and important predictor of behavior and are commonly used when actual behaviors cannot be measured (Sheeran, 2002).

Previous reviews of empirical HBM studies indicate that the associations between the perceived health risk constructs and behavioral intentions are not the same for all the constructs. Meta-analyses of empirical HBM studies find that perceived barriers and benefits tend to be the strongest predictor of behavior (Carpenter, 2010; Janz & Becker, 1984). Although not included in many HBM studies (Carpenter, 2010), self-efficacy is a strong predictor of behavioral intentions (Sheeran et al., 2016). Self-efficacy is at times considered a perceived barrier, rather than a separate component of the model (Janz & Becker, 1984) because, if an individual's belief in their ability to change their behavior is low, perhaps because of low self-efficacy, then these beliefs could be interpreted as a perceived barrier (Kim & Cooke, 2020). Meta-analyses provide limited insight about the strength of associations between the HBM constructs and behavioral intentions because associations depend on the context and behavior being examined (Harrison et al., 1992; Jones et al., 2015). While the primary associations proposed by the HBM are reinforced by empirical studies, methods for evaluating health risks and behaviors through the model must be reevaluated across contexts and behaviors.

Applying the HBM to Environmental Risk

The HBM may be used to understand community members' motivations to practice health protective behaviors related to environmental risk. However, empirical applications of the HBM in the contexts of long-term environmental contamination, such as mining waste and metal contamination of surrounding communities, remain limited. Recent studies about associations between risk perception and well water testing behaviors provide insight about how the HBM applies to the context of health protective behavioral intentions and Pb contamination. Health risk perceptions of well water contamination may be similar to perceptions of Pb contamination because, in both cases, the health risk is more commonly associated with chronic rather than acute health consequences. Two reviews of private well water testing behaviors, Munene and Hall (2019) and Colley et al. (2019), focus explicitly on empirical studies based on the HBM. These reviews conclude that the proposed associations of the HBM generally match empirical associations between risk perception and behavioral intentions. In other words, health protective behavioral intentions to test well water for contamination are associated with beliefs that well water contamination poses a health risk, that the benefits of testing well water are greater than the barriers, and the belief that taking action to prevent well water contamination will mitigate the health risk (i.e., self-efficacy). Internal and external reminders to test well water for contamination (i.e., cues to action) are also associated with testing behavior in these reviews. For well water contamination and health protective behaviors, perceived barriers such as cost, awareness, and convenience, appear to be particularly strong indicators of behavior (e.g., Munene et al., 2020; Stillo III et al., 2019; Straub & Leahy, 2014).

The barriers to practicing health protective behaviors related to avoiding Pb contamination are not necessarily explicit factors such as cost. They include perceived access to information and resources and the perceived inconvenience of practicing health protective behaviors. For environmental health risks associated with long-term health consequences and where barriers to action are not associated with a monetary cost, perceived benefits and cues to action are associated with behavioral intentions (Akompab et al., 2013; Lipman & Burt, 2017; Shafiei et al., 2016). For instance, Akompab et al. (2013) found that only perceived benefits and cues to action were associated with behavioral intentions to adopt health protective behaviors during a hypothetical future heat wave. Only one of the perceived barriers in that study related to a cost barrier (the cost of running the AC to stay cool), and few respondents reported experiencing this barrier. Studies about well-water testing behaviors provide a starting point for conceptualizing risk perception, health protective behaviors, and Pb contamination.

Socio-demographic characteristics can influence associations between perceived risk and behavioral intentions (Carpenter, 2010). In the context of health protective behaviors and possible Pb exposure at Superfund sites, age, gender, and mining affiliation may influence whether an individual undertakes health protective behaviors. Age may play a role because a person's age is an indicator of how much experience they have with Pb contamination and whether they are likely to have young children (Halpern & Warner, 1994; Rinker et al., 2014). Gender may influence behavior because women and children are more vulnerable to negative health outcomes from Pb exposure and might be more likely to practice health behaviors (Davidson & Freudenburg, 1996; Harclerode et al., 2016; McGee, 1999; Rice et al., 2015). Affiliation with mining is likely relevant because several previous studies have linked involvement in livelihoods related to a polluting industry with lower perceived health risk (Greenberg, 2020; Hamm et al., 2019; Wiséen & Wester-Herber, 2007).

Hypotheses and Rationale

Theoretically, the HBM can be used to evaluate a causal structure, or parallel mediation model, in which an independent variable such as behavioral intentions is associated with all of the HBM constructs, and then these affect an outcome variable or an actual behavior (Jones et al., 2015). The HBM framework does not assume shared influence or paths between constructs (Glanz, 2015). For our study, we proposed associations among HBM constructs and behavioral intentions that can be evaluated by a parallel mediation (path) modeling approach. Figure 2.2 illustrates the hypothesized associations between perceived risks and behavioral intentions related to Pb contamination in the Silver Valley communities. We hypothesized that the six HBM constructs are associated with behavioral intentions for practicing protective health behaviors in this environment of long-term, Pb contamination. For the outcome expectancy constructs, perceived benefits and barriers, we hypothesized that high perceived benefits and low perceived barriers to action will be associated with behavioral intentions. Age, gender, and mining affiliation were included in the analysis as covariates because they have been found to influence health protective behaviors in the context of Pb contamination. Based on the literature review and our reasoning, the following hypothesis and sub-hypotheses are proposed:

H1. Behavioral intentions to undertake health protective behaviors to avoid Pb contamination will be positively associated with (H1a) perceived severity, (H1b) perceived susceptibility, (H1c) perceived benefits, (H1d) self-efficacy, and (H1e) cues to action and negatively associated with perceived barriers (H1f), proposed in the HBM.

Methods

Study Area

Historical mining, smelting, and associated waste disposal practices in the Silver Valley resulted in the contamination of soils, sediments, groundwater and surface water with Pb as well as arsenic and other toxic metals (Figure 2.1). Once the wealthiest county in Idaho, the Silver Valley's Shoshone County currently has an aging population of around 12,700 (U.S. Census, 2018). The population is predominantly white, and poorer than most counties in Idaho (U.S. Census, 2018). Over 20% of the county's population under the age of 65 years is on disability, compared to 13% for the state of Idaho. Nearly 11% of children (5 to 17 years old) have a disability, relative to just 5.7% of children in the state (ACS, 2017). The Silver Valley also reports higher rates of non-communicable diseases (e.g., cardiovascular disease) relative to the state (Panhandle Health District, 2018).

Primary prevention activities, including land remediation through soil removal and replacement of city infrastructure, began in the 1980s following the designation of the Superfund site

(Elias & Gulson, 2003). Today, the majority of private properties within the communities of Pinehurst, Kellogg, and Wallace have been remediated along with the smelting areas and some of the old mine sites (Alta Science and Engineering, Inc, 2019; EPA, 2012; Mix, 2016). Blood lead level concentrations among children living in nearby communities fell from approximately 64 µg/dL to 2.7 µg/dL during 1974-2001 (Klemick et al., 2020; Schoof et al., 2016; von Lindern et al., 2003). Yet, the Silver Valley remains heavily contaminated at remaining abandoned mine sites and in the floodplains of creeks and rivers where the mine waste was dumped and continues to be distributed by high flows (Restoration Partnership, 2018). With the remediation of most private properties, Pb exposure occurs primarily through use of recreational areas in floodplains and near mine sites (Alta Science and Engineering, Inc, 2019; Helkey, 2018).

Survey Development

To assess perceived risk and behavioral intentions of the communities in the Silver Valley, a drop-off, pick-up survey was developed by University of Idaho researchers and District staff. The study protocol was approved and certified exempt by the University of Idaho Institutional Review Board (#18-080). The survey was validated through pretesting the survey questions at community events hosted by the District in 2018 (n=87) in a nearby county. Results from survey pretesting were submitted to a principal components analysis (varimax rotation) to determine whether the survey items aligned with HBM variables. The analysis of the pretest survey responses was deemed acceptable because alignment between survey items and the corresponding HBM variables produced factor loadings greater than 0.4 (Brown 2014).

<u>Drop-off, Pick-up Survey Procedures</u>

We drew stratified random samples from neighborhood clusters in Wallace, Kellogg, and Pinehurst (Table 2.1) based on 2010 U.S. Census Data. The samples were stratified based on proportional representation of single- and multi- family housing in each community. Neighborhood clusters increased the efficiency of house-to-house visits. A total of 773 households were identified for inclusion in the study. The DOPU method for distributing surveys to the households followed recommendations in Jackson-Smith et al. (2016) and Steele et al. (2001) for hard to reach communities and limiting non-response bias (Trentelman et al., 2016). In March 2019, a pre-survey notification was mailed a week prior to the in-person survey drop-off period. Field staff visited each household up to three times to deliver surveys. Only consenting adults (18 years of age or older) were eligible to participate, and participation was randomized by requesting the responsible adult with the closest birthday complete the survey (Dillman, 2011). When a respondent agreed to participate, field staff left the survey and a pen, and coordinated a time to return to the house to collect the completed survey. After three failed delivery attempts, field staff left a survey packet (including a cover letter, survey, pen, and prepaid return envelope) on the door of the residence. Of the 773 households, 306 surveys were completed, with 30 of those completed by mail. Excluding the 204 households in the original sample that were vacant or unsafe, the response rate was 53.8%. Conducting the survey in March helped to ensure that the sample primarily included our target respondents – residents of the Silver Valley – rather than winter and summer second home and rental populations. Completed survey data were manually entered into Qualtrics, an online survey platform. Each survey was entered twice by two different researchers and an accuracy check was performed. Discrepancies between the two entries (<1%) were manually corrected.

Survey Measures

For the 33 survey items conceptualized to represent the six health belief constructs (study variables) and a behavioral intentions variable, a 5-point response scale was used. Some studies suggest no difference among 5-, 7-, and 10-point scales (e.g., Dawes, 2008), and others suggest that a 5-point scale, offers higher data quality than 7- or 11- point scales (Revilla et al., 2014). The full survey instrument is included in Appendix A, not all survey items were used in this analysis.

<u>Behavioral intentions</u>

Respondents were asked to consider their intentions to complete six health protective behaviors related to avoiding exposure to Pb contamination over the next year. Participants responded to all items on a 1 = very unlikely to 5 = very likely scale. A “does not apply” option was included, but these responses did not have a significant impact on the analysis and were therefore excluded.

<u>HBM constructs</u>

Twenty-seven items related to the HBM constructs perceived severity, perceived susceptibility, perceived benefits, perceived barriers, and self-efficacy (Table 2.3). Participants responded to all items on a 1 = strongly disagree to 5 = strongly agree scale. These items were adopted from several studies related heavy metal contamination: Bland et al. (2005), Devitt et al. (2016), Rinker et al. (2014), and Straub & Leahy (2014). The cues to action construct was measured through two items that asked respondents about how frequently they had thought about or read or heard about Pb contamination issues in the past year. The scale ranged from 1 = never to 5 = very often.

<u>Socio-demographic characteristics</u>

The survey included eight items about socio-demographic characteristics (Table 2.2). Three of the survey items about socio-demographic characteristics were included in the model as covariates.

Survey respondents were asked to indicate gender (male, female, prefer not to answer), age (continuous), and connections to mining. The latter item was phrased: “has a member of your household ever worked in a mining-related job in your local area?” Response options included “yes”, “no”, and “I don’t know.” Response options for “I don’t know” and “prefer not to answer” were excluded from the model analysis. Remaining items about the socio-demographic characteristics of the sample are reported in the results.

Data Analysis

RStudio (version 1.2.1335) was used to analyze the data. Descriptive statistics (means, frequencies, and standard deviations) were calculated for each Likert-type question and the demographic variables. Primary analysis included structural equation modeling (SEM), a combination of factor analysis and multiple regression analysis (Kline 2015), which allowed for analysis of the structural relationship between items in the survey and the latent variables of the HBM.

<u>Imputation</u>

The data were analyzed for outliers and missing items – survey responses with fewer than 20 missing items were included. While many methods exist for handling missing data within SEM, multiple imputation or maximum likelihood methods are recommended because they produce consistent parameter estimates, standard errors, and test statistics (Brown, 2014; Olinsky et al., 2003). Prior to statistical modeling analysis, we conducted 20 rounds of imputation using a maximum likelihood estimation, in the R package called mice, for the remaining missing response items (<1%), including for responses coded as “does not apply” (van Buuren & Groothuis-Oudshoorn, 2011).

<u>Structural equation model analysis</u>

Model testing was performed in the R package Lavaan (Rosseel, 2012). Analysis included an exploratory factor analysis (EFA) followed by a two-step SEM to evaluate the measurement and structural properties of modeled associations between perceived risk and behavioral intentions. Data were first assessed for factorability using Bartlett’s Test of Sphericity and the Kaiser-Meyer-Olkin Measure (KMO) of sampling adequacy (Williams et al., 2010). The Bartlett’s Test of Sphericity resulted in a Pearson’s Chi-square test statistic, χ^2 (465, n=306) =5,466, p<.001, and a KMO value= 0.83 above the acceptable threshold of 0.5. Because of the significance of the Bartlett’s test and the KMO value being in the acceptable range, data were suitable for factor analysis. An EFA was performed to evaluate the correlation of the items, validate their groupings with the theorized health belief constructs and behavioral intentions, and establish variable parameters for modeling (Brown, 2014). The EFA was performed using maximum likelihood extraction method with a direct oblimin rotation due to the expected correlation between the survey items (Costello & Osborne, 2005). Factor selection was performed using the Kaiser-Guttman rule based on an eigenvalue cut-off of one (Brown, 2014). As a preliminary test of validity, each factor was analyzed for internal reliability using Cronbach's Alpha and a threshold of ≥ 0.7 (Santos, 1999).

The variable groupings derived from the EFA were entered into a confirmatory factor analysis (CFA) to evaluate the measurement properties of the SEM (Rahman et al., 2015). Each factor (variable) identified in the EFA was treated as its own latent variable in the CFA. The model was estimated with a weighted least square mean and variance adjusted (WLSMV) estimator as a suitable estimator for ordinal data (Muthén, 1984; Şimşek & Noyan, 2012; Suh, 2015). We evaluated model goodness-of-fit to the data using multiple indices and the recommendations in Kline (2015). Given the sensitivity of the chi-squared statistic to sample size, the Comparative Fit Index (CFI), the Tucker Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA) were used to asses model fit (Xia & Yang, 2019). The acceptable threshold for CFI and TLI is $\geq .0.9$ and for RMSEA is $\leq .08$ but ideally below ≤ 0.05 (Kline, 2015).

After assessing the measurement properties of the SEM, we evaluated its structural properties, or the associations between the perceived health risk and behavioral intentions variables. This evaluation included exploring the correlations between the health risk variables as some studies based on the HBM indicate that variable ordering of the health risk variables is important due to possible direct and indirect effects between variables (Jones et al. 2015). The two items related to cues to action were included as well as the covariates age, gender, and mining affiliation. Error correlation between the perceived health risk variables was allowed. Correlated errors assume that the latent variables share at least one omitted characteristic in common and allow the model to account for the possibility of measurement error that develops from similarly worded and measured items (Brown, 2014; Kline, 2015). We report on multiple models to demonstrate indirect and direct effects of the perceived health risk variables as well as the influence of the covariates.

Results

Sociodemographic Characteristics

The survey results indicated 44% male, 91% white, 36% of respondents had s bachelor's degree or higher, and on average were 54.5 (SD=17.7) years old (ages ranged from 19 to 92) (Table 2.2). On average, respondents reported having lived in the Silver Valley for 62% of their lives, with over 75% reporting that they lived in the Silver Valley for at least 75% of their lives. Household income estimates align closely with the income levels of the Silver Valley with 52% reporting annual incomes under $50,000. Ten percent of respondents opted not to provide an estimate of their household income. Slightly less than half (44%) of respondents reported having a family member (or being involved themselves) in a mining-related occupation.

Exploratory Factor Analysis

The total variance explained by the EFA was 54% and six variables (factors) were extracted (Table 2.3). Item means are reported in the table. Nine items were excluded from further analysis because the items did not align with the primary EFA factor. One theorized behavioral intentions item, "how frequently do you recreate in or near the South Fork of the Coeur d'Alene River," had a loading of only 0.19. Two items conceptualized as relating to self-efficacy, "I seek out information about lead contamination" and "I can prevent lead contamination from entering my home," cross-loaded >0.3 with other variables and were therefore removed from the analysis. Two items conceptualized as perceived barriers about whether avoiding indoor and outdoor Pb contamination was inconvenient and two items conceptualized as self-efficacy about avoiding Pb contamination indoors and outdoors failed to load on any factor. Two other items conceptualized as perceived barriers, "I need more information about how to avoid lead contamination while spending time outdoors," and "I need more information about how to prevent lead contamination from entering my home," loaded with perceived severity and were therefore excluded from the analysis.

The items conceptualized to measure self-efficacy were divided into two variables. In evaluating the items intended to measure self-efficacy, two items formed a variable that measured self-efficacy in individual knowledge about Pb contamination while two other items measured self-efficacy beliefs related to respondents' beliefs about accessing information and resource about Pb contamination. We named this variable "information and awareness barriers." Since the four items conceptualized to measure perceived barriers did not form a cohesive variable, the variable was not included in the analysis. The final six variables extracted through the EFA included behavioral intentions, perceived benefits, perceived severity, perceived susceptibility, self-efficacy, and information and awareness barriers. These six variables demonstrated acceptable reliability with Cronbach's Alphas above 0.7 (Santos, 1999).

Confirmatory Factor Analysis

The initial model demonstrated acceptable fit ($\chi 2(194, n=306)=550.32$, $p<.001$; $\chi 2/df=2.83$). Although the chi-square test was significant, the RMSEA value (0.078) was within the acceptable limits, and the CFI (0.987) and TLI (0.985) were above the minimum threshold of 0.9 suggested by Kline (2015). The perceived susceptibility item, "if it is my destiny to experience health effects related to lead contamination, there is nothing that I can do to prevent it," revealed a low standardized coefficient of 0.40 in the CFA relative to the other items for the perceived susceptibility variable, so the item was dropped from the analysis. High correlations between several items for the perceived severity items were suggested by the modification indices, which indicated a need to adjust model parameters. Correlations are often prevalent between items that share something in common outside of the properties captured by the variable (Barrett, 2007). Following a recommendation by Rossell (2012), we accounted for the correlations in the perceived severity variable items by adding residual variances between items measuring the same cognitive concepts for indoor versus outdoor lead contamination. The adjusted model revealed improved fit (Table 2.4: $\chi2$ (172, n=306)=422.30, p<.001; CFI=0.992; TLI=0.990; RMSEA=0.069). The revised model did not meet the ideal threshold of $\leq .05$ for the RMSEA value but was within the acceptable range of $\leq .08$. Due to the exploratory nature of the model and acceptable model fit, the revised CFA was considered plausible.

Associations Between Perceived Health Risk and Behavioral Intentions

Table 2.5 includes the associations between the perceived health risk variables and behavioral intentions base on three path models. The high correlation between the perceived benefits and perceived severity (r=0.50, p<.001) led to a decision to evaluate the structural properties of two models with and without the perceived benefits variable. The full correlation matrix with the six latent variables is in Appendix B. Model 1 includes the path coefficients for the variables included in the CFA. Only the association between perceived benefits and behavioral intentions was significant (H1c: β= 0.67, p<.001). Model 2 reflects the same model without the perceived benefits variable ($\chi2$(92, n=306)= 186.76, p<.001; CFI=0.976; TLI=0.994; RMSEA=0.058). Model 2 had a lower chi-square value and RMSEA than Model 1, and the association between perceived severity and behavioral intentions was significant (H1a: β= 0.62, p<.001). The finding suggests that perceived severity has an indirect effect on behavioral intentions.

Model 3 included the latent variables, the two cues to action variables, and the covariates gender, age, and mining affiliation ($\chi2$(272, n=306)= 1147.98, p<.001; CFI=0.961; TLI=0.970; RMSEA=0.103). The path coefficients are illustrated in Figure 2.3. The RMSEA exceeded the recommended threshold of 0.08, however, the CFI and TLI were within the acceptable range. Based on discussion in Kline (2015) and Xia & Yang (2019) we decided that the model fit was reasonable despite the RMSEA because it is sensitive to sample size and was not developed explicitly for ordinal categorical data. The perceived benefits variable was again significantly associated with behavioral intentions (H1c: β= 0.61, p<.001). One of the cues to action variables, the survey item that asked if respondents "thought about lead contamination issues" was significantly associated with behavioral intentions (H1e: β= 0.27, p<.001). Gender was the only covariate with a statistically significant association with behavioral intentions with women more likely that man to report intentions to practice health-protective behaviors (β= -0.36, $p<.001$).

Discussion

From the SEM results, we found that perceived benefits and one of the cues to action variables were significantly associated with the behavioral intentions variable (H1c and H1e), while perceived severity, perceived susceptibility, information and awareness barriers, and self-efficacy were not. When we excluded the perceived benefits variable from the model, due to its high correlation with perceived severity, perceived severity and the same cues to action variable had significant associations with behavioral intentions (H1a and H1e). Overall, results suggest that respondents who perceived the threat of lead contamination as severe, benefits to protecting themselves from lead contamination, and thought about lead contamination frequently had higher behavioral intentions. Only the covariate gender had a significant association with behavioral intentions, indicating that women were more likely than men to report practicing health protective behaviors.

Related studies demonstrate that risk perception is not only linked to the contaminants present, but also to cues such as the equipment used for remediation or how organized remediation sites appear (Weber et al., 2001; Messer et al., 2005). Observations of environmental changes at contaminated sites, such as the changes associated with Superfund remedial actions, influence risk perception (Shiver et al., 2019). In this study, the associations between perceived benefits and perceived severity with behavioral intentions may relate to the District's current health risk messaging efforts and the improved environmental conditions in the Silver Valley due to the Superfund site remediation. First, health risk warning signs are posted at public recreation areas and at old mining sites (Helkey et al. 2018). Second, the District regularly hosts workshops about lead contamination and offers free annual blood lead screenings (Alta Science and Engineering, Inc, 2019). Third, primary prevention actions (remediation such as road replacements and waste removal) have improved the aesthetic conditions of the landscape and decreased the risk of exposure (von Lindern et al. 2016). For instance, hillsides, once bare due to smoke fallout from the lead smelter, have been revegetated, and rivers and streams, once milky with mine waste, now run clear (Mix, 2016). The improved environmental conditions and continued focus on health risk communication may lead people to believe that there are health benefits to practicing recommended health-protective behaviors.

Cognitive effects such as availability heuristics and cognitive dissonance, may explain the associations illustrated in this study. Perceived severity, but not perceived susceptibility, was associated with behavioral intentions. This result may be explained through the "availability heuristic," or a mental shortcut that relies on immediate examples that come to mind when making decisions (Tversky and Kahneman 1974). For environmental risk, the influence of the availability heuristic may inform perceptions of acute or immediate health risks as they may be more associated with perceived risk to the individual (i.e., perceived susceptibility) relative to longer-term health risks. For instance, Walpole & Wilson (2020) illustrated that personal perceived risk was significantly associated with perceived severity but not perceived susceptibility for perceived risks related to contaminated waterways, while the inverse was true (i.e., perceived susceptibility was associated, but not perceived severity) for risks related to extreme weather events and walking in a dangerous neighborhood that pose more immediate and acute risks (i.e., perceptions of the health risk are more immediately available). In the Silver Valley, primary prevention activities may lead residents to view the negative health consequences of lead contamination as a long-term rather than acute health issue. If this is the case, perceived susceptibility would be less influential in informing an individual's perceived health risk.

Cognitive dissonance (also called threat denial) is the idea that people will hold strongly to a belief by denying any evidence that appears counter to the belief (Festinger 1957), may explain why neither the self-efficacy nor awareness and information barrier variables were associated with behavioral intentions. Baxter and Lee (2004) found that a strong sense of community pride and a fear of stigmatization prevented people from outwardly expressing concern about the health risks of a nearby hazardous waste facility. Stigma and concerns about economic development have long been associated with cognitive dissonance towards health risk at Superfund sites (Edelstein, 1988). Grasmück and Scholz (2005) provides additional evidence for the possible role of dissonance reducing heuristic through a finding that the desire for additional information about the risk of heavy metal contamination in soil was not affected by a lack of knowledge but was affected by emotional concerns. In this study, respondents who reported being unlikely to practice health-protective behaviors but who also reported high self-efficacy and low perceived awareness and information barriers may be influenced by cognitive dissonance. Accounting for this effect in future studies can be achieved by including survey questions about doubt and uncertainty related to lead contamination within survey questionnaires.

In our study, women were more likely than men to report practicing health protective behaviors. This could be because women and children are more vulnerable to experiencing health effects from lead contamination (Bland et al., 2005; Needleman, 1991). Women are also more likely to report high behavioral intentions to practice health protective behaviors relative to men (Davidson

& Freudenburg, 1996). The non-significant effects for mining affiliation and age may indicate that these variables do not influence behavioral intentions in the Silver Valley. While nearly half of respondents reported having a familial affiliation with the mining industry, employment opportunities in the Silver Valley are limited. Other studies that have found that affiliations with a polluting industry influences risk perceptions are linked to difference in behavioral intentions have been conducted in areas where the polluting industry plays a more influential economic role (e.g., Greenberg, 2020).

Our results indicate that future risk communications in mining-impacted areas with lead contamination should target communicating about the perceived benefits of undertaking health protective behaviors while continuing to emphasize the severity of the risk. Further evaluation of differences between perceived risk, behavioral intentions, and socio-demographic characteristics is important in developing risk communication strategies that are tailored to specific contexts and population subgroups (Hoover, 2017; Wester-Herber, 2004). Because self-efficacy was not associated with behavioral intentions, there may be an opportunity for risk communication strategies that focus on increasing self-efficacy by improving awareness of health protective behaviors. For instance, the District could send an annual mailer to residents in the Silver Valley as a reminder about the resources available to them to help limit their possible exposure to lead.

Limitations

Despite its popularity, cross-sectional empirical HBM studies have several limitations including 1) relying on measures of health behavioral intentions variables rather than actual behaviors (Noar & Zimmerman, 2005); 2) failing to account for feedbacks between perceived risk and behavior (Sheeran & Abraham, 1996; Weinstein, 2007; Weinstein et al., 1998); 3) not establishing direct relationships among HBM variables and behaviors (Basil & Witte, 2012; Glanz, 2015; Jones et al., 2015; Witte, 2001); and 4) does not account for external cultural or cognitive or affective responses (Kasperson et al., 1988, 1992; Radcliffe & Klein, 2002).

In this study, we found that survey respondents were “likely” or “very likely” to intend to perform health protective behaviors, a finding that contrasts with the District’s concerns that residents are practicing non-health protective behaviors, such as recreating in areas that may have high levels of contamination (Helkey, 2018). Study results may be influenced by the social desirability bias or the tendency of survey respondents to give socially desirable responses instead of choosing responses that are reflective of their true feelings (Grimm, 2010). While the DOPU method may have increased the influence of social desirability bias, it improved our ability to collect data across a hard to reach population. To overcome the intention-behavior gap and social desirability bias, empirical work should measure actual behaviors rather than behavioral intentions if possible. The HBM's primary benefit is that it is relatively easy to employ and can be applied and compared across contexts and behaviors. Future work should focus on developing more systematic ways to measure the HBM variables to allow empirical studies to become more comparable across contexts. In developing comparable survey instruments, it is important to consider the possible influence of cognitive effects such as availability heuristics and cognitive dissonance.

Conclusion

Statistical modeling of survey items indicates that risk communication strategies should develop cues to action to encourage people to consider the benefits of practicing recommended health protective behaviors. Our study findings have practical implications for environmental educators, scientists, related government officials, and policy makers who try to understand, inform, and persuade the US public to practice health protective actions to reduce possible consequences of long-term lead contamination in mining-impacted communities. Reminders about the severity of risks are also necessary for encouraging people to practice health protective behaviors. Beliefs about perceived susceptibility and perceived self-efficacy were not strongly associated with behavioral intentions and the items conceptualized as perceived barriers did not correlate as primary variable for modeling. Future research should continue to focus on comparing associations between risk perception and behavioral intentions across contexts.

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Tables

Table 2.1 Drop off, pick up survey response results

	n (%)	Household Type: Multi-family	Household Type: Single-family	Community: Kellogg	Community: Pinehurst	Community: Wallace
Selected households	773 (100%)	193 (25%)	580 (75%)	365 (47%)	255 (33%)	159 (20%)
Removed from sample						
Vacant or unsafe	204 (26%)					
Refusals	126 (16%)					
Unreturned mailers	119 (15%)					
Incomplete	18 (5%)					
Completed survey households	306 (40%)	58 (18%)	248 (82%)	143 (47%)	113 (37%)	49 (16%)

Note. The final analysis was based on 306 surveys. Surveys with more than 20 incomplete items were excluded from the analysis. Towns were sampled proportionately based on number of households.

Table 2.2 Description of sample (n=306)

Characteristic	**Mean (SD)** **% (Freq)**
Age (years, M [SD])	54.5 (17.7)
Years lived in Silver Valley (years, M[SD])	33.3 (21.5)
Gender (% [Freq])	
Female	54% (165)
Male	44% (134)
Prefer not to say	2% (6)
Race/Ethnicity (% [Freq])	
White	90.8% (278)
No Response	4.6% (14)
All others	5% (14)
Highest education (% [Freq])	
Advanced degree	9.8% (30)
College degree	26.1% (80)
Some college but no degree	30.1% (92)
High school graduate	28.1% (86)
Less than high school degree	5.2% (16)
Occupational status (% [Freq])	
Retired	35.6% (109)
Working full-time	36.3% (114)
Homemaker	8.8% (27)
Working part-time	7.2% (26)
Disabled/Medical Leave	4.6% (5)
Student	0.7% (2)
Unemployed	1.3% (4)
No Response	3.0% (9)
Approximate household income (% [Freq])	
Less than $20,000	21.6% (66)
$20,000 to $49,999	30.7% (94)
$50,000 to $79,999	22.5% (69)
$80,000 to $99,000	8.2% (26)
$100,000 or more	6.5% (21)
No Response	10% (30)
Family in mining (% [Freq])	
No	53.3% (163)
Yes	44.4% (136)
Not sure	1.6% (5)

Note. ‘No response’ categories excluded for characteristics when less than 1%

Table 2.3 Exploratory factor analysis and descriptive statistics for perceived risk and behavioral intentions (n=306)

	Mean (SD)	[b] Perceived Benefits	Perceived Severity	Behavioral Intentions	Perceived Susceptibility	Self-Efficacy	Information and Awareness Barriers
Cronbach's Alpha		0.86	0.84	0.83	0.82	0.87	0.81
Mean (SD)		3.9 (0.77)	3.0 (0.97)	3.8 (1.0)	2.2 (0.89)	3.1 (0.97)	3.4 (1.0)
Indicate to what extent you agree that completing the following actions are good for your health:							
Promptly removing dirt from your clothes, toys, pets, cars, and equipment after spending time outdoors.	3.9 (0.89)	0.68[a]					
Staying on designated trails while recreating in areas with lead contamination warning signs posted.	3.9 (0.95)	0.79					
Washing your hands with clean water or wipes before eating or drinking after recreating or working outdoors.	4.2 (0.76)	0.74					
Using a protective barrier such as a blanket when sitting on a sandy beach.	3.8 (0.95)	0.72					
Following the advice of a local public health official about ways to safely avoid lead contamination.	3.9 (0.87)	0.8					
I worry about lead contamination while spending time outdoors.	2.6 (1.18)		0.72				
It is worth my time to avoid lead contamination while spending time outdoors.	3.3 (1.16)		0.56				
I need more information about how to avoid lead contamination while spending time outdoors.**	2.9 (1.28)		0.64				
I worry about lead contamination entering my home.	2.6 (1.26)		0.80				
It is worth my time to clean my home to prevent lead contamination.	3.6 (1.11)		0.59				

I need more information about how to prevent lead contamination from entering my home.**	3.0 (1.23)	0.61				
Consider your recreational and outdoor activities in your local area over the next 12 months. How likely is it that you will?						
Promptly remove dirt from your clothes, toys, pets, cars, and equipment after spending time outdoors?	3.7 (1.33)		0.55			
Stay on designated trails while recreating in areas where lead contamination warning signs are posted?	3.8 (1.35)		0.69			
Wash your hands with clean water or wipes before eating or drinking after recreating or working outdoors?	4.3 (1.12)		0.56			
Use a protective barrier such as a blanket when sitting on a sandy beach?	3.6 (1.37)		0.63			
Follow the advice of a public health official about ways to avoid lead contamination while spending time outdoors?	3.6 (1.34)		0.83			
I have experienced health effects related to lead contamination.	2.0 (1.10)			0.91		
I feel I will experience health effects related to lead contamination at some time during my life.	2.3 (1.12)			0.94		
I am more likely than the average person to experience health effects from lead contamination.	2.3 (1.14)			0.66		
If it is my destiny to experience health effects related to lead contamination, there is nothing that I can do to prevent it.	2.1 (1.07)			0.40		
I know a lot about the health effects from lead contamination.	3.2 (1.04)				0.76	
I am better informed about the health effects of lead contamination than most people.	3.0 (1.03)				0.78	
I seek out information about lead contamination.**	2.7 (0.96)	0.43			0.60	
I know how to prevent health effects from lead contamination.**	3.3 (1.01)				0.45	0.36
I know who to ask if I have questions about preventing health effects from lead contamination.	3.5 (1.04)					0.98
I am aware of the available resources for preventing health effects of lead contamination.	3.3 (1.12)					0.63

Notes. Maximum likelihood extraction with direct oblimin rotation; 54% variance explained; Cut-off Eigenvalue=1.00

**Item not included in CFA or Cronbach's Alphas [a]Values are factor loadings from the direct oblimin pattern matrix. Items with loadings below 0.30 were suppressed.

[b]All variables are perceived variables derived from survey items and

Table 2.4 Confirmatory factor analysis of perceived risk and behavioral intentions (n=306)

Item	**b(SE)[ab]**	**β**
Perceived Benefits		
Indicate to what extent you agree that completing the following actions are good for your health:		
Promptly removing dirt from your clothes, toys, pets, cars, and equipment after spending time outdoors.	1.00	0.80
Staying on designated trails while recreating in areas with lead contamination warning signs posted.	1.01 (0.03)	0.87
Washing your hands with clean water or wipes before eating or drinking after recreating or working outdoors.	0.92 (0.04)	0.77
Using a protective barrier such as a blanket when sitting on a sandy beach.	1.03 (0.03)	0.86
Following the advice of a local public health official about ways to safely avoid lead contamination.	0.10 (0.03)	0.83
Perceived Severity		
I worry about lead contamination while spending time outdoors.	1.00	0.80
It is worth my time to avoid lead contamination while spending time outdoors.	1.02 (0.06)	0.79
I worry about lead contamination entering my home.	0.97 (0.04)	0.75
It is worth my time to clean my home to prevent lead contamination.	1.01 (0.06)	0.79
Behavioral Intention		
Consider your recreational and outdoor activities in your local area over the next 12 months. How likely is it that you will?		
Promptly removing dirt from your clothes, toys, pets, cars, and equipment after spending time outdoors.	1.00	0.80
Staying on designated trails while recreating in areas with lead contamination warning signs posted.	0.90 (0.05)	0.72
Washing your hands with clean water or wipes before eating or drinking after recreating or working outdoors.	0.90 (0.06)	0.71
Using a protective barrier such as a blanket when sitting on a sandy beach.	0.97 (0.05)	0.77
Following the advice of a local public health official about ways to safely avoid lead contamination.	1.07 (0.05)	0.85
Perceived Susceptibility		
I have experienced health effects related to lead contamination.	1.00	0.90
I feel I will experience health effects related to lead contamination at some time during my life.	1.10 (0.03)	0.99
I am more likely than the average person to experience health effects from lead contamination.	0.88 (0.03)	0.79
Self-Efficacy		

I know a lot about the health effects from lead contamination.	1.00	0.90
I am better informed about the health effects of lead contamination than most people.	0.96 (0.04)	0.90
Information and Awareness Barriers		
I know who to ask if I have questions about preventing health effects from lead contamination.	1.00	0.90
I am aware of the available resources for preventing health effects of lead contamination.	1.03 (0.03)	0.96

Note. Both unstandardized (b) and standardized (β) beta coefficients are reported. Model: $\chi 2$ (172, n=306)=422.30, p<.001; CFI=0.992; TLI=0.990; RMSEA=0.069).
[a]The first items for each variable are fixed as a reference item at 1.00 in Lavaan
[b]Regression weights significant at p<.001

Table 2.5 Associations between perceived risk and behavioral intentions (dependent variable), n=306

	Model 1		**Model 2**		**Model 3**	
Independent Variable	b (SE)	β	b (SE)	β	b (SE)	β
Perceived Severity	0.17 (0.09)	0.16	**0.57 (0.07)**	**0.62**	0.15 (0.09)	0.12
Perceived Susceptibility	0.00 (0.06)	0.00	-0.12 (0.07)	-0.14	0.04 (0.06)	0.04
Perceived Benefits	**0.64 (0.06)**	**0.67**			**0.63 (0.06)**	**0.61**
Perceived Information and Awareness Barriers	-0.06 (0.09)	-0.08	0.07 (0.10)	0.08	-0.08 (0.09)	-0.09
Self-Efficacy	0.05 (0.08)	0.06	0.02 (0.09)	0.02	0.08 (0.09)	0.08
Cue to Action (think about)					**0.21 (0.04)**	**0.26**
Cue to Action (read or heard about)					-0.02 (0.05)	-0.03
Gender (0=F, 1=M)					**-0.36 (0.10)**	**-0.22**
Mining Affiliation (0=No, 1=Yes)					-0.13 (0.10)	-0.07
Age					-0.00 (0.00)	-0.03

Note. Model 1: $\chi2(172, n=306)= 422.30$, $p<.001$; CFI=0.992; TLI=0.990; RMSEA=0.069
Model 2: $\chi2(92, n=306)= 186.76$, $p<.001$; CFI=0.976; TLI=0.994; RMSEA=0.058
Both unstandardized (b) and standardized (β) beta coefficients are reported. The coefficients and error terms measure the strength of the statistical association and the corresponding p-value quantifies the statistical significance of that association.
The following demographic variables are controlled: gender, age, and mining affiliation
*** $p<.001$

Figures

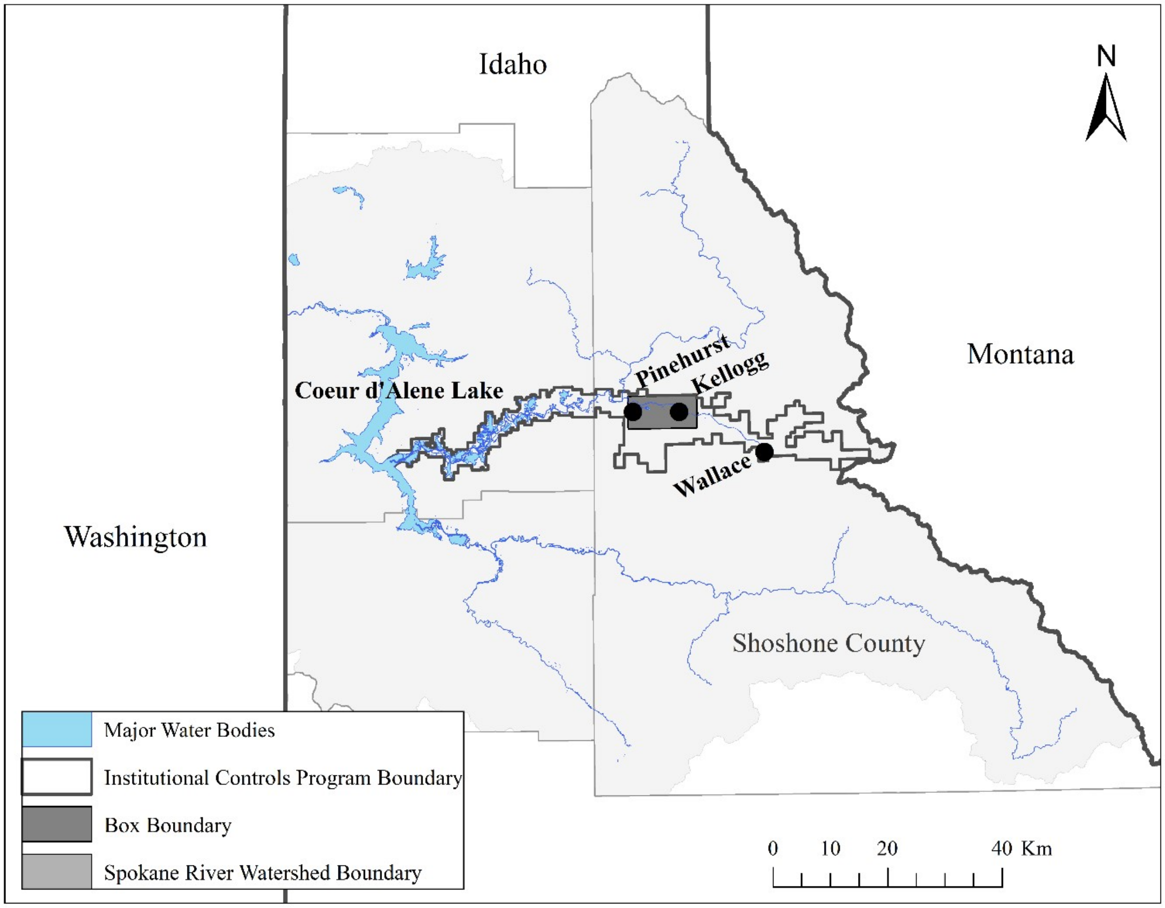

Figure 2.1 Communities of Pinehurst, Kellogg, and Wallace in the Silver Valley of Idaho. The dark gray rectangle incorporating Pinehurst and Kellogg represents the 54 km^2 area known as "the Box"— the area of the original Bunker Hill Superfund Site that included a smelter and other processing facilities. The Institutional Controls Program Boundary includes the expanded Superfund site that includes 394 km^2 of floodplains and wetlands.
Sources: US Geological Survey (2013), Alta Engineering and Science (2019)

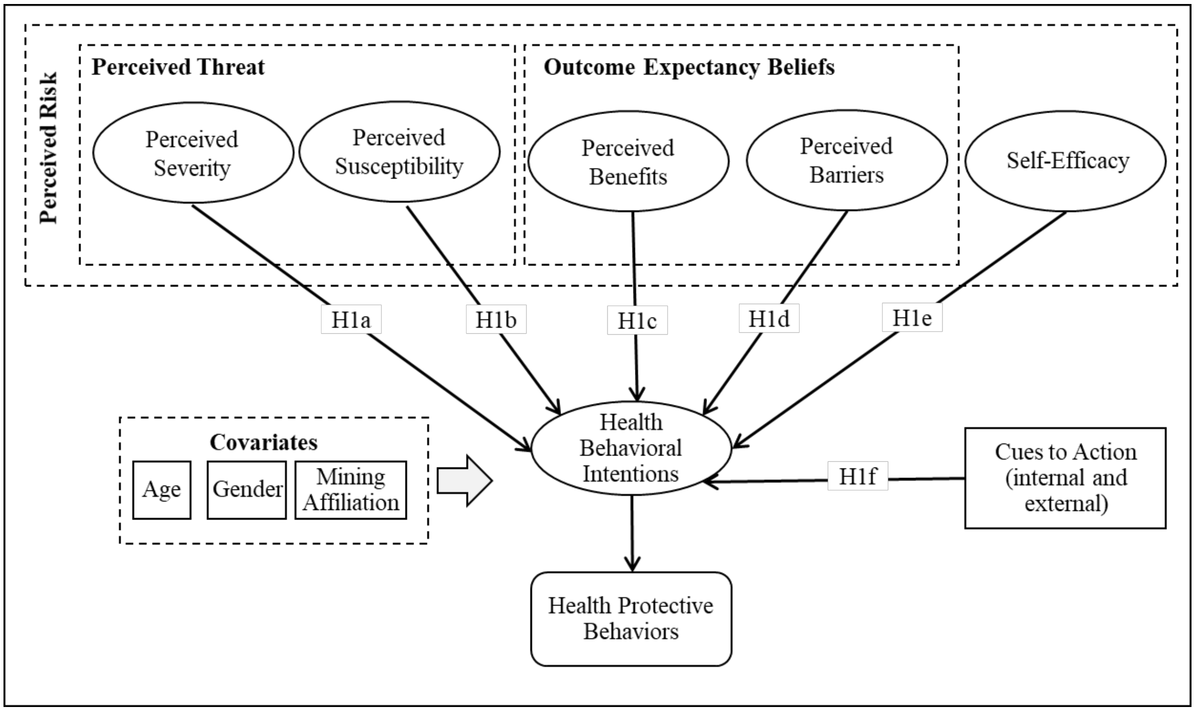

Figure 2.2 Proposed model of perceived risk and behavioral intentions related to lead contamination in the study's mining-impacted communities. Behavioral intentions are hypothetically the strongest indicators of actual behavior.

Note. Ovals represent latent variables and rectangles represent observed variables. Mining affiliation refers to a survey variable about whether not the respondent had a family member in a mining-related occupation.

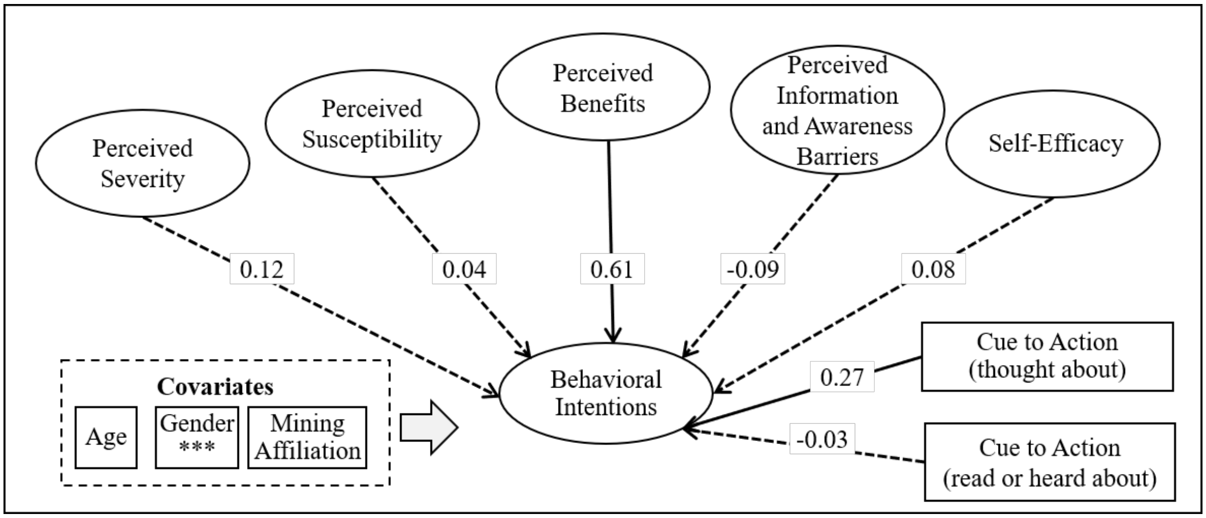

Figure 2.3 Path analysis for the full model. Significant paths represented by solid lines. The covariates variable for gender had a significant association with behavioral intentions in both models with women being more likely than men to report performing health-protective behaviors.

Note. Ovals represent latent variables and rectangles represent observed variables

Chapter 3: Environmental, public health, and economic development framing at a Superfund site: A Q methodology approach

Abstract

Environmental remediation and restoration activities conducted through the Superfund program often produce outcomes that fail to satisfy community stakeholders. Issue frames, or the interpretive lenses that shape attention to an issue, are important to understanding how stakeholders perceive the program. Differences in issue frames are influenced by stakeholder priorities related to environmental, economic development and public health issues. We used Q methodology, an approach that combines priority sorting and interviews, to elicit and interpret the primary issues frames shared by 28 stakeholders, representing government entities, non-profits, and industries, in the Coeur d'Alene Basin of Idaho, USA. Issue frames were interpreted as: 1) government intervention, 2) Superfund remediation, 3) local concern, and 4) public-private partnerships. While results indicate the presence of a collaborative stakeholder network, which prioritizes both economic development and environmental goals, views about local government and economic development distinguished the four frames. Understanding stakeholder priorities is important to facilitating more collaborative planning processes within the Superfund program.

Introduction

Since 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which enables the Superfund program, has guided United States Environmental Protection Agency (USEPA) site remediation and restoration aimed at reducing public health risks across many of the nation's most mining-impacted regions (USEPA, 2020). Despite reductions in risk, the program has encountered challenges. Critiques of the program have included unpredictable project outcomes, untenable project durations, extreme cost, and uneven distribution of costs and benefits (Burns et al., 2019; Cannon, 2005; Daley & Layton, 2004; Gupta et al., 1996; Rahm, 1998). Differences in stakeholder priorities related to economic development, public health, and environmental issues are often catalysts for these critiques (Halter & Acevedo, 2019; Shriver & Kennedy, 2005). Over the past three decades, the USEPA has responded to these critiques, by shifting from mostly top-down planning processes towards collaborative processes that acknowledge differences in stakeholder priorities (Arquette et al., 2002; Cannon, 2005; Ellis & Hadley, 2009; USEPA, 2013; Virapongse et al., 2016).

Fair representation of stakeholder voices, including government entities, non-profits, citizens, and industries, has developed into a complex and collaborative process at Superfund sites (Tuler &

Webler, 2010). While not without challenges, collaborative planning processes help to identify, order, and apply stakeholder priorities (Apitz et al., 2018; Mukherjee et al., 2018; Westra et al., 2012; Cannon, 2005;). Foley et al. (2017) demonstrates a mismatch between ideal and actual collaborative processes through a case study of a multi-stakeholder collaboration at a Superfund site in Arizona. The study reports that underlying factors such as a lack of trust and power asymmetries led to a collaborative process that lacked a shared vision of success, particularly in terms of a post-remediation economic redevelopment plan. To overcome challenges related to power and trust, the Portland Harbor Sustainability Project relies on a site-specific framework that integrates three pillars – environmental quality, economic viability, and social equity – to consider potential community values–based trade-offs among the Superfund remedial action alternatives (Apitz et al., 2018). Questions related to trust and power asymmetries influence how stakeholders perceive the legitimacy, defined as whether stakeholders perceive a process as unbiased and meeting standards of political and procedural fairness (Cash et al., 2002), of collaborative planning processes.

Understanding issue frames offers an approach to describe and elaborate on how stakeholders view collaborative planning processes at Superfund sites. A frame functions as an interpretive lens that directs participants' focus to desired aspects of an issue (Buijs et al., 2011). Frames can thus convey ethical stances, influence preferences for dispute resolution, and mobilize others to act (Gray, 2004). Issue framing refers to how stakeholders prime and activate knowledge schemas, – or representations of a plan or theory in the form of an outline or model – which then guide individual perceptions, inferences, and actions (Cornelissen & Werner, 2014). The framing concept has been applied across psychology, sociology, social movement theory, and media research (Benighaus & Bleicher, 2019; Entman et al. 2007). Framing, because of its focus on understanding how stakeholders prime and activate knowledge schemas, is useful for understanding issues related to perceived legitimacy, including identifying and addressing challenges associated with accountability for management outcomes, power imbalances, exclusion of the general public, and cultural miscommunications (Buijs et al., 2011; Wutich et al., 2019).

In this study, we evaluate how stakeholders frame collaborative planning processes at a complex Superfund site. Our primary objective was to identify and compare issue frames related to priorities about public health, economic development, and environmental issues. We used Q methodology (Q hereafter), a quantitative and qualitative technique that allows reflexive understanding of subjective perspectives through priority sorting and semi-structured interviews (Brown, 2019; Stephenson, 1935, 1953). Q is well-tailored for identifying and evaluating issue frames because it is relatively simple to employ and allows for a holistic comparison of viewpoints relative to other views (Addams & Proops, 2000; Robbins & Krueger, 2000; Watts & Stenner, 2012).

The Superfund Program and Issue Frames

Early on, planning processes related to the Superfund program were informed by an ignorant public model, which assumed the public was dependent on the government and scientific experts and would trust those parties to manage risk effectively (Edelstein, 1988; Freudenberg et al., 2011). This model eroded public trust in government, particularly when the public perceived that environmental protection and health goals undermined local economic interests (Shriver & Kennedy, 2005; Wulfhorst, 2000). Collaborative planning processes have required abandoning the ignorant public model. There are challenges to abandoning the ignorant public model, including the possibility of allowing powerful private interests to subsume the common good and a deep distrust of institutions (Tuler & Webler, 2020). Despite challenges, community stakeholders are more likely to view collaboratively planning processes as legitimate when they are developed under assumptions that the public is informed and plays a prudent role in decision-making (Adams et al., 2018). As collaborative planning processes have been implemented by the USEPA, emergent issue frames, influenced by the perspectives of stakeholder groups including Native American Nations, industries, and community development groups, have reshaped planning processes.

Native American Nations have played a primary role in defining issue frames at Superfund sites because of their strong connections to place, and, in many cases, their unique position as sovereigns. Self-determination, often interpreted as meaning that Native Nations must assert sovereignty by “performing the functions of effective government” (Sanders, 2010, p. 564) and pushing the federal government to honor treaty obligations has led Native Nations to play a key role in collaborative planning processes at Superfund sites (Clark, 2020). Native people commonly experience health effects from exposure to pollution because of a high frequency and intensity of environmental interaction including higher rates of air inhalation, soil contact, and fish ingestion (Arquette et al., 2002; Harper et al., 2002). Native Nations have advocated for protection of practices such as fishing, hunting, and gathering within Superfund sites (Holifield, 2012; Reo et al., 2017). These practices of Native Nations have subsequently been formally integrated within risk assessment at Superfund sites, where decisions about health risk include ties to spiritual and cultural practices (Holifield, 2012).

Industries and local businesses have endorsed an issue frame oriented towards preserving the Superfund program in a form that is more agreeable for business (Nakamura & Church, 2003). Changes resulting from pressure exerted by these stakeholder groups have included several rollbacks to the original Superfund program. For instance, polluting industries are allowed to perform their own site assessments, which was originally the responsibility of the USEPA, and risk assessment and remediation standards were updated from an assumption of residential use to “reasonably anticipated future uses” (USEPA, 1995). Increasing the speed and efficiency of remediations and litigation processes has been a focus of additional reforms (Baroni, 2018).

Community development interests support issue frames that focus on local economic development priorities. Concerns about stigmatization and lasting health issues influence the issue frames that develop around community development interests (Adams et al., 2018; Atari et al., 2011). Stigma is linked to economic, social, cultural, and psychological impacts in communities impacted by contamination (Gregory & Satterfield, 2002), such as through decreased real estate prices (Maxwell et al., 2018). Communities with Superfund sites have developed a range of strategies for overcoming stigmatization and redeveloping economies, for instance, by promoting outdoor recreation activities (Christensen, 2016; Colocousis, 2012). Issues frames oriented towards supporting community development are variable across Superfund sites because what constitutes a completed Superfund site remediation and restoration varies based on social, cultural, and economic factors (Gregory & Satterfield, 2002; Maxwell et al., 2018). The diverse interests of community stakeholders are important to consider when conducting collaborative planning processes.

Methods

Study Area

The study area is the Coeur d’Alene Basin of northern Idaho, USA, a region where a 140-year year history of lead, silver, and zinc mining instigated a public health crisis, and eventually, a Superfund designation in 1983. Historical mining, smelting, and associated waste disposal practices in Shoshone County, Idaho and surrounding areas (known as the “Silver Valley”) resulted in the contamination of soils, sediments, groundwater and surface water with arsenic, lead and other toxic metals (Figure 3.1). The Superfund site is divided into three Operational Units – the technical term used to designate jurisdiction boundaries for Superfund sites – encompasses most of the Coeur d’Alene Basin. Primary remedial activities at the site include both remediation, or the removal or containment of hazardous waste, and restoration, or the recovery of damaged natural resources. The USEPA and the State of Idaho initially focused on remedial actions in the Bunker Hill “Box,” a 21 square- mile area surrounding the historic smelter complex (NRC, 2005). A remediation, which included removing or capping contaminated residential and commercial areas in the Silver Valley, is mostly complete, although other remediation activities in the “Box” continue (von Lindern et al., 2016).

Contaminants have been carried down the Coeur d'Alene River from the Silver Valley and are deposited at the bottom of Lake Coeur d'Alene and in smaller lakes and wetland areas. The Lake, a popular recreational destination and an economic catalyst for northern Idaho and eastern Washington (IDEQ & Coeur d'Alene Tribe, 2009), contains approximately 75 million metrics tons of contaminated sediments (IDEQ & Coeur d'Alene Tribe, 2009). While contaminants are currently sequestered at the bottom of the Lake, there is concern among scientists and others that rising nutrient levels and Lake temperatures could lead to a future tipping point in which decreased oxygen levels release contaminants into the water column (Benson, 2019). Legacy mine waste challenges the Coeur d'Alene Tribe's (Tribe) ability to self-govern its aboriginal homeland. The Tribe's Reservation boundary includes the beds and banks of the southern third of Coeur d'Alene Lake (Frey & Stensgar, 2012).

A lake management plan and restoration partnership are the primary institutions steering environmental decision-making. In 1998, the Superfund site boundaries were expanded to include the Coeur d'Alene River and tributaries, the Lake, and portions of the Spokane River downstream in Washington state. The expansion of the site set forth planning for ecological restoration-focused environmental management activities such as constructing wetlands, planting trees and vegetation, and improving water quality. In 2002, the USEPA deferred specific remedial actions for the Lake to the State of Idaho and the Coeur d'Alene Tribe to develop and implement an updated Lake Management Plan that would monitor and address metals-contaminated sediments in the Lake (Restoration Partnership, 2018). This decision made the Lake out ineligible for environmental management implementation with the funds available in the Superfund trust. The official Institutional Control Program boundaries, the area where Superfund Trust money can be used, includes the Coeur d'Alene River corridor and upstream tributaries (Figure 1).

The Basin Environmental Improvement Project Commission (BEIPC) was established by the Idaho legislature to, "protect and promote the health, safety and general welfare of the people of Idaho in a manner consistent with local, State, Federal and tribal participation and resources" (IDEQ, 2002). BEIPC operations focus on implementing and coordinating environmental remediation, natural resource restoration, and related measures to address water quality and heavy metal contamination in the region (IDEQ, 2002). Following a 2009 settlement with mining companies, the Superfund Trustees (U.S. Departments of Interior and Agriculture, the State of Idaho, and the Coeur d'Alene Tribe) jointly developed a Restoration Plan, which now guides how funds within the Superfund Trust are managed. The Restoration Plan took shape over a seven-year collaborative planning process. In

2019, the Restoration Partnership implemented its first round of projects (Restoration Partnership, 2018).

The Tribe, as a primary Superfund Trustee, plays a role in collaborative planning in the region. In 2019, they withdrew from the Lake Management Plan, explaining to local press that they are, "discouraged over what it sees as the state's inability to take serious action to prevent the Lake quality from deteriorating due to heavy metal pollution on the Lake bottom and increasing amounts of phosphorus entering the Lake from various sources, including excess fertilizer" (Jackson, 2019). To address the Tribe's concerns, the State of Idaho has asked for a third-party to conduct a scientific review and analysis of previous Lake management and monitoring (Francovich, 2019).

Study Design

Q is both a cognitive and interactional methodology and offers an approach for eliciting holistic views of stakeholder perspectives (Addams & Proops, 2000; Asah et al., 2012). The method can be used to identify issue frames. Findings can then be corroborated and nuanced through interview data. Developed by psychologists to study subjective perspectives – how people conceive and communicate their viewpoint about a subject – the methodology is well-positioned as a participatory and reflexive method (Robbins & Krueger, 2000). We followed recommendations for conducting Q in Watts and Stenner (2012) and Robbins and Krueger (2000). Our approach included four primary steps: (1) statement selection, which included developing statements about regional issues related to the Superfund site (Q-concourse); (2) narrow those statements to a final selective list (Q-set); (3) identify study participants to sort the statements based on their viewpoints (Q-sort) and conduct semi-structured reflective interviews; and (4) conduct a factor analysis of the Q-sorts to identify primary frames (Brown, 1996). The basic analytical goal is to correlate and compare the entire responses of individuals (Zabala, 2014).

<u>3.2.1. Statement Selection (Q-concourse and Q-set)</u>

The Q-concourse included a set of subjective statements developed from informal interviews of key informants, document analysis, and participant observation at meetings related to the Superfund site. The statements in a Q-concourse represent the conversation surrounding any topic in the ordinary discourse of everyday life. The final Q-concourse included 90 statements that we compiled until statements became redundant. We reduced the concourse to 30 statements for the Q-set that represented perspectives across issues related to one of five categories: environmental protection, human health related to heavy metal exposure, the Superfund site, economic development, and tradeoffs between categories (Table 3.1). Statement sources are outlined in Appendix C.

3.2.2. Participant Selection and Recruitment

We conducted participant sampling in phases to represent stakeholders both directly and indirectly involved in implementing remediation and restoration activities related to the Superfund program. The first phase focused on environmental managers who were active in the Restoration Partnership or BEIPC. Our sampling strategy relied on a combination of maximum variation and theoretical construct sampling. Maximum variation sampling involves recruiting a range of participants who represent variations in the phenomena under study, while theoretical construct sampling involves recruiting participants based on theoretical constructs or characteristics (Tracy, 2019). We initially reached out to two representatives from the primary groups involved in environmental management. In cases when we were unable to identify a contact, we identified a third representative. For the second phase of sampling, we used snowball sampling based on recommendations from study participants to identify local people more indirectly involved in restoration or remediation. This second phase was critical to meeting our study objectives because decision-making at Superfund sites is influenced by environmental managers and local stakeholders (Cannon, 2005). Participants were sent an initial recruitment email and a follow-up email one week later if they did not respond, 16 potential participants did not respond to our study recruitment emails, 3 others responded and did not participate.

We collected 28 Q-sorts (response rate, 59.5%) from 12 women and 16 men and conducted follow-up interviews with 21 participants. Interviews were recorded and transcribed. In Q, the sample does not need to be large or representative of the population, but it must be diverse (Zabala, 2014). Participants were classified with the affiliation that they most strongly identified with as determined during the reflective interviews. Eleven participants (41%) had direct involvement in environmental management. Among these participants, five identified primarily as managers, three as scientists, and three as both scientists and managers. The remaining participants identified their primary affiliations as industry employees, non-profit employees, community development (including participants who worked in real estate, with local chamber of commerce, and small business owners), or university employees (Table 3.2). Several participants identified with multiple stakeholder groups, such as a university employee and small business owner. Three participants were local elected officials, but categorized by their primary employment, which were roles other than elected officials. State employees (25%) and community development (25%) were the largest stakeholder categories.

3.2.3. Q-Sort Procedure

Card sorting was completed in an open-source web application called the Q-Method Testing and Inquiry Program (Q-TIP: Nost et al., 2019). Participants were recruited over email and provided with a unique link to their Q-sort with embedded instructions. Statements were sorted into a grid based on participants' strength of agreement with the statement (Appendix B). The activity was pilot tested with three key informants to ensure statement interpretability. Scores ranged from -3 to 3 or "least like how I think" to "most like how I think." The sorting activity took between 15 and 30 minutes to complete. After completing the Q-sort, participants answered online questions about the statements that they felt were most worth commenting on either because they felt strongly about the statement or thought the statement was difficult to place. In follow-up semi-structured phone interviews, participants elaborated on the statements that were difficult to place and shared information about their personal and professional background.

Statistical Analysis

Data analysis was completed in the R/R Studio package called qmethod (Zabala, 2014). A correlation matrix using a Pearson's coefficient was first created between individual Q-sorts to evaluate the degree of similarity between the sorts. A principal components analysis (PCA) using a varimax rotation was used to identify the primary issue frames. The number of issue frames (components) extracted in the PCA was based on whether the frame had an eigenvalue >1 and made theoretical sense when rotated (Watts & Stenner, 2012). We investigated the inclusion of higher and lower numbers of issue frames, but the alternative solutions had more participants confounded on more than one issue frame, higher inter-frame correlations, or less variance explained. Thus, these alternative solutions were not as informative about the differences in perspectives among participants. The most representative Q-sorts for each emergent frame were flagged for the remaining analysis, a method described in Zabala (2014) where a Q-sort is categorized with a frame when the loading is high (>0.5) and the squared loading for that Q-sort is higher for that frame than the sum of the squared loadings for the Q-sort across the other frames. These flagged Q-sorts defined how participants clustered with the issue frames.

Participant clusters for each issue frame were used to calculate statement z-scores for each frame. The final analysis was based on a comparison between statement z-scores, which included evaluating the correlation coefficients and the standard error of differences (SED; based on standard error of frame scores). Comparison of z-scores between statements and across frames was used to highlight distinguishing and consensus statements (Table 3.3) (Zabala, 2014). A distinguished statement had a statistically significant different z-score as compared with all other frame z-scores for that statement. A consensus statement does not differ significantly between frames. Statements where some but not all statement z-score pairs between frames were statistically significant were considered non-distinguishing statements.

Interpretation

Issue frame interpretation in Q is both inductive and deductive. It is deductive because Q-sort statement reflection are used to identify themes – which we used to describe resulting issue frames – and inductive because researchers evaluate how participants interpret the statements. The two researchers iterated and discussed primary themes and assigned names to each frame by considering the statement z-scores, distinguishing statements, and the demographic characteristics of participants clustered within the frame. We highlight the statements that ranked highest and lowest for each frame but considered the overall configuration of statements for each frame by evaluating the rank of each statement relative to other statements. Our approach to interpretation closely followed the recommendations of Watts & Stenner (2012) and Gubrium et al. (2012).

The quantitative interpretation of the issue frames was enhanced through the inclusion of qualitative comments made during data collection. Open-ended comments entered by participants in the Q-sort activity and follow-up interviews were analyzed to further interpret each frame. In the interviews and in the open-ended comments, participants commented on the statements they found most confusing or difficult to place along the scale. In interviews, participants elaborated on the placement of statements at the extreme ends of the Q-sort continuum. The comments and interview data were organized and combined into a matrix in an Excel Spreadsheet (Saldana, 2015), organized by frame and Q-sort statements. Two rounds of coding were used to distinguish patterns in comments between participants clustered within each frame. In the first round of coding, we observed similar patterns between participants regarding the statements that they chose to comment on. In the second, we identified common themes in participant comments that expanded our interpretation of the frame. We compared how participants' comments on a statement aligned with the statement ranking for the issue frame.

A limitation to our interview analysis is that not all participants commented on statements in the Q-sort activity and not all completed reflective interviews. In Q, participants with the highest loadings had perspectives that were most reflective of the issue frame (i.e., a loading of 1 indicates that the participant perfectly represents the frame). As indicated in Table 3.4, apart from frame 4, we completed interviews with the participants who had the highest loading for each frame. In coding the data, we considered how strongly participants loaded on an issue frame as an indicator of how representative their comments were for the frame.

Results

Four issue frames were identified through the PCA that explained 67% of the study variance (Table 3.4). The frames included: A) government intervention (24% of variance); B) Superfund remediation (18%); C) local concern (16%); and D) public-private partnerships (8%). Table 3.4 illustrates how participants clustered by primary stakeholder affiliation and frame. Four participants (P3, P5, & P13) did not cluster with a frame because they had high loadings for more than one frame. Interview data from these participants provided insight about areas of consensus between frames.

Frames A, B, & C were significantly correlated with each other at the $p<.001$ level or higher. Frame D was not significantly correlated with the other frames and was least like frame A (Appendix C). Table 3.5 indicates the top five highest and lowest z-scores and most distinguished statements for each frame. A positive z-score indicates agreement, or a statement that was "most like" how participants for a frame thought, while a negative z-score indicates disagreement, or a statement that was "least like" how participants thought. Next, we discuss the four frames and how the participants who clustered with the frame view tradeoffs in economic and public health priorities.

Frame A: Government Intervention

The eleven participants clustered in frame A had community development, non-profit, Tribe, and university affiliations. These participants were all from the second phase of sampling, which included people who were not directly involved in collaborative partnerships in the Coeur d'Alene region. Two participants who worked with the State (P5 & P16) loaded highly on the frame but were not included in the frame's z-score calculations because they also loaded highly with frame B. One other participant (P3) loaded highly but inversely with the frame. Seven statements were distinguishing for the frame A. Statement 10 that, "good water quality is essential for sustaining economic growth," was the highest ranking statement and statement 3, "current levels of economic growth are sustainable," ($z= -1.43$) was both a distinguishing statement and the lowest ranking statement for participants in frame A. Statement 14, "promoting climate resilient policies makes economic sense" ($z= 1.05$), was distinguishing and indicated high levels of agreement for the frame. The frame is titled "government intervention" because it is distinguished from the other frames by participants who felt most strongly about statements on the role of government in environmental protection and community development, relative to other types of statements. Participants in this frame expressed beliefs that the existing regulatory structure needs to be reevaluated both for economic stability and environmental protection in interviews and online comments.

In interviews, participants expressed concern about others' views that they saw as potentially detrimental to government intervention. One participant expressed doubts that industries could operate with any sort of "corporate conscience" (P15). Another explained how some community members expressed "angry" and "close-minded" attitudes towards the USEPA, which she found difficult to understand and viewed as a "roadblock" to community development (P24). When commenting on disagreement with statement 20, that "mining and timber industry jobs are the backbone of the economy," a participant explained that the statement was "uninformed, and most likely the largest roadblock to positive sustainable change in our region" (P12). Participants expressed dissatisfaction related to statement 19, "over the past decade, water quality has improved." For instance, one participant thought that this view could hinder further progress on water quality.

> [Water quality improvement] is something that gets thrown out there a lot, [people will say] "if you look at this" and "if you look at that" the water in the 1970s was disgusting, we flushed our toilets directly into the Lake, like it was a sewer. So, of course, things have improved. But, since the 1990s water quality has been getting worse and people do not take factors like climate change and warming temperatures or the zinc and oxygen issues into the equation. Sometimes it is a lack of understanding, sometimes it is deliberately used to mislead people (P15).

Many participants clustered in frame A disagreed that environmental and economic conditions were improving and thought that the baseline conditions for environmental standards were low and that failures to improve water quality are often ignored.

Some frame A participants believed that other people in the region may be unwilling to voluntarily make changes to protect the environment, which is why government intervention was important. Two participants (P1 & P15) explained how they had grown tired of volunteering with projects and events hosted by environmental organizations because of the unfriendly ways in which people involved in environmental protection were treated in the region. Another expressed little confidence that people will be motivated to protect the environment, especially without proper enforcement, commenting that "people who buy big boats, spending $70,000, aren't going to make sure they're doing the right things in terms of wastewater discharge and wakes. Who is going to enforce them anyhow?" (P8). Participants believed that changes to the existing regulatory structure and regional politics are critical to both environmental protection and economic development. Another participant who loaded highly on both frames A & B said, "the current regulatory structure does not match the scope of our 21st century problems. We need to do a fundamental rethink" (P5).

Participants described how, without a specific catalyst for change, they believed that the existing government structure is unlikely to change. This view was evident in responses to statement 15, "the threats posed by heavy metals are uncertain." For instance, P8 believed that while the science of contamination is clear, changes to the existing regulatory structure are unlikely.

> No one knows for certain how imminent [heavy metal] threats are or, if Lake conditions do go anoxic, how pervasively the metals will mobilize throughout the water column. And, I think, from the state's perspective, that uncertainty makes them hesitant to act (P8).

While participants looked to the government for enhanced environmental protection, they expressed doubts that large institutional changes would occur in the absence of a shock to the current system (i.e., large-scale changes in lake chemistry). P14 expressed doubts about the capacity of local government when discussing his strong disagreement with statement 14, "county and city governments need to be held more accountable to protecting water quality about city and county." He commented that it has always been his observation that "lower tiers of government are more prone to shenanigans." Relative to the other frames, participants in frame A believed that there was a need for changes in the structure of local government.

Frame B: Superfund Remediation

The six participants clustered in frame B had affiliations with State, Federal, and community development groups. There was one participant who worked in economic development – the only one in the frame who did not also have a direct role in the Superfund remediation. The frame is titled "superfund remediation" due to its eight distinguishing statements specific to remediation conducted through the Superfund program. Two primary statements were distinguishing and high ranking: agreement with statement 17, "over the past decade, water quality has improved" ($z= 1.65$), and disagreement with statement 15, "the threats posed by heavy metals are uncertain" ($z= -1.70$). Participant comments indicate a commitment to the fundamental importance of Superfund remediation, for instance this quote: "There is great certainty through scientific research, and site-specific information in the Basin, that heavy metals pose numerous threats and should be managed in perpetuity" (P22).

Several of the participants who completed reflective interviews in frame B, expressed optimism about the remediation and ongoing collaborations while noting that conflict is a necessary component of collaboration. For instance, one described the importance of conflict in collaboration in their comment on statement 24, "tension between stakeholder groups limits the effectiveness of environmental policies."

> While there is certainly a lot of disagreement, there is more collaboration. Because even in collaboration there is conflict. Part of why it works so well is that there are differing viewpoints. So, you must deal with the disagreements even during effective collaboration. (P7).

The statement demonstrates that the participant is aware that differences across organizations can make collaboration challenging. Some participants indicated a level of dissatisfaction with the responsibilities they must carry out with in their jobs, explaining that their roles in enforcing regulation limit their abilities to collaborate.

Participants in frame B emphasized water quality improvements most often. It was the only frame with slight overall agreement for Statement 19, "over the past decade, water quality has improved." In interviews, participants shared a sense of awareness about the complexity of water quality issues. For instance. one participant acknowledged that there are different types of pollutants that can degrade water quality beyond heavy metals but considered the water quality improvements associated with the Superfund site as especially beneficial.

> Looking across the whole basin, there are certainly areas where water quality has improved…In the areas where we have been doing projects…there have been drastic improvements. And, the overall picture of metals in the Basin has improved in the last 10 years, but the nutrients are trending the other way. And so, defining water quality is challenging (P18).

Optimism towards improved water quality was tempered by concern about nutrient levels for this participant, but the response highlights a belief that the Superfund remediation work has contributed to tangible water quality improvements.

While committed to their work, some environmental managers were overwhelmed by the enormity of the human health issues attributed to contamination. Most concerning, there remain children with blood lead levels that are higher than recommended in some cases.

> We would like to clean up more than we are able to every year. We know that there are children out there with high blood lead levels and that those levels are often attributed to recreation…a challenge is to remember that every cleanup we do comes closer to reaching cleanup objectives. When you look at the whole picture, it is overwhelming (P9).

Because of this desire to make remedial actions go further, there was support for regulation among these participants. However, enforcing existing regulations was thought to be challenging. For instance, P4 explained that existing water quality regulations were adequate, but the ability to enforce regulations at the local level was more limited.

Support for economic development existed alongside the Superfund remediation and restoration in this frame, with the caveat that remediation and restoration should not cost local taxpayers additional money. The participant who works in community development within this frame perceived a relationship between trust in a successful Superfund process and the willingness of new people to move to the area:

> I see the Silver Valley home prices increasing along with homes sales and growth in general. I think the successful remediation along with the increased ability to work remotely with technologies has contributed to this. And, home prices are quite affordable in Shoshone County as compared to Kootenai County (P22).

The same participant suggested that she thinks that the State and Federal government should require counties and cities to "create and implement strategies to improve water quality in order to get funding." On the other hand, there was resistance among participants clustered in this frame towards increasing taxes. One participant who worked with the State said: "I wouldn't come out and say we're going to increase taxes because it will be dead on arrival (P18)."

Frame C: Local Concern

Six participants affiliated with economic development, the Tribe, and university groups clustered in frame C. The participants affiliated with the Tribe were involved in both the Superfund remediation and the collaborative partnerships. Five statements were distinguishing for the participants clustered in frame C. Two statements were distinguished and high ranking: agreement with 6, "tradeoffs between public health and economic gains are sometimes necessary," (z=1.10), and 13, "county and city governments need to be held more accountable to protecting water quality" (z=1.66). The frame was titled "Local Concern" because, relative to the other frames, participants held stronger beliefs about the need for environmental protection that starts at the local level. Participants in the frame believed strongly in local unification around environmental protection.

Participants grouped in this frame believed that the economic growth in the region was closely associated with recent economic development but had differing views about whether the growth was positively impacting the region. One participant, who works with a chamber of commerce, explained that being able to provide tangible evidence that the area is safe, due to the Superfund remediation, gives him an advantage when working with customers. He saw benefit to his business from the transparent risk communication efforts of the government (P2). Another participant, quoted below, believed that the Superfund site cannot have had a detrimental effect on the regional economy because the economy has grown:

> Since the early 80s the Lake has been part of the Superfund site. What has happened to the Kootenai County economy since then? It has gone crazy. Look at the land values around the Lake. There is no economic stigma because of a Superfund site (P21).

He believed that ignoring the hazardous waste in the Lake would eventually be devastating to local communities and argued that the Superfund site bolsters the regional economy. Even participants with otherwise similar views had differing opinions of whether the regional economic growth was beneficial.

When discussing possible remedial actions for the Lake, several participants believed that a strategy to address hazardous waste should be a leading priority. One participant asked rhetorically, "Why are we fighting about data points? What about Mother Earth and our grandchildren? What are simple things [environmental-protection actions] that all humans can rally around?" (P21). He argued that motivating local concern is crucial because momentum at the local level could motivate the State to act through a "snowball" effect (P21). However, participants simultaneously expressed both optimism and pessimism about the prospects for motivating local concern. One participant who works directly in collaborations related to the Superfund program described the feeling of holding these two views in this way:

> Within our work, we can have different views from day to day, but I think that folks are really starting to understand that they are a part of the broader solution for protecting the Lake…I do not think that [the public] understand how their behaviors translate into water quality protection…relying on the government is not going to do it (P10).

Others expressed concerns about an unaware public and the negative influence that the "far-right influence" has for environmental protection in the region (P20).

Individual actions have clear repercussions for Lake Coeur d'Alene, which is increasingly polluted by sediments and nutrients from development in the Basin. P20 argued that "the EPA needs to reevaluate what they plan to do for the Lake." The vulnerability of the lake to pollution is particularly concerning to Tribal members, as the Lake lies partially within their Reservation boundary and is central to the Tribe's cultural and spiritual practices (Frey 2012). While participants in this group were supportive of local collaborations, some expressed frustration about how a remedy for the Lake was not within the scope of the Superfund program.

Frame D: Public-Private Partnerships

Frame D was least like the others, with ten distinguishing statements, and included three participants who worked either in the timber and mining industry or community development. A fourth participant, a State scientist involved in implementing public-private partnerships related to floodplain and wetland restoration, did not cluster with any frame but loaded highly on this frame. The distinguishing statements in frame D revealed acceptance of existing environmental protection policies but resistance to policies that would require stricter regulations or government involvement in environmental management. Participants supported and valued environmental stewardship but believed environmental protection could be achieved without additional government intervention. Statement 30, "Local leaders agree on approaches to manage heavy metal contamination" (z= -2.01), was distinguishing and the lowest ranked statement for the frame. On the other side of the spectrum, statement 8, "raising city and county taxes restricts economic growth" (z=1.14), was high ranking and distinguishing. The group was primarily involved with actions related to the Superfund program through their involvement in the Restoration Partnership, either in advisory roles or through project implementation.

Frame D participants emphasized beliefs that local communities and industries have a responsibility for environmental protection. One participant described a partnership between his company, non-profits, and the Restoration Partnership as an example:

> We [the participant's company] are in the middle of a creek restoration partnership right now. We own some property on a creek that was really devastated by mining at the turn of the century…We were planning to sell the property to the government, but making land purchases with the government is a long and drawn out process and we just finally said that this is taking so long and needs to get done so let's just undertake this ourselves (P23).

The participant discussed how greater involvement from the city and local government would add unnecessary complexity to his job and to projects implemented through the Restoration Partnership. Another participant described frustration with slow government processes for implementation but optimism that the current Restoration Partnership would be successful. One participant, who did not cluster with a frame but had a loading of 0.3 for frame D, described how he believed that the Restoration Partnership would allow agencies to demonstrate that they can get work done.

> Without degrading the process, I say "let's just get in there and get it done"… politics have really been the biggest challenge. Now having said that, we're only into our second year of implementation [with the Restoration Partnership]. So, we're just beginning to do projects…but the agencies know how to get work done (P3).

This comment reflects the participant's relief at the opportunity to get work done on the ground following the collaborative planning process employed to from the Restoration Partnership. The completion of the Restoration Plan was a step forward for collaboration in the Basin and perhaps an important moment for frame D participants. Participants who worked directly with the Restoration Partnership exemplified how project implementation is already contributing to increased involvement from the private sector in Superfund activities.

Areas of Consensus and Dissensus

We found consensus beliefs for statements related to the Superfund site and collaboration. Statement 21, "strategies to reduce heavy metals should be based only on the best available science," was the only complete consensus statement, with all frame z-scores for this statement falling between zero and one. The z-score for statement 15, "the threats posed by heavy metals are uncertain," was negative for all frames, indicating that participants believed that the threats posed by heavy metals were not uncertain. Consensus for statements 15 & 21, along with participant comments in interviews that collaborative processes were generally fair, indicate a collaborative and science-centered stakeholder network. A primary caveat to these consensus beliefs emerged in interviews as participants differed in how they discussed the nature of the hazardous waste issue for the Lake. One participant, who clustered in frame A, referred to the Lake contamination issue as the "800-pound gorilla in the room" because it is an issue that stakeholders working on the Superfund site do not have the capacity to address (P6). Three participants in frame C explained that the capacity to address the problem existed but a lack of political will prevented action. In contrast, many participants who clustered in frames B & D did not mention Lake contamination issues in interviews and instead focused on issues in other areas of the Superfund site. Discrepancy in viewpoints about addressing contamination in the Lake is an example of a barrier to developing shared visions in collaborative processes.

Frames A, B, & C were divided across a few key differences while frame D differed considerably. Dissensus beliefs emerged primarily for statements about environmental regulations and economic development. Statement 18, "drawing attention to heavy metals pollution is bad for the economy," and statement 13, "county and city governments need to be held more accountable to protecting water quality," had the widest distribution of z-scores across frames, indicating variation in views. For statement 18, participants grouped in frame C disagreed strongly (z= -1.91) while frame D participants placed the statement towards the middle of the scale (z=0.03). For statement 13, frame C had a strong positive z-score of 1.67, frames A & B both had positive but smaller z-scores, and frame D had a negative z-score of -1.67. Discrepancies suggests that future collaborative processes around environmental decision-making may benefit from efforts to articulate roles and expectations of local government in environmental protection. There may be a need to communicate the economic benefits of managing heavy metals since many participants believed that the Superfund program has facilitated rather than hindered economic growth, and yet frame D participants believed that drawing attention to heavy metals was bad for the economy.

Conclusion

While results indicate the presence of a collaborative stakeholder network in the Coeur d'Alene Region – one that prioritizes both economic development and environmental goals – views about local government and economic development distinguished the four primary issue frames. The perspectives that informed the issue frames were also influenced by differing views about the role of the public in environmental planning, the presence of the Tribe in collaborative planning processes, and a desire among stakeholders for project implementation. Reconciling these differences in perspectives may improve the perceived legitimacy of collaborative planning processes, particularly for stakeholders not directly involved in the Superfund remediation or restoration activities.

One way to improve the perceived legitimacy of collaborative planning processes is by focusing on the prudent public model. The model is characterized by a reciprocal knowledge exchange between scientific experts and officials; stakeholder groups; and the public (Webler &

Tuler, 2018). Local citizens often become disenfranchised by long and slow processes that afford too few tangible improvements (Gregory & Satterfield, 2002). Frustration at a lack of intervention has been observed in other communities with long-term involvement in the Superfund program (Hoover, 2017). In the Coeur d'Alene region, transparent communication is important for improving public involvement in the Superfund program. The Restoration Partnership, through its focus on project implementation may encourage increased community involvement in collaborative planning process. One indication that the Restoration Partnership is encouraging more community involvement is the presence of frame D. Participants in frame D primarily had affiliations with industries, these participants described how contributing to restoration projects motivated them to participants in environmental restoration projects.

The Coeur d'Alene Tribe's legal authority to influence decision-making at the Superfund site has a unique influence on collaborative planning processes. Prior to data collection for this study, the Tribe backed out of the Lake Management Plan (Jackson, 2019). Even prior to this withdrawal, the Tribe has challenged decisions about Superfund site management. For instance, to gain more control over Lake resources and a stronger position at the negotiating table, the Tribe turned to the legal system to gain control of the beds and banks of navigable waterways (Blades, 2010). A challenge for Native Nations' governments is that maintaining "separateness" as sovereign nations requires "maintaining a difference that is recognizable and acceptable to both the dominant culture and its institutions and tribal citizens within the minority culture" (Ranco & Suagee, 2007, p. 693). In this study, beliefs expressed by participants affiliated with the Tribe demonstrate a desire to balance increased environmental protection with recognition of the importance of local collaboration.

Study participants who were directly involved in implementing remedial actions through BEIPC or the Restoration Partnership described a collaborative process that was fair and dependent on a science-centered stakeholder network. The collaboration closely reflects what Tuler and Webler (2010) as a "science-centered stakeholder consultation" typology, where stakeholders share a "high degree of scientific consensus about the relevant policy issue and they believe that the government is committed to the process" (p. 265). The desired goals of the process are often assumed to be agreed upon by planners and participants, however, variation in perspectives can go undetected (Webler et al. 2001). While science-centered decision-making provides an effective way to maintain trusting relationships between primary agencies and organizations, they may be inadequate for promoting a prudent public model. Pidgeon (1998) argued that balancing best available science judgements and evidence with aspects of ethical or other values on the other hand, is a key challenge in democratic societies. In this study, four clear issue frames were identified. Recognizing the differences between these frames can improve collaborative planning processes.

Designing collaborative planning processes where distinct perspectives are integrated into coherent frameworks is critical for building trust and balancing power (Cannon, 2005; Hoover, 2017; Nagisetty et al., 2020; Virapongse et al., 2016). Key challenges for implementing more collaborative approaches to the Superfund program in the Coeur d'Alene region include reconciling differing perspectives about future remedial actions for the Lake. For many, frustrations in long and bureaucratic processes have been tempered by the initial round of project implementation set forth by through the Restoration Partnership. The results from this study should advance efforts to develop a site-specific framework for collaboration in the Coeur d'Alene region similar in concept to the framework described in Apitz et al. (2018). Primary differences between frames provide a starting point for developing a unifying conceptual model. For instance,

Identifying primary issue frames is an important step in improving the perceived legitimacy of collaborative planning processes. After issues frames are identified, they can be used to demonstrate where and how power asymmetries and a lack of trust degrade perceptions of collaborative processes. However, distinguishing stakeholder priorities and values can be resource intensive and challenging. After an initial training period, Q can be employed quickly and reflexively, at little burden to the stakeholders involved, the approach offers a promising tool for evaluating shifts in priorities and values over time. Stakeholders involved in leading collaborative planning processes should continue to emphasize interconnected values across issues areas and provide tangible actions that individuals can practice.

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Tables

Table 3.1 Q statements and sources with their z-scores and ranking for each factor or frame. Negative scores represent disagreement while positive scores denote agreement. Statement numbers are based on Q-sort ordering. Factor rankings represent the Q-sort value that a participant who loaded 100% on the factor would hypothetically score.

		Frame			
#	**Statement**	A	B	C	D
Economic		*z-scores (factor ranking)*			
2	Economic conditions are improving	**-0.92 (-1)**	0.69 (1)	1.24 (2)	0.55 (0)
3	Current levels of economic growth are sustainable	**-1.59 (-3)**	-0.22 (0)	-0.38 (0)	**1.12 (2)**
8	Raising city and county taxes restricts economic growth	-1.44 (-2)	-0.72 (-1)	-1.05 (-2)	**1.14 (2)**
14	Decisions that promote climate resiliency make economic sense	**1.05 (2)**	0.04 (0)	0.13 (0)	**-1.63 (-2)**
20	Mining and timber industry jobs are the backbone of the economy	-0.99 (-1)	**-0.27 (0)**	-1.14 (-2)	**0.72 (1)**
Environmental					
1	Improving water quality requires individual behavior changes	1.00 (1)	1.07 (1)	1.40 (2)	**-1.09 (-2)**
5	Conservation districts that levy local fees for environmental protection would strengthen enforcement of water quality standards	0.28 (0)	**-0.35 (-1)**	0.66 (1)	**-1.64 (-2)**
7	Environmental protection efforts should consider climate resiliency	1.06 (2)	0.58 (1)	0.2 (0)	0.57 (0)
11	Nutrient reduction strategies need to be implemented to protect water quality	0.98 (1)	1.55 (2)	1.01 (1)	1.09 (2)
13	County and city governments need to be held more accountable to protecting water quality	1.02 (1)	0.84 (1)	**1.67 (2)**	**-1.69 (-2)**
19	Over the past decade, water quality has improved	-0.53 (0)	**1.05 (1)**	-1 (-1)	-0.54 (-1)
22	The State of Idaho should do more to regulate water quality	1.28 (2)	-0.24 (0)	0.26 (0)	0.71 (1)
24	Tension between stakeholder groups limits the effectiveness of current environmental management efforts	0 (0)	0.41 (0)	**-0.79 (-1)**	0.51 (0)
25	Environmental monitoring efforts conducted by the Coeur d'Alene Tribe and the State of Idaho are needed to protect water quality	**1.04 (2)**	0.34 (0)	0.27 (0)	0.17 (0)
30	Local leaders agree on approaches to manage heavy metal contamination	**-1.11 (-2)**	-0.58 (-1)	-0.52 (0)	**-2.01 (-3)**
Human Health and Heavy Metals					

9	[a]The public is well-informed about the health effects of heavy metals	-1.04 (-1)	-0.24 (0)	-1.55 (-2)	0.91 (1)
15	The threats posed by heavy metals are uncertain	-1.13 (-2)	**-1.7 (-2)**	-0.67 (-1)	-0.89 (-1)
17	Protecting human health and safety is the primary reason for managing heavy metals	0.99 (1)	**1.65 (3)**	**0.19 (0)**	0.89 (1)
21	[b]Actions to reduce heavy metals should be based only on the best available science	0.54 (1)	0.65 (1)	0.54 (1)	0 (0)
28	Cultural and spiritual health are tightly linked to ecosystem health	**0.81 (1)**	-0.4 (-1)	-0.68 (-1)	-0.22 (0)
Superfund Site					
4	Limitations on how Superfund (CERCLA) funds can be used are too restrictive	0.48 (0)	**-1.48 (-2)**	1.05 (1)	0.91 (1)
16	Site-wide approaches to the Superfund cleanup should be prioritized	0.11 (0)	1.2 (2)	0.29 (0)	0.92 (2)
23	The remediation of residential areas within the Superfund site is a success story	0.42 (0)	1.32 (2)	0.44 (1)	1.63 (3)
26	Current approaches to the Superfund cleanup are ineffective	-0.2 (0)	**-1.74 (-3)**	-0.73 (-1)	-0.75 (-1)
Tradeoffs					
6	Tradeoffs between public health and economic gains are sometimes necessary	-1.09 (-1)	**-0.23 (0)**	**1.10 (2)**	-0.92 (-1)
10	Good water quality is essential for sustaining economic growth	1.77 (3)	1.09 (2)	1.83 (3)	0.75 (1)
12	The Superfund site designation hinders economic growth	-1 (-1)	-1.04 (-1)	-1.45 (-2)	-0.69 (-1)
18	Drawing attention to heavy metals pollution is bad for the economy	**-0.82 (-1)**	-1.57 (-2)	-1.91 (-3)	**0.03 (0)**
27	Federal environmental regulations are too restrictive of local economic growth	-1.43 (-2)	-1.36 (-2)	**-0.76 (-1)**	**-0.02 (0)**
29	Managing heavy metal contamination is essential for sustained economic growth	0.48 (0)	-0.31 (-1)	0.35 (1)	-0.54 (-1)

Notes.
Bolded z-scores were distinguishing for the frame.
[a] Statement was distinguishing for all frames
[b] Statement in consensus, indicating no comparisons between frame z scores were significantly different.

Table 3.2 Overview of study participants (n=28)

Characteristic	% (Freq)
Sex	
Women	43% (12)
Men	57% (16)
Sub-Group	
Community Development[a]	25% (7)
Federal	7% (2)
Non-Profit	11% (3)
State	25% (7)
Timber and Mining	7% (2)
Tribe	11% (3)
University	14% (4)

Note. sub-group based on the participant's primary role.
[a]Community development includes participants who worked in real estate, with local chamber of commerce, and small business owners.

Table 3.3 Descriptions of comparative statement categories

Comparative Statements Category	Description
Distinguishing Statement	Statements that scores are statistically unique for a specific factor
Consensus Statement	Statement that do not differ statistically between factors
Non-Distinguishing Statement	One or more pairs statistically differ, but no pairs statistically different from all other frames for the statement.

Note. Comparisons are based on correlations between statement z-scores.

Table 3.4 Loading scores of each participant on the four frames, sorted by sub-grouping

	Issue frames loadings			
	A	B	C	D
Community Development				
P1	**0.65**	0.22	0.47	-0.13
P2	0.08	0.32	**0.74**	-0.28
P20	*0.23*	0.12	**0.70**	0.31
P22*	0.07	**0.72**	0.34	0.05
P24	**0.61**	0.31	0.10	0.01
P25	0.04	0.23	**0.56**	-0.19
P28*	0.17	0.04	-0.10	**0.77**
Federal				
P9	0.31	**0.75**	0.02	0.03
P12*	0.29	**0.72**	0.22	0.02
Non-profit				
P8	**0.67**	0.25	0.47	-0.24
P13	**0.60**	0.54	0.20	-0.08
P27*	**0.77**	0.18	0.13	-0.13
State				
P3	-0.62	0.18	0.33	0.33
P4	0.14	**0.66**	0.16	0.33
P7	0.58	0.47	0.32	-0.37
P5	**0.67**	0.52	0.15	0.17
P16	0.57	0.59	0.20	0.12
P17	0.09	**0.73**	0.41	0.00
P18	0.30	**0.68**	0.08	0.46
Timber and Mining				
P23	-0.27	0.14	-0.14	**0.51**
P26*	-0.11	0.41	0.07	**0.47**
Tribe				
P10	0.39	0.18	**0.61**	0.27
P11	0.30	0.13	**0.76**	-0.10
P15	**0.75**	0.04	0.42	0.04
University				
P21*	**0.72**	0.11	0.34	0.28
P6	**0.68**	0.30	0.11	0.18
P14	0.36	0.17	**0.76**	-0.05
P19	**0.77**	0.15	0.38	-0.02
Variance Explained	24%	18%	16%	8%

Note. Participant clusters for each frame are bolded. Clusters occurred for Q-sorts loading above 0.5 for a frame and when sum of squared loadings from the other frames were less than the squared loading. Participant loadings that are not bolded did not cluster with a frame.
*Participant did not complete a reflective interview

Table 3.5 Overview of the four frames revealed and their associated five highest and lowest ranked statements with z-scores.

Frame A: government intervention			**Frame B: Superfund remediation**		
ID	Statement	Z-score	ID	Statement	Z-score
Most Like How I Think			*Most Like How I Think*		
10	Good water quality is essential for sustaining economic growth	1.77	17	Protecting human health and safety is the primary reason for managing heavy metals*	1.65
22	The State of Idaho should do more to regulate water quality	1.28	11	Nutrient reduction strategies need to be implemented to protect water quality	1.55
7	Environmental protection efforts should consider climate resiliency	1.06	23	The remediation of residential areas within the Superfund site is a success story	1.32
14	Promoting climate resilient policies makes economic sense*	1.05	16	Site-wide approaches to the Superfund cleanup should be prioritized	1.20
25	Environmental monitoring efforts conducted by the Coeur d'Alene Tribe and the State of Idaho are needed to protect water quality	1.04	10	Good water quality is essential for sustaining economic growth	1.09
Least Like How I Think			*Least Like How I Think*		
3	Current levels of economic growth are sustainable*	-1.43	26	Current approaches to the Superfund cleanup are ineffective	-1.74
8	Raising city and county taxes restricts economic growth	-1.31	15	The threats posed by heavy metals are uncertain*	-1.70
27	Federal environmental regulations are too restrictive of local economic growth	-1.43	18	Drawing attention to heavy metals pollution is bad for the economy	-1.57
15	The threats posed by heavy metals are uncertain	-1.13	4	Limitations on how Superfund (CERCLA) funds can be used are too restrictive*	-1.48
30	Local leaders agree on policies related to heavy metal contamination*	-1.11	27	Federal environmental regulations are too restrictive of local economic growth	-1.36
Frame C: local concern			**Frame D: public-private partnerships**		
ID	Statement	Z-score	ID	Statement	Z-score
Most Like How I Think			*Most Like How I Think*		
10	Good water quality is essential for sustaining economic growth	1.83	23	The remediation of residential areas within the Superfund site is a success story	1.63
13	County and city governments need to be held more accountable to protecting water quality*	1.66	8	Raising city and county taxes restricts economic growth*	1.14

1	Improving water quality requires individual behavior changes	1.40	3	Current levels of economic growth are sustainable*	1.12
2	Economic conditions are improving	1.24	11	Nutrient reduction strategies need to be implemented to protect water quality	1.09
6	Tradeoffs between public health and economic gains are sometimes necessary*	1.10	16	Site-wide approaches to the Superfund cleanup should be prioritized	0.92
Least Like How I Think			*Least Like How I Think*		
18	Drawing attention to heavy metals pollution is bad for the economy	-1.92	30	Local leaders agree on policies related to heavy metal contamination*	-2.01
9	The public is well-informed about the health effects of heavy metals	-1.55	13	County and city governments need to be held more accountable to protecting water quality*	-1.69
12	The Superfund site designation hinders economic growth	-1.43	5	Conservation districts that levy local fees for environmental protection would strengthen enforcement of water quality standards*	-1.64
20	Mining and timber industry jobs are the backbone of the economy	-1.13	14	Promoting climate resilient policies makes economic sense*	-1.63
8	Raising city and county taxes restricts economic growth	-1.05	1	Improving water quality requires individual behavior changes*	-1.09

Note. * indicates distinguishing statements.

Figures

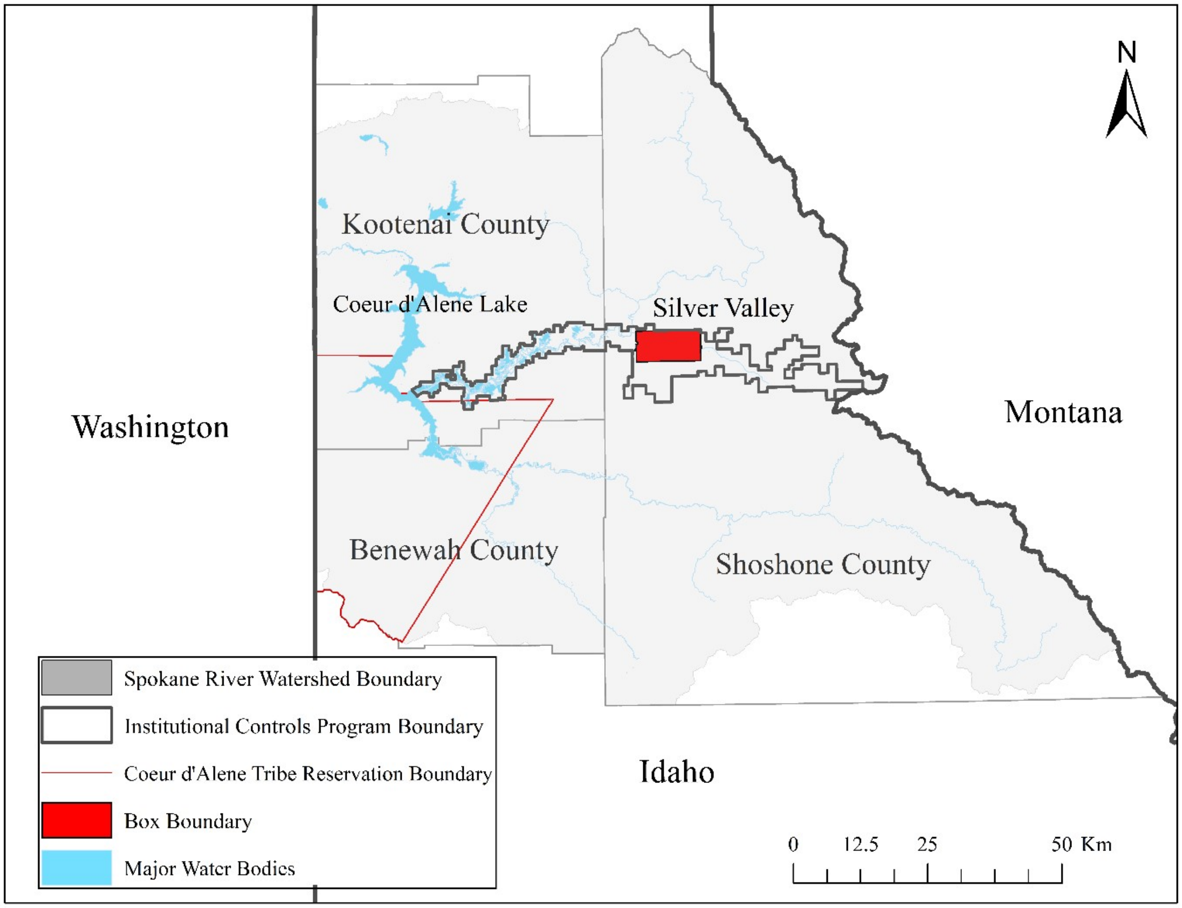

Figure 3.1 Study area location. The red rectangle indicates the 54 km^2 area known as "the Box"—the area of the original Bunker Hill Superfund Site that included a smelter and other processing facilities. The Institutional Controls Program Boundary includes the expanded Superfund site that includes 394 km^2 of floodplains and wetlands.

Source: USGS Watershed Boundary Dataset; Alta Engineering and Science; Coeur d'Alene Tribe of Indians.

Chapter 4: Participatory research approaches in mining-impacted hydrosocial systems

Forthcoming in the Hydrological Sciences Journal

Abstract

Participatory research approaches can facilitate capacity building, promote data accessibility, and accomplish community goals. To demonstrate challenges and opportunities for participatory research, we describe hydrosocial territories in a mining-impact region in northern Idaho. We then compare two community-university partnerships in the study region, which included Tribal and non-Tribal rural communities. We find that the Participatory Action Research and Indigenous Research Methodologies frameworks provide a robust set of practices and methods for conducting more equitable and inclusive research. Further, participatory research approaches in research involving mining-impacted hydrosocial systems should: (1) build from established programs, goals, and practices; (2) identify respectful levels of partnership engagement, and (3) recognize partnership limitations. Future inquiry in complex hydrosocial systems should continue to build from the existing collection of participatory scholarship to address power imbalances and cultural differences and implement non-intrusive approaches to evaluate outcomes.

Introduction

The emerging field of hydrosocial research offers promise for understanding regarding the relationships between water and society (Linton & Budds, 2014). However, there is a lack of clear direction on how to design equitable and inclusive interdisciplinary research that addresses traditional power imbalances in communities and between researchers and communities (Jepson et al., 2017; Wutich et al., 2019). Scholars have advocated for replacing linear models of knowledge production, where knowledge has a unidirectional flow from researchers to communities, with participatory research where knowledge is co-created (Mach et al., 2020). While participatory research approaches are more often discussed in hydrosocial research, they are also important to researchers in sociohydrology (Wesselink et al., 2017). For instance, participatory research approaches can provide ways for models in hydrosocial to be more reflective of a reality in which values, norms, and behavioral responses influence governance outcomes (Roobavannan et al., 2018). In this paper, we refer to research about water and society as hydrosocial research for simplicity, noting Ross and Chang's (2020) recent argument that hydrosocial research and sociohydrology are "two sides of the same coin."

Participatory research fits within a number of methodological frameworks (e.g., Cornwall & Jewkes, 1995; Ferreira & Gendron, 2011; Hall, 1992; Mackenzie et al., 2012), but at its core, this research aims to guide inquiry that addresses systemic power imbalances through capacity building to promote community voices and goals, improve data accessibility, and enhance scientific literacy (Finn & O'Fallon, 2015; Marques et al., 2018). Participatory research is often conducted through partnerships between university researchers and communities or organizations (e.g., (Caxaj, 2015; Datta et al., 2015; Martenson et al., 2012). Participatory approaches, while time intensive, can guide research in more equitable and inclusive directions that are sensitive to local contexts and meet rigorous standards for scientific research (Hacker, 2013). A primary reason for the growing popularity of participatory research is the recognition that social context and community partnerships have value (Leung et al., 2004; McMillan, 2012; Wilmsen et al., 2012). Hydrosocial researchers have used participatory research to integrate different forms of knowledge and knowledge production systems in efforts to diffuse and contextualize power (Berry et al., 2012; Wutich et al., 2019) and advance water security and water governance (e.g., Arsenault et al., 2018; Zoanni, 2017). Recommendations and best practices for conducting equitable and inclusive participatory research are important because a robust collection of case studies is needed to guide future research.

In this paper, we compare two participatory research partnerships related to environmental contamination, water, and society within the same mining-impacted region of northern Idaho, USA. The region includes a rapidly growing urban corridor, a rural Tribal community and other rural communities that were established to support natural resource extraction. The Tribal research partnership is between the Coeur d'Alene Tribe and university researchers, while the Silver Valley partnership is between university researchers, community members in an area known as the Silver Valley, and the Panhandle Health District (District). This paper's reflection is guided by our perceptions and experiences as members of the two partnerships. In the following sections, we provide a description and history of the region and describe both partnerships and the participatory approaches employed. In our descriptions of the research partnerships, we acknowledge researcher positionality, as positionality is influenced by cultural norms as well as education and professional fields which drive personal interests, research directions, and collaboration (von der Porten et al., 2016). We reflect and compare the application of participatory research approaches between the two research partnerships by analyzing three primary research phases of the partnerships. The phases include: (1) establishing a research agenda; (2) promoting community voices and goals, data accessibility, and literacy; and (3) maintaining ethical partnerships. Structuring the comparison around these three primary research phases provided a way to compare participatory research approaches between the two partnerships even though they were guided by different participatory research frameworks.

Our analysis is based on formal conversations conducted with five key partnership members during the spring and summer of 2019. Members were selected based on their involvement with each study or program affiliated with the community-university partnership and specific knowledge of the partnership objective and affiliated studies. The research design was reviewed by the University of Idaho's Institutional Review Board for the use of human subjects. Interview participants are given pseudonyms to ensure confidentiality. The findings from our partnership comparison inform a set of recommendations for conducting participatory research about water and society in rural and Indigenous communities.

Study Region: Hydrosocial Territories

One way to understand complex narratives about water and society is by describing characteristics of *hydrosocial territories*. Hydrosocial territories are "socially, naturally and politically constituted spaces that are (re)created through the interactions amongst human practices, water flows, hydraulic technologies, biophysical elements, socio-economic structures and cultural-political institutions" (Boelens et al., 2016). We use the hydrosocial territories concept to frame our overview of mining impacts in the study region in order to illustrate the complexity of efforts to manage mine waste contamination and to briefly map and characterize complex jurisdictional boundaries that influenced the development of the two community-university partnerships.

The study region is located in the northern Idaho Panhandle and is composed of the Coeur d'Alene and lower St. Joe subwatersheds, spanning a mining-impacted drainage area of 5,225 km^2 nested within the greater Spokane River Watershed (USGS, n.d.) (Figure 4.1). Within this drainage area, the Coeur d'Alene River flows west from the Idaho-Montana state line for approximately 85 kilometers before reaching the dam-controlled Coeur d'Alene Lake (Restoration Partnership, 2018). About 109 million metric tons of mine tailings were produced through mining activities in the Silver Valley and an estimated 60% of these materials washed into the mainstem and adjacent floodplain of the Coeur d'Alene River (NRC, 2005). In 1983, the region was listed as a Superfund site on the National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act or CERCLA (NRC, 2005).

Since then, the US Environmental Protection Agency (US EPA) has conducted Superfund remediation (under CERCLA), at the Bunker Hill Superfund Site in the Silver Valley

(NRC, 2005). The most intensive Superfund remediation activities have occurred in a 21 km^2 area known as 'the Box,' which once contained a smelter and extensive mining infrastructure. In addition, a large portion of the region was listed on CERCLA's National Priorities List, which initiated a Natural Resource Damage Assessment and Recovery (NRDAR) process that continues to prompt restoration and remediation activities. The region remains heavily contaminated at abandoned mine sites and in the mainstem, tributary streams, and floodplain of the Coeur d'Alene River where the mine waste was directly discharged and is now distributed by annual high flow events (Bookstrom et al., 2013; Gustavson et al., 2007; Langman et al., 2018). A 2009 settlement with ASARCO Mining and Smelting Company for $436 million provides resources for continuing restoration and remediation activities within the boundaries of the Institutional Controls Program (Restoration Partnership, 2018).

The hydrosocial territories of the region are socio-politically divided by county boundaries (NRC, 2005; U.S. Census Bureau, n.d.). The Coeur d'Alene Tribe's reservation boundaries overlap with Benewah County, the Silver Valley is in Shoshone County, and the growing city of Coeur d'Alene in Kootenai County (Table 4.1). The socio-demographic characteristics in Benewah and Shoshone County are similar; their populations are poorer, more rural, and less educated relative to Kootenai County, and most other counties in Idaho. Over 20% of Shoshone County's population under the age of 65 is on disability. Benewah County contains the smallest population, with 8.5% of its population being American Indian and Alaskan Native. Kootenai County, Idaho's third largest county, reflects a growing population and a socio-economic status that either exceeds or is similar to average for Idaho. Coeur d'Alene Lake is a primary reason for growth in Kootenai County as shoreline development, featuring multiple resorts and residential development, has increased in recent years (Criscione, 2018).

Investigating the nature of the hydrosocial relations experienced by the Tribe as well as rural communities in the Silver Valley following the collapse of the mining industry provides insight into the different ways that Shoshone and Benewah County have arrived in similar socio-demographically underprivileged positions relative to Kootenai County and the rest of Idaho. Events in the 1970s, including a downturn in the global economy, a public health crisis from acute lead [Pb] toxicity, and new environmental regulations, brought an end to primary mining activities in the Silver Valley (Mix 2016). Blood screenings in this decade revealed that 99% of Silver Valley area children had a Pb level greater than 40 micrograms of Pb per deciliter of blood (μg/dL), with the highest recorded at 164 μg/dL (Idaho Department of Health and Welfare, 2018; von Lindern et al., 2003). Remediation of 7,153 properties and removal of primary mining infrastructure has greatly reduced the health risks associated with Pb contamination. As of 2018, social and economic conditions are slowly improving as economic redevelopment activities progress and childhood blood lead levels approach national averages (Helkey, 2018). Redevelopment strategies in the Silver Valley have included development of trails and recreation areas that further contribute to the strong connection with place found in Silver Valley communities.

Remediation activities, such as source control and water treatment remedies, are a major focus of management in the Silver Valley (BEIPC, 2017). The Panhandle Health District manages two programs that support continued efforts to protect human health and the existing environmental remedy – the lead health intervention program and the Institutional Controls Program (Panhandle Health District, 2018). Local control of these programs has allowed the District to develop – and continually adapt – programs that are more effective in protecting health in the tightknit communities of the Silver Valley. For instance, in 2018, the District posted new warning signs at popular recreation areas to better communicate remaining health risk from primary contact with Pb contamination (Helkey, 2018). The new signs were developed in close consultation with community groups.

Although the socio-economic situation in Benewah County appears similar to that of Shoshone County and the Silver Valley, the hydrosocial narrative of the Coeur d'Alene Tribe is quite different. The Coeur d'Alene Tribe has been and continues to be disproportionately impacted by hazardous waste because of Federal Indian policy guided by the ideals of the Doctrine of Discovery[1] and Manifest Destiny[2] (Royster, 1993). The Coeur d'Alene Tribe is a sovereign nation that has occupied the region since time immemorial (Frey & Stensgar, 2012). Mining activities in the Silver Valley were a primary driver for European settlements and a source of disruption and severe hardship within the Coeur d'Alene Tribal community (Mix, 2016). To maximize the economic potential of the region, the Coeur d'Alene Indian Reservation boundary was finalized under an executive order of 1891, which subsequently reduced Tribal authority over ecosystem governance (Woodworth-Ney, 2004). Mining challenged the Coeur d'Alene Tribe's ability to self-govern by transforming the social and ecological landscape. The

[1] The Doctrine of Discovery was an international legal principle that justified the settlement of non-European territories inhabited by Indigenous communities by European nations (Miller 2011).

[2] Influenced by the Doctrine of Discovery, Manifest Destiny was a concept implemented by the American government to give reason for the westward expansion and conquest of Native American Tribal territories to spread the religious and governance practices reflective of the American society (Miller 2011).

mining industry directly threatened the Tribe's water security and governance, a common outcome for many mining impacted Native American Tribes across the western United States (Curley, 2019a, 2019b; Montoya, 2017). Today, metal contamination jeopardizes the well-being of the Tribal community by limiting access to culturally significant foods and recreational activities. For example, contaminated wetlands throughout the lower reaches of the Coeur d'Alene River have compromised flora and fauna that are culturally and spiritually significant to the Tribe such as water potato (*Sagittaria latifolia*), a traditional food source for the community (Campbell et al., 1997). Collectively, contaminated resources threaten the cultural values and subsistence practices of the Tribe, thereby affecting their self-determination.

Mitigation efforts administered by the Tribe reflect a holistic perspective focused on improving ecosystem health from a seventh-generation perspective (IDEQ & Coeur d'Alene Tribe, 2009). The Tribe prioritizes restoring damaged ecological and cultural resources (i.e., water potato) through mitigation, remediation, and restoration methods. These methods are informed by scientific monitoring and management efforts administered by scientists employed by the Tribe and the State of Idaho. Scientific data is a critical component for the preservation of place and acknowledgement of Tribal sovereignty (i.e., inherent right to govern) for Native Nations (McCarty & Lee, 2014). The Tribe's sovereignty within reservation boundaries and its aboriginal territories, which expand beyond the catchment boundaries, has supported these efforts.

The diversity of priorities and stakeholder groups in this region, along with years of contentious governance, have led to the establishment of several carefully planned collaborative institutions in the region. These institutions include the Basin Environmental Improvement Project Commission (BEIPC) and the Restoration Partnership (Figure 4.2). Together, these collaborative bodies set joint priorities and resolve conflicts between groups. BEIPC was established by the Idaho Legislature under the Basin Environmental Improvement Act of 2001 (section 39-8105) to coordinate environmental remediation, natural resource restoration, and related measures to address water quality and heavy metal contamination (Basin Environmental Improvement Act, 2001). BEIPC's purpose and function are outlined by a Memorandum of Agreement between seven primary governments including the federal government, Coeur d'Alene Tribe, States (Idaho and Washington), and the three counties (Benewah, Shoshone, Kootenai) (Basin Environmental Improvement Act, 2001).

The Restoration Partnership is a product of years of planning and a series of lawsuits. Partners – called Natural Resource Trustees in CERCLA – include the Tribe, State of Idaho, and

Federal government. A series of lawsuits between Trustees and mining companies, including the 2009 settlement with ASARCO Mining and Smelting Company, provides the Trustees with resources for conducting restoration and remediation activities within the boundaries of the Institutional Controls Program (Restoration Partnership, 2018). In 2018, a final Restoration Plan, aligned with the Environmental Impact Statement for recovering damaged natural resources through NRDAR, was finalized with a goal of restoring, rehabilitating, replacing, or acquiring the equivalent of the natural resources and the services they provide injured by mine water contamination. The two research partnerships described in this paper aimed to contribute to research that benefited the partnership participants and advanced community goals related to reducing ecological and public health risks.

Theoretical Frameworks

Reciprocal relations are a core value across participatory research approaches and invoke intimate, mutual obligations between place and people (Diver et al., 2019). Reciprocal relations have been explored in hydrosocial research and in the common pool resources literature where increased reciprocity has been demonstrated to motivate collective action by influencing social norms and individual decision-making (Ostrom, 1990). In Indigenous communities, participatory research is more than a research practice, it is a political and ethical undertaking; Indigenous knowledge is rooted in a holistic knowledge system that is inseparable from the socio-cultural, political, legal, and relational structure (Mach et al., 2020). Diver et al. (2019) contends that reciprocal relations are important in communities "seeking to regain not simply benefits, but rather mutually beneficial relationships and responsibilities to land, water, and resources" (p. 406).

Acknowledging the cultural values of the Coeur d'Alene Tribe, the Tribal partnership drew from of Participatory Action Research (PAR) approaches grounded in the fundamental principles of Indigenous Research Methodologies (IRM). For the Silver Valley partnership, PAR provided guidance for co-producing knowledge with a community group focused on ensuring that people can live safely in a place with a long history of industry and extraction. These frameworks guide research development and help researchers to recognize primary phases of conducting ethical research. Common phases of IRM and PAR include: (1) establishing a research agenda; (2) promoting community voice and goals, data accessibility, and literacy; and (3) maintaining ethical partnerships (Figure 4.3). Ultimately, these frameworks helped researchers address questions summarized in Chambers (1997, p. 284): Whose categories and concepts count? Whose values and criteria? Whose preferences and priorities? Whose analysis and planning? Whose action? Whose monitoring and evaluation?

Participatory Action Research

PAR aims to facilitate more equitable and inclusive research by placing the research process in the hands of the community (Cornwall & Jewkes, 1995; Curwood et al., 2012). The premise of PAR is that models making causal inferences about human behavior are more likely to reflect the local context when the "human beings in question participate in building and testing them" (Argyris & Schön, 1989, p. 613). PAR offers guidance for engaging community partners throughout the research process (Figure 4.3). Community partners aid in articulating research goals and assist in research design and implementation (Hacker, 2013). Ideally, as a partnership develops, the decision-making power shifts as community partners take on more control of the research. Throughout the partnership, researchers should ensure that the project remains responsive to community voices and goals by employing iterative cycles of inquiry, action, and reflection (Mackenzie et al., 2012). When community partners control partnership activities, research outcomes are more likely to persist (Schensul et al., 2008). The success of PAR depends on the strength of partnership, skills of researchers, and the ability to sustain research outcomes (Greenwood et al., 2015).

Indigenous Research Methodologies

While socially responsive, the guidance of PAR on its own does not provide adequate direction for forming equitable and inclusive partnerships with colonized Indigenous communities. Historically, Indigenous communities, such as Native American Tribes, have been severely mistreated by western researchers (Hodge, 2012; Mello & Wolf, 2010; Mitchell, 2018). The disrespect and mistreatment of Indigenous communities during and after the research process stem from a colonialism mentality (Smith, 2013). The acknowledgement of colonialism in research led Indigenous scholars to develop IRM, which aims to decolonize the research process by elevating Indigenous epistemology and principles through ethical relationships (McGregor et al., 2018; Mitchell, 2018). Over the past twenty years, Indigenous scholars have advocated for the use of IRM facilitated through PAR to form ethical, trusting, and lasting relationships with Indigenous communities (Bang & Medin, 2010; Brayboy & Deyhle, 2000; Kovach, 2010; Peltier, 2018; Smith, 2013; N. J. Wilson et al., 2015). As articulated in Wilson (2001), IRM offers a fundamentally different paradigm because knowledge is not owned by an individual entity, rather, it is "shared with all of creation… It goes beyond the idea of individual knowledge to the concept of relation knowledge" (p. 176-177).

Among Indigenous people, relational knowledge includes water not as just a physical substance but as an important link across all relations, an entity that connects, nourishes, and stewards (Arsenault et al., 2018; Wilson & Inkster, 2018). Grounded in the Indigenous principles of the four Rs (i.e., relationship, respect, responsibility, and reciprocity), IRM offers an approach to inquiry that recognizes the importance of community control in sustained capacity building (Evans et al., 2009). Applying principles for building relationships and respect helps to initiate partnerships, while responsibility and reciprocity are appropriate for promoting community goals and maintaining trust (Kovach, 2010). PAR can sometimes have constructive applications in Indigenous communities because the framework includes acknowledgment of relational knowledge (Datta et al., 2015). However, for PAR to be effective, Indigenous scholars emphasize that research must have empathy for their participants and aim to be accountable to the community (Smith, 2013; Wilson et al., 2015).

Partnerships in the Study Region

The two research partnerships described in this paper were associated with two doctoral students' dissertation research and began in the spring of 2016. Both students were National Science Foundation's Integrative Graduate Education and Research Traineeship (NSF-IGERT) fellows via the University of Idaho. The IGERT program provides students with an interdisciplinary water resources education that promotes socially responsible practices in research and the development of innovative problem-solving approaches (e.g., Cosens et al., 2011). Students received training on topics such as science communication, Tribal sovereignty, conflict mediation, and values. The two doctoral students, also the lead authors of this manuscript, led the design and implementation of the research, providing a suitable opportunity for comparison between projects. Both students are female scientists raised and educated under a western Eurocentric lens, and neither student had prior experience working or living in the region. The projects conducted within the partnerships were conceived as primary deliverables for the students' dissertations. Both partnerships included research designs that relied on primary data collection and projects aimed at capacity building by promoting community voice and goals, increasing access to scientific data, and improving scientific literacy of local citizens. Table 4.2 provides an overview of the projects conducted through both partnerships. In addition to working towards community capacity building goals, the final deliverables from these projects contribute to more generalizable scientific research outcomes.

The Tribal partnership, between the Coeur d'Alene Tribe and university researchers, supports existing Tribal efforts to mitigate water quality issues stemming from toxic metal contamination within the lower reaches of the Coeur d'Alene subwatershed and St. Joe subwatershed through an interdisciplinary framework that draws from approaches in community engagement, aquatic ecology, and education. The doctoral student connected with the Tribal partnership had training and a disciplinary background in science, informal education, and management. The Silver Valley partnership with the District, occurred in the upper reaches of the Coeur d'Alene River subwatershed in the communities near the Superfund site. The student's training and background in the Silver Valley Partnership focused in law, policy, and management. The Silver Valley partnership assesses risk perceptions and behavioral responses to lead contamination among residents and community leaders to inform the District's risk communication strategies.

Coeur d'Alene Tribe (Tribal) Partnership Overview

The Tribal partnership and collaborative research commenced informally during the summer of 2015, while the doctoral student served as an intern for the Tribe's Department of Education (DoEd) and Lake Management Department (LMD). Primary research studies were guided by an interdisciplinary research framework and stemmed from conversations during the student's summer internship experience (Repko, 2008). This framework relied on research approaches in community engagement, aquatic ecology, and science, technology, engineering, and mathematics (STEM) education to support the Tribal community's existing water quality mitigation goals. The researcher consulted with educators and ecologists from the Tribe throughout all phases of the studies.

The studies conducted through the partnership included a limnological study and a culturally-relevant STEM education study involving Coeur d'Alene Tribal youth. The limnological study was conducted with the Tribe's LMD and explored the role of aquatic macrophytes in metal and nutrient distribution within temperate lakes. The LMD and the Tribe's DoEd collaborated with the graduate student to develop and implement a STEM education study which entailed the evaluation of a culturally-relevant STEM program and affiliated internship on Tribal youth interest in STEM. The STEM education program and internship focused on the development of Tribal leaders in STEM to manage their impaired waters, while the limnological study provided valuable scientific data on the distribution and cycling of metals within a lake ecosystem. When combined, the studies explored how interdisciplinary approaches support the Tribal community's capacity to mitigate their contaminated water resources as a sovereign nation.

Silver Valley Partnership Overview

The partnership with the District began during conversations with District employees at quarterly BEIPC meetings and other community events. These conversations inspired the development of a research project to better understand residents' behavioral responses (e.g., avoiding contaminated areas) to lead contamination. The District's interest in the partnership objective developed from concerns that people were not taking adequate steps to avoid lead contamination, particularly while recreating in area rivers and working outside. District employees expressed strong connections to the Silver Valley, as evidence by their long employment tenure in the region and interest in building community capacity. The objectives and research design implemented in the Silver Valley partnership were co-developed between District employees and university researchers. An initial study, about residents' behavioral responses contributed a social science perspective to the existing data and research studies about blood lead levels in children and physical data about contamination in the environment (e.g., Spalinger et al., 2007). A follow-up study focused on how community leaders prioritize economic development and issues related to environmental health, including regional water quality impairments.

As the partnership formed, the District was also implementing a new risk communication campaign that involved posting updated signage at public recreation access points. As a result, the researchers and District employees developed and tested a college-level curriculum focused on a critical illustration of the rationale behind the new risk communication strategies (Cooper et al., in review). The team also worked together to establish a science and technology fair in the Silver Valley, now in its third year, the event annually attracts around 200 industry representatives, non-profit groups, agency personnel, and students.

Comparing Phases of Participatory Research

In this section we compare the participatory research approaches that guided the Tribal and Silver Valley partnerships. Specifically, we compare three overlapping partnership phases: establishing, promoting, and maintaining (Figure 3). By focusing on these three phases, we reflect on how using different participatory research frameworks influenced how the two partnerships developed.

Establishing Research Agendas

Initially, university researchers attended events hosted by community partners without discussing specific research agendas. Participation in events included volunteering at education programs and attending culturally significant events such as community dinners and outdoor recreational activities. Attending events without a specific research agenda allowed researchers to learn about the complex hydrosocial territories and provided time for cultural and social recognition (Kovach, 2010). Both doctoral students devoted a significant amount of time to establish an authentic relationship within their respective communities since they were not former residents of the region or members of the community. Research questions in both partnerships originated from ideas that aligned with existing programs, scientific reports and data, as well as community goals. However, formal community needs assessment was not conducted in either partnership as recommended in PAR (Hacker, 2013). Both the District and the Tribe already had goals and ideas in place regarding approaches for conducting scientific research investigations.

The doctoral student formed an authentic relationship with the Tribe by attending events and interning with the Tribe's LMD and participating in a culturally relevant STEM camp affiliated with the Tribe's DoEd. These experiences provided the doctoral student with an opportunity to learn about the community and culture as well as existing programs and research needs. Stemming from these experiences, the limnological study was informed by five years of data collected by the Tribe's LMD on the fate and transport of metals within aquatic ecosystems. The culturally-relevant STEM program and affiliated internship opportunity built from existing programs and previous research partnerships. A community partner with the Tribal partnership highlights the importance of positioning research alongside community goals and programs by urging researchers to "start the relationship early and let the Tribe's needs guide you" (Sam, March 2019). Taking the time to form a relationship with the partner, allowed the doctoral student and additional researchers to educate themselves about the Tribe's unique cultural and connection to their land. This additional time allowed them to recognize existing efforts as well as community voices and goals in each study.

In the Silver Valley partnership, informal interviews and participant observation were essential for establishing research projects that aligned with community goals. Initial conversations with community leaders improved the researchers' understanding of health issues and community goals. Conversations focused on identifying different perspectives about healthy living environments in the Silver Valley rather than focusing on a specific research question. The participatory approach was reinforced by a District employee who suggested that "it's important to constantly check in with the people who are in the thick of it to understand the small bits of information that mold ideas and dictate decision making," adding that researchers should "attend community social events to become a familiar face" (Cindy, June 2019). In both cases, university researchers provided space for community partners to share their stories, interests, and experiences. As researchers without prior experience in the region, attending community events helped to develop reciprocal relations and an understanding of existing social dynamics.

In both partnerships, roles and responsibilities were defined by both formal (e.g. Institutional Review Board (IRB) protocol) and informal agreements (Cross et al., 2015; Leisey, 2008). However, the partnership with the Coeur d'Alene Tribe required two IRB protocols, one with the University and one through the Tribe. The need for two or more IRB protocols is not uncommon in participatory research (Kelley et al., 2013). Participants working in Silver Valley partnership did not have this same experience as the District regularly works with University researchers and operates through service agreements. The need for careful consideration of possible ethical issues outside of those considered by University IRB protocols is an important component of establishing community-university partnerships. Flicker et al. (2007) stress that traditional university review protocols may not sufficiently address the ethical research dilemmas. In addition to developing protocols and designing research, the establishment phase provided time to identify the resources and expertise needed to complete studies that would build community capacity.

Promoting Community Voice, Data Accessibility, and Literacy

Once the partnerships formed, it was important for university researchers to continue building trusting relationships, learning about community goals, and understanding existing research infrastructure and projects (Hacker, 2013; Kovach, 2010). Both the limnological study and the study about behavioral responses to Pb contamination exemplify how partnerships can improve access to scientific data and advance community goals. The Silver Valley partnership supports a need to better protect human health through improved risk communication while the Tribal partnership supported science data that will help recover culturally-important, injured resources. The projects that formed within the two partnerships took these directions because of the goals of their community partners. However, because the researchers and community partners formed relationships prior to beginning research, the studies also developed around the doctoral students' background, strengths, and expertise. Working on projects, based on both community goals and the students' expertise helped to ensure more sustainable projects.

The limnological study with the Tribe filled an ecological research gap within the LMD. In addition to providing scientific data, educational programming was a primary outcome. The STEM education study evaluated a six-week internship and affiliated STEM program. This informal educational opportunity relied on the local environment and cultural knowledge to educate Native American youth on the environmental hazards impacting their local waterways. The results of this study indicate that an increase in youth relationship to place and comprehension of STEM strengthened their interest in pursuing a career path in STEM fields for the Tribe. The Silver Valley partnerships provided the District with support for improving their risk communication strategies, including funding for research from two small pilot grants. Participating in community outreach activities was also important in the Silver Valley partnership. Members established and organized an annual educational science and technology fair in the Silver Valley. At the fair, college students and local primary school students interacted with education and outreach groups, industries, and non-profits to learn about health and environmental contamination. The fair expands the District's outreach capacity and provides an opportunity for community engagement.

Open communication within the partnerships allowed university researchers to alter research designs when necessary to redirect the research to meet capacity building goals. For instance, during conversations conducted with the Tribe a community partner emphasized that, "it is key to be upfront and open, what it is the University is getting from it and what the Tribe or community is getting from it" (Julie, March 2019). Interviews associated with the Silver Valley partnership reinforced the importance of open communication. An interviewee stated that "if you (the researcher) are trying to do some research that could help the community, then you absolutely have to involve them. Otherwise, you might be missing the point in terms of what you come up with" (Sarah, June 2019). In the two partnerships, open communication allowed the research studies to align with the goals of the community partners. These examples are central to the rationale behind conducting research through practice described in relational knowledge paradigms and through participatory research approaches (Datta et al., 2015; S. Wilson, 2001).

Maintaining Ethical Partnerships

Maintaining trusting relationships through the duration of a partnership requires commitment between partners and frequent reflection (Hacker, 2013; Kovach, 2010). Partnership personnel must remain dynamic and flexible to adjust to changing circumstances (McMillan, 2012; Wallerstein & Duran, 2006). To mitigate impending change, Indigenous scholars advocate for community participants to provide the 'final say' in the development, implementation, and dissemination of research (Kovach, 2010). However, transitioning between personnel and projects can present issues because building trusting relationships requires an investment of time and resources (Christopher et al., 2008).

The doctoral student and affiliated Tribal partner worked to sustain the partnership by broadening access to a place-based science curriculum and integrating activities into informal and formal curricula. Currently, the curriculum provides “a groundwork for other informal curriculums...It is something that was easy to follow for other resource managers” as expressed by a DoEd employee affiliated with the Tribal partnership (Julie, March 2019). The limnological study drew from multiple scientific disciplinary approaches for studying contaminated aquatic environments. An aquatic ecologist with the LMD thought the data affiliated with this study was “very helpful in assisting [LMD scientists] to understand the role of macrophytes (aquatic plants) in contaminated aquatic environments” (Tom, March 2019). The LMD will implement the data into a lake wide model to study the biogeochemical cycling of metals and the impact of remediation methods on lake ecosystem function. Developing datasets that community partners can use is a recommended method in PAR as data sharing promotes community capacity building (Datta et al., 2015).

The Silver Valley partnership relied on techniques from PAR to sustain knowledge developed through the research studies. For example, prior to conducting a survey of residents within the Silver Valley, the researchers pre-tested the instrument with residents at events and reviewed preliminary results with the District. Pre-testing the tool provided an opportunity for reflection, which allowed the survey instrument to become more reflective of community goals. Further, the survey was distributed through the drop-off, pick-up method, which is a recommended method in PAR practices as it capitalizes on the social exchange theory, allowing researchers to briefly interact with community members who participate in data collection (Trentelman et al., 2016). The District will be able to use the data, as well as project deliverables, to improve their risk communication strategies.

Continually planning for and applying to future opportunities was integral to maintaining relationships in the Silver Valley partnership. After initial data collection, the University researchers and an employee from the District attended a workshop together at the Socio-Environmental Synthesis Center to collaboratively develop curriculum to teach both the lay public and college students about the health risk of Pb contamination. In late phases of the Silver Valley partnership, the University researchers helped to secure additional funding and mentor another doctoral student to continue working towards partnership goals. In addition, the final project in the partnership was designed primarily as a reflective study for the doctoral student. The project assessed environmental health (e.g., good water quality) and economic development. Results from this study contribute to broader discussions about future decision-making and policies in the Basin.

Recommendations for Participatory Research

PAR and IRM provided guidance for conducting more inclusive and equitable research processes. Partnership limitations were related to traditional barriers in participatory research such as the researchers' positions as students and partners' time (Chambers, 1997; Mackenzie et al., 2012). Because these limitations were made transparent from the onset of the projects, the researchers were able to form lasting relationships within the communities and lower barriers that may be experienced in future partnerships between the university and community partners in the region. The emphasis on process and the time lags between project implementation and outcomes posed more formidable barriers to partnership success. Reflecting these challenges, several lessons emerged within each phase of partnership development: (1) build from established programs, goals, and personnel, (2) identify respectful levels of community engagement, and (3) recognize partnership limitations. These lessons learned are relatively simple and supported by an extensive collection of research about participatory process. Their simplicity reiterates the importance of developing context-specific approaches to participatory research and provide starting points for developing participatory research.

Building from Established Programs, Goals, and Personnel

Wilk and Johnson (2013) argue that participatory research approaches often, "fail to acknowledge and address the plurality of standpoints, uneven power dynamics, conflicting stakes, and distributive inequalities" (p. 697). While true, this critique also applies to research based on one-way knowledge flows. In the partnerships explored here, spending extra time in the beginning to establish relationships helped to balance power throughout project implementation. Both partnerships formed around established programs, goals, and personnel, and neither of the graduate students had existing reciprocal relations within the study region. Working with established partners allowed the research studies to better align with other ongoing projects and goals in the region. In both partnerships, community partners goals prioritized reducing existing health and economic disparities in the region. Understanding the hydrosocial dynamics was important to developing research studies within each partnership. In addition, it allowed university researchers to build on the existing community of practice, limiting the possibilities of research fatigue, and redundancy.

Identifying Respectful Levels of Community Engagement

The university researchers within both partnerships found participatory methods essential for identifying a respectful level of community engagement. For the partnership with the Tribe, researchers found guidance from IRM was particularly useful in building ethical relationships during the first year of the partnership. Establishing trusting relationships lowered other barriers to participatory research by decreasing the additional resources needed to engage communities. Learning about community goals and issues prior to initiating research provided the time needed to define realistic goals and objectives for the research projects. Although not always the case, both partnering entities had specific research interests and needs, which guided the projects that developed from the partnerships.

Recognizing Partnership Limitations

Identifying an appropriate balance between developing graduate students' disciplinary depth and community capacity building is important both for ensuring that students are well-directed and that the research processes leads to a bi-directional flow of knowledge (Duchelle et al., 2009; Morse et al., 2007). This is a critical step that requires careful consideration on both sides of the partnership. If not properly addressed, proposed research may not be completed, which can jeopardize the partnership. Researchers must acknowledge structural constraints by, for instance, being prepared to provide extra time to complete projects if needed (Flicker et al., 2007; Halbe et al., 2018; Long et al., 2016). Establishing relationships early on helps to identify disciplinary expertise among the partnership and build a support network for navigating structural constraints to conducting participatory research.

Non-structural barriers to participatory research remain more challenging to overcome. One such barrier is the challenge of documenting outcomes for research where measures of success are embedded in the process. Participatory research provides limited guidance for best practices in evaluating participatory research outcomes (Mach et al., 2020; Turnhout et al., 2020). While important, monitoring and evaluating outcomes is both a logistically challenge and can compromise the iterative nature of a participatory process (Anticona et al., 2013). Whether participatory research has a positive impact is ultimately a subjective judgement made by the people involved in the research projects (Martenson et al., 2012). Focusing on outcomes can lead to unidirectional knowledge exchange that detracts from the goals of participatory research and shifts power back to the researchers (Mach et al., 2020).

Creating venues for open forums and community advisory boards is essential for effective monitoring and evaluation (Hacker, 2013). For the two partnerships explored here, the doctoral students were encouraged by mentors and through the guidance of participatory research methods to evaluate project impacts by creating an open forum for iterative knowledge exchange. Once space for knowledge exchange emerges, it is possible to understand how research outcomes can be more equitably evaluated. Systematically monitoring decisions in open forums is ideal for building understanding of outcomes but such monitoring must be implemented in ways that do not compromise the organic nature of knowledge production (Mach et al., 2020; Mukherjee et al., 2018). Future participatory research should continue to develop methods that include clear, flexible, and minimally intrusive methods for monitoring and evaluating project outcomes. Recognition of the diversity of approaches for participatory research is necessary for evaluating, funding, and advancing the processes that lead to more equitable approaches. Researchers conducting participatory research should utilize participatory frameworks to guide research that are sensitive to local contexts and meets rigorous standards for scientific research.

Conclusion

Qualitative assessment of the three phases of community-university partnership development evaluated in this study provide an approach for comparing participatory processes. We demonstrated applications of PAR and IRM through two partnerships involving Tribal and non-Tribal rural communities in a mining-impacted region. Difficult questions about how to design more equitable and inclusive research did not disappear within the two partnerships explored in this paper, rather they are made more explicit and provided an opportunity for researchers and community members to work together to balance power associated with research design and implementation. Participatory research frameworks such as PAR and IRM prioritizes community capacity building through equitable partnerships that acknowledge and embrace relational knowledge alongside scientific inquiry.

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Tables

Table 4.1 Select socio-economic characteristics of counties in the study region

Demographic		**Benewah County**	**Shoshone County**	**Kootenai County**	**State of Idaho**
Population					
	Total	9,226	12,796	161,505	1,787,065
	Population density (per km^2)	31.1	12.7	288.3	49.2
Race					
	White	86.6%	94%	94.5%	93.0%
	American Indian and Alaskan Native	8.5%	1.8%	1.3%	1.7%
Education					
	High school graduate or higher	88.3%	85.6%	92.5%	90.6%
	Bachelor's degree or higher	15.1%	11.6%	24.9%	26.9%
Health					
	Disability, under the age of 65	13.2%	20.3%	9.1%	9.3%
Income & Poverty					
	Mean household income	$46,507	$39,091	$54,457	$53,089
	Persons in poverty	14.7%	18.8%	10.3%	11.8%

Table 4.2 Primary partnership projects.

Partnership Project Titles	Summary	Capacity Building Goals
Silver Valley		
Behavioral responses to Pb contamination in a mining-impacted area	Community survey of resident's perceptions and behavioral responses to lead contamination. Supported by pilot grant program.	• Data accessibility • Community engagement • Resource generation
Challenges and opportunities for risk communication in the Silver Valley	Case studies-based curriculum development about the Health District's risk communication strategy.	• Policy recommendations • Risk communication strategies • Curriculum development
A Q methodology approach to identifying environmental, public health, and economic development perspectives	Interviews and card sorting activity (Q method) to understand how leaders view tradeoffs between environmental health and economic development.	• Policy recommendations • Data accessibility
Silver Valley science and technology fair	An annual event to exchange information between community members, environmental managers, university students, and researchers.	• Community engagement • Information dissemination
Tribe		
Variations in aquatic macrophyte phenology across three temperate lakes	Phenology assessed through the collection of water quality parameters, biomass and biovolume. Results informed the experimental design for lake enclosure experiment.	• Data accessibility • Sampling methods • Community engagement
Metals and Nutrients Association with Macrophyte Senescence and Decomposition in Thompson Lake	Temporal change within the physicochemical environment as well as nutrients and metal concentration was examined in two enclosures types (plants vs. no-plants)	• Data accessibility • Contamination management • Community engagement
Supporting Native American Community Leadership through Culturally-Relevant STEM Education	Culturally-relevant STEM programming to further youth interest in STEM. Impact of study was evaluated through a case study research approach.	• Literacy • Community engagement • Curriculum development and instruction

Figures

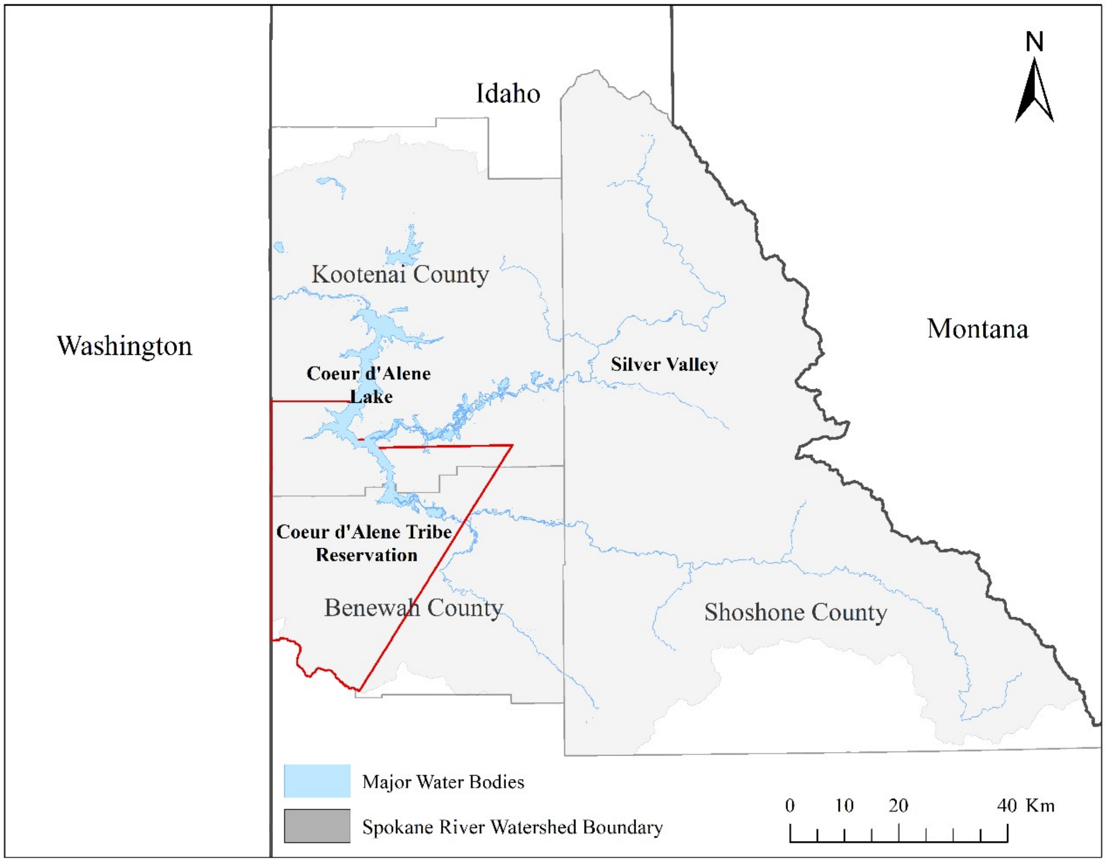

Figure 4.1 Map illustrating the hydrosocial territories of the study region, which includes three counties (Benewah, Kootenai, Shoshone), jurisdictional boundaries of the Superfund Site, as well as geographical boundaries for the Spokane River Watershed, Coeur d'Alene (CdA) subwatershed, and St. Joe subwatershed.

Source: USGS Watershed Boundary Dataset, Alta Science and Engineering, Coeur d'Alene Tribe of Indians (accessed at Koordinates.com).

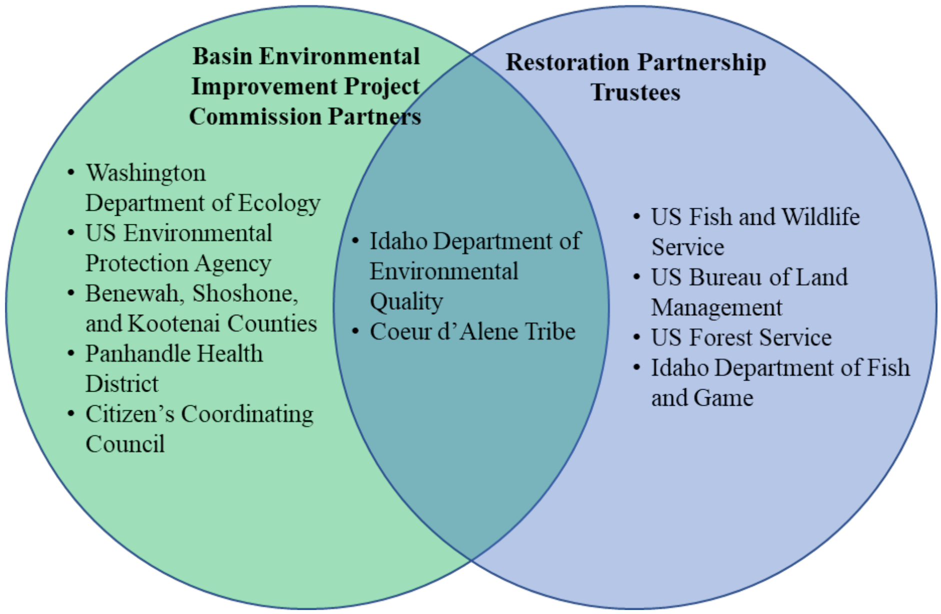

Figure 4.2 Primary partners included in collaborative groups related to managing mining impacts in the Coeur d'Alene region.

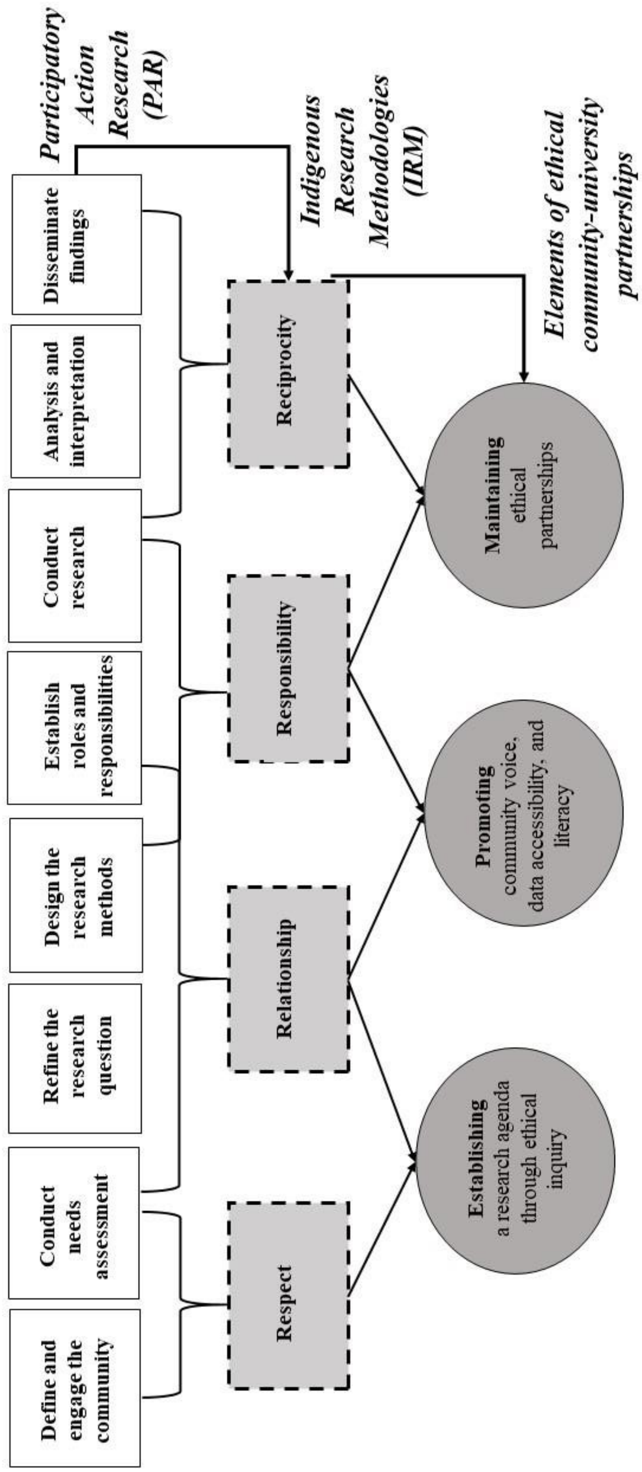

Figure 4.3 Conceptual diagram illustrating the three partnership phases and the iterative cycles of inquiry, action, and reflection employed in participatory research approaches.

Chapter 5: Challenges and opportunities for communicating lead exposure risk in Idaho's Silver Valley

Abstract

Sources and exposures to lead [Pb] have declined in the United States following enforcement of new regulations and the removal of Pb from gasoline and paint. However, even small amounts of Pb in the human body have negative health consequences and contaminated soil remains a primary source of exposure, particularly in mining-impacted regions. Communicating the health risk associated with exposure to Pb is an important objective for health districts in these regions. Idaho's Silver Valley, the location of a complex Superfund site, provides a unique case for examining challenges and opportunities for communicating the health risk and recommended behaviors associated with possible exposure to Pb-contaminated soil and dust. The objective of this case is to evaluate how residency time in a contaminated area influences risk perceptions and behavioral intentions, and to describe challenges and opportunities for communicating risk in regions with long-term contamination. We draw from risk communication strategies and a community survey about risk perception. The survey indicates that most residents are aware of the existing health risk and that a risk perception normalization effect may have a small influence on level of concern for longer-term residents relative to shorter-term residents. The same effect is not apparent for residents' behavioral intentions. Lessons learned from this examination – for example, updating health risk communication messages regularly through deliberative processes – may help other communities impacted by long-term contamination.

Introduction

Heavy metal contaminants such as lead [Pb] are associated with public health risk and often present at Superfund sites (Jaishankar et al., 2014). The Superfund program is a federal program, administered by the US Environmental Protection Agency (USEPA), to investigate and remediate and restore sites containing hazardous substances such as heavy metals (USEPA, 2018). Pb exposure is one of the most widely recognized risk associated with heavy metal contamination (Needleman, 1991). Exposure to Pb can damage the central nervous system, lead to learning difficulties, and cause behavioral changes (Friedman et al., 2015; Muller et al., 2018). Children and pregnant women, especially low income and minority groups, are most vulnerable to health effects (Canfield et al., 2003; Kegler & Malcoe, 2004; Whitehead & Buchanan, 2019). People can be exposed to Pb by ingesting or inhaling contaminated materials including dust, soil, consumer products, or water (Vorvolakos et al., 2016). Pb is a primary contaminant of concern in and around hundreds of Superfund sites in the US (Klemick et al., 2020). In 2012, the Centers for Disease Control (CDC) concluded that there is no evidence of a safe level of Pb exposure for children due to results from recent studies about the long-term negative consequences of Pb exposure (Betts, 2012; Vorvolakos et al., 2016). While Pb exposure is often associated with developmental delays in children, it is also linked with other negative health outcomes including non-communicable diseases such as obesity and cardiovascular disease (Betts, 2012).

Primary prevention, or the complete removal of a hazard, is a priority at Superfund sites. However, the complete removal of hazards is often infeasible, and primary prevention must be complemented by secondary prevention. Secondary prevention includes risk communication. Risk communication is formally defined as the exchange of real-time information, advice, and opinions between experts and people facing threats (WHO, 2019). Formal risk communication includes promoting exposure-reducing health protective behaviors, or actions to reduce exposure risk, for example, washing hands and avoiding contaminated areas (Kegler & Malcoe, 2004). Informal risk communication also occurs as communities develop coping strategies for managing a risk (Adeola, 2011; McGee, 1999). Informal or formal means of risk communication are both important for promoting health protective behaviors, mitigating negative health outcomes, and informing community-based decisions (Hoover, 2017). When someone perceives a higher risk, they are more likely to act, so risk communication often focuses on elevating risk perception (Schulz & Northridge, 2004). While there are many definitions of risk perception, Aven & Renn (2009) define it as a two-dimensional judgement that a person holds towards how severe the consequences of an activity or event might be, and how uncertain those consequences are. For Pb exposure, the perceived severity of consequences includes beliefs that exposure to Pb poses a severe health threat, and that one could experience health effects. However, people may have different perceptions of how certain it is they are being exposed to Pb.

Health risk messaging literature provides insight into how to encourage health protective behaviors through the Extended Parallel Process Model (EPPM; Figure 5.1). The EPPM has guided thousands of public service announcement campaigns, like smoking cessation (Glanz, 2015). The model guides parallel understanding of whether a health risk message will lead to a desired behavior change. The model is based on assessment of: (1) perceived risk (perceived susceptibility + severity); and (2) perceived efficacy (perceived response efficacy + self-efficacy) (Bandura, 1977). Perceived severity and perceived susceptibility distinguish whether a person perceives a risk as severe and believes they are susceptible to experiencing negative health outcomes, respectively (Glanz, 2015). Perceived response efficacy and self-efficacy relate to beliefs that a behavior will effectively prevent negative consequences associated with a risk and beliefs that the person can effectively perform the recommended behavior (Witte, 2001). A risk message that fails to elevate perceived risk and perceived efficacy is less likely to lead to the desired behavior change (Witte, 1992). When a risk is not detected, an individual is unlikely to change their behavior. Furthermore, when perceived efficacy is low, defensive reactions and fear may mean the message backfires.

Effective health risk messages improve awareness and knowledge of a risk and assure that there are things individuals can do to effectively limit the risk. Cognitive, affective, social, and cultural factors influence an individual's risk perception (Harclerode et al., 2016; Wolde et al., 2019). For instance, existing literature suggests that prolonged awareness of and exposure to a risk can result in risk perception normalization, where individuals develop strategies to reduce their risk perceptions towards a known threat (Luís et al., 2018). Risk perception normalization has been linked to length of residency in a risk-impacted area and the degree of severity of the hazard (Janmaimool & Watanabe, 2014; Wolde et al., 2019). People who have lived in an area longer may perceive persistent hazards as being less risky relative to the perceived risk of shorter-term residents (De Dominicis et al., 2015). For example, Luís et al. (2015) found that people who lived in a flood prone area for longer and had direct experience with floods were more likely to exhibit signs of risk perception normalization. While the risk perception normalization effect is difficult to measure and represents only one of the many factors that influences risk perception, the effect may influence how individuals receive health risk messages at Superfund sites with long-term health risk from heavy metal exposure.

The goal of this case examination is to explore risk communication and risk perceptions related to Pb in the Silver Valley of Idaho, USA through an analysis of a community survey of risk perception and existing risk communication strategies in the region. The Silver Valley includes the second largest Superfund site by size with the largest residential population living within a Superfund site boundary (Mix, 2016). Remediation has been in progress since 1983 when the site was listed on the Superfund National Priorities List (EPA, 2012). The Panhandle Health District (District) leads initiatives to communicate the remaining health risk to residents.

Case Examination

Shoshone County, which encompasses the Silver Valley, has a mostly white population that has remained around 12,700 residents since the 2010 Census (Figure 5.2). The median income is $39,935 compared to $50,985 for Idaho as a whole. The population is aging, with nearly 25% of people above the age of 65. Shoshone County was 41st out of 42 counties in the 2018 Idaho County Health Rankings. On average, incidence of chronic diseases such as cardiovascular disease and obesity are higher in Shoshone County than other Idaho counties (Institute for Health Metrics and Evaluation, n.d.). Despite social, health, and economic disparities, the Silver Valley and the greater region are growing recreation and tourism destinations and is recognized tourism activities including skiing and downhill mountain biking.

Historic Mining

The Silver Valley is named for its 140-year history of metals mining. Mining began in 1883 and continues today on a much smaller scale (NRC, 2005). At the mining industry's peak, the Silver Valley included a sophisticated network of mining infrastructure, an extensive railway network, a zinc processing plant, and hundreds of mine sites (Aiken, 1994). The area is one of the largest metal-contaminated regions in the US, with close to 10,000 people living within the Superfund site boundary (2012). Concerns about human health and environmental degradation date back to the early 20th century. Discharging mine waste into rivers and streams was a common practice, and both miners and domestic animals began exhibiting symptoms of Pb poisoning (Mix, 2016). In addition, atmospheric emissions from a Pb smelter, which operated from 1917-1981, further increased levels of metal contaminants in the soil (Elias & Gulson, 2003).

Following a fire at the smelter in 1973, children experienced the worst case of acute symptoms of Pb poisoning ever documented in the US (Aiken, 1994; Rosen, 2003). Blood screenings of area children at the time revealed that 99% had Pb levels exceeding 40 µg/dL (von Lindern et al., 2003). These events, along with decreasing Pb prices and a changing regulatory environment, led to cutbacks and closures in mining operations (Mix, 2016). Contaminated mine waste washed down the South Fork of the Coeur d'Alene River and its tributaries and is documented as far as Spokane, Washington, approximately 75 miles away from the Bunker Hill Superfund site in the Silver Valley (Benson, 2019; Restoration Partnership, 2018).

Environmental Remediation and Restoration

Over 7,000 residential yards, green spaces, commercial properties, and other public areas have been remediated in the Silver Valley as part of the USEPA's primary prevention efforts (EPA, 2012). Remediation has included removal and replacement of a top layer of contaminated soil with clean soil. Blood lead levels among children have dropped to levels that are close to the national averages. Once-treeless hillsides have been revegetated and recreation sites draw all-season tourists in increasing numbers. Despite the remediation successes, complete containment of mine waste is infeasible, and risk remain (von Lindern et al., 2016). The clean soil that currently acts as a cap over the contaminated materials can be washed away during flooding events, re-exposing contaminated materials. Approximately 2500 km^2 of floodplains and wetlands, also popular recreation destinations, are a focus of primary prevention efforts as these areas are often contaminated. Seasonal flooding events exacerbate the health risk as even areas that were previously remediated can be re-contaminated.

Risk Communication

Risk communication is an important part of the District's approach to secondary prevention of Pb exposure. The District offers free blood lead level screenings, posts warning signs in areas with possible contamination, and provides resources to help residents limit contamination sources on their property (Panhandle Health District, 2019). People are also encouraged to practice health-protective behaviors. These include hand and face washing prior to eating and following recreation or outdoor work in contaminated areas, playing in grassy areas rather than on bare soils, not eating produce grown in contaminated soil, and washing potentially contaminated pets, toys, and recreation equipment (Panhandle Health District, 2019). Many of these behaviors help to ensure that contaminated materials do not enter indoor spaces where they can recirculate with house dust (Spalinger et al., 2007). The District recently updated its risk communication strategies for promoting health-protective behaviors. The changes were initiated because of concerns that people were engaging in non-health protective behaviors such as sitting directly on contaminated beaches rather than using a protective barrier like a towel. Even areas that look safe can be contaminated and posting signs in all contaminated areas is challenging because of the large size of the region.

Signs are a primary means of warning people when metal contaminants are present at public recreation access points and old mine sites in the Silver Valley. Initial signs featured skull and crossbones imagery (Figure 5.3)—a clear warning of the severity of the issues, but which failed to communicate the importance of practicing recommended health protective behaviors (i.e., building perceived efficacy). Silver Valley communities also expressed strong resentment towards agencies like the USEPA, especially in early phases of remediation at the site (Mix, 2016). The District replaced the initial signs with ones that listed recommended health protective behaviors and provided contact information. These signs were posted in more places but were difficult to read and often ignored by the public (Figure 5.4). For instance, signs were posted in areas set back from contaminated beaches that are also popular destinations for recreationists. Observations by the District indicated that recreationists did not pay attention to the signs.

The new risk communication strategy aims to take a more comprehensive approach to warning residents about Pb contamination risk through signage. To develop new signs, the District worked closely with other government agencies, local government, community members, and private landowners (US EPA, 2018). The revised signs integrate the region's rich mining history, illustrate historic images of mining, and explain why dangerous mine waste remains in the sediments (Figure 5.5). In doing so, they remind people of the severity of the risk. The new signs include a list of recommended health-protective behaviors, contact information for the District, and an outline of the associated health risk of Pb exposure. They are customized to specific locations, and in some instances, tailored to audience types. For instance, signs located on highly contaminated beaches, accessed only by water, will be replaced with signs that can be easily read from a boat. To appeal to dog owners, who should be washing off their pets, signs posted in contaminated areas where people frequently walk their dogs feature a picture of a dog playing outside (Figure 5.6). Eye-catching colors and images also help draw attention to the signs. Signs are connected to opportunities to practice recommended behaviors; temporary handwashing stations have been installed at certain recreation locations next to signs (IDEQ, 2016). Another communication venue is an Environmental Science and Technology Fair hosted by the District that allows residents and experts working on the Superfund remediation to exchange ideas and network .

Community Survey of Risk Perception

The long history of mining, environmental remediation, and risk communication in the Silver Valley could mean that long-term residents experience a risk perception normalization effect. The effect may influence resident's risk perception and the likelihood or whether they will practice health-protective behaviors. To investigate how the variables of the EPPM, perceived risk and perceived efficacy influence behavioral intentions, we conducted a community survey in March 2019, as the District's updated signs were being posted. The survey was distributed during the transition to the new health risk communication strategy and before the first summer recreation season when the new signs were posted. Respondents' exposure to the new signs was likely limited.

Design

The community survey was designed and pre-tested at community events in the Silver Valley (n=87). Pretesting the survey allowed validation – ensuring that questions were interpretable for residents. Survey questions asked people about their perceived risk related to possible exposure to Pb contamination, perceived efficacy, and behavioral intentions to practice recommended health behaviors, as well socio-demographic questions related to age, length of residency in the Silver Valley, gender, occupational status, and educational attainment. Survey questions were developed using the primary variables of the EPPM (perceived threat, perceived efficacy, and behavioral intentions), which align with other health behavior models (Glanz, 2015). In this paper, we report on several of the survey questions, for more detail on the community survey and the underlying variables associated with health behavioral intentions, see Cooper et al. (in review).

Two survey questions asked respondents about their general health risk perceptions related to Pb contamination, the Likert scale ranged from 1= no risk to 5= very high risk and included a "don't know" response option. Questions about perceived severity allowed respondents to report their general concern for household health issues and their specific concerns about health issues related to Pb contamination, the scale ranged from 1=not at all concerned to 5=very concerned. Respondents' perceived susceptibility was assessed through questions about whether a person believed they were susceptible to experiencing negative health consequences from Pb contamination. Questions related to perceived efficacy asked about whether respondents believed that they could act to prevent health consequences of Pb contamination, for instance, by believing that they were informed about the issue. The scale for questions about perceived susceptibility and efficacy ranged from 1=strongly disagree to 5= strongly agree. The scale for behavioral intentions ranged from 1 = never to 5 = very often. These questions also included an "I don't know" response option, which was excluded from the analysis.

Distribution and Data Entry

In March 2019, the full survey was distributed using a drop-off, pick-up distribution method in neighborhood clusters proportional to community populations in Wallace, Kellogg, and Pinehurst, 773 households were sampled. Neighborhood clusters contained multi- and single-family households. A pre-survey notification was mailed a week prior to the survey drop off period, and field staff visited each household up to three times to deliver surveys. Consenting adults (18 years of age or older) were eligible to participate, and participation was randomized by requesting that the responsible adult with the closest birthday complete the survey (Dillman, 2011). When a respondent agreed to complete the survey, staff coordinated a time to return to the house to collect the completed survey. After three failed delivery attempts to drop-off a survey, staff left a survey packet (cover letter and survey) and prepaid return envelopes at the residence. Of the 773 households, 306 surveys were completed, 30 of which were completed by mail. Conducting the survey in March ensured that the sample included our target respondents—full-time residents of the Silver Valley—because of variable winter and summer populations from recreation and tourism.

Survey data were manually entered into Qualtrics, an online survey platform. Each survey was entered twice by two different researchers and an accuracy check was performed. Discrepancies between the two entries (<1%) were manually corrected. The R Package mice was used to impute values for remaining missing data (<1% of response options) (van Buuren & Groothuis-Oudshoorn, 2011). Imputation did not change the level of significance of the chi-square tests.

Analysis

RStudio was used to analyze the data. Descriptive statistics (means, frequencies, and standard deviations) were calculated for each Likert-type question and the socio-demographic variables. As an exploratory approach to evaluating whether the amount of a time a person had spent living in the Silver Valley influenced perceived risk and behavioral intentions, we computed a variable that we named *residency*. The variable was divided between survey responses into three equal interval categories based on the percent of life a respondent had reported living in the Silver Valley. The categories were titled *short*-, *medium*-, and *long-term*. Several different category divisions were explored, we selected three categories because it provided the simplest comparison between residents. We compared differences in survey questions related to the eight questions about the primary variables of the EPPM with the *residency* variable. Pearson's Chi-square tests were performed to assess differences for the *residency* variable and between questions. We performed the analysis on two questions related to overall perceived health risk, two questions about household health concerns in general and related to Pb contamination (perceived severity), a question about perceived health effects (perceived susceptibility), a question about feeling informed about Pb contamination (perceived efficacy), and two questions about behavioral intentions. Fully understanding the associations between behavioral intentions and the variables of the EPPM requires more complete measurement of the variables, see Cooper et al. (Cooper et al., in review) (in press). The results included here are intended to provide exploratory understanding of the EPPM.

Results

We report on survey demographics and the chi-square tests comparing questions related to the EPPM and the *residency* variable. The age of respondents ranged from 19 to 92 with a mean of 54 years (Table 5.1). Forty-nine percent of respondents reported living in the Silver

Valley for greater than 66% of their lives (*long-term* category for the residency variable). Fifty-four percent of respondents were females. Ninety-one percent indicated a race/ethnicity of white, consistent with the demographics of the Silver Valley. Thirty-three percent reported having a high school education or less while 36% reported having a college (two or four year) or advanced degree. Reflective of the aging population in the region, 36% of respondents were retired. Slightly fewer than half (44%) of respondents reported having a family member (or being involved themselves) in a mining-related occupation.

Three survey questions asked about how often respondents had thought, read, or attended events about Pb contamination (Figure 5.7). Respondents "rarely" or "sometimes" reported doing these activities. Fewer than 20% reported having attended a meeting or event about Pb contamination in the past year. Respondents did report moderate levels of reading or hearing about Pb contamination. Over 60% of respondents reported at least "sometimes" reading or hearing about Pb contamination. Fifty-nine percent of respondents indicated that they participate in recreation activities "often" or "very often" while only 15% "never" or "rarely" recreate or work outdoors.

Overall results indicate low levels of perceived risk, moderate levels of perceived efficacy, and high levels of behaviors intentions. While there were some differences across the three response categories of the *residency* variable, most of the chi-square tests were not significant. The most significant difference was for the question about household health concerns related to Pb contamination. The results of the Pearson's Chi-square test statistic (χ^2) are reported with each question significant levels included: *$p<.10$, **$p<.05$, ***$p<.001$.

About 65% of respondents reported less than a moderate level of long-term health risk related to Pb contamination for themselves and to others in their local area, 15% reported that they "did not know" the level of health risk associated with Pb contamination (Figure 5.8, a-b). Responses for "I don't know" were not included in the chi-square tests, although removing these responses did not change the significance levels. Respondents reported slightly lower risk related to health effects of Pb contamination for themselves relative to others (χ^2 (16, N=254)=401.14, $p<.001$***). We did not find any differences in perceived health risk across the three categories for the *residency* variable for the question about long-term health risk to myself (χ^2 (8, N = 254) 9.94, p = .269, 8a) or for the question about long-term health risk to others (χ^2 (8, N = 254)= 9.94, p = 0.269, 8b).

Figure 5.9 (a-f) reports on the results of the chi-square analysis for the six questions representing dimensions of the EPPM against the *residency* variable. Two questions compared overall household health concerns with household health concerns related to Pb contamination. Survey respondents were less concerned about overall health household health issues relative to health issues about Pb contamination (χ^2 (16, N=306) =207.71, p<.0001***). Nearly 60% of respondents reported being "moderately concerned' or "very concerned" about general household health issues relative to about 30% of respondents being concerned about health issues related to Pb contamination. We found no differences in general perceived household health issues across the *residency* variable (χ^2 (8, N = 306) =8.07, p = .425; 9a). We did find a difference for perceptions of household health concerns related to Pb contamination (χ^2 (8, N = 306)= 21.74, p = .005**, 9b). Nearly 40% of respondents in the *long-term* category reported that they were "not at all concerned" about household health issues related to Pb contamination compared to only about 20% for respondents in the *short* and *medium-term* categories.

Over 70% of respondents "disagreed" of "strongly disagreed" with the question related to perceived susceptibility, "I have experienced health effects related to lead contamination," and there was no significant difference between the categories for the *residency* variable (χ^2 (8, N = 306) 12.77, p = .120, 9c). Respondents in the *short-term* category were least likely to agree with the question. We found moderate levels of agreement for the survey question related to perceived efficacy, which was "I am better informed about the health effects of lead contamination than most people," and a small significant difference (χ^2 (8, N = 306) =17.74, p = .023*, 9d) across the *residency* variable. This question is a proxy for perceived efficacy because feeling informed about Pb contamination suggests that a person can integrate their understanding of the health effects of Pb contamination. Respondents in the *long-term* category disagreed with this question more strongly, relative to the other two *residency* categories.

For both questions related to behavioral intentions, respondents were "likely" or "very likely" to report intentions to complete the behavior (9e & f). The two questions related to behavioral intentions did not indicate much difference between the categories of the *residency* variable. These two questions asked respondents to report how likely it is that they would complete each behavior in the next year. The chi-square test for the question about the likelihood that a respondent would "promptly remove dirt from your clothes, toys, pets, cars, and equipment after spending time outdoors?" was not significant (χ^2 (8, N = 279) =4.51, p = 0.81, 9e). The second question pertaining to behavioral intentions asked how likely it was that respondents would "stay on designated trails while recreating in areas where lead contamination warning signs are posted," there was a small significant difference across the *residency* categories (χ^2 (8, N = 279) =13.9, p = 0.08*, 9f). Respondents who had spent less time living in the Silver Valley were slightly more likely to report "very likely" for this question relative to the long-term category. There was a significant difference between the two questions about behavioral intentions (χ^2 (16, N=279) 136.07, p<.001). Respondents were more likely to report being "very likely" to stay on designated trail that they were to clean potentially contaminated equipment.

Discussion

The survey provides an overview of perceptions related to the variables of the EPPM and indicates possible challenges and opportunities for risk communication strategies. The EPPM is based on the theoretical premise that elevated levels of perceived threat and perceived efficacy will lead to behavior change. Survey respondents did report high levels of intentions to practice recommended health behaviors, which indicates that respondents are generally aware of the specific behavioral recommendations. However, overall levels of perceived threat, as indicated by the questions related to perceived risk, perceived severity and perceived susceptibility were moderate to low. The question related to perceived efficacy reflected moderate levels of efficacy.

It is also important to recognize that an intention-barrier gap may influence the results of this survey. The high levels of behavioral intentions found in the survey did not align with the District's observations of non-protective behaviors (e.g., not cleaning contaminated recreation equipment). Discrepancies between the survey results and the behavioral observations of the District provide an example of the challenges that District faces in monitoring and evaluating the success of their risk communication strategies. Previous literature has demonstrated that an intention-behavior gap often influences cross-sectional survey results (Glanz, 2015; Weinstein, 2007). Future research should continue to develop strategies for monitoring actual behaviors over behavioral intentions.

The community survey did not reveal strong support of a risk perception normalization effect. The biggest difference was that longer-term residents reports lower concern about the health effects from Pb contamination in their household. We also found a small difference in levels of perceived efficacy. It was surprising that residents in the *longer-term* category disagreed more strongly that they were more informed than most people about Pb contamination considering that they have lived in Pb contaminated area longest. Longer-term residents were also slightly less likely to report staying on designated trails, which could mean that longer-term residents are more likely to make their own judgements about which areas are contaminated relative to shorter-term residents. Future research should continue to explore the ways in which the duration a person spends living in a contaminated area influences their risk perceptions because it may impact how people receive and act on risk messaging information.

Challenges and Opportunities

Maintaining long-term awareness and concern to motivate health protective behaviors at Superfund sites is difficult (Hoover, 2017). Building trusting relationships between experts and citizens may be a key to enhancing risk communication (Colley et al., 2019; Hoover, 2017; Tuler et al., 2005). Tuler et al. (2005) argues that risk communication should rely on a deliberative process. Deliberative processes should consider which risk to focus on, how to compare and frame risk, and how to determine what constitutes credible channels of communication. A process that is viewed as unfair or illegitimate may result in reluctance to follow risk communication messages. In the Silver Valley, recent risk communication strategies were developed through a more deliberative process than in the past. For instance, the District has also focused on hosting educational events and workshops to improve awareness and public buy-in.

The survey results elucidate several barriers and opportunities for future risk communication. Despite efforts to improve awareness through meetings and events, few survey respondents reported attending events or meetings related to Pb contamination in the past year. This gap suggests an opportunity to continue to expand awareness. Low levels of self-reported meeting attendance, moderate levels of agreement about feeling more informed about Pb contamination than others, and the 15% of respondents who reported that not knowing their level of health risk suggests that opportunities remain to engage residence through risk communication strategies more fully. Future education might also focus on sharing information about how the range of negative health consequences associated with Pb, for instance, its connection to non-communicable diseases such as diabetes and cardiovascular disease.

The new health risk messages are tailored in ways that highlight the health threats for Pb contamination and are also more aesthetically pleasing. Signs include positive messages about the community and/or recreation sites where they are posted. The new signs are intended to increase perceived efficacy by providing portable handwashing stations at several public access points. As the visibility of health risk decreases, it becomes more difficult to communicate the severity of health risk (De Dominicis et al., 2015). The EPPM demonstrates the importance of targeting an appropriate balance between increasing the perceived threat and the perceived self-efficacy. However, if a person's perceived threat is not elevated, they are unlikely to change their behavior (Witte, 2001). Given the small possibility of a risk perception normalization effects identified through the community survey and an influx of tourists in the Silver Valley, future signage could provide information about the negative health consequences of exposure to Pb contamination and/or explicitly report scientific evidence about the negative health effects of even low-levels of exposure to Pb.

Conclusion

This case examination encourages a critical analysis of future risk communication challenges and opportunities at Superfund sites. Recent risk communication strategies have carefully included input from community groups in the Silver Valley. The risk communication strategies have increased the visibility of the risk at a time when visual evidence of contamination is fading. In addition, new strategies increase the accessibility of information and may lead to higher levels of perceived self-efficacy. These efforts are important and complementary to the ongoing efforts to implement additional primary prevention measures at the site. Health risk messaging may be improved by highlighting the negative health consequences of Pb contamination with scientific evidence of the health risk associated with even low levels of exposure. Lessons learned from this case could be used in other communities with historic contamination issues where secondary health protective behaviors are being promoted.

Case Study Questions

1) What are two dimensions of perceived risk and what implications do they have for risk communication?

2) How are primary and secondary prevention of Pb contamination defined? Which is prioritized at Superfund sites, and why?

3) Describe the two appraisal processes that affect whether a health risk message will lead to behavior change according to the Extended Parallel Process Model.

4) What is the risk perception normalization effect? How can it create barriers to effective risk communication in the Silver Valley? How could risk communication strategies in the Silver Valley help to minimize risk perception normalization effects?

5) Reflect on times that you have been exposed to risk communication. Which aspects of the message or strategy resonated with you? Did any aspects backfire and make you feel defensive or uninterested? What aspects of your background do you think influenced how you reacted to that communication?

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Tables

Table 5.1 Survey demographic profile

Characteristic	Mean (SD) % (Freq)
Age (years, M [SD])	54.5 (17.7)
Residency in Silver Valley (years, M[SD])	33.3 (21.5)
Short-term: 0-33% of life	27% (83)
Medium-term: 34%-66%	23% (71)
Long-term: 67%-100%	50% (152)
Gender (% [Freq])	
Female	54% (165)
Male	44% (134)
Prefer not to say	2.0% (6)
Race/Ethnicity (% [Freq])	
White	90.8% (278)
No Response	4.6% (14)
All others	5.0% (14)
Highest education (% [Freq])	
Advanced degree	9.8% (30)
College degree	26.1% (80)
Some college but no degree	30.1% (92)
High school graduate	28.1% (86)
Less than high school degree	5.2% (16)
Occupational status (% [Freq])	
Retired	35.6% (109)
Working full-time	36.3% (114)
Homemaker	8.8% (27)
Working part-time	7.2% (26)
Disabled/Medical Leave	4.6% (5)
Student	0.7% (2)
Unemployed	1.3% (4)
No Response	3.0% (9)
Approximate household income (% [Freq])	
Less than $20,000	21.6% (66)
$20,000 to $49,999	30.7% (94)
$50,000 to $79,999	22.5% (69)
$80,000 to $99,000	8.2% (26)
$100,000 or more	6.5% (21)
No Response	10% (30)
Family in mining (% [Freq])	
No	53.3% (163)
Yes	44.4% (136)
Not sure	1.6% (5)

Note. 'No response' and "prefer not to answer" categories excluded for characteristics when less than 1%

Figures

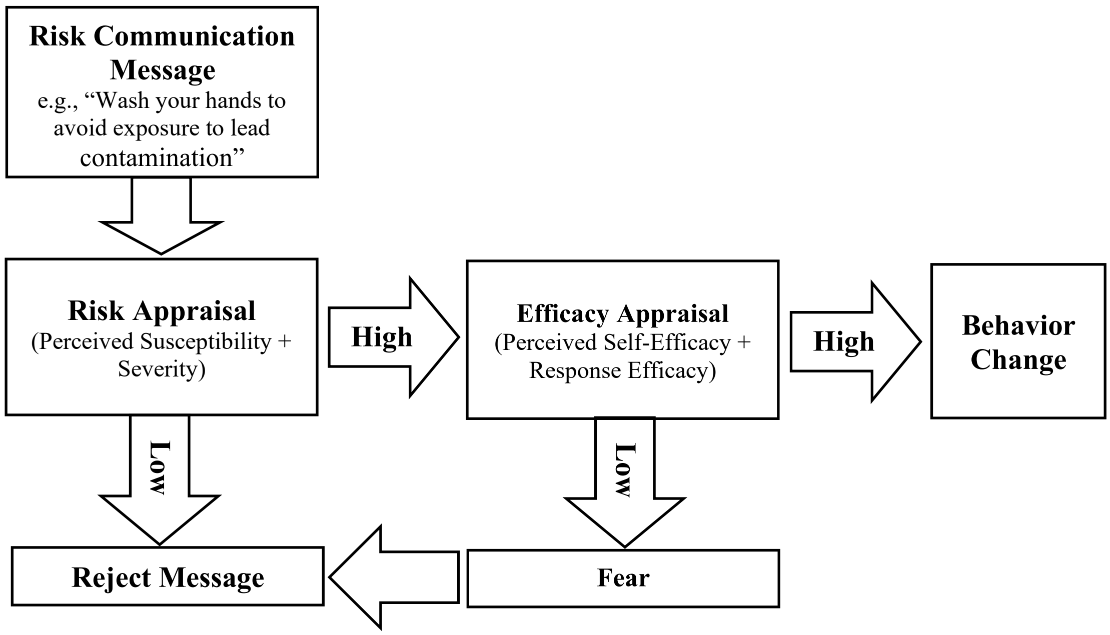


Figure 5.1 Simplified Extended Parallel Process Model decision tree (Witte, 2001). Behavior change is likely under conditions of high appraisal for both perceived risk and efficacy.

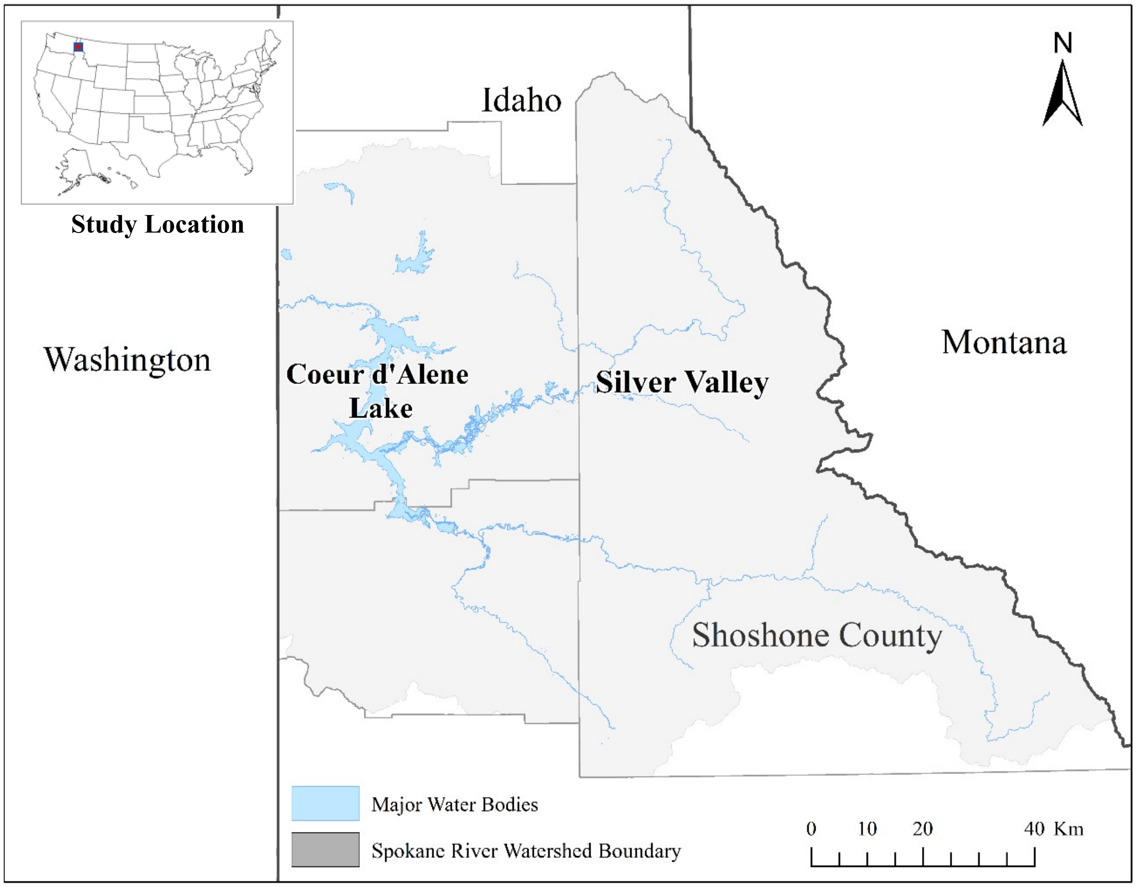


Figure 5.2 Shoshone County location. The Silver Valley historic mining district is located within Shoshone County. The Spokane River Watershed drains into the State of Washington.

Figure 5.3 Example of an initial sign used in the Silver Valley. The sign clearly communicates that there is a risk.
Source: Panhandle Health District

Figure 5.4 An example of old signage used in the Silver Valley. The signs were difficult to see and did not provide context about why the area is contaminated.
Source: Panhandle Health District

Figure 5.5 An example of new signage in the Silver Valley. The sign is posted at a popular recreation site that is often contaminated with sediments containing lead. A temporary handwashing station was placed next to the sign to encourage people to rinse possible contamination off their hands.
Source: Panhandle Health District

Figure 5.6 Example of a new tailored sign. The bright colors and eye-catching image may draw attention to signs.
Source: Panhandle Health District

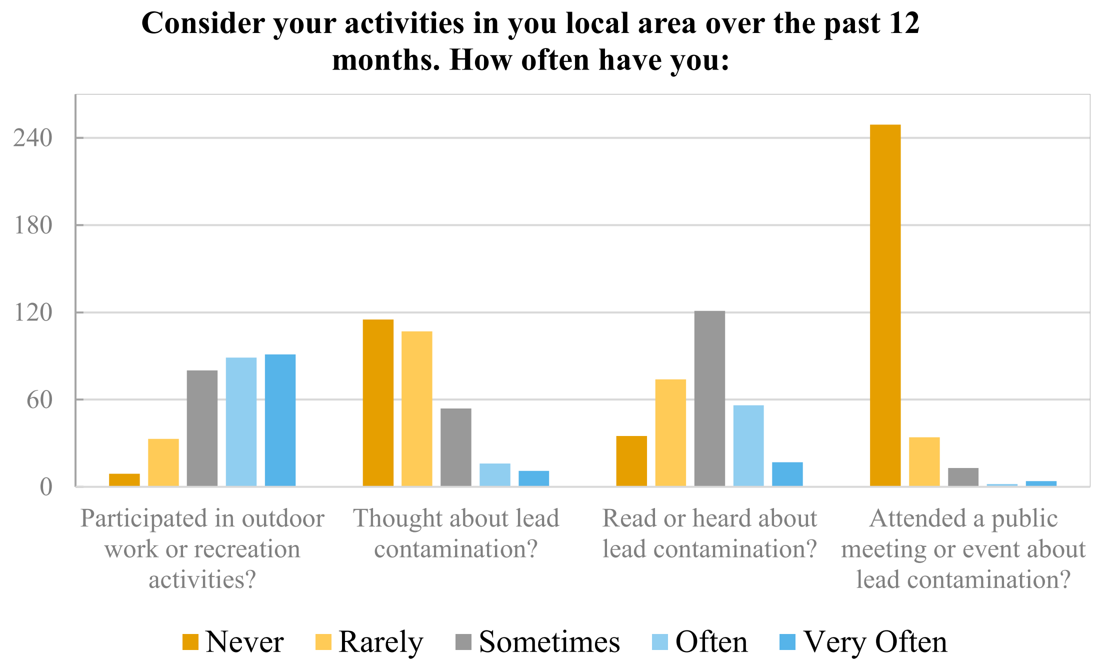
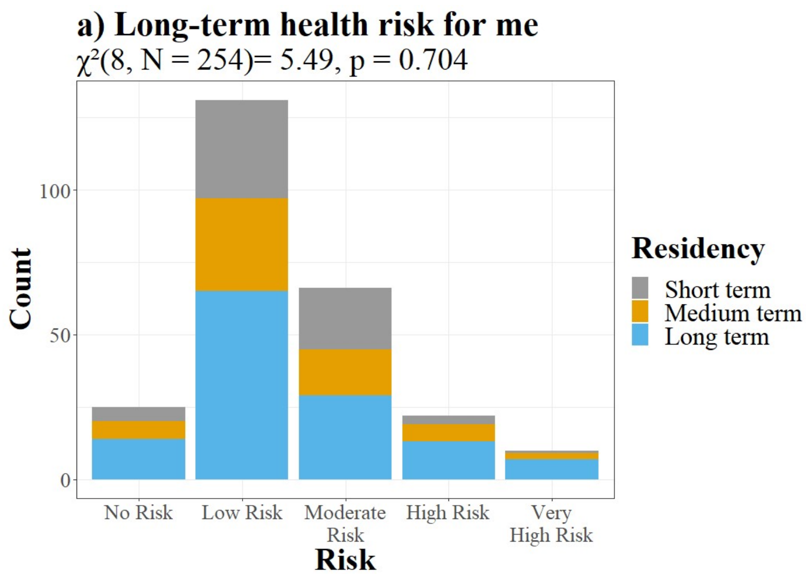


Figure 5.7 Self-reported participation in recreation and outdoor activities and actions related to lead contamination.



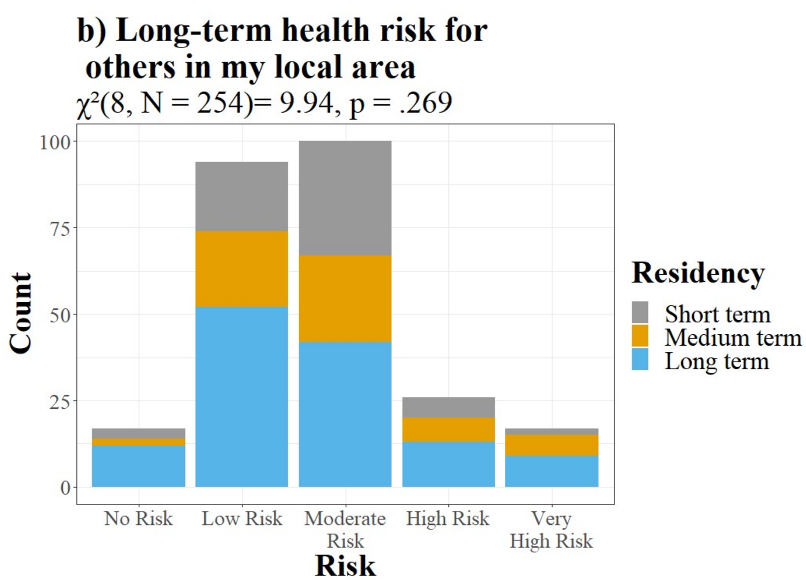
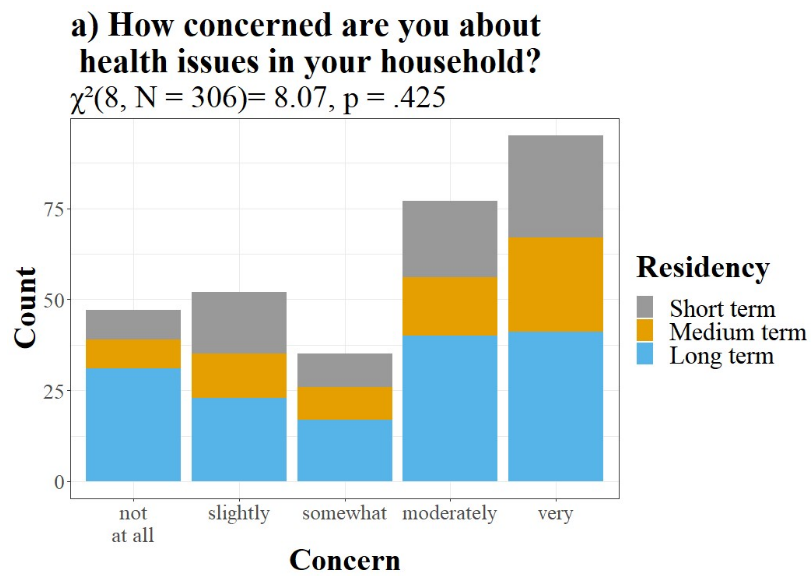
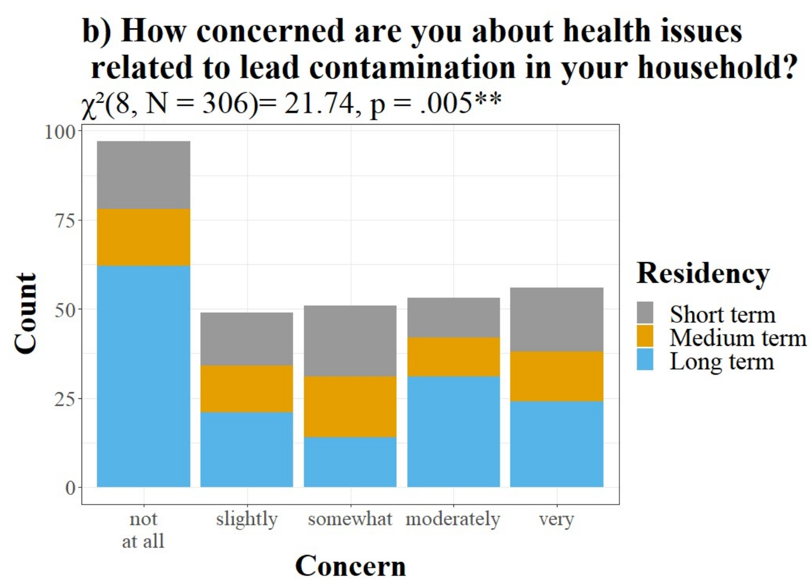


Figure 5.8 a&b Level of perceived long-term and immediate health risk associated with lead contamination in the Silver Valley. About 15% of respondents reported that they "did not know," and are not included in this figure.

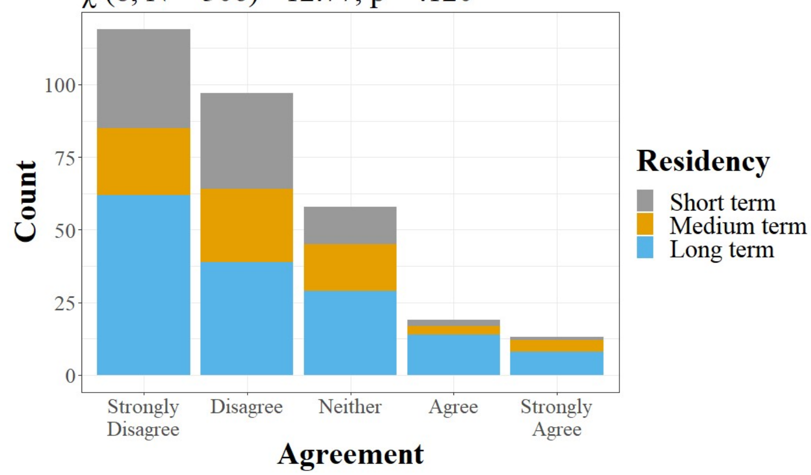
Note. There was a significant difference between responses for these two questions: χ^2 (16, N=254)=401.1, p<.001***.


a) How concerned are you about
health issues in your household?
χ²(8, N = 306)= 8.07, p = .425
Count
0
25
50
75
not
at all
slightly
somewhat
moderately
very
Concern
Residency
Short term
Medium term
Long term


b) How concerned are you about health issues
related to lead contamination in your household?
χ²(8, N = 306)= 21.74, p = .005**
Count
0
25
50
75
100
not
at all
slightly
somewhat
moderately
very
Concern
Residency
Short term
Medium term
Long term

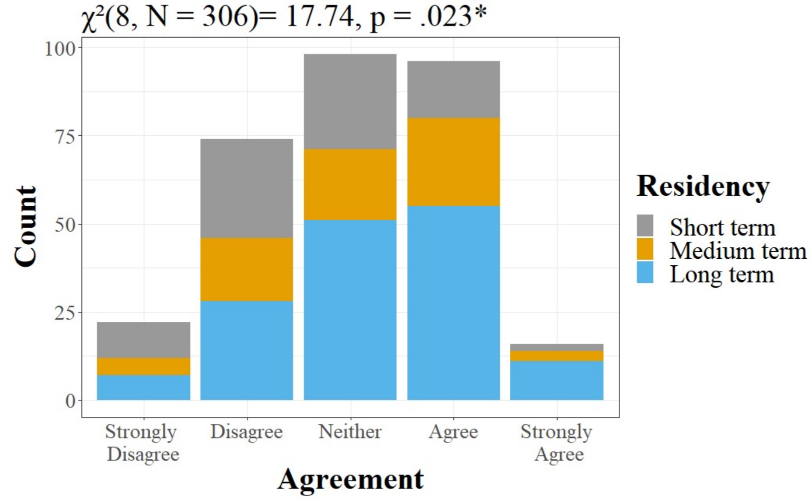
c) I have experienced health effects related to lead contamination

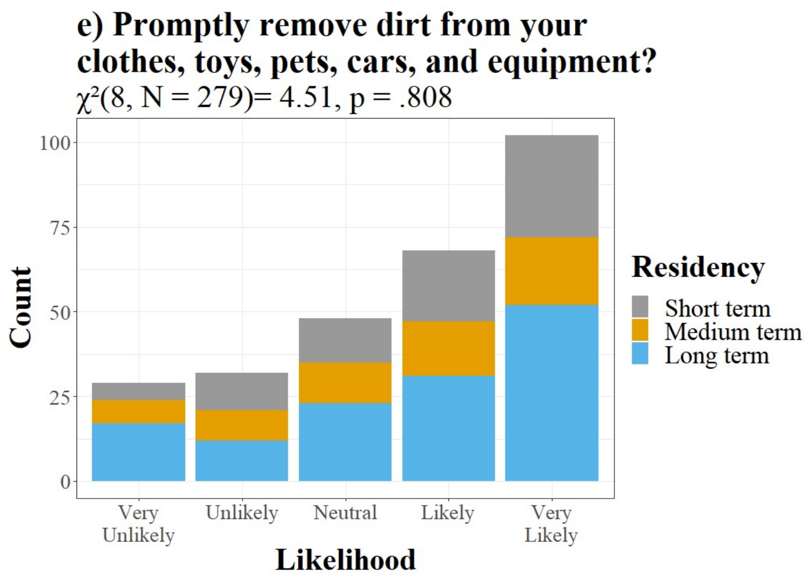
$\chi^2(8, N = 306) = 12.77, p = .120$



d) I am better informed about the health effects of lead contamination than most people

$\chi^2(8, N = 306) = 17.74, p = .023^*$





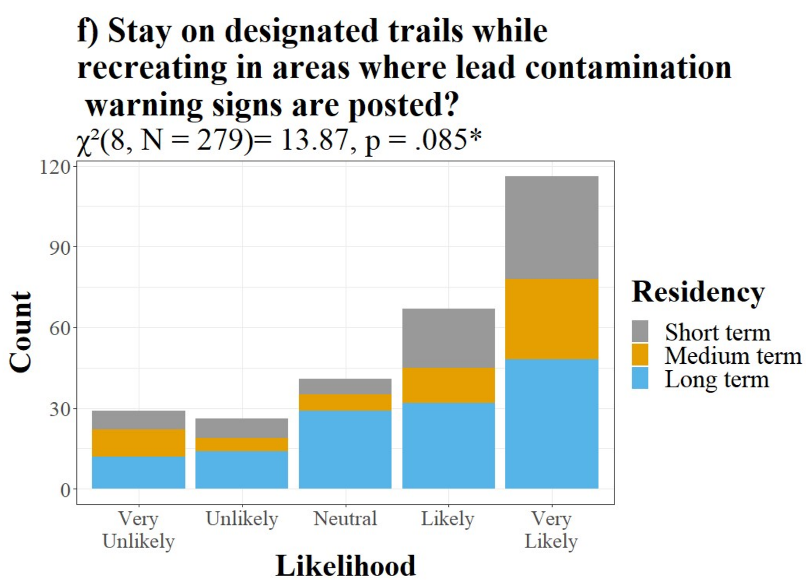


Figure 5.9 a-f Distribution of responses to survey questions across three categories for the *Residency* variable, which divides survey respondents into three equal interval categories by the percent of their life they reported living in the Silver Valley.

Note. Chi-square test statistic (χ^2) reported with each question; *p<.10, **p<.05, ***p<.001. Figure e & f exclude "does not apply" response and survey questions asked respondents: "Consider your recreational and outdoor activities in your local area over the next 12 months. How likely is it that you will:"

Chapter 6: Conclusion and research reflection

Introduction

Studying motivations to undertake health protective behaviors in the Silver Valley illustrated many challenges and opportunities for measuring and promoting health protective behaviors related to environmental health risks. Identifying priorities about the environment, public health, and economic development demonstrated how stakeholders collaborate to manage the risks posed by heavy metal contaminants. My experiences studying risk perceptions, stakeholder issue framing, and behavioral intentions inform a set of lessons learned about conducting community-university partnerships within graduate education.

Lessons Learned

I include three lessons learned based on the three primary projects of this dissertation, including the Silver Valley survey research (Chapters 2 & 5), the Q-methodology study (Chapter 3), and the comparative hydrosocial partnership analysis (Chapter 4). Lessons include: (1) co-develop a plan to apply research findings prior to beginning research; (2) understanding primary issue frames can promote collaboration by highlighting areas of potential conflict; (3) community-university partnerships teach graduate students critical skills needed to bridge gaps between science and practice.

Lesson 1: Develop a plan to apply research findings prior to beginning research.

When time and funding allow, research related to questions about the associations between perceived risk and behavioral intentions should be designed with specific risk communication goals in mind. My experiences working with the District were a humbling illustration of the challenges and opportunities for developing research that responds to community goals. The research was designed around a clear need for the District, a desire to better understand community awareness and willingness to undertake health protective behaviors. Together, we wrote a small pilot grant to fund the project and considered the implications the research might have on risk communication at the onset of the project. Attending meetings, organizing events, and frequent trips to the Silver Valley helped to integrate my findings with risk communication strategies. However, despite my involvement, I occasionally found myself critical of the idea that my results advanced community goals. It is possible that more attention to deliverables early on could have helped me to develop a more concrete plan to connect the research with risk communication implications. Disseminating results from participatory research is challenging yet critical to avoiding the “helicopter researcher” phenomena and avoiding community research fatigue (see: Flicker et al., 2007). Planning in early stages of research is a good strategy for conducting more impactful participatory research.

Lesson 2: Primary issue frames include views that balance economic development and public health goals

In Chapter 3, I evaluated how stakeholders in the Coeur d'Alene region prioritize environmental, economic, and public health issues and evaluate primary issue frames. Findings suggest that stakeholders believe there is a strong collaborative network of professionals who work on the Superfund site. They also understand the economic importance of reducing pollution in and around Lake Coeur d'Alene. As stakeholders investigate new solutions to addressing risks associated with mining contamination, it is important that plans clearly define leadership roles through actionable plans.

Participants described a collaborative process that is fair and dependent on a science-centered stakeholder network. Stakeholders value decisions based on scientific consensus about the relevant policy issue and they believe that people who work in environmental management in the Coeur d'Alene region are committed to reducing the public health, ecological, and environmental risks of Pb contamination. The view is an effective way to maintain trusting relations between primary agencies and organizations but may be a less ideal approach for promoting a "prudent public model" that encourages a high level of public participation. Many study participants, who were not directly involved in environmental management, reflected on how they were disenfranchised by long and slow environmental management processes that afforded too few tangible improvements. At the same time, stakeholders directly involved in environmental management discussed struggles with gaining political support for projects. Key challenges for implementing more collaborative planning processes include reconciling differing perspectives about future remedial actions for the Lake.

Lesson 3: Community-university partnerships teach graduate students critical skills needed to bridge gaps between science and practice

A final lesson relates to the challenges of conducting research through community-university partnerships as a graduate student. During my doctoral work, I spent the first two years learning about concepts related to values, epistemology, and ontology (e.g., Cosens et al., 2011; O'Rourke et al., 2019) and forming relationships with colleagues and community partners. The next three years I developed more specific skills as an applied environmental social scientist. When I first joined the NSF-IGERT program, I recall the PI asking me "what kind of "T" I wanted to be?" He explained that the shape of the "T" referred to a balancing between learning about a breadth of issues, visions, and skills (the width of the "T") and acquiring disciplinary depth (the length of the "T"). My tendency towards broad research interests led me to think of my ideal educational trajectory as including a wide "T," however, I have slowly arrived at the opinion that Ph.D. programs, even interdisciplinary ones, prioritize disciplinary depth over interdisciplinary breadth.

In Chapter 5, my colleague, Kathleen Torso, and I argue that the opportunity to conduct our research through community-university partnerships helped us understand how to more successfully cultivate relationships to develop research that builds capacity and promotes community goals. Our hope for the future is for partnerships to become a formal option for graduate students who want to expand their breadth as well as depth. Interdisciplinary graduate programs that intend to teach students how to develop interdisciplinary skills, such as how to form community-university partnerships, should consider the following:

> (1) Develop protocols and memorandums of understanding for accountability and mutual benefits to external partners. This would include allowing and, when possible, incentivize people outside of academia, who do not hold PhD's, to serve on dissertation and thesis committees.
>
> (2) Require students to include stakeholder reports or similar deliverables in dissertations (not as appendices but chapters) and offer opportunities or courses for students to learn how to write these reports.
>
> (3) Invite guest speakers from diverse backgrounds to speak and lead graduate student seminars.
>
> (4) Minimize the institutional barriers involved in forming partnerships between universities and external agencies and organizations.
>
> (5) Ensure that committee members and advisors receive training about the guidelines and expectations for students conducting research through partnerships. When possible, these trainings should be incentivized, in the very least they should not pose an additional work obligation for faculty.

One way to incentivize more participatory research would be through implementing a small grant program. Graduate students could write and apply for the grants early in their program, for instance as part of their written qualifying exams. Grant requirements could integrate the recommendations provided above. Conducting research through partnerships, in the absence of formal guidelines, is possible if students seek supportive mentors and form community advisory boards (see: Hacker (2013) and Wilmsen et al. (2012)) and utilize participatory research frameworks (e.g., Participatory Action Research) to guide research that is sensitive to local contexts. However, conducting research through partnerships can become an extra obligation for everyone involved. Removing the barriers to conducting participatory research is a key component in expanding students' breadth.

Future Directions

Lake Coeur d'Alene is a state gem and primary economic driver in Idaho, yet the Lake's water quality is deteriorating, and legacy mining contamination continues to threaten public health, wildlife, and the economy. Limiting these risks requires a collective policy response and individual behavioral shifts. As the regional population grows, environmental policies and behaviors have remained relatively unchanged. Scientists, health professionals, and managers face mounting challenges as they work, on increasingly limited budgets and in the face of climate change, to develop strategies for protecting environmental and human health. Frustrations in long and bureaucratic processes have been tempered by the project implementation set forth through the Restoration Partnership. Developing a plan for addressing both heavy metal and nutrient issues at the Lake is important in future collaborations. New policies should promote individual behavior changes because pollution is added to the Lake from residential, agricultural, and industrial sources. The Lake is a critical natural and economic resource and threats are imminent, every leader has a role to play in improving lake health. Community-university partnerships can contribute to efforts to reduce health and ecological risks in the Coeur d'Alene region.

My partnership with the District provided me with a diverse set of experiences and skills and a rich network of supportive colleagues. Concluding my dissertation amidst a pandemic and rising calls for social justice was challenging but provides an impetus for conducing more rigorous interdisciplinary and participatory research. I have developed confidence in my abilities to contribute and support collaboration, even in the face of controversy. The most difficult aspect of acknowledging the ramifications of concluding a dissertation based on participatory research methods amidst a global pandemic was shifting how I disseminated my research findings. Event cancellations prevented opportunities for in person presentations, for instance, a conference presentation at the National Environmental Health Association's Annual Health Conference. The experience has reaffirmed that relationships are more meaningful when in person interactions are possible. In my future career, I will be less likely to take opportunities to attend conferences and to meet with people in person for granted.

I look forward to continuing to expand my skills and experiences in conducting participatory research while developing my disciplinary depth as a social scientist studying risk perception and communication. For future graduate students, reflect often on the reasons that you are interested in your research topic. Find a topic that you are genuinely enthusiastic about and identify colleagues and mentors with similar interests. When possible, make the research process "social" by joining or forming support groups. For instance, meeting with colleagues for a writing group. Without a supportive community and a motivating research topic, I would not have the energy to carry on as a researcher.

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Appendix A: Survey instrument (Chapter 2 & 5)

In Supplementary Information

Appendix B: Structural equation model correlation matrix (Chapter 2)

	1	2	3	4	5	6
1. Perceived Severity	1					
2. Perceived Susceptibility	0.56**	1				
3. Perceived Benefits	0.50**	0.09	1			
4. Information and Awareness Beliefs	-0.27**	-0.28**	0.06	1		
5. Self-Efficacy	-0.12	-0.05	0.07	0.75**	1	
6. Behavioral Intentions	0.51**	0.17**	0.75**	-.03	0.06	1

Note. Correlation is significant at the 0.01 level (two-tailed). **$p < .01$.

Appendix C: Q-Methodology statement sources, grid structure frame, and correlations between frames

Statement Sources

No	Statement	Primary Statement Source(s)
Economic		
2	Economic conditions are improving	Management Report
3	Current levels of economic growth are sustainable	Newspaper Articles
8	Raising city and county taxes restricts economic growth	Conference
14	Decisions that promote climate resiliency make economic sense	Conference
20	Mining and timber industry jobs are the backbone of the economy	Newspaper Articles
Environmental		
1	Improving water quality requires individual behavior changes	Conference
5	Conservation districts that levy local fees for environmental protection would strengthen enforcement of water quality standards	Conference
7	Environmental protection efforts should consider climate resiliency	Interviews; Meetings; Conference
11	Nutrient reduction strategies need to be implemented to protect water quality	Interviews; Meetings; Conference
13	County and city governments need to be held more accountable to protecting water quality	Conference
19	Over the past decade, water quality has improved	Newspaper Articles; Interviews
22	The State of Idaho should do more to regulate water quality	Meeting; Interviews
24	Tension between stakeholder groups limits the effectiveness of current environmental management efforts	Meeting; Newspaper Article
25	Environmental monitoring efforts conducted by the Coeur d'Alene Tribe and the State of Idaho are needed to protect water quality	Newspaper Articles
30	Local leaders agree on approaches to manage heavy metal contamination	Conference
Human Health and Heavy Metals		
9	The public is well-informed about the health effects of heavy metals	Meetings; Interviews
15	The threats posed by heavy metals are uncertain	Management Plan
17	Protecting human health and safety is the primary reason for managing heavy metals	Management Plan
21	Actions to reduce heavy metals should be based only on the best available science	Management Plan

28	Cultural and spiritual health are tightly linked to ecosystem health	Newspaper Articles; Interviews
Superfund Cleanup		
4	Limitations on how Superfund (CERCLA) funds can be used are too restrictive	Newspaper Article; Meeting
16	Site-wide approaches to the Superfund cleanup should be prioritized	Restoration Plan
23	The remediation of residential areas within the Superfund site is a success story	Meeting; Interviews
26	Current approaches to the Superfund cleanup are ineffective	Meeting
Tradeoffs		
6	Tradeoffs between public health and economic gains are sometimes necessary	Newspaper Article; Management Plan
10	Good water quality is essential for sustaining economic growth	Conference
12	The Superfund site designation hinders economic growth	Meeting
18	Drawing attention to heavy metals pollution is bad for the economy	Interview; Meeting
27	Federal environmental regulations are too restrictive of local economic growth	Interview

Q-sort grid structure

Least like how I think				**Most like how I think**		
Statement Scores						
-3	-2	-1	0	1	2	3
Number of Statements						
1	4	6	8	6	4	1

Note. Q-sorts were completed in an online web application. Participants sorted statements based on their regional perspectives.

Pearson's correlation coefficients and p-values between the four frames

Frame	**A**	**B**	**C**	D
A	1			
B	0.54 (.002)**	1		
C	0.64 (.000)***	0.53** (.002)	1	
D	-0.09 (.919)	0.17 (154)	-0.06 (.765)	1

Note. p-values:**p<.001, ***p<.0001

Appendix D: Institutional Review Board Approval (Chapters 2 & 5)

University *of* Idaho
Office of Research Assurances
Institutional Review Board
875 Perimeter Drive, MS 3010
Moscow ID 83844-3010
Phone: 208-885-6162
Fax: 208-885-5752
irb@uidaho.edu

To:	Chloe Wardropper
Cc:	Chantal Vella, Jeffery Langman, Roger Lew, Courtney Cooper
From:	Jennifer Walker, IRB Coordinator
Approval Date:	April 25, 2018
Title:	Health disparities by environmental condition: Assessing perceptions of lead contamination and health in a rural mining region
Project:	18-080
Certified:	Certified as exempt under category 2,4 at 45 CFR 46.101(b)(2,4).

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the protocol for the research project Health disparities by environmental condition: Assessing perceptions of lead contamination and health in a rural mining region has been certified as exempt under the category and reference number listed above.

This certification is valid only for the study protocol as it was submitted. Studies certified as Exempt are not subject to continuing review and this certification does not expire. However, if changes are made to the study protocol, you must submit the changes through VERAS for review before implementing the changes. Amendments may include but are not limited to, changes in study population, study personnel, study instruments, consent documents, recruitment materials, sites of research, etc. If you have any additional questions, please contact me through the VERAS messaging system by clicking the 'Reply' button.

As Principal Investigator, you are responsible for ensuring compliance with all applicable FERPA regulations, University of Idaho policies, state and federal regulations. Every effort should be made to ensure that the project is conducted in a manner consistent with the three fundamental principles identified in the Belmont Report: respect for persons; beneficence; and justice. The Principal Investigator is responsible for ensuring that all study personnel have completed the online human subjects training requirement.

You are required to timely notify the IRB if any unanticipated or adverse events occur during the study, if you experience and increased risk to the participants, or if you have participants withdraw or register complaints about the study.

Note that this certification includes the agreement that the surveys/questionnaires will be submitted prior to use.

Appendix E: Institutional Review Board Approval (Chapter 3)

University of Idaho
Office of Research Assurances
Institutional Review Board
875 Perimeter Drive, MS 3010
Moscow, ID 83844-3010
Phone: 208-885-6162
Fax: 208-885-6014
Email: irb@uidaho.edu

To: Chloe Wardropper, PhD

Cc: Cooper, Courtney

From: University of Idaho Institutional Review Board

Approval Date: November 14, 2019

Title: An Application of Q Method: Views of heavy metal contamination in North Idaho

Project: 19-244
Certified: Certified as exempt under category 2 & 3 at 45 CFR 46.104(d).

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the protocol for this research project has been certified as exempt under the category listed above.

This certification is valid only for the study protocol as it was submitted. Studies certified as Exempt are not subject to continuing review and this certification does not expire. However, if changes are made to the study protocol, you must submit the changes through VERAS for review before implementing the changes. Amendments may include but are not limited to, changes in study population, study personnel, study instruments, consent documents, recruitment materials, sites of research, etc.

As Principal Investigator, you are responsible for ensuring compliance with all applicable FERPA regulations, University of Idaho policies, state and federal regulations. Every effort should be made to ensure that the project is conducted in a manner consistent with the three fundamental principles identified in the Belmont Report: respect for persons; beneficence; and justice. The Principal Investigator is responsible for ensuring that all study personnel have completed the online human subjects training requirement. Please complete the *Study Status Check and Closure Form* in VERAS when the project is completed.

You are required to timely notify the IRB if any unanticipated or adverse events occur during the study, if you experience and increased risk to the participants, or if you have participants withdraw or register complaints about the study.

Appendix F: Institutional Review Board Approval (Chapter 4)

University of Idaho
Office of Research Assurances
Institutional Review Board
875 Perimeter Drive, MS 3010
Moscow, ID 83844-3010
Phone: 208-885-6162
Fax: 208-885-6014
Email: irb@uidaho.edu

To: Kathleen Torso

Cc: Kern, Anne Mary

From: Sharon K. Stoll
Chair, University of Idaho Institutional Review Board

Date: February 12, 2020

Title: Holistic Investigation of Heavy Metal Mobility in the lower Coeur d'Alene River.

Project: 16-112
Approved: 10/14/2019
Expires: 10/13/2020

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the above-referenced non-exempt study is approved for another year in accordance with 45 CFR 46.111. The approval period is listed above.

This study may be conducted according to the protocol described in the application. Research that has been approved by the IRB may be subject to further appropriate review and approval or disapproval by officials of the Institution. Every effort should be made to ensure that the project is conducted in a manner consistent with the three fundamental principles identified in the Belmont Report: respect for persons; beneficence; and justice. As Principal Investigator, you are responsible for ensuring compliance with all applicable FERPA regulations, University of Idaho policies, state and federal regulations.

Federal regulations require researchers to follow specific procedures in a timely manner. For the protection of all concerned, the IRB calls your attention to the following obligations that you have as Principal Investigator of this study.

1. For any changes to the study (except to protect the safety of participants) , an Amendment Application must be submitted to the IRB. The Amendment Application must be reviewed and approved before any changes can take place.

2. Any unanticipated/adverse events or problems occurring as a result of participation in this study must be reported immediately to the IRB.

3. Principal investigators are responsible for ensuring that informed consent is properly documented in accordance with 45 CFR 46.116.

University of Idaho
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Institutional Review Board
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Moscow, ID 83844-3010
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Email: irb@uidaho.edu

4. A Continuing Renewal Application must be submitted and approved by the IRB prior to the expiration date else automatic termination of this study will occur. If the study expires, all research activities associated with the study must cease and a new application must be approved before any work can continue.

5. Please complete the Continuing Renewal/Closure form in VERAS when the project is completed.

6. Forms can be found at https://veras.uidaho.edu.

Appendix G: Chapter 5 teaching guide and notes

In Supplemental Information.