UNDERSTANDING RISK PERCEPTION AND HEALTH RISK COMMUNICATION MESSAGE TESTING RELATED TO HARMFUL ALGAL BLOOMS (HABS) IN MICHIGAN LAKES

By

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ABSTRACT

In the Great Lakes region, harmful algal blooms (HABs) also known as cyanobacterial blooms (blue-green algae) have become well-known due to severe public health risks, environmental, and socio-economic effects. Environmental and public health information related to risks from HABs are mainly communicated through state and local government health agencies, the efficacy of those approaches is unknown. The purpose of this study is to learn how to effectively communicate risks caused by HABs and understand the public's perception of risk from HABs when engaging in recreational activities in several lakes in Michigan. Drawing upon the Social Amplification of Risk Framework (SARF) and Theory of Planned Behavior (TPB) the study design developed two phases: (1) needs assessment in 2021 and (2) experimental message testing and evaluation in 2022. The first phase consists of conducting a fieldwork and 27 interviews with selected individuals from vulnerable populations to explore existing health-advisory messages about HABs near recreational areas, communication preferences, knowledge, and lake experiences with HABs in several communities. Throughout the first phase a gap between existing information provided by government entities about HABs, and individuals awareness of HABs and its effects was found. The second phase experimentally tested two communication frames (cognitive vs. emotional framing). Using TBT as our main framework, among the different behavioral beliefs measured to understand how they influence risk perception; attitude was shown to be significant. Based on our findings, emotional framing was able to achieve a higher level of risk perception than cognitive framing, demonstrating a need to effectively communicate risk using different framing approaches. This study contributes to the policy and practice of how to effectively communicate human health risks from freshwater HABs in the Great Lakes region.

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myself, my career, and my dreams. Becoming the first woman in my family to obtain a master's degree, it is a great honor to share this success. To everyone that made this possible, thank you immensely.

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LIST OF ABBREVIATIONS

CDC Center for Disease Control and Prevention

CCRP Climate Change Risk Perception

EPA Environmental Protection Agency

HABs Harmful Algal Blooms

HRWC Huron River Watershed Council

LAMP Lakewide Action and Management Plan

MDHHS Michigan Department of Human Health Services

NOAA National Oceanic and Atmospheric Administration

SARF Social Amplification of Risk Framework

TPB Theory of Planned Behavior

WHO World Health Organization

GENERAL INTRODUCTION

The problem with harmful algal blooms (HABs)

The existence of algae and its role in our ecosystem is vital. Through photosynthesis, algae produce oxygen utilized by millions of organisms (Buteyko 2010; Chapman 2010; Vidyasagar 2016). However, under specific conditions, algae can become a threat to our aquatic ecosystems. Harmful Algal Blooms, also known as "HABs", are large colonies of blue-green algae derived from cyanobacteria (Cyanophyceae) found in freshwater and marine environments (Schmidt et al., 2014). Throughout the last decades, the appearance of cyanobacterial blooms in the Laurentian Great Lakes of North America has become well-known (Sterner et al., 2020, Barlett et al., 2018, Heisler 2008, & Boyer 2008) due to severe public health risks, environmental, and socio-economic effects (Walker 2014; Moore et al. 2020, & Wang et al., 2021). Although cyanobacteria is a natural part of the global aquatic ecosystem, due to warm temperatures attributed to climate change and long-term trends of agriculture practices, the excessive amount of nutrient pollution derived from chemical fertilizer runoff has caused large bodies of water to reach high concentrations of nitrogen and phosphorous (Walker 2014; Carmichael 2016; Gill et al 2018). The high levels of nitrates and phosphates have altered the naturally occurring cyanobacteria to produce harmful toxins, such as cyanotoxins and microcystins, causing serious detrimental human and animal health effects (Hitzfeld et al., 2000; Butler et al., 2009; Lekki 2019). The variety of toxins attributed to HABs can present a hazard for those who accidentally ingest contaminated water when attending lakes for recreational purposes, and for communities relying on its drinking water (Hitzfield et al., 2000). Among other effects, HABs are causing severe socio-economic impacts such as negative recreational experiences and fishery closures due to the high levels of cyanotoxins and seafood contaminants,

thus reducing the recreational value of surface waters. In addition, this can also influence the tourism industry, and the quality of life for visitors and communities residing nearby Great Lakes (Walker 2014; Moore et al. 2020). Because of HABs, according to a recent report published in 2020, Lake Erie's $12.9 billion tourism revenue can potentially be disrupted, putting at risk approximately 119,491 jobs (Bingham and Kinnell 2020; Tourism Economics 2014).

During the last several decades, HAB events have been occurring more frequently than ever throughout the United States (Hoagland et al 2002; NOAA 2021). Bigger challenges for society lie ahead as HAB events are becoming well-known for their direct impacts in the Great Lakes. According to Environmental Protection Agency [EPA] (2012), National Oceanic Service [NOS] and NOAA (2022), the appearance of HABs has been reported in every U.S. coastal state and in the Great Lakes. Several reports indicate that drinking water violations of nitrates produced from HABs have nearly doubled in the last decade (EPA, 2012), and others have considered it to become a 'global epidemic' (Smayda 1989; Hallegraeff et al., 2021). Due to climate change and pollution, the presence of HABs is expected to increase, presenting severe potential threats in the future (Smayda 1989; Hoagland et al 2002).

Although HABs occur worldwide (Hallegraeff 1993; Anderson et al., 2012), according to NOAA (2022), HABs presence has increased drastically in the Great Lakes, which represent 20% of the world's freshwater (Carmichael & Boyer, 2016). The presence of cyanobacterial HABs can be found in the shallow western basin of Lake Erie (Watson et al., 2016), Saginaw Bay in Lake Huron (Millie et al., 2008), Green Bay in Lake Michigan (Barlett et al., 2018); and in smaller embayment, tributaries, and nearshore areas, such as Muskegon Lake, Lake St. Clair, Sandusky Bay, western Lake Superior, the Sandusky, and Maumee River, as well as other inland

lakes in Michigan (Fahnenstiel 2008; National Science and Technology Council 2017; Lekki et al., 2019; Michigan Sea Grant 2021).

Among the Great Lakes, Lake Erie, known for its nutrient-rich and shallow body of water, primarily received from the Maumee River (Kane et al., 2014; Gil et al., 2017), it has also become well-known for its HAB events and their effects. Threatening the aquatic ecosystem in Lake Erie, HABs and hypoxia, oxygen deficiency in a biotic environment (Diaz 2001), are two major environmental problems that may cause human health and economic effects (Wang et al., 2021). In 2011, the Western Basin of Lake Erie was known to have the largest freshwater HABs recorded history (Michalak et al., 2013), threatening the health of millions of residents, animals, the coastal economy, among other ecological risks. According to the Lake Erie Management Plan, also referred to as Lakewide Action and Management Plan (LAMP), Lake Erie supplies drinking water and recreational opportunities to more than 11 million residents in the U.S. and Canada. In 2014, a drinking water crisis was reported in the city of Toledo, Ohio when high levels of microcystins were reported at the water treatment plant in Lake Erie (Guo et al., 2019, Steffen et al., 2017). More than half a million residents were unable to drink, cook or brush their teeth with their tap water for less than 48 hours, leading to distribution of potable water during August (Steffen et al., 2017). Due to this unfortunate experience, many Lake Erie residents may have learned about HABs and their effects for the first time through this personal experience. In addition to the Great Lakes, the prevalence of HABs found in inland lakes are also becoming more frequent (Brooks et al. 2016; Steffen et al. 2014).

There have been advanced scientific findings on HABs, such as learning about its ecological causes, harmful effects, and technological advancement to forecast and determine HABs and their attributed toxins (Anderson et al., 2015). However, due to limited studies

conducted with HABs found in inland waters, they are poorly understood across space and time because of how greatly they may vary (Brooks et al., 2016; Steffen et al., 2014). Their effects would depend on their magnitude, frequency, duration, and how they are managed in states, tribes, in different locations (Brooks et al., 2016; Steffen et al., 2014). Because HABs frequency continuously varies each year, constant communication about HABs and the risks and health effects can be inconsistent. This can present a challenge to effectively communicate risks caused by HABs. Currently there are limited case studies on how different communities around the Great Lakes engage with HABs and the sociological implications (Brooks et al., 2015; Steffen et al., 2014; Gil et al., 2018; Moore et al., 2020). Much less research has analyzed how communities that reside near lake-reported blooms are learning about its health effects.

Cyanotoxins have been affiliated with human illness through biotoxin exposure by consumption of fish, shellfish, and drinking water; inhalation; or dermal contact (Brooks et al., 2005). According to several government agencies human illnesses caused by HABs can vary from mild symptoms to death, in extreme cases. (NOAA 2020; CDC; EPA, 2020). Many communication products that discuss HABs rarely explain the hazardous health effects they may cause. There are limited resources informing who are the vulnerable populations that may have a higher health risk if directly exposed to HABs.

Another challenge HABs communication faces are distinguishing between “harmful” blooms and “nuisance” blooms (Watson and Boyer 2014). “Harmful” blooms that are related with having health impacts and those that are “nuisance” blooms that are natural components linked with no class of harm (Watson and Boyer, 2014). The physical appearance of a nuisance and harmful bloom can be very similar, however HABs contain poisonous chemicals such as cyanotoxins and microcystins. Due to physical similarities, this can be a potential threat to

animals and human health if directly exposed to the contaminated water (Watson and Boyer, 2014; Hitzfeld et al., 2000; Butler 2019; Lekki 2019). The only way to detect whether blooms are nuisance or harmful is by taking a water sample into a laboratory and testing for its toxicity (EPA 2022).

This may produce different perceptions of risks when interacting with HABs. Because some have previously experienced nuisance blooms, while others have experienced HABs' detrimental effects first-hand, understanding of how the public perceives HABs remains unclear. HABs are becoming more frequent every year (Carmichael & Boyer, 2016), thus, to avoid the public from learning about HABs health risks through direct impacts, to effectively communicating HABs health risks is vital.

Purpose of the study

This study aims to understand how to effectively communicate health risks from HABs to individuals that attend Belleville Lake, Ford Lake, and Lake Erie, referred to as "lake users" herein. Using community outreach and engagement approach allowed us to gain a better understanding of the relationship between how the users attending these lakes are learning about HABs and how government entities are currently communicating about HABs to the selected communities. The study is divided in two phases (Fig. 1). Through fieldwork and semi-structured interviews, the first phase explores selected vulnerable populations' communication preferences, lake experiences, knowledge, and awareness about HAB events. Using data from the first phase, a communication product with two different communication frames, cognitive and emotional, was tailored based on our findings. The second phase experimentally tested two communication frames (cognitive vs. emotional framing) that were informed by the results from the phase 1 needs assessment as well as a control group. Through an online survey and in-person fieldwork

(observations and interviews), the second phase aimed to understand how behavioral beliefs (attitude, subjective norm, perceived behavior control), and different communication frames (cognitive and emotional) can shape the public's risk perception of health risks caused by HABs and intentional behavior to avoid engaging in recreational activities when blue-green algae blooms are present. The study used the Theory of Planned Behavior (TPB) originally used to study individuals' intention to engage in a behavior at a specific event, and integrating concepts derived from Social Amplification of Risk (SARF) Framework to understand how risk are perceived, interpreted, and amplified, allowed us to tailor methods to further understand how to effectively communicate risks.

Chapter 1 explores understanding how to effectively communicate risks, risk perception and behavioral beliefs assessment of selected vulnerable populations and lake users attending Belleville Lake, Ford Lake, and Lake Erie. It focuses in understanding how selected vulnerable populations are learning about HABs and measuring what behavioral beliefs can influence risk perception towards avoiding engaging with HABs when performing recreational water activities. Using SARF and TPB the two-phased study developed a communication needs assessment from summer 2021-2022. The first phase allowed us to understand how communication preferences of vulnerable populations' shape their knowledge and awareness about HABs and its health risks. In this phase, we discovered a potential gap between how users are learning about HABs health effects, and how sources such as EPA, NOAA, Center Disease and Control (CDC), and Environment, Great Lakes, and Energy (EGLE) are currently communicating health risks about HABs. During our second phase, using a pre and posttest approach, an online survey was administered to measure how public's behavioral beliefs influence risk perception among the different communication frames they received, the virtual factsheets were randomly distributed

within survey, and respondents were assigned to three groups: cognitive, emotional and control group. from the study used independent variables from the TPB: behavioral beliefs such as attitude, subjective norm and perceived behavior control, and incorporated knowledge as an additional independent variable. Risk perception was the dependent. Using TPB and SARF allows us to further understand how risk perception can be measured and influenced through different communication preferences, behavioral beliefs, and communication frames, helping us learn more how to better communicate essential scientific findings about HABs health risks to the public.

Chapter 2 focuses on answering the third research question, which focuses on evaluating different communication frames and how each can influence risk perception to avoid engaging in recreational water activities when HABs are visibly present. Based on our findings through the first phase of the study. The cognitive communication frame was designed representing how existing government and health agencies communicate about HABs health risks, whereas emotional communication frames was designed based on the preliminary findings from our first phase of the study. Using different communications frames, we aim to evaluate if a specific communication frame influences the level of risk perception among the users attending Belleville Lake, Ford Lake, and Lake Erie. The work in this thesis has furthered our understanding of the importance of communicating HABs' potential health risks and effects, as well as contributing to limited studies that discuss how HABs risks are being communicated and learned about in communities within the Huron River watershed.

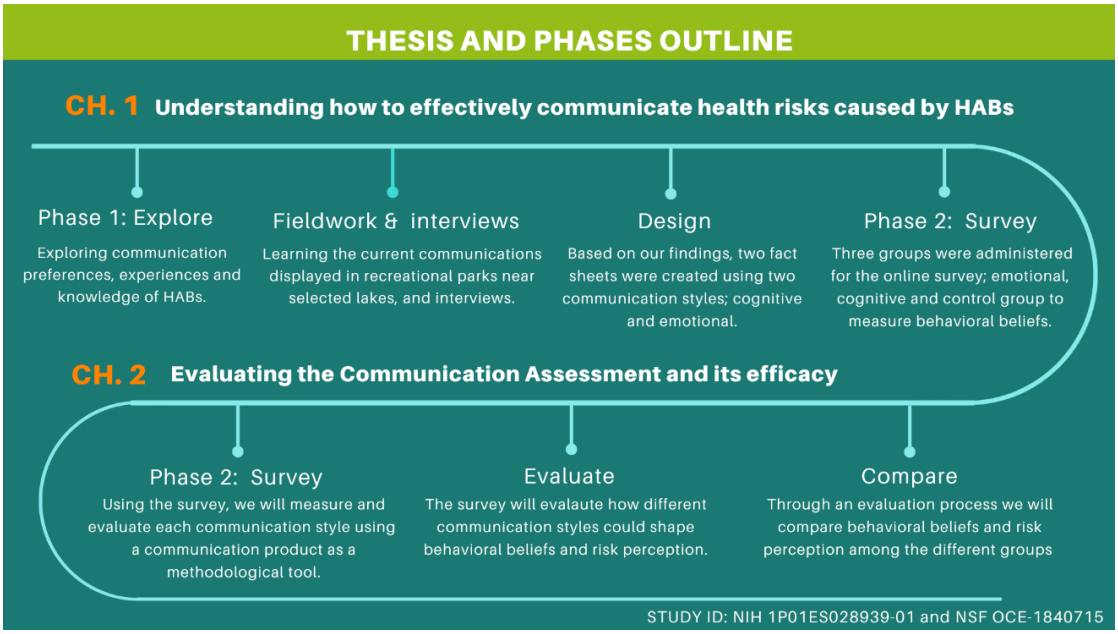

Figure 1. Outline of the thesis and chapters

Research questions:

1. Communication preferences:

   How are communication preferences of vulnerable populations' attending Belleville Lake, Ford Lake, and Lake Erie shaping their knowledge about HABs and their health risks?

2. Behavior Beliefs:

   How are the public's behavioral beliefs (attitude, knowledge, subjective norms, and perceived behavior control) shaping their risk perception towards HABs?

3. Different communication frames:

   How do different communication frames (emotional vs. cognitive) influence the public's risk perception of HABs and intention to avoid engaging in recreational water activities when HABs are visibly present?

CHAPTER 1: UNDERSTANDING HOW TO EFFECTIVELY COMMUNICATE RISKS: RISK PERCEPTION AND BEHAVIORAL BELIEFS ASSESSMENT

INTRODUCTION

The need to effectively communicate environmental health risks to prevent harmful incidents caused by HABs is vital. Communicating about health risks with intent to increase the public's risk perception can be a challenge given that an individual's perception is driven by multiple psychological factors (Frewer 2004). Although it is the responsibility of risk management to effectively inform and protect environmental health risks to the public, the public perception of risk tends to be excluded from policy processes by risk assessors and managers, claiming it is 'irrational' (Frewer 2004). However, some would argue studying risk perception is a crucial component of health behavior change (Ferrer & Klein 2015). Risk perception is widely known to be influenced by behavioral changes and has a direct impact on how individuals respond to risk and risk management activities (Frewer 2004, Kim et al., 2017; Ning et al., 2020). Findings by Heydari et al., (2021) found risk perception and risk communication to be directly correlated. Although one would expect risk perception and risk communication to work alongside, this study emphasized the importance of how understanding risk perception can contribute to effectively communicate risk and promote self-protectiveness efforts. Unfortunately, due to climate change, many environmental effects will continue impacting human health and livelihoods, causing a great need to effectively communicate environmental health risks. Many studies have shown how perception of risk can be better understood by analyzing health behaviors (Rimal, 2002; Witte, 1994; Rimal and Juon 2010) and health information processing and seeking behaviors (Rimal & Real, 2003, Turner, Rimal, Morrison, & Kim 2006; Rimal and Juon 2010). Although it is the responsibility of risk managers to inform and protect the public about environmental health hazards (Frewer 2004), little is known how

coastal populations perceive risks caused by HABs (Cordova et al., 2018). Currently there are limited case studies on how communities near the Great Lakes engage with HABs and how society copes with HABs (Brooks et al., 2015; Steffen et al., 2014; Gil et al., 2018; Moore et al., 2020). Much less research discusses how communities residing near small lake-reported blooms are learning about its health effects in Michigan. As stated by Brooks et al. (2016) and Steffen et al. (2014), HABs found in inland waters are poorly understood across space and time because of how greatly their magnitude, frequency, and duration may vary. In recent years, the intensity and frequency of HABs has increased globally (Backer et al. 2015; Schmale et al. 2019). Many regions of the Great Lakes have recurring cyanobacterial harmful algal blooms (Binding et al. 2020), however there is a critical gap between human and animal health impacts and the range of conditions that occur in relation to the toxins HABs produce (Chorus and Bartram 1990; Schmale et al. 2019). Addressing this gap is critical to understand in order to effectively communicate, promote, and regulate public health measures caused by HABs (Cordova et al., 2018). Especially explore how those attending lake reported HABs are perceiving risks (caused by HABs). Risk communication and risk management must take account of societal concerns and values, the goal of risk communication should aim to "rectify the knowledge gap" between the creators of the scientific information and those receiving information, which can be done by listening to the actual needs and concerns of the public (Frewer 2004).

In this study we aim to contribute to the field of risk communication to improve our understanding of how to effectively communicate human health risks caused by HABs to lake users attending Belleville Lake, Ford Lake, and Lake Erie. According to Michigan Department of Human Health Services (MDHHS) (2021), the selected lakes have reported large presence of HAB events every year since 2017 and is expected to continue increasing in the future. Including

several lakes with different characteristics in Michigan can capture a more diverse study population and different characteristics can shape the public's perception of risk towards HABs, enabling us to learn how to better tailor the message towards the public. Using SARF and TPB, the two-phased study developed a communication needs assessment during the summer of 2021 and 2022. In this chapter, we explore ways to understand the public's perception of risk caused by HABs through learning about the public's communication preferences, level of knowledge about HABs human health risks, concerns about the lake(s), and evaluating how behavioral beliefs shape risk perception.

METHODOLOGY

Defining key concepts

A. Risk

For the purpose of this study, *risk* refers to individuals' instinctive and intuitive reactions and feelings to danger (Slovic 2006). Concepts of risk distinguish between possible and chosen action regarding future events or circumstances. Humans have the option of choice, to identify different options as well as design different futures (Heath 2010). Risk perception includes evaluations of the probability as well as the consequences of an uncertain outcome (Gellman & Turner 2013). A challenge when addressing risk is uncertainty. According to Slovic (2000), to describe risk, there is no set of characteristics that can be defined in a universal manner. There is always consistency for staying the same, but change is a risk.

Risks need a voice, an advocate to inform people about the risk event, and this is often done through risk communication (Heath 2010). Successful risk communication involves having a common set of signs, symbols and common understanding, experiences, and values. However, a fundamental problem of risk communication is that the term "risk" varies greatly between people

and the scientific experts. There are enormous discrepancies in the way how risk is defined, perceived, and evaluated (Hampel 2006), thus highlighting the importance of understanding your audience and their values, experience among other factors that may influence having an effective communication about risk. In this section, we will discuss the importance of risk communication, effective ways to communicate risks, and the importance of understanding the public's risk perceptions of an event to develop an effective targeted communication campaign.

Modern risks, crises, and disasters present new kind of trouble for humans that require effective risk communication and action (Erikson 1994; Heath 2010). Industrial and information ages have created a new range of risks and crises while new technological and communication advancements (such as artificial intelligence, geotargeting, etc.) have evolved over time (Heath 2010), thus providing the opportunity to for increasing people's awareness, and dialogues. How information is distributed, presented, trusted, and understood are few challenges that risk communication can face. Two-way communication involves trust-building and stakeholder participation for one's message to reach intended audience (Heath 2010).

The ontological side of risk can be defined widely depending on the field of study. Althaus (2005) defines risk in various forms. In anthropology, risk is seen as cultural phenomenon, in economics, as a decisional phenomenon, in sociology it is seen as a social phenomenon, in history it is seen as a narrative, and in psychology it is viewed as a behavioral or cognitive phenomenon. In our study, we define risk as feelings referring to individuals' instinctive and intuitive reactions to danger (Slovic 2006). According to Slovic (1992), "risk" is a human invention, "it does not exist independent of our minds and culture. Concepts of risk have the distinction between possible and chosen action regarding future events or circumstances.

The perception of risk, however, includes evaluations of the probability as well as the consequences of an uncertain outcome (Gellman & Turner 2013). What human beings perceive as threats is very well influenced by their values, attitudes, social influences, and cultural identity (Ren et al., 1993). A challenge when addressing risk is uncertainty (Heath 2010). Traditionally technical risk analysis is focusing on the probability and consequences of events (Freudenberg 1988). Nevertheless, when humans perceive threat, how they evaluate the probabilities and magnitudes of the risk event should also include understanding individual's values, attitudes, social influence, and cultural identity (Ren 1993; Douglas & Wildavsky 1982).

B. Risk Perception

Risk Perception is defined in our study as individual's risk assessment and beliefs about potential harm or the possibility of a loss (Slovic 1987). It is an assertation people make about the characteristics and severity of a risk (Gellman & Turner 2013). Risk perception can be measured differently, to better understand this concept we used essential foundations from Slovic et al., (1987), the Extended Parallel Processing Model (EPPM) (Witte, 1994), how attitude can play a role when understanding risk perception (RPA, Rimal & Real, 2003) framework, and SARF(SARF) by Kasperson et al., (1988). Risk perception is an intuitive risk assessment that individuals perceive, through beliefs or attitudes related to harm (Slovic 1987; Ning et al., 2020). Some would argue perception of risk is a mental construct (Sjoberg, 2000; Van der Linden 2015). One of the most important paradoxes mentioned throughout different studies include how risks that harm people are often very different from the risks that concern, worry, and upset people (Slovic 1987; Covello 2011). The nature of human perception permits a differentiation between the real-world threats and what is subjective based on the individual's perceptual experience of those threats (Pidgeon, Kasperson & Slovic 2003), highlighting a key challenge

when measuring an individual's perception. The EPPM is a methodology used to study efficacy beliefs and emotional reactions to determine behavioral decisions. Threat or fear management use this model to better understand health behaviors. Witte (1994) uses this model to study AIDS prevention, including the underlying cognitive and emotional mechanisms of success and failure of appeals. Within Witte's findings, risk perception about the response that was recommended as prevention was associated with danger but unrelated to the factor of fear. Efficacy beliefs were evaluated by defining it as response efficacy, how effective are the proposed solution, and self-efficacy, which measures the level of confidence that can successfully practice the proposed solution (Witte 2005; Rimal 2006). Meaning, when rational considerations (efficacy beliefs) are strong, perceived risk can become a mediation correlation between emotional fear and behavior. In response to Witte's EPPM, Rimal and Real (2003) use concepts derived from EPPM and introduce RPA framework to further categorize individuals in four groups: responsive, avoidance, proactive, and indifference. Both EPPM (Whitte, 1994) and RPA Framework (Rimal & Real, 2003) mention risk perception consists of *perceived susceptibility* (individual's beliefs about its vulnerability towards the risk), and *perceived severity* (seriousness of the risk or effects the harm may cause, if exposed). Using EPPM (Witte 1994) and RPA framework (Rimal & Real, 2003), we can better understand what types of beliefs can drive risk perception. EPPM theory focuses on how individuals process messages, RPA framework theorizes how individuals' perception of risk can influence them to act (Turner et al., 2006).

The nature of human perception permits a differentiation between the real-world threats and what is subjective based on the individuals perceptual experience of those threats (Pidgeon, Kasperson & Slovic 2003). This presents a possible challenge, as Rimal and Juon (2010) describe while there are some studies that show a positive correlation between risk perception

and preventive behavior (Weinsten et al., 1998; Brewer et al., 2004; Heydari et al., 2021). There are several theories of health behavior such as protection motivation theory (Rogers 1975), health belief model (Rosenstock, 1974), and extended parallel process model (EPPM; Witte, 1994) that state having a personal risk to a disease is a reliable predictor of an individual to act (Rimal and Juon, 2010). Having this in mind, we hypothesize those who have a higher health predisposition (vulnerable populations) if exposed to HABs are likely to have a higher perception of risk than the public. Judgements about the severity of the potential effects caused by HABs are the risk perceptions evaluated in this study. EPPM by Whitte (1994), and RPA framework (Rimal & Real, 2003), we can understand more what drives risk perception. Using *perceived susceptibility*, individuals' beliefs about their vulnerability to disease, and *perceived severity*, which signifies the seriousness of the disease, we were able to integrate key concepts and design our risk perception questions in our online survey for our second phase. When discussing avoidance, it refers the behavior of avoiding engaging with the risk (Rimal and Real 2003). Within the four attitudinal groups mentioned in the RPA framework, avoidance was a relevant factor that was also measured throughout the online survey between the individual and a HABs event.

According to Rimal and Juon (2010), based on RPA framework, they found those with avoidance conditions are more likely to have a higher risk perception and weak efficacy beliefs. Findings from EPPM (1994) and Rimal (2002) demonstrate how the relationship between risk perception and health behavior can be influenced by efficacy beliefs, referring to the capacity the individual may have to execute the behavior (Bandura 1997, 1986, 1997). Rimal and Real (2003) also demonstrated how motivations to engage in a better health behavior is guided by the influence of risk perception and efficacy beliefs (Rimal and Juon 2010). Learning about concepts

that may influence risk perception allows us to integrate risk perception within TPB model. Using this approach, we can better understand public's perception of risk towards HABs. Behavioral changes influence risk perception (Kim et al., 2017; Ning et al., 2020). Many studies have shown how perception of risk can be better understood by analyzing health-behaviors (Rimal, 2002; Witte, 1994; Rimal and Juon 2010), such as health information processing (Rimal & Real, 2003) and seeking behaviors (Turner, Rimal, Morrison, & Kim 2006; Rimal and Juon 2010). However, some argue perception of risk must be investigated through people's efficacy beliefs (Rimal and Juon 2010). In this study, to better understand how behavioral beliefs can influence risk perception, our chosen efficacy beliefs include the three main beliefs from TPB; attitude, subjective norm, and perceived behavior control, and integrated knowledge to further understand what factors could influence the level of risk perceived by the public. Within the TPB framework, attitude refers to the degree which a personal has a favorable/unfavorable evaluation of the behavior of interest, subjective norms refer to the belief about whether most people approve or disapprove of the behavior, and lastly perceived behavioral control, refers to a person's perception of the ease or difficulty of performing the behavior of interest.

C. Trust

Trust was a concept explored during our first phase of the study, for the purpose of our study we defined trust as a psychological intention to accept vulnerability in relation to expectations of intentions and behavior of others (Rousseau 1998). The component of trust and confidence can be further studied using the Trust, Confidence and Cooperation Model (Earle & Siegrist 2008). Trust is social and relational; confidence is instrumental and calculative (Earle, Siegrist, & Gutscher, 2007). Trust is based on social relations, on *shared values*. Defining trust as the willingness, in the expectation of behavioral outcomes, to make oneself vulnerable to

another based on judgement or similarity of others (Earle & Siegrist 2008). When discussing trust and confidence there is a difference in their terminology. According to Siegrist et al., (2005) confidence is measured by experiences and actions, trust is not. Generally, trust depends on feelings, and is defined as a belief that other people can rely on, whereas confidence is a belief that everything is under control. A low level of trust and low confidence can negatively influence risk perception (Siegrist et al., 2005).

D. Knowledge

Knowledge is defined as justified true belief (Bolisani 2017). In our first research question we will be evaluating what the true beliefs vulnerable populations have regarding what HABs are and their effects, as well as associating the sources that they use to influence and understand risk perception. This will help us understand the kind of information and beliefs the selected vulnerable populations have regarding HABs, as well as understanding how the sources of communication that are being used influence their beliefs about HABs and lake conditions. In our study, knowledge was measured in both the first and second phase of the study. In our first phase of the study, it consisted of several open-ended questions such as asking participant to share their general understanding of HABs, their effects and what they look like. In addition, other questions that explored participants' knowledge asked if they knew how HABs were caused. As for the second phase, knowledge was measured through the online survey, asking four questions regarding HABs' potential health risks. An example included asking the participant to check all the possible symptoms that would apply if they were to swim with HABs present in the lake, another example was by asking what type of populations would be more likely to have higher health risks if they were to be exposed to HABs.

RESEARCH DESIGN AND METHODS

Theories and a conceptual theoretical framework

To understand effective risk communication, a mixed-method approach was designed through an iterative process consisted of applying concepts derived from SARF and TPB (Fig. 2). SARF is a theoretical tool used to understand how risks are perceived, interpreted, and amplified as they are communicated throughout society (Kasperson et al. 1988; Mase et al., 2015; Pidgeon et al., 2002). SARF discusses how certain types of potential hazard events or risks (in relation to the lake) interact with the psychological, social, institutional, and cultural processes, which could attenuate (decrease) or amplify (increase) perceptions of risks (Pidgeon and Henwood 2010). This framework helps design our questions administered through semi-structured interviews in the first phase of the study. It helps understand how sources of communication drive risk perception by applying community engagement such as exploring social and cultural events within the communities that reside near Belleville Lake, Ford Lake, and Lake Erie. Although semi-structured interview questions were based on concepts from SARF, engaging with community members, events, observational fieldwork, and becoming aware of the positionality as a researcher, from an "outsider-insider" perspective helped us gain a better understanding of how people perceive risk towards HABs. Using basic component from grounded theory help explore findings that were not in our initial outcomes, such as learning personal lake stories and incidents, how trust toward government agencies when receiving information about lake conditions (hazards, health effects, risks, etc.), or how different social characteristics among the lake users vary, as well as the type of communication preferences and lake experiences were observed. Through qualitative research, we explored individuals' beliefs about the health consequences (Glanz et al., 2008) if and/or when engaging directly with HABs

while performing recreational activities. Using TPB, and integrating risk perception, can help measure how behavioral beliefs shape public's risk perception based on the different communication frames (emotional and cognitive) distributed through a virtual factsheet within an online survey. Using SARF and TPB can help us better understand risk perception using an interdisciplinary approach such as the socio-psychological, cultural, and behavioral beliefs. This can help contribute future studies better understand how risk perception can be influenced and better integrated within the field of science communication and HABs.

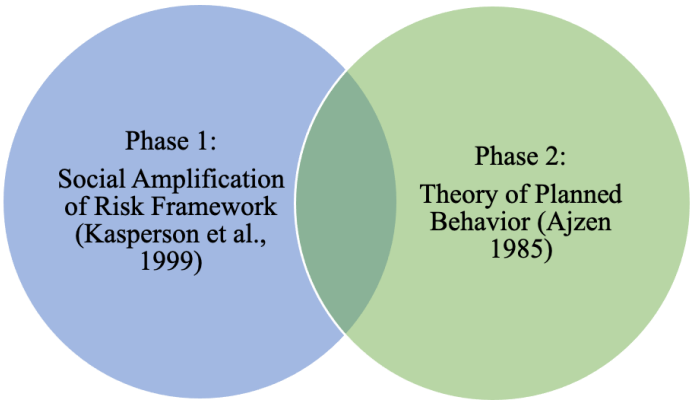

Figure 2. Social Amplification of Risk Framework (SARF) by Kasperson et al. 1998, and Theory of Planned Behavior (TPB) by Ajzen 1985

Social Amplification of Risk Framework (SARF)

SARF (Fig. 3 and 4) is a theoretical tool that will allow us to understand how risks are perceived, interpreted, and amplified as they are communicated throughout society (Kasperson et al. 1988; Mase et al., 2015; Pidgeon et al., 2002). There are two main stages in social amplification/attenuation of risk process: "the transfer of information about the risk/risk event, and the response mechanism of society" (Kasperson et al., 1988). There are four information mechanisms that SARF proposes contribute to the amplification of risk perception: volume of information about a risk event, ambiguity of information, dramatization of facts and potential consequences, and symbolic connotations communicated in the process of sharing information

(Strekalova 2016; Kasperson et al., 1988). The SARF Framework will allow us to understand how certain types of potential hazard events or risks interact with the psychological, social, institutional, and cultural processes that attenuate (decrease) or amplify (increase) perceptions of risks (Pidgeon and Henwood 2010). The amplification in the framework refers to the process during which audience members spread health risk information through social networks, thus creating a larger reach for information to be engaged (Strekalova 2016; Pidgeon 2003). This can be seen through SARF, exploring communication preferences, labeled as "information channels" (orange box in Fig. 3), evaluating individuals' interpretation of the message, labeled as "individual stations" (blue box in Fig. 3) and understanding the cultural and social groups, seen under "social stations" (green box in Fig. 3). Risk attenuation and amplification processes proposed by Kasperson et al. (1998) allow to understand the basic risk communication processes, that can lead to improved health environmental policies (Pidgeon and Henwood 2010). Many studies apply the SARF Framework to understand how mass media and interpersonal communication influence risk perceptions. Other studies have applied SARF to understand environmental communications, for example about wildfires, and strategic communication based on individual's thoughts and receptiveness of communicating risks caused by climate change within U.S agriculture (Mase et al., 2015). In this research we extend the application of the SARF to learn how the sources of information, and its socio-cultural channels. Using data from the first phase, a communication product with two different communication frames: cognitive and emotional, was tailored based on our findings and served as a methodological tool to evaluate its efficacy in the second phase.

Sources of information, channels of information, individual, and social behavior were components implemented in our research design for the first phase of the study to gain a better

understanding on how to better communicate risks caused by HABs. Exploring lake users' needs and concerns, experiences, current knowledge about HABs health effects were ways the study was able to comprehend how certain behavioral beliefs could shape vulnerable population's risk perception of HABs. The social amplification stations are seen as receivers and transmitters, allowing the flow of information to influence our perspectives and information we share and learn (Kasperson et al., 1988; Mase et al., 2015). Exploring what kind of sources of information vulnerable populations use to learn about their lakes, its conditions, news, as well as what sources they use to retrieve health related risks and concerns, will help us understand how those sources can influence their level of knowledge and perception of risk through their individual and social communication preferences. Applying this framework for our first phase (see Fig. 4) will allow us to apprehend how the role of media compared to interpersonal communication influences the attenuation/amplification of risk in communities. By learning how their social information, its channels and social stations drive vulnerable populations' individual process of communication, we can further understand how that can influence their attitudes, knowledge about HABs and how they perceive risk, in this case, from HABs events. The individual amplification station represents how each person receives a risk signal and this can influence if it attenuates/amplifies the information they receive. Learning what sources of information and channels vulnerable populations consider trustworthy will allow us to understand how it may influence vulnerable populations' perception of risk. By conducting fieldwork research, we compare and evaluate how existing communications about HABs / signage near parks in Ford Lake and Belleville Lake to Lake Erie may vary. A limitation from the SARF framework is that it remains unclear how to measure certain abstract concepts and it does not provide a way to analyze or predict whether a risk can be amplified or attenuated. For this reason, using SARF

will allow us to understand the social and cultural components on how perception of risk can be influenced. However, we will be applying TPB (Ajzen 1985) to analyze perception of risk, among other behavioral beliefs.

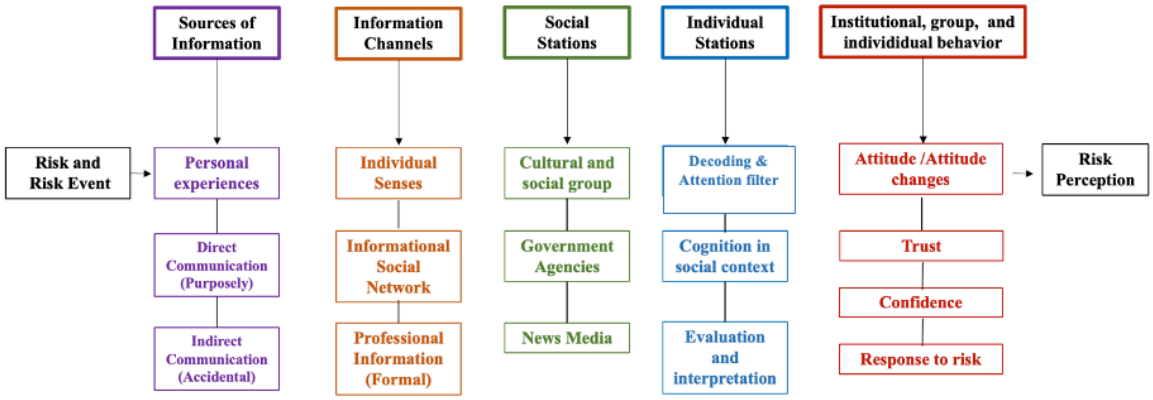

Figure 3. SARF Framework Adaptation (Kasperson et al., 1998)

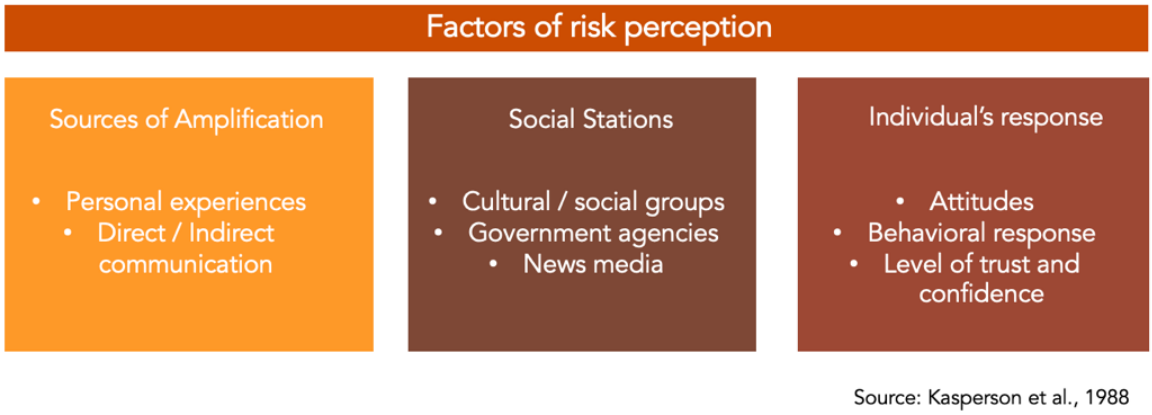

Figure 4. Simplified adaptation of the channels from SARF

Theory of Planned Behavior (TPB)

TPB will be our primary conceptual framework used for our study. This will allow us to understand how certain individual motivational factors will help determine the likelihood of performing a specific behavior (Glanz et al., 2008). TPB explores the relationship between behavior and beliefs, attitudes, and intentions. TPB has several concepts, it is initiated by its behavioral intentions, following attitude, subjective norm, and perceived behavioral control.

Behavioral intentions for this study will be learned through the first phase of the study by learning about their personal lake experiences, stories and interactions vulnerable populations have expressed when interacting with the lake. For the conceptual framework, attitude is defined as personal evaluation of the behavior or individual beliefs about outcomes (Fishbein and Ajzen 1975). Two important scholars that developed several TPB components throughout the years include Fishbein and Ajzen (1975), they demonstrated that attitude toward the behavior is much better predictor of that behavior than the attitude toward the object at which the behavior is directed. TPB framework studies individual's behavior to engage in a specific behavior. In our study, to understand if trust and attitude play important role that may influence risk perception and learn how to effectively communicate risk toward vulnerable populations. Using this framework and integrating it with our two-phase method will allow us to develop an effective communication campaign product to increase awareness and risk perception about HABs as our intentional behavior outcome. Factors that TPB take into consideration include attitudes, subjective norm, and perceived behavioral control, through the intention, we obtain an outcome (behavior). Within the framework, attitude refers to the degree which a personal has a favorable/unfavorable evaluation of the behavior of interest, subjective norms refer to the belief about whether most people approve or disapprove of the behavior, and lastly perceived behavioral control, refers to a person's perception of the ease or difficulty of performing the behavior of interest. The subjective norm is a conceptual component of the TBP that is defined as beliefs regarding the approval or disapproval of the behavior, observing the motivation to behave a certain way. An individual who believes that they should perform a behavior and is motivated to meet expectations of those referents will hold a positive subjective norm. An individual who believes that these referents they should not perform the behavior will have

negative subjective norms, and lastly those individuals that are less motivated to comply with any of the referents established will have a neutral subjective norm. Although risk perception is not included in this framework, using SARF as reference to understand more how risk can be perceived, and using data analysis behavioral beliefs from TPB, we are able to include intentional behavior and perception of risk as two main dependent variables. Behavior is predicted by behavioral intention which is, in turn, predicted by three base components: attitudes toward the behavior, subjective norms regarding the behavior, and perceived control over the behavior (Asare 2015). For this study, we included knowledge within the base components to study intentional behavior.

TPB is largely used to understand behavioral intention, and potential health behaviors. This theory has been successfully used to predict and understand a wide range of health behaviors and intentions such as drinking, smoking, health services utilization, exercise, sun protection, breastfeeding, HIV/STD-prevention behaviors, and the use of contraceptives (Ajzen 2020; Gatz et al., 2008). Applying TPB to our study (Fig. 4) will allow us to understand the how to effectively communicate risk towards vulnerable populations, and to increase their risk perception when encountering a HAB risk event. The specific intentional behavior we want to promote is avoiding engaging in recreational activities in the selected lakes when blue-green algae blooms are present. The behavioral beliefs that will allow us to understand the likelihood of risk perception and intentional behavior include knowledge, attitude, subjective norm, and perceived barrier to understand vulnerable populations' likelihood of behavior and risk perception. Although knowledge is not in the original TPB, through our exploratory findings considered it an essential component to include within the study, and measure if knowing about HABs health effects previously influences how public perceives risk differently than those

unaware of HABs health effects. The outcome for our study, is understanding what behavioral beliefs may influence perception of risk and public's intentional behavior between those that received a factsheet and does that did not.

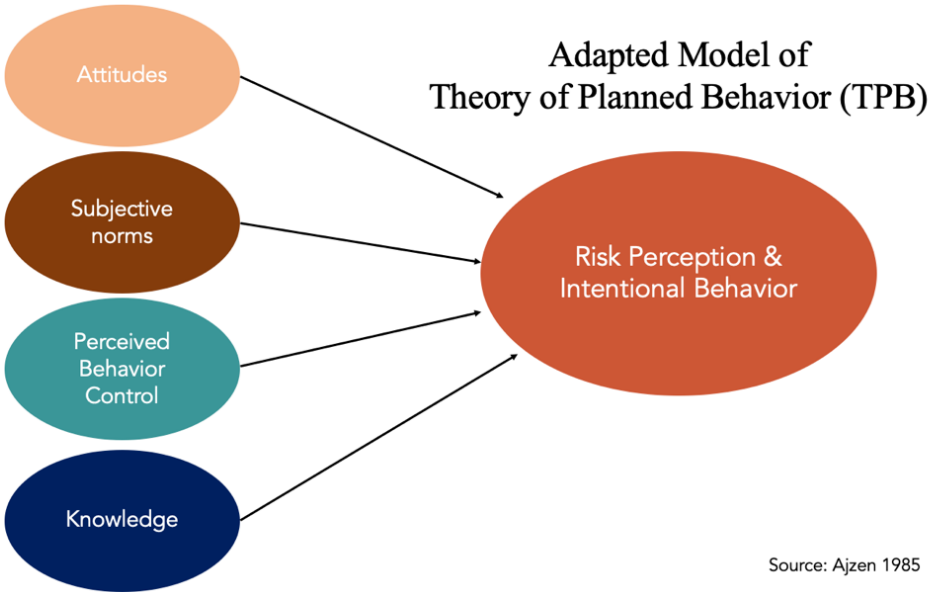

Figure 5. TPB Adaptation (Ajzen 1985)

Study design of the two phases

The study consists of two phases designed through an iterative process. Using a mixed method approach and integrating community engagement elements, the study aims to understand how to effectively communicate HABs health risks. Throughout the first phase, the study consisted of a qualitative research method, exploring how selected vulnerable populations attending Belleville Lake, Ford Lake, and Lake Erie are learning about HABs and their health effects. Through observational research, administering fieldwork and semi-structured interviews, the study learned about vulnerable populations' communication preferences, knowledge, and personal stories regarding personal lake experiences, among other lake concerns. Based on the exploratory data collected throughout the first phase, the study was able to design two factsheets with different communication frames: a cognitive and emotional appeal. For the second phase of

the study, through fieldwork, online survey and administering a small focus group, we were able to evaluate how different behavioral beliefs influence risk perception. By experimentally exposing respondents to different factsheet using the different communication frames, the study aims to determine which intervention exposure achieves desired risk perception. Applying TPB, and integrating concepts derived from SARF (SARF) Framework, the study aims to evaluate how behavioral beliefs can shape the public's risk perception to avoid performing recreational activities when HABs are present. The selected behavioral beliefs for this study were adapted by TPB, and concepts derived from SARF, include attitude, subjective norm, perceived behavior, and knowledge. The concept of risk perception was integrated within the conceptual framework of TPB to compare and evaluate how behavioral beliefs may influence perception of risk and intentional behavior. To measure and compare the efficacy of the cognitive and emotional product, we administered an online survey among three groups: one exposed to the cognitive appeal product, one exposed to the emotional appeal product, and a control group that was not exposed to any communication product. This was designed to analyze how risk perception and intentional behavior vary among the different communication products. In the first chapter, we explore how the public is learning about HABs potential health effects. Through learning about vulnerable populations' knowledge, communication preferences and lake experiences during the first phase, we were able to identify possible behavioral beliefs. Integrating concepts learned from TPB, we will discuss how attitude, subjective norm, and perceived behavior control (behavioral beliefs) can shape risk perception.

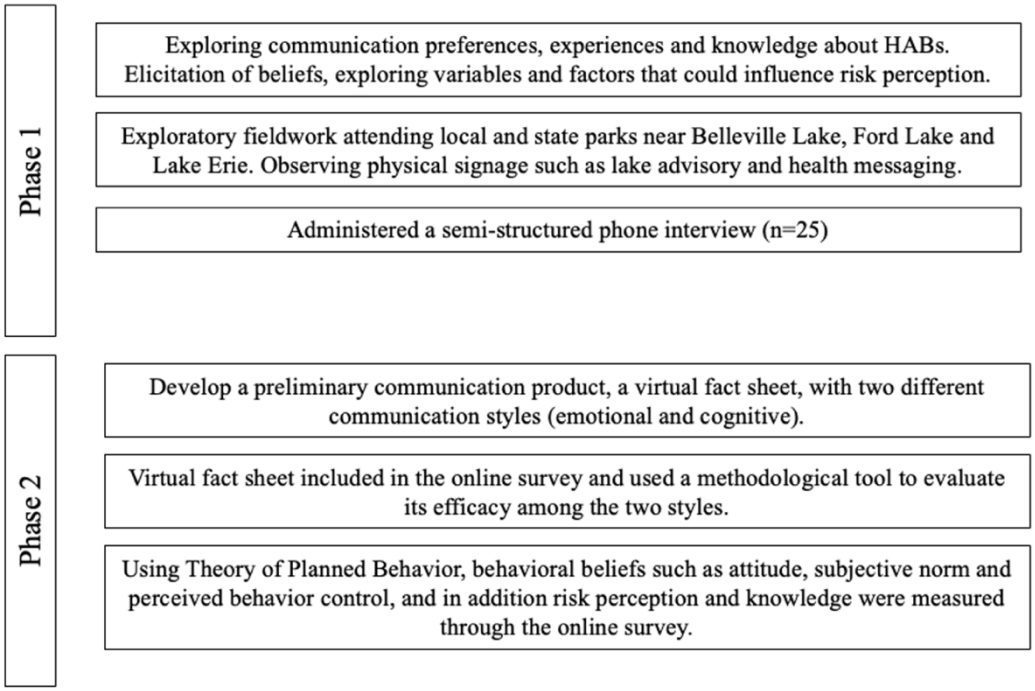

Figure 6. Design method of the two phases

Study sites: Belleville Lake, Ford Lake, and Lake Erie

Limited studies discuss the HAB events that occur in inland lakes in Michigan. According to Michigan Department of Human Health [MDHHS] (2021), Belleville Lake, Ford Lake, and Lake Erie have reported the presence of HAB events since 2017. Among the Great Lakes, Lake Erie is the southernmost, warmest, shallowest, and most biologically productive of the lakes (Watson et al., 2016). It is the most seriously impacted by nutrient pollution, and it's thought to be more prone to eutrophication because of its shallower depth (Preppas 2003; Brooks et al., 2015). Belleville and Ford Lake form part of the 'Middle Huron', according to the Huron River Watershed Council [HRWC] (2022), the 'Middle Huron' is defined as the section of the Huron River that begins in the Mill Creek basin in western Washtenaw County and extends through Belleville Lake in western Wayne County. The Huron River drains into Lake Erie, therefore the land in the Huron River watershed is also part of the Lake Erie watershed (HRWC,

2022). Lake Erie is considered one of the best-publicized examples of the serious impacts of humans on water quality (Preppas 2003), whereas Belleville and Ford Lake have had less media coverage regarding HABs events. Because Lake Erie is more well-known for its publicized events, whereas Belleville and Ford Lake have more limited media coverage, we expect risk perception of HABs for those that attend Lake Erie will be higher. In addition to different geographic characteristics, through a social dimensional lens, and community engagement, we were able to observe different recreational activities among the selected lakes, presenting an interesting comparison we did not initially expect to observe.

Justifying the selection of the lakes: Belleville Lake, Ford Lake, and Lake Erie

There are limited studies discussing the human scope such as the social and cultural impacts in relation to HABs events occurring in inland lakes in Michigan. Before conducting fieldwork research, interviews and administering surveys for this study, we contacted the Michigan Department of Human Health (MDHHS), among other scientists, researchers and professionals that work with HABs for suggestions regarding what potential lakes we select for our study. Using a excel spreadsheet of the cumulative multiyear from 2017-2020 presence of HABs from MDHHS, we were able to narrow down our selected lakes. As seen on Table A-C, Belleville Lake, Ford Lake, and Lake Erie have reported positive toxin advisory level exceeded (Table 2), and positive presence of HAB events since 2017 (Table 1). However, variation was presented based on the recreational toxin level (Table 3).

HABs report on Belleville Lake, Ford Lake, and Lake Erie

Selected lakes:	County	*Blooms reported*			
Year:		2017	2018	2019	2020
Belleville Lake	Wayne	Y	Y	Y	Y
Ford Lake	Washtenaw	Y	Y	Y	Y
Lake Erie	Monroe	Y	Y	Y	Y

Table 1. HABs Report (Source: Cumulative multiyear MDHHS HABs 2021)

Toxin advisory level exceeded report on Belleville Lake, Ford Lake, and Lake Erie

Selected lakes:	County	*Positive toxin test*			
Year:		2017	2018	2019	2020
Belleville Lake	Wayne	Y	Y	Y	N
Ford Lake	Washtenaw	Y	Y	N	Y
Lake Erie	Monroe	Y	Y	UNK	Y

Table 2. Toxin advisory level exceeded report (Source: Cumulative multiyear MDHHS HABs 2021)

Recreational Toxin Advisory Level exceeded report on Belleville Lake, Ford Lake, and Lake Erie

Selected lakes:	County	*Recreational Toxin Advisory Level exceeded*			
Year:		2017	2018	2019	2020
Belleville Lake	Wayne	N	Y	Y	N
Ford Lake	Washtenaw	N	Y	N	Y
Lake Erie	Monroe	Y	UNK	N	N

Table 3. Recreational Toxin Advisory Level exceeded report (Source: Cumulative multiyear MDHHS HABs 2021)

Selected populations:

Vulnerability is often described as populations at risk for premature mortality or morbidity (Aday 1994). The etymology of the word "vulnerable" comes from late Latin, "vulnerabilis" or the root vulnus which means "wounding". The concept of vulnerability implies that everyone is potentially vulnerable (at risk), however the risk is greater to those that have least social status, social capital, and human capital resources (Aday 1994). In addition, those with poor health and healthcare access experience significant disparities in life expectancy could lead to morbidity and mortality (AJMC, 2006). Three main domains of vulnerable populations include physical, psychological, and social components (Aday 1994 & AJMC 2006). In this study we define 'vulnerable populations' using the epidemiological concept of risk, thus describing the population of having a higher probability of becoming ill.

Susceptibility is defined as "capacity characterized by biological (intrinsic) factors that can modify the effect of a specific exposure, leading to higher health risk at a given relevant exposure level" (Hines et al., 2010). Sensitivity is defined as "the capacity for higher risk due to the combined effect of susceptibility, and differences in exposure" (Hines et al., 2010), whereas vulnerability incorporates concepts from the susceptibility and sensitivity, and includes the social and cultural parameters such as the location of residency (Aday 1994; Purdy 2004; Hines et al., 2010). For this reason, the study utilizes concepts from susceptibility and sensitivity, addressing the terminology 'vulnerable' for the selected population.

Due to limited literature that discuss the specific vulnerable populations' if exposed to HABs, the study used EPAs criteria of vulnerable populations if exposed to HABs through a HABs drinking water factsheet created by EPA (2022). Vulnerable populations exposed to HABs include nursing mothers, individuals receiving dialysis treatment, the elderly, individuals with pre-existing conditions such as liver conditions, severe asthma, and chronic kidney disease,

those nutritionally and economically reliant on fishery resources, among other types of risk-sensitive populations, such as those who cannot tolerate chemical exposures (EPA, 2022). The selected vulnerable populations for this study include the elderly population (65+), pregnant and nursing mothers, those with pre-existing conditions such as chronic kidney disease, diabetes, cancer patients, asthma, respiratory complications, liver conditions, dialysis patients, and community members residing near Belleville Lake, Ford Lake, and/or Lake Erie, and claimed to be residents in Washtenaw, Wayne or Monroe County. During our first phase of the study, a total of 27 participants consisted of selected vulnerable populations that attend Belleville Lake, Ford Lake, and Lake Erie were interviewed. For the second phase of the study, the online survey was open to the public willing to share their behavioral beliefs, lake experience and knowledge about HABs. A higher preference was given for the public to attend at least one of the following lakes: Belleville Lake, Ford Lake, and/or Lake Erie, and for this reason they survey was sponsored mainly through closed Facebook groups, and lake events within the selected lakes. The option to not know or experience HABs were given, and not excluded. If participant had other HABs experiences in other lakes, the option was given to include the other lake(s) they had attended. Hard-copy and virtual flyers were administered and displayed in events and online formats affiliated with these specific lakes. Learning about vulnerable populations' knowledge, communication preferences and lake experiences allowed us to have a better understanding how several behavioral beliefs could shape community members' risk perception of HABs and develop a preliminary communication product.

METHODS: PHASE 1

Study design and data collection

The first phase consists of exploring vulnerable populations' knowledge, communication preferences and lake experiences. The first phase (IRB ID STUDY00006225) was conducted during June-July 2021 during strict regulations due to the global pandemic (COVID-19) had emerged. Through fieldwork and semi-structured phone interviews the study was able to understand vulnerable populations' communication preferences, sources they trust and lake experiences in Belleville Lake, Ford Lake, and/or Lake Erie. Due to MSU and IRB policies, interviews were administered by phone, providing an incentive of $5 Amazon gift card per participant, and sent via email. A mixed-recruitment strategy included: designing flyers sponsoring the semi-structured phone interviews and pasting them in public spaces in fifteen local and state parks, handing flyers to those attending the park for recreational purposes, and using snowball sampling method; a random sample of individuals drawn from a finite population, helping the study make statistical inferences about various aspects in the given population (Goodman, 1961). The objective of snowball sampling is growing sample size hence described as a rolling snowball (Kirchherr and Charles 2018, Goodman, 1961). With the help of informally talking with community members, we were able to learn more about community events, parks, and help potentially recruit potential participants. During fieldwork, while pasting flyers in the state and local parks, the study explored existing physical messages about the lake announcements and hazards posted in bulletin boards and other public spaces. In addition, several photographs of the physical water-health advisory messages were taken as part of the data and attending community events that formed part of our preliminary findings to better understand how existing messages are communicating hazards towards the public and compare images and signs among the different

parks. Community events included attending fishing tournaments, Public Library events, and lake festivals.

Conducting interviews was a helpful method to understand vulnerable population's story behind their lake experiences. This allowed emerging themes, and stories to be explored (McNarmara 1999). A semi-structured questionnaire was designed to explore communication preferences, sources they consider trustworthy, current behaviors engaging with HABs, lake experiences, and knowledge about HABs' human health effects of selected vulnerable populations. Questions within the semi-structured interviews were divided in three sections: communication preferences, lake experiences and knowledge. Questions asked to better understand selected vulnerable populations' communication preferences include "what sources /where do you look for information to learn about your lake and its conditions?", and "what sources of information would you consider trustworthy to learn about what is going on in your lake?", for lake experiences, example of questions that were asked focused on their day-to-day event when attending their lake of preference: "Walk me through a usual day attending Belleville Lake, Ford Lake, and/or Lake Erie…", and "What kinds of activities do you do?", and lastly asking about their current knowledge about HABs, such as asking "What do you know about HABs?", and "Can you share your first experience seeing Harmful algal blooms (HABs)?". This allowed us to better understand how perception of risk could be influenced and better communicated.

While attending these events and parks, and unobtrusive participant observation was conducted while attending lake events and parks nearby the selected lakes (McKechnie 2000). Observatory research consists of focusing on behavior of interests while remaining apart (McKechnie 2000). It allows to extend our understanding of lived experiences and behaviors

(Aldridge 2006). Using this technique can uncover data without recollecting any actual words being exchanged between the researcher and participants. Using this method, it is highly suggested for researchers to be unobtrusive and listen more than they speak (Aldridge 2006; Arksay 2004). Using photographic methods is a common approach in qualitative research, visual representation is a central concept to cultural construction of social life (Rose 2011). Through a series of photos taken during fieldwork helps gain a better sense of how the public engages in recreational activities among the different lakes, as well as observe the different types of existing physical water-health advisory messages, and how community events are interacted with the selected lakes. Findings of this project include a series of photographs captured during fieldwork including physical signage posted in local and state parks nearby selected lakes, lake, and community events, among other findings such as proximity between the public library and the lake, and a boating adventure in Belleville Lake. Photo Story method is a two-dimensional narrative giving the visual and written representation of the exploratory findings (Keremane & McKay 2011), using a brief concept of this method, we plan to share the journey of the fieldwork experience attending the selected local and state parks. Throughout the semi-structured interviews, emerging stories from community members allowed new findings and themes about HABs and in addition, other concerns occurring in the selected lake to be discovered. These methods help gain a better understanding of how people are learning about conditions occurring in the lake, and how to design the preliminary communication product.

Data analysis of phase 1

Data retrieved from fieldwork, photographs, and semi-structured interviews were analyzed through qualitative data analysis. Using these techniques helped understand more how existing messages communicate about environmental-health news and lake conditions. Through

qualitative data we learned about selected vulnerable populations' communication preferences, lake experiences and level of knowledge of HABs human health effects.

The semi-structured phone interviews were analyzed through thematic analysis and coding (Saldaña 2010; Fereday & Muir-Cochrane 2006). NVIVO Software program was used to provide an organized structure and coding analysis. Thematic coding is a method to identify, organize, and describe themes found in a data set, it can produce trustworthy and meaningful findings (Nowell et al., 2017; Braun & Clarke 2006). Thematic analysis is searching for themes emerging throughout the collection of data, the process comes from re-reading data and pattern recognition, through this process emerging themes become the categories for analysis (Fereday & Muir-Cochrane 2006; Rice & Ezzy, 1999; Daly et al. 1997).

Through this qualitative data analysis, allowed us to create nodes, and emerging themes learnt about vulnerable populations communication preferences, lake experiences and knowledge about HABs. Using the three main objectives, allowed us to code qualitative data easily and organize nodes within the content analysis. Through our semi-structured interviews and community engagement such as attending social events, discussing about HABs and lake conditions with community members, and conducting fieldwork, allowed us to better understand our audience, thus shape a better personalized communication product. Among other findings, potential colors and imagery were explored during this phase. Using SARF(SARF) allowed to understand how exploring behavioral beliefs could influence how risks are perceived, interpreted, and amplified and communicated throughout society (Kasperson et al., 1988, Pidgeon et al., 2002). Incorporating SARF within defining risk perception in the study allowed us to develop a more socio-cultural understanding of how risk perception can be shaped. Using channels from SARF such as exploring selected vulnerable populations' personal experiences,

understanding the sources and social stations as mediators such as government agencies and news media communicate about HABs, and learning about attitudes and behaviors can allow us to better comprehend how risk can be influenced. By comparing how physical messages from government and health agencies are communicating health risks about HABs in the community, researching existing information online, and how they community is learning about HABs and its health effects, help narrow down our communication product (virtual factsheet) and design. The virtual factsheet will be evaluated in our second phase of the study with the objective to measure how individual's behavioral beliefs can influence risk perception, and how different communication frames can influence such perceptions of risk.

METHODS: PHASE 2

Study design and data collection

The second phase (IRB ID: STUDY00007642) consists of an online survey and focus group to measure behavioral beliefs and understand public's opinion regarding the communication product. The cross-sectional survey was administered from June to July 2022. Survey started with a brief explanation of the purpose and protocol of the study, and if the participant were to start the survey, they must confirm with two important statements: they are 18 or older, and they agree to voluntarily participate in the survey. It was conducted online, recognizing the survey to have an advantage of reaching large audiences with a bias towards those who have access to the online platform (Kim & Song 2017). Using our preliminary findings from the first phase, the study created several flyers; hard-copy and digital versions, to sponsor our online survey. The online flyer was sponsored by posting a digital flyer attached to the survey link in Facebook groups that focused on recreational activities in Belleville Lake, Ford Lake and Lake Erie, and Listerv emails from Michigan Sea Grant, Lake Huron Watershed

Council, among others. The hard-copy version of the flyer included a QR code that would lead you to the survey, and an email was provided in case they were unable to retrieve the QR code but would still like to participate. For taking the online survey, an incentive of $5 Amazon e-gift card was offered per each participant that fully answered the survey. Before distribution, a brief pilot test was administered with ten community members to receive feedback on the recruitment flyers and for the online survey. To gain the public's attention, multiple flyers were designed using different imagery and messages with the objective to promote more users to participate in the online survey. In addition to pasting flyers through state and local parks nearby the selected lake, the survey was sponsored by attending local lake fests events, among other small community events such as Rotary club meetings, and pasting flyers in local shops, libraries, and bathrooms. Individually approaching people during these events allowed to gain more insight on how the public attending selected lakes feel towards HABs and the lake. Introducing the project and the research objectives, allowed more people to share their personal opinions and stories about HABs.

Using preliminary data from the first phase, within the online survey the study created a virtual factsheet with two communication frames; one a cognitive style representing existing messages about HABs sponsored by EGLE, CDC, and EPA agencies, and another using an emotional communication style, involving more pictures of loved ones such as dogs, kids, elderly, and phrases associating feelings. The two different communications style virtual factsheets were included in the online survey designed through Qualtrics; they were included within the online survey serving as a methodological tool. The efficacy was evaluated by comparing how each communication frames influenced the public's perception of health risk of HABs and its intentional behavior to avoid engaging directly with HABs. Although the online

survey used the same set of questions, using a randomization process, the participant was categorized as one of the three groups: those receiving the emotional factsheet, cognitive factsheet, or the control group (no-factsheet). A total of 115 participants received a virtual factsheet with a different communication style, one group received the emotional communication frames factsheet (n=66), and cognitive communication frames factsheet (n=49), and a total of 43 participants took the survey without any exposure to a virtual factsheet, serving as our control group.

Using TPB in our survey help measure public's behavioral beliefs, attitudes, subjective norm, and perceived behavior control, risk perception and intentional behavior towards HABs and its human health effects. For participants that received the emotional and cognitive factsheet in the online survey, a test-pretest method was included measuring only risk perception and behavior. The same sets of questions were asked before and after seeing the virtual factsheet. The mean score was calculated for both to evaluate if there was a significant difference among each group (emotional and cognitive).

In addition to measure the communication frames of each factsheet, after the survey was finalized, a casual small focus group was administered in Belleville Public Library with the Belleville Rotary Club. During the focus group, factsheets were provided hard-copy format, communication frames were randomly distributed at the same time, the participants would switch among each other the flyer and write down general thoughts of what information they considered helpful, which type of flyer they liked the best and why and was asked what details of the flyer they liked, and/or did not like. Although there was no incentive, after having a brief discussion of the flyer, the meeting consisted of presenting a PowerPoint of the research,

fieldwork experience and preliminary results, allowing community members to express their opinions and concerns.

Data analysis of phase 2

By applying the TPB and Ajzen's et al. (1991; 2011) techniques to analyze behavioral beliefs we will understand how behavioral beliefs (such as knowledge, attitude, trustworthiness, etc.), and the different communication frames influence risk perception and intentional behavior to avoid performing recreational activities when HABs are present. Using Statistical Package for Social Sciences (SPSS), we were able to identify what behavioral beliefs shape risk perception (research question #2) through a multiple regression analysis. In addition, each behavioral belief was analyzed through the Coefficient alpha, or Cronbach's alpha, known as "one-way", to quantify reliability, this represents the proportion of observed score variance that is true score variance (Multon and Coleman, 2010).

Reliability test: Cronbach's alpha

Cronbach alpha is considered a scale of reliability; it measures the internal consistency related to a set of items per each group. According to "SPSS Survival Manual" by Julie Pallant (2020), a great coefficient alpha should be greater >0 .70. If items are less than 10, it should be at least greater than > 0.5. Based on our results, the two items that had at least 9 or more items included subjective norm and risk perception successfully met with a good Cronbach alpha scale of greater than .70, representing a good internal consistency, and does not imply the measure is unidimensional, but that a series of items were able to measure the scale of reliability per behavioral belief. Those with less than 5 items, must at least have a greater Cronbach alpha of > 0.5, based on our results, attitude, subjective norm, perceived behavior control, knowledge, and intentional behavior were greater than 0.5. However, if there are few items or a low alpha

coefficient, it is suggested to also include the inter-item correlation to better explain the relationship among each item per each belief.

Correlation regression analysis on risk perception and intentional behavior

A correlation regression and a t-test were conducted in this section to compare the risk perception and intentional behavior among the emotional and cognitive group. The correlation analysis is referred as the degree of relationship between variables; however, it does not identify specifically the variable that has caused such effect (Kafle 2019). Using correlation analysis in our study allows us to understand the relationship between before and after they received the factsheet per communication frames group.

Survey design

A 29-item was developed for data collection. Items were designed and developed to measure attitude (3 items), subjective norm (4 items), perceived behavior control (3 items), knowledge (4 items), intention (3 items) and risk perception (3 items). These items were scored on a 7-point Likert scale with answers that vary from strongly agree to strongly disagree, or extremely likely to extremely unlikely. Socio-demographic information was included such as gender, age, race, level of education, and health condition (if any). To ensure anonymity of participants, there was no personal identifying information of participants was collected, except email strictly to send incentive. Items assessing behavioral beliefs and risk perception are based on core elements of TPB (Ajzen 1985). To avoid any misguided persuasion of beliefs towards risk perception, the term “blue-green algae blooms” was utilized in the survey instead of mentioning the word “harmful”.

TPB measurements

Originally TPB is focused on individual's intention to perform a given behavior, for this study using Ajzen et al. (1991; 2011) methods to analyze the dependent variable (intentional behavior), the study incorporated risk perception as an additional dependent variable. TPB explores the relationship between behavior and beliefs, attitudes, and intentions. It allows us to understand how certain individual motivational factors will help determine the likelihood of performing a specific behavior (Glanz et al., 2008). The intentional behavior primarily was focused is evaluating if participants would avoid engaging in recreational activities when blue green algae blooms are present in the selected lakes. Behaviors included asking participants several different recreational activities such as kayaking, boating, fishing, and or other activities such as jet skiing, tubing, etc. Originally the TPB is guided by three main components, beliefs producing a favorable or unfavorable attitude towards the behavior, beliefs in result to perceived social pressure also known as "subjective norm", and control beliefs giving rise to any potential barrier that can limit the individual from performing the behavior, also known as "perceived behavior control" or self-efficacy. For this study, an additional independent variable was included within the TPB framework, knowledge. All variables were analyzed using the same equation and approach within the TPB conceptual framework. Each variable was calculated using the total sum and average. Through online survey, a series of 3-4 questions were categorized per behavioral belief. The questionnaire consisted of a total of 17 items designed to measure the TPB constructs in relation to public's perception of HABs and engaging in recreational activities in the lake. To measure the beliefs of each concept in TPB, responses to all items were provided on a seven-point bipolar adjective scale, typically employed measurement within the TPB (Ajzen 1991; Glanz et al., 2008). A general rule known among the beliefs in

TPB, the more favorable the attitude, stronger subjective norm, thus it is expected a greater perceived behavior control, given the directly proportional statements, it is expected to have a higher expectancy for the person to carry out their intentions of such behavior (Ajzen 2020).

Risk perception

Focuses on the possibility of danger, harm, or chance of hazard (Wolff et al., 2019). It refers to individual's risk assessment and beliefs about potential harm or the possibility of a loss (Slovic 1987). It is an assertation people make about the characteristics and severity of a risk (Gellman & Turner 2013). Following EPPM (Whitte, 1994) and RPA Framework (Rimal & Real, 2003) risk perception consists of perceived susceptibility, defined as individual's beliefs about its vulnerability towards the risk, and perceived severity; defined as the seriousness of the risk or effects the HABs may cause if they were to become directly exposed. Using multiple examples from Heck et al., (2005), Ning et al. (2020), Ajzen (2011), Turner et al., (2006), Wolff et al. (2019), and van der Linden (2014), we were able to design three questions categorized as risk perception. Each question represented one of the three concepts: the average perceived susceptibility, perceived severity, and hazard (Whitte, 1994; Rimal & Real, 2003; Gellman & Turner 2013

Survey design to measure risk perception included a matrix and a slider scale. To measure harm the following question was conducted: *"From "0" being "Not hazardous at all", to "7" being "Very hazardous", how hazardous would you consider blue-green algae blooms to be in relation to your health and well-being?",* to measure the likelihood and susceptibility: *"From what you know, how likely are you to experience negative health effects as a result of performing any of following activities when visible blue-green algae blooms are present?"* and lastly, to measure severity: *"From "0" being "Not severe at all", to "7" being "Very severe", in your*

opinion, if you were to perform the following activities when blue-green algae blooms are present, how severe would you think the negative health effects would be?".

We would expect, if the individual feels the lake is unsafe, it is more likely they would have a higher level of risk perception, whereas if the individual found the lake to be safe, the risk perception may be lower. Other behavioral beliefs will help us evaluate and understand if risk perception can be subjective.

Knowledge

Defined as "justified true belief*",* shown to have the limitations given by the justification condition of nature (Bolisani 2017). Also defined as a series of factual assertions, in which information people receive consider is accurate (Ajzen 2011). Obtaining knowledge within our study impedes a better understanding on how knowing about potential health risks can influence the public's perception of risk towards HABs. According to Ning et al., (2020) knowledge can facilitate the public to act. Four questions with fourteen items were administered to evaluate the public's belief of what health risks caused by HABs they may obtain if directly exposed, and the type of selected vulnerable populations' they believed were prone to having a higher potential health risk if exposed directly with HABs. Within the four knowledge questions, two were marking all the answers that applied, and two multiple choice questions. The objective of the knowledge questions in the survey consisted of measuring their beliefs after reading the factsheet. For those that received the virtual factsheet within the survey, the knowledge questions were asked afterwards, and asked the same content that appeared on the factsheet. Example of some knowledge questions included asking about HABs human health effects, the type of vulnerable populations if exposed to HABs, and if they knew where to report a HABs event. To acquire an overall level of knowledge, it was calculated using a

weighted average, this is often used to equalize the frequency of each value each number in the data, it is multiplied by a predetermined weight before the final calculation (Ganti 2022).

Intentional behavior

Will be determined by measuring the factors: attitude, subjective norm, perceived behavior control, and in addition specifically to our study, knowledge (Ajzen 2020). According to Ajzen (1991) the intentions are based on the motivational factors that influence a behavior. Through the original TPB attitudes, subjective norms and perceived behavior control are the three indicators of the likelihood of people to perform a particular behavior. The intentional behavior (outcome) for this study was understanding if individuals were more likely to avoid performing recreational activities such as kayaking, swimming, boating, and fishing while HABs were present in the lake. A mean score is calculated across the total number of items per each behavioral belief. During the survey, an example of how intentional behavior was asked was: *"From extremely likely to extremely unlikely, how likely are you to perform the following activities when visible blue-green algae blooms are present in the lake?"*. Intentional behavior assumes to capture the motivational factors that influence behavior (Ajzen et al., 1991). TPB postulates that the degree of behavioral control influences the effect of intentional behavior, thus, by having greater control of the behavior, it is more likely the intention to be carried out (Ajzen et al., 2020). Intentional behavior is calculated through its three determinants: attitudes, subjective norm, and perceived behavior control. According to Ajzen et al., (2011; 2020) by having a favorable attitude, supportive subjective norm, and strong perceived control provides a motivation to engage in the behavior thus have a strong and more concrete intention. To measure the likelihood of the performance and behavior, examples of the bipolar scale ranged from "extremely unlikely to very likely", or "extremely disagree to extremely agree". Associating

other beliefs such as “not concerned to “very concerned”, or “not hazardous to very hazardous”. Using literature from the creator of the TPB, Ajzen (1991), favorable behavior is associated to have large desirable consequences, whereas unfavorable behavior is associated with undesirable consequences. The outcome subjective value is a contributing factor to the attitude in a direct proportion to the strength of the belief (Ajzen 1991). Evaluations are measured with the outcome “good-bad” scales (Glanz et al., 2008). For example, having a more favorable behavior to avoid HABs would be considered part of a “good” scale.

Attitude

Defined as a “relatively enduring organization of beliefs, feelings, and behavioral tendencies towards socially significant objects, groups, events or symbols" (Hogg & Vaughan 2005), it is also a “mental and neural representation organized through experience, asserting a dynamic influence on behavior” (Pratkanis et al. 1989). *Affect* is defined as an instinctive emotional state that people experience, which can be related to an individual’s attitude. It is an experience that individuals associate with perception about the object and its negative or positive feelings attached to them (Árvai & Rivers III 2014). During our interview process we can narrow down affection based on how vulnerable populations express their emotions towards their experiences and expressions toward the lake. A 7-point Likert scale was administered to measure attitude within the three items. Attitude focuses on the beliefs about the behavior (Ajzen 2020). Measuring a degree to which it is favorable or unfavorable evaluation or appraisal was how we designed the three items (Ajzen 1991). Defining attitude as beliefs about behavior can also include emotions toward an intentional behavior, event, person, object, etc. (Cherry 2021). In this case we are focusing on the attitude toward engaging in recreational activities when blue green algae blooms are present. Negative items are reversed scored, from very positive or

favorable being the lowest score (1) to being very negative or unfavorable being the highest score (7). Within the online survey under the category of attitude, three questions using the slider technique were administered. Example of some of the questions include: "*From "0" being "Not negative", to "7" being "Very negative", how would blue-green algae blooms impact your recreational experience?",* a scenario question regarding feelings such as worry*: "Imagine you just went for a swim, but later found out there were blue-green algae blooms in the lake, from "0" being "Not worried at all", to "7" being "Very worried", how worried* would you be from contracting any potential health symptoms?", and lastly how concerned: *"From "0" being "Not concerned" to "7" being "Very concerned", how concerned are you regarding the presence of blue-green algae blooms in your lake?".*

Subjective norm

Is referred to the perceived social pressure to perform or not to perform the behavior" (Ajzen 1991). It is the approval or disapproval belief of the behavior, relating whether peers and people of importance to the person think he or she should engage in the behavior (LaMorte2019). Relating whether peers and people of importance think or perform the same behavior we are evaluating in the individual taking the survey. A total of four items were used to assess descriptive norms, defined as perceived behavior of others (Ajzen 2011, Ajzen 2020). Two ways it can be measured include descriptive normative belief, whether important others themselves perform the behavior, and injunctive normative belief, expectation, or subjective probability that an individual or group approves or disapproves of performing the behavior under consideration (Fishbein & Ajzen 2010; Ajzen 2020). Descriptive norms were selected to understand how most people in a group or in their social group think, feel, or do (Baumeister, & Vohs 2007). For our study, subjective norm was measured by asking what the likelihood of their friends, family, and

people in their community is to perform different kinds of recreational water activities. Negative items are reversed scored, from very positive or favorable being the lowest score (1) to being very negative or unfavorable being the highest score (7). By mentioning different types of recreational activities, we will evaluate and compare how the different recreational activities vary within the different friends, family, and people in their community. Example of questions asked under the category of subjective norm were designed through matrix, asking a total of four questions with different recreational water activities (fishing, swimming, boating, other water activities) and the type of approval per group (family, friends, and people in the community). Example of a subjective norm question includes: *"How likely are your family members, friends, and the people in your community to swim in the lake(s) when visible blue-green algae are present?"*

Perceived behavior control

Defined as the level of difficulty or ease of performing the behavior and it is assumed to reflect experience as well as anticipated impediments and obstacles (Ajzen 1991). It is the determinant of both behavioral intention and of the behavior itself (Ajzen 1988; Wallston 2001). The perceived behavior control involves beliefs with the presence of factors that could impede performance of the behavior (Ajzen 2020). A key difference that distinguishes Theory of Reasoned Action (TRA) with TPB is this key concept found essential component to understand behavior. According to Ajzen et al. (2011) the most compatible conceptual definition of perceived behavior control relates with Bandura (1982) regarding self-efficacy, where it consists of how well one can execute the course of action with a situation. People's behavior is strongly influenced with the confidence and ability to perform such action (Ajzen et al. 2011). Two reasons within perceived behavior control that can allow behavior achievement include the

constant intention of performing the behavior such as measuring the confidence of individuals likelihood to perform behavior, and secondly the control the individual must perform such behavior (Ajzen et al., 2011; 2020). Perceived behavior control was measured through the survey through a total of three questions, to measure the level of difficulty question was asked: *"For me, the decision to avoid getting in the water when blue-green* algae blooms are present is easy.", control: *"It is entirely up to me whether I decide to perform any lake activities when blue-green* algae blooms are present. For example, my job does not require me to attend the lake.", and confidence: *"This summer I plan to avoid swimming or performing any water activities when blue-green algae blooms are present in the lake."*

RESULTS: PHASE 1

Overview

Although HABs health risks are mainly communicated through government and health agencies, the public is learning about HABs effects through direct and personal experiences. Newspapers and blogs have significantly communicated individuals learning about these effects due to the loss of their pets by accidentally swallowing contaminated water derived from cyanotoxins (Colas et al., 2021). Addressing research question #1: "How are communication preferences of vulnerable populations' attending Belleville Lake, Ford Lake, and Lake Erie shaping their knowledge about HABs and its health risks?", the objective of the first phase aimed to gain a better social and cultural understanding between the lake and the selected vulnerable populations, how they are learning about HABs, among other hazards within their lakes, their communication preferences and lake experiences. During this phase, throughout fieldwork and photographs we identified existing physical signs and messages containing information about HABs, among other lake conditions and hazards. Within the selected lakes, the recreational

activities mainly observed in all three lakes consisted of fishing, boating, and swimming. Using thematic coding analysis (Saldaña 2010), for the interviews the study narrowed down five main themes: communication preferences, knowledge about HABs, Lake experiences, Fish consumption, and other concerns (Fig. 7). The communication preferences among Belleville and Ford Lake varied in comparison to Lake Erie (see Table 4). For Belleville and Ford Lake, we found more local and community-oriented resources, such as private community Facebook (FB) groups, local newspaper, friends, and family, whereas in Lake Erie there was more government agency tendencies, such as Detroit Free Press, Detroit News, Toledo Blade, Wall Street Journal. Within existing information mainly distributed online through government agencies, and how vulnerable populations are learning about HABs effects, and their communication preferences, the study found an existing gap. Although Lake Erie contained more prominent awareness about how HABs are caused, the study found none of the participants were aware about HABs human health effects. Based on lake experiences the study found a more negative attitude toward Belleville and Ford Lake than Lake Erie, following on the negative experiences and attitudes, the negative attitude could also be in relation to the 'Do Not Eat the Fish' health advisory posted in 2018 by EGLE for Belleville and Ford Lake. In comparison, Lake Erie showed to have a higher level of knowledge about HABs, and a more positive behavior to consume fish given it did not have a health advisory message that said otherwise. PFAS and E. coli were other concerns expressed throughout the interview.

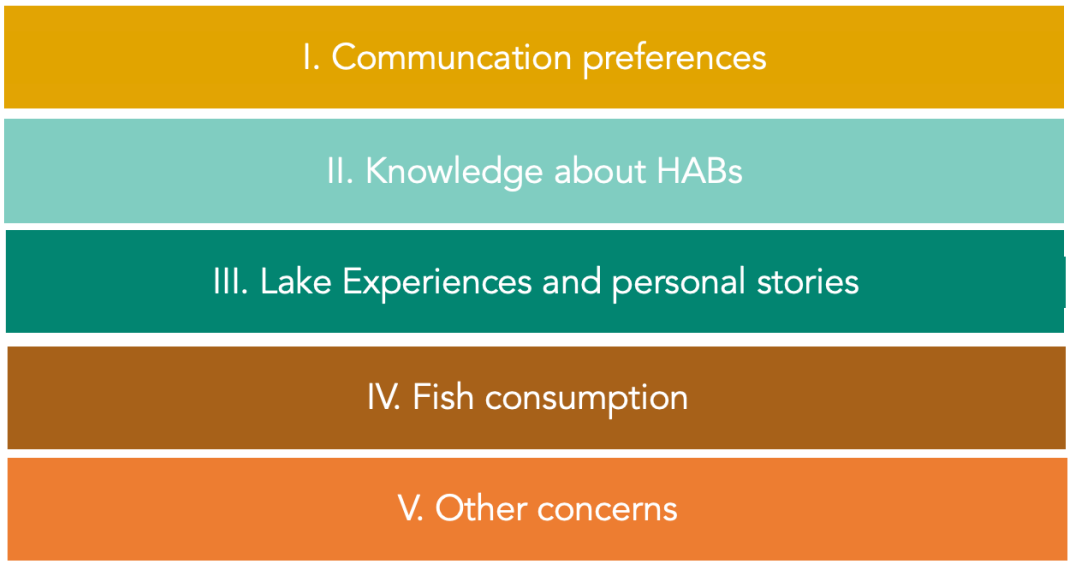

Figure 7. Five main themes from NVIVO interview analysis

	Communication preferences		
Nodes	Lake Erie	Belleville Lake	Ford Lake
Sources	Detroit Free Press, Detroit News, Toledo Blade, Wall Street Journal	Facebook (FB) groups, local newspaper, friends and family, Lake Huron Watershed council, Belleville Yacht Club (BYC), Michigan government agency (EGLE)	
Format	Online	Word of mouth, online, hard-copy	Online and word of mouth
Trustworthy sources	DNR (4), other government agencies such as Michigan.gov (3), NPR (1), Park authority on Lake Erie Metropark (1) The Guardian (1)	FB groups, Neighbors, friends and family, government agencies such as Michigan.gov, Lake Huron Watershed council, BYC	Neighbors, friends and family, and Facebook groups

Table 4. Communication preferences of selected vulnerable populations based on the lake

Phase 1: fieldwork and photos

Conducting fieldwork consisted of taking pictures and exploring existing communications about HABs and other hazards in the lake are currently being administered. Using a photo-story and narrative method we explain the process of exploring, gathering data and gaining a better cultural and social understanding of the selected lakes for our study. Some examples include attending local and state parks (Table 5) nearby the selected lakes to observe the physical water health advisory signs, attending local events such as fishing tournaments and lake festivals, and attending one of the public libraries in one of the communities, Belleville Public Library. This also gave us a better idea how HABs are currently communicated and potential outlets of how it can be better communicated to the public. With the help of a community member, Mama Vesta we were able to learn about community events and potentially recruit more participants for our study.

Attending local and state parks

Attending local and state parks nearby the selected lakes was an opportunity to recruit members by pasting flyers through bulletin boards, docks, bathroom stalls, among other public locations. While attending the following local and state parks (Table 5), we can learn from an outsider perspective how current water advisory ads are presented in different recreational areas near this lake, and explore how the public engages with the lake, such as what recreational water activities are performed among the different lakes. By administering the following activities, we gained a better social and cultural understanding of how the community engages with the selected lakes.

Selected Lakes:	Parks attended:
Belleville Lake	Belleville Yacht Club (BYC) Belleville Boating Launch Horizon Park Van Buren Park Beach North Hydro Park South Hydro Park
Ford Lake	Ford Lake Park Ford Lake Park Boat Launch North Bay Park Lakeside Park
Lake Erie	William C. Sterling State Park River Raisin Marina & Campground Lake Erie Metropark
Huron River	Lower Huron Metropark

Table 5. Selected lakes and parks attended during fieldwork research – Phase 1

Photo-story of conducting fieldwork in Belleville Lake, Ford Lake, and Lake Erie

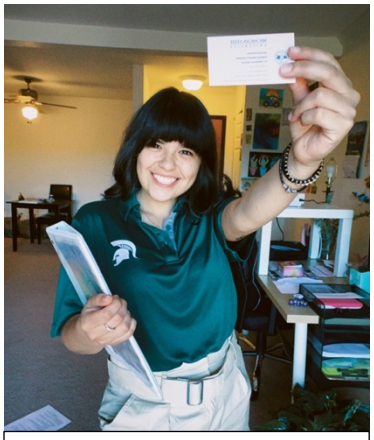

Photo 1. First day of fieldwork

Photo 2. Bulletin board and flyers

Photo 3. Posting flyers

Figure 8. Photo story journey: First Day of Fieldwork

I. First Day of Fieldwork: First impressions are everything, my first day of fieldwork consisted of preparing my uniform; Michigan State polo-shirt and khakis, and having my business cards in hand, providing additional contact opportunities for community members to reach me in case they were interested in setting up a meeting for interviews. While attending fieldwork, many people openly expressed their Michigan sports preference, being manly wolverine fans over Spartan fans. To recruit participants to be part of a phone interview, a flyer was designed to sponsor our study. Pasting flyers in local and state parks to sponsor gave us the opportunity to observe what recreational water activities were performed among the lakes and learn about the existing physical messages about water and health advisory messages are currently displayed in different parks nearby the lakes.

Photo 4. Algae Awareness signs

Photo 5. HABs signs near Lake Erie

Photo 6. QR codes

Figure 9. Photo story journey: Existing messages about HABs

II. Existing Messages about HABs: As we continued pasting flyers and conducting fieldwork research throughout a total of fourteen state and local parks, less than five signs of algae awareness and "If it's green, don't go in" messages were seen. Photo 4. was taken in North Hydro Park near the Belleville Lake, a few signs were posted throughout different spots. Photos 5-6 were taken in two different parks near Lake Erie and show how HABs are currently communicated. Photo 5. Shared an interesting story regarding QR codes. Accompanied by some of the community members, one of which was older than 65 years of age, did not know what a QR code was or how it was used. This brings potential consideration and accessibility of QR codes, keeping in mind one of our selected vulnerable populations consist of the elderly. Photo 6. is a picture sent from one of the participants that participated in the interview process. None of the ads include the terminology "Harmful Algal Bloom", and none mentioned the human health effects, or who is at risk (vulnerable populations).

Photo 7. PFAS

Photo 8. Use of language

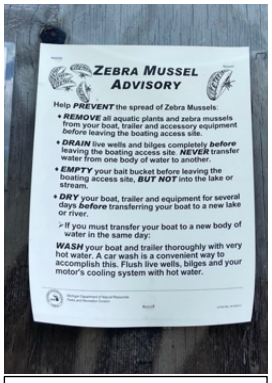

Photo 9. Zebra mussel

Photo 10. Bulletin boards

Figure 10. Photo story journey: Other physical signs in relation to Health and Hazard Advisory

III. Other Physical signs in relation to Health and Hazard Advisory: With the goal of observing the existing physical signage communications posted about HABs, other signages related to water quality public health were found. This demonstrated the limited content of information physically displayed regarding animal and health risks caused by HABs and who would be at a higher stake if directly exposed to HABs. Additional advertisement included “Do not eat the fish”, “Avoid foam” (PFAS) and “Zebra Mussel Advisory” displayed in several parks nearby the selected lakes (Photo 7-9). According to our interviews, the “Do not eat the fish” advisory was recently mandated (less than 5 years), however even before the mandate, in our interviews more than half expressed the uncertainty of fish consumption caught in Belleville and Ford Lake prior than 5 years. In Photo 10 “Do Not Eat the Fish” Health advisory was published on August 31st, 2018, from MDHHS. The original issue was on August 4th, 2018, within the fourteen lakes, Ford Lake and Belleville Lake were included.

Photo 11. Fish facts

Photo 12. Beach testing results

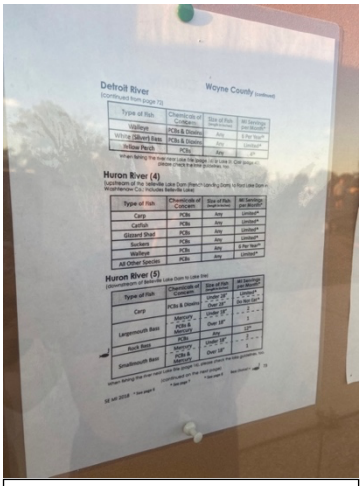

Photo 13. Chemicals and water quality

Figure 11. Photo story journey: Additional communication findings

Additional communication findings: Bulletin boards were commonly seen throughout recreational areas. Flyers in Photo 11 sponsored by Michigan Department of Natural Resources included a Zebra mussel advisory, with “do’s and don’ts”. Another display included visuals of common / native fishes found in Michigan, including the size limits between a Muskellunge and a Northern Pike, providing a visual using the colors red and yellow to highlight the maximum amount required. Photo 13. Indicated a notice from MDHHS to report the type of fish, along with the chemical concern associated, chemical concerns mainly included PCB, dioxins, and mercury. Photo 12 is a flyer titled “Beach testing results” under the title it described: “The water quality of this public bathing is tested by the Monroe County Health Department”. Test results could be accessed through a written hyperlink on the flyer. Using the link, the report indicated findings from 2005 through 2020. Within the report, Van Buren Township Park in Belleville Lake, reported high levels of bacteria and park closures from 2005-2018. And in Lake Erie, report indicated high levels of bacteria since 2010-2020.

Photo 14. Big Blass Club

Photo 15. Lakeview of the library

Photo 16. Local newspaper

Figure 12. Photo story journey: Exploring community events and local newspaper

V. Community experiences in Belleville Lake: While attending Belleville Lake, I had the experience of attending a weekly fishing tournament sponsored by the "Big Bass" club (Photo 14), where every Tuesday, a catch and release competition is done, weighting the biggest fish caught in Belleville Lake. During this time, I was able to recruit one participant for my interview, and he claimed that although the 'Do not eat the fish' advisory was administered, he would still continuously fish and consume fish in Belleville Lake. Photo 15. Gives us a visual between the distance of Belleville Lake and Belleville Public Library. The library is an important location for community members, it is actively involved with Belleville Rotary club, town hall meetings, and is greatly promoting occurring events sponsored for children and youth in the community. Photo 16. Shows a way I learned about the Belleville Lake festival was through a local newspaper called "The Independent" through this newspaper I was able to request clippings from HABs announced in the community, as well as gain more knowledge of ways community members learned about lake conditions using this as one of the main sources.

Photo 17. Big Blass Club

Photo 18. Lakeview of the library

Photo 19. Local newspaper

Figure 13. Photo story journey: Boating experience in Belleville Lake

VI. Boating experience in Belleville Lake: The opportunity to participate on a boat ride through Belleville Lake (Photo 17) helped learn more how people engage with the lake, such as the type of recreational water activities commonly seen. As shown on Photo 18-19. one of the bridges we were able to go underneath, I caught a picture that said: “No wake, No fishing, No anchoring

within 100 feet". While returning to the dock, we witnessed a man fishing (ironically underneath the "No fishing sign" and holding a white bucket. Someone in the boat called out: "Hey, you're not supposed to eat the fish, or go fishing in this area!" The man stared and said nothing, as he proceeded to fish. We kept boating while we wondered what the white bucket was for…

Photo 20. Green water in Ford Lake

Photo 21. Lake Erie, questionable HABs?

Photo 22. Duckweed found on Lake Erie

Figure 14. Photo story journey: Is it algae, duckweed or HABs?

VII. Is it algae, duckweed or HABs? Photo 20-22 are several pictures taken while attending state and local parks. Duckweed and possible contaminant were found in Lake Erie. Extremely shallow green water was commonly seen during the time attending Ford Lake Park. Passing by these lakes and asking community members if they knew how to detect HABs, they replied with "I don't know, it's probably just duckweed".

High levels of bacteria

While conducting fieldwork and learning about the beach and park closures website sponsored through a flyer in a bulletin board found on Sterling State Park near Lake Erie, we were able to design Table 6 with our selected lakes, parks and dates using EGLE data that

reported beach or park closures due to high levels of bacteria. Although no further comment or indication mentioned HABs, or algae, the notice “swim at your own risk” was commented on several sections of the reports.

V. EGLE report on High levels of bacteria on Belleville Lake and Lake Erie

Selected Lake	*Number of times reported*	*Year*
Belleville Lake, Van Buren Township Park	*Twice*	*2005*
	Three times	*2006*
	Once	*2008*
	Once	*2010*
	Once	*2011*
	Once	*2014*
	Once	*2016*
	Once	*2017*
	Five	*2018*
Lake Erie, Luna Pier	*Twice*	*2010*
	Three times	*2013*
	Twice	*2016*
	Once	*2017*
	Twice	*2018*
Ford Lake, Sterling State Park	*Once*	*2010*
	Once	*2014*
	Once	*2015*
	Twice	*2016*
	Twice	*2018*
	Once	*2020*

Table 6. Beach and Park closure due to high levels of bacteria reported in Belleville Lake and Lake Erie (Source: Environmental Great Lakes Energy, 2022)

Phase 1: semi-structured interviews

A total of 27 participants were interviewed within our semi-structured interview phase, and they consisted of a selected vulnerable population. The selected vulnerable populations for this study included community members that lived in proximity from Belleville Lake, Ford Lake, and/or Lake Erie and claimed to be residents in Washtenaw, Wayne and / or Monroe County, the elderly population (65+), pregnant and nursing mothers, and those with pre-existing conditions such as chronic kidney disease, diabetes, cancer patients, asthma, respiratory complications, liver conditions, and dialysis patients. Using a series of semi-structured questionnaire allowed to have a better understanding to explore vulnerable populations' attitudes towards HABs, personal stories and lake experiences, sources considered trustworthy, communication preferences, and current knowledge about HABs and its potential health effects. The semi-structured interviews were analyzed through qualitative data analysis, using a combination between thematic inductive and deductive coding and NVIVO Software to further analyze and understand emerging themes, concerns, experiences, and stories. Throughout this analysis, five themes emerged (see Figure 7 and 8); communication preferences, HABs knowledge and personal stories, lake experiences (attitude, socio-cultural context, and health incidents), fish consumption, and lastly, other concerns (additional findings emerged through the interview).

Deductive themes learned from concepts derived from SARF (Kasperson et al. 1988), were initially explored within interviews. These included understanding vulnerable populations' communication preferences, including nodes such as 'format' and 'sources' they would use to receive information about lake conditions and asking what sources participants would consider trustworthy. Another deductive theme included HABs, with nodes such as level of 'knowledge' and awareness, 'sources', or stories of how they learned about HABs, and in addition 'personal

stories or experiences they would like to share. Inductive themes, emerging throughout the interview and analysis, within the theme of 'communications', under the node of 'trustworthy sources', a sub-node / code was creating specifically about government agencies. Other nodes include 'physical signs near lakes', asking participants if they have seen any water health advisory sign and describe the content of the kind of physical messages seen on the parks nearby the selected lakes, and the other code included 'communication barriers', expressing stories of people desiring to learn more and unfortunately not having a great experience in receiving the information about lake conditions and hazards. In addition, a theme labeled as 'other concerns' included emerging concern on PFAS, and E. Coli appearance on the lake. Lastly through inductive coding, we were able to create a theme labeled 'Fish consumption', with nodes such as perception of the safety consuming the fish. Through fieldwork and interviews, we were able to learn more about the 'Do Not Eat the Fish' Advisory effective in 2018 on Belleville and Ford Lake, among other small lakes. A variation between consuming fish on Lake Erie seemed a lot more common and expressed more safety than Belleville and Ford Lake.

Themes, and nodes

I. Communication preferences

Learning concepts retrieved from SARF (Kasperson et al., 1988), we gained a better idea to design our survey questionnaire. SARF components integrated with developing this theme included exploring the sources of information, its channels, social stations, and individual/social behavior components. By exploring this theme, we can gather a better understanding how sources could shape vulnerable populations' perception of risk. Several nodes included sources of communication, personal stories of communication, opinions about communication, and trustworthy sources. Within the theme of communication preferences, nodes included: 'sources

of communication' or in the SARF terminology would be called 'direct communication' (from the lake they mainly attended), 'channels', or in the SARF terminology it would be called "social stations". Among other inductive coding nodes included creating a node for Belleville's local newspaper, 'The Independent', another node labeled as 'Shaping communication campaign' focused on how others expressed the desire for a better way to communicate HABs and lake conditions.

II. HABs knowledge and stories

A theme specifically about HABs was created by gathering findings that included selected vulnerable populations' stories, awareness, description of its appearance and level of knowledge about HABs and its health effects.How much and what kind of information about HABs generally was asked throughout the interview. It consists of openly asking first what they knew about HABs, following with the causes/effects, if they knew it was harmful and what kind of effects they knew or had heard about. Generally, most participants were unaware with HABs, however those that did were aware of its causes, not its human or environmental effects.

III. *Lake experiences*

The third key theme consisted of learning about selected vulnerable populations' attitude, recreational activities, as well as personal stories that allowed us to learn social and cultural context.

IV. *Fish consumption*

Fourth theme emerged while conducting interviews. Through a photo taken in fieldwork we were able to read a letter from MDHHS, addressing a 'Do Not Eat Fish' Advisory issued in August 2018. However, throughout the interviews, different perception and safety concerns were expressed regarding the consumption of fish specifically in Belleville and Ford Lake.

V. *Other concerns*

PFAS and E. Coli were among the two additional concerns vulnerable populations expressed when questioned what other additional hazards or concern they had.

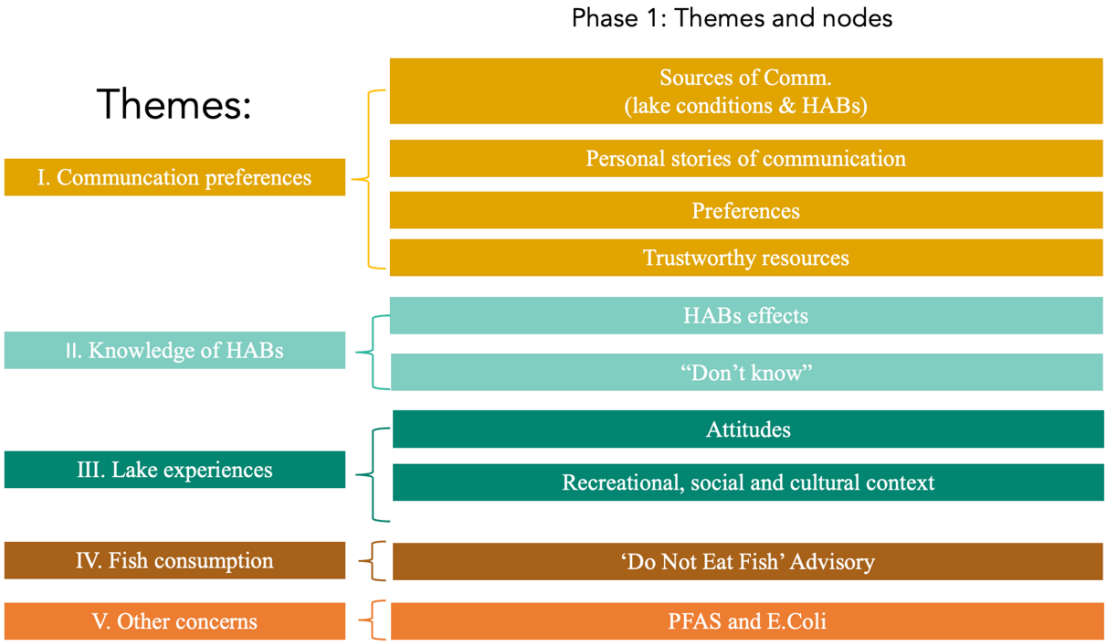

Figure 15. Themes and nodes from NVIVO interview analysis

INTERVIEW RESULTS: PHASE 1

I. Communication preferences: Sources of communication: Lake Erie:

"*I read, tons of newspapers, I read the Free Press, the Detroit Free Press, The Detroit News, the Toledo blade, I read those papers every week plus you know lots of other things, Wall Street Journal…"* - Participant 14

Many expressed several government agencies, FB groups and national news and media when it came to learning about Lake Erie's Lake conditions, presence of HABs, among other lake-related news, such as fishing reports or water quality. When asked about sources selected vulnerable populations' used to learn about the lake's condition, within Lake Erie we predominately received a broader range of replies related to National news, local and state media

such as Detroit Free Press, Wall Street Journal, two participants mentioned radio stations such as WJR & WWJ, two replies sharing a private Facebook group titles 'Bolles Harbor / Sterling State' page, and online government agency resources such as DNR, Monroe county website, and Sterling State park webpage, other sources mentioned included bulletin boards and signs on boat launches or parks in Sterling State Park.

Sources of communication: Belleville Lake and Ford Lake

"Sometimes it's the people that are living on the lake that do their own research and contact people to get answers and they'll be honest and not gossip but share the facts that they have learned you kind of have to trust your sources and double check with more than one so you can get the same type of story…" (Participant 13).

Due to proximity, most of the participants that attended Belleville and Ford Lake received similar sources. Although there were no participants that only attended Ford Lake, three participants reported mainly attending Ford Lake, although they also shared their experience attending Belleville Lake. Sources in Belleville and Ford Lake consisted of word of mouth, Facebook, and the local newspaper in Belleville called 'The Independent'. Among our findings 'The Independent' was expressed even more when asked about trustworthy sources (see section II). Some expressed government agencies, two mentioned the DNR, other two participants mentioned Van Buren Township, three mentioned the Huron River Watershed council, and some mentioned Mlive.com and Michigan.gov. The resources on Belleville Lake and Ford Lake focused more on local resources, such as Belleville Yacht Club, Bass Club weekly fishing tournaments that hosted lake announcements, and the Belleville Public Library. A source shared from a participant that mainly attended Ford Lake mentioned a private Facebook group that also related to the Huron River Watershed council.

When asking what sources learned about the lake conditions, news, etc., in Lake Erie, there was more prominent sources from newspapers: **"***I read, tons of newspapers I'm big on… I read the Free Press, the Detroit Free Press, The Detroit News, the Toledo blade, I read those papers every week plus you know lots of other things, Wall Street Journal*…" (Participant 14). Few examples of government entities as main sources: "*Michigan.gov is what I love, I googled it so maybe an Ohio government one popped up*" (Participant 19), "*I probably checked the sterling State Park site…"* (Participant 20), *"The Monroe County website*" (Participant 3). Radio stations were among other findings: "*WJR & WWJ are probably the two most listened to radio stations in metro Detroit, and since our water is located next to metro Detroit, I think that's really where the local population is right now*" (Participant 21), "*WWJ news radio 9, they do a really good job, another one would be WJR radio, great voice the Great Lakes*…" (Participant 27). Private Facebook groups were mentioned as another way that people learned about the lake conditions, "*Lake Erie Bolles harbor and the different fishing ones I pretty much only use Facebook now it's the most accurate you get to follow and see what dudes are legit or which aren't*…" (Participant 19). "*I'm on sterling State Park web page… FB private group Bolles Harbor / Sterling State Park fishing*" (Participant 11). Lastly other sources included attending boat launches to learn more about the lake conditions: "…*boat launches like the big ones by the metro parks like Lake Erie Metroparks there's a lot of people that always walk or like the different access points where people are actually going to be going in the water*" (Participant 19).

In Belleville and Ford Lake, mostly reported word of mouth and local sources including newspaper, Facebook group, and a few mentioned government related agencies. For Belleville lake, an example of a word of mouth: "*I'm probably a combination of things…word of mouth, just talking with other residents, you know that kind of stuff*" (Participant 7), "*Just a word of*

mouth and my own personal experience of just visually but then obviously living in Belleville my whole life I have met people that have been on the lake for like 70 years or whatever so I've talked to a lot of different people in this area because I've lived here for so long and universally speaking it seems like a lot of people have the same opinion in mind with the exception of people who really don't know any different" (Participant 12), "*Sometimes it's the people that are living on the lake that do their own research and contact people to get answers and they'll be honest and not gossip but share the facts that they have learned you kind of have to trust your sources and double check with more than one so you can get the same type of story I mean it's not going to be word for word when you talk to different people but the information is going to be the same and the sources that there documenting they have gave them the information would be the same*." (Participant 13). Example from those reported using Facebook groups as a main source: "*I got some of my sources online you know there's different pages on Facebook that are specific to my area of different news and updates and all that kind of stuff going on*" (Participant 12), "*Probably Facebook I'm really not on Facebook much anymore if we're planning on doing anything in Belleville even, we'd look to Facebook events basically*" (Participant 5). In addition, few government agencies such as "*Through the Huron River Watershed council, and Mlive.com, it's a website to local Ann Arbor*" (Participant 14), *DNR website* (Participant 2), and "*the Van Buren Township, probably what we might read from the local Environmental Quality people…*" (Participant 7). Local clubs mentioned include the Belleville Yacht Club (BYC), "*Belleville Yacht Club, it's a howty-taughtie club I'm involved in, but they do a lot of stuff for the community…"* (Participant 2), the Belleville District Library, "*we used to go to the Belleville Public library all the time before COVID-19, it was like a weekly event that we just we love the library*" (Participant 9), and lastly the local newspaper called 'Belleville the Independent', "*I*

typically get the independent that Belleville paper that comes out every week because I mean like I said I've grown up in this area my whole life and I used to work in a hardware store in this area and I got to know a lot of people and I like to see who this in the obituary if it's anybody that I knew so I do read the paper pretty much every single week" (Participant 12). In addition to the sources mentioned previously another example of those attending mainly Ford Lake included other Facebook pages and government entities such as the following quote mentions: "*I get stuff from the Huron River Watershed council; I have a Facebook page just for Ford Lake people and subjects our subdivision here but I think it gets passed beyond there so if I get something you know email or Facebook post I will share it to the group*." (Participant 14).

Trustworthy sources:

"*Honestly it's hard to know who to trust*" (Participant 7).

In this section, we asked vulnerable populations what sources they would consider trustworthy when receiving information about lake conditions. An unexpected emerging discovery was finding a wide range of concern and mistrust and low confidence toward government agencies when it came to health-related information, this was mainly expressed by those attending Belleville Lake and Ford Lake. Whereas Lake Erie expressed more trust with low confidence toward government agencies. According to Oxford dictionary, trust is a "firm belief in the reliability", and confidence is defined as a feeling or experience arising from one's own abilities or qualities.

Smith (2001), and Luhmann (1998) mention confidence is based on an attitude entailing danger, whereas trust refers to an attitude that accepts risk, risk of disappointment. When asking participants in Belleville and Ford Lake, many expressed mistrust and low confidence given previous experiences with messengers representing government agencies or private companies

that would attend town hall meetings to advise certain hazards but not necessarily explain the cause or effect directly. An example of this can be seen in the following quote provided by the first participant of our study, the individual described how a town hall meeting held in 2018 by an unknown representative from a government agency in Belleville Lake, the messenger wouldn't disclose the adequate information about what is environmental-health hazard was occurring in Belleville Lake. The individual is an elderly cancer patient residing near Belleville Lake, in detail the most lake residents attending the meeting were alerted to avoid watering their garden with the water from Belleville Lake but wouldn't provide an explanation on why.

I used to listen to this radio station guy, he'd say, "I love my country, but I fear my government", and you know it's to the point where I don't trust what the government puts out. Just like that meeting in townhall we walked away with our hands in the air, they didn't tell us didley. I had to go surfing the net and read people's comments to know about it that kind of thing (HABs and PFAS). (Participant 1).

An example of lack of confidence by trust toward government agencies can be seen in the following quote below. The participant attended all the selected lakes, but preferred Lake Erie, expressing it's not the government agencies who are provoking mistrust, but the private companies that are polluting and sending the "wrong people". *"Oh, I don't know I have a tendency to believe them (DNR) more than I do corporations that are polluting. They don't have an agenda, but corporate America does…" (*Participant 24). When it comes to informing health-related and environmental hazards in the lake, throughout the interview a key importance discovered was distinguishing who is the messenger and the type of information your audience should know and in addition what sort of questions they would like to be addressed. The following quote is from an individual that lived on Belleville Lake for over 30 years, the

participant highlights how several messengers sugarcoat or avoid providing essential information. When asked about trustworthy sources, the participant expressed the local newspaper Belleville Independent to be one of the most trustworthy sources considered to learn about lake and its conditions. *"Sometimes there are private companies or even the DNR who send the wrong people. They want to sugarcoat everything or either they've been prompt before they attend the meetings about what you're allowed to say, and don't address this topic. They have people who aren't real familiar and don't understand how knowledgeable their audience is. You can tell that they are uncomfortable with knowing how to answer the questions and they're trying to sugarcoat things and not be honest with you and then you feel like you're totally wasting your time..."* (*Participant 13).* An example of two participant expressing strong level of trust toward the DNR and government agencies: **"***Yeah, as much as you can trust anyways"* (Participant 19), *"I would say that most of the people that work for the DNR have the best interest in in mind, I'm sure there's some crazy people on both ends, but you know, if you're going to get information about the environment and what's going on it's probably a good place to start at least" (*Participant 15). Based on the interviews, the lack of trust and low confidence was built more on individuals experiences in the past, creating more trust within friends and family in the community than the representatives that would show up to inform vague information about Belleville and Ford Lake conditions.

How to better improve communication and increase better understanding of HABs:

When asking selected vulnerable populations about what sort of information they would like to know, several findings included them desiring more honest information, and improving their communication skills and strategies. We asked, "What do you think our communication campaign should target in terms of how to communicate HABs?"**,** few answers included:

"*People need to have honest information" (*Participant 1)**,** "*People want more honest information*" (Participant 13)**,** "*Well, I don't know I feel like they haven't done a good job telling people that something is wrong with it (HABs) because I never knew about it so I feel like they need to be at least like posting it at beaches I feel like that's where people would be swimming at least so people know that it could be harmful to certain people. I feel like I would that would probably be the best way because you can make the decision if you're gonna swim or not or something*…" (Participant 5). "*If you get involved with the right committee that will have people come in and not be censored, they share the information with you, and you can learn a lot and be able to ask the questions that you really want answers to and walk out with honest information*" (Participant 13).

After the interview process, participants were curious and asking questions such as what the effects are caused by HABs, one of the quotes from a participant appreciative of explaining some of the effects caused by HABs said: "*I think one of the key is and what you are doing right now, asking and giving people relative correct information*" (Participant 26). In addition, another participant expressed: *"Yeah, I think they should include more information on HABs digitally. Usually, to know the presence of HABs, I have to go to the beach and check if it's safe."* (Participant 5).

DNR employee:

During this phase the study interviewed a DNR employee working within the camping grown of Lake Sterling Park. During this interview. *"I would say that people that live down here in the county are aware…but the campers that come in from other parts of the state, you know, or out of state that don't live on the lake don't necessarily know*…" The DNR employee expressed some challenges when communicating to the public about HABs: "*Of course, now we*

have the algae blooms because of phosphate runoff and fertilizer runoff, and you can see it come in, changes in the color of the lake, we tried to tell people…They don't care, they're going to swim. My golly, except for the lady who asked us why we didn't put a swimming pool in, well because generally we have a lake. Most of the time it's fine but you do have to be a little careful… there is a website that they do have on information that you can check; they test the water every Tuesday…". In addition, HABs information provided is mostly online or the large bulletin board that says, "If it's green, don't go in". "*Getting the information out to people in the campground is needed, people don't necessarily see the sign out front… we actually thought about getting the flag system and putting it up so that people could see them and maybe question why we have a flag up of that color…"*. In addition, the DNR employee expressed given the time of COVID-19 the public was tense, and worried about her own safety when instructing individuals about the park rules. "*Yeah, we do warn the public, we see it and we hear it, the problem is having enough staff to police it and we can't, we're volunteers, so we aren't able to do that aspect of it, but you know for a park this size, the number of Rangers or summer staff that we have, it's very hard to police that down at the beach and then people are very, they are quick to anger right now (COVID-19) and they're aggressive so when you tell someone you're worried they're going to pull a gun, we've had several incidents here this summer (2021) already of people pulling guns on each other… Because they ran over their fishing line or they told them not, they honk their horn because they were in the line so long and it's just stupid things"*. When asking what ways or strategies can better improve for the public to know about HABs the DNR employee suggested: "*Signs would be good, but again, only for people who read, others will walk right by the sign that says "no dogs, no alcohol, no glass" … And they are like "what sign?" I'd be like "the one you just walked by*". Based on the interview the DNR expressed one

of the challenging components is informing the public about HABs but the public still ignoring their warning about avoiding swimming in the water when its severely green during summertime.

From another perspective, a participant in the study expressed she learned somewhat about HABs through a DNR employee attending Lake Erie but was left more confused. "*I guess I want to know why there is algae blooms and why is it unsafe…my kids and I were about to go for a swim and they (DNR employees) just like came along and said to not swim in the water because of the algae blooms and that was just about it. It was very informal, I wish they would have told us more, I still don't understand how it works…"* (Participant 9)

II. HABs Knowledge:

In this section, when asking about HABs health effects, causes and general information participants may know about HABs, few participants, mainly from those attending Lake Erie were aware of how HABs were caused. Example included: "…*It's really thick it's like neon green and it's really just yeah nasty.*" (Participant 10). None were aware of its hazardous effects. An example of a quote from a participant expressed beavers as an indicator it is safe to fish when algae is present: *"You know I don't know a lot about that... there a lot of farms in Ohio fertilizer and contaminants getting in the water and yeah I got little kids so we eat a good amount of walleye, I clean them and eat 'em…Where I live there's a shit-ton of beavers that are doing a lot of damage with the trees building their dams and whatnot but they say it is a big indicator if the waters cleaned up or the beaver won't be there, that's how I know it's safe to be in the lake"* **(**Participant 19). An example of having low level of knowledge about HABs, repeated word was "I don't know": "*I literally know nothing about algae blooms, I feel like what I've seen it was just like green basically nothing crazy, not stinky but I would say was kind of gooey. I don't think*

I touched it I just saw it and said that it's gross and let's not go over there…" (Participant 5), "*I don't know… it's polluted and the next time it's not, I don't know much about algae, except the fact that carps like it! That's how we know its safe to fish or not.*" (Participant 17), "*I don't know anything about algae blooms, except that it's blue-green thing, I would assume it's always there…*" (Participant 6).*"You know don't drink the water in the lake because its polluted, but we never experienced any kinds of sickness or illness or issues like that…" (Participant 7)***,** *"I don't know, I really can't say, it's a natural phenomenon, but I don't know if it has something to do with being near Toledo, I have no idea… I think it just has to do with global warming…Water getting warmer, it can be just from a populated area, the water is going to be warmer, And because it is shallow…*" (Participant 20).

Example of those aware of HABs causes and effects mainly attended Lake Erie and learned about HABs because either the participant or their family worked for Michigan Department of Environment, Great Lakes, and Energy (EGLE), government agencies, or because they had heard it from a word of mouth: *"Last year in Lake Erie it was pretty bad, they couldn't boil the water you know enough to kill the algae, and that's kind of crazy, when you think about, if you can't get the water hot enough. It's no livable. What's going on with the system? How do they treat our drinking water and everything else? When they say, "hey don't swim, don't fish in it". And it was pretty bad last year in Ford Lake, in Belleville it's not as common." (*Participant 20), **"***I used to read the paper quite frequently and worked into Toledo so I got the read the Toledo blade and I've seen when they were trying to convince farmers to try to have some sort of filters strips so the fertilizer wouldn't drain off into the lake and prevent HABs…"* (Participant 11), some mentioned the intense warm weather a primary factor: "*I think we know when there is green stuff in the water it's an algae bloom and we kind of just know from experience, we*

understand the hotter it gets the more it can cook. I call it Cookville lake (Belleville Lake), it's just when algae thrive you know its green, but then working with my cousin at EGLE I learned about its effects…" (Participant 10), others described its physical appearance and color: "*I think I saw it (HABs) in 2015 and 2016 but it wasn't as dominant you know it wasn't intrusive but yeah after that it's just floating out there and it's so green, like pea soup color and just not attractive, I certainly would not swim in it or water ski in it either… There's actually a professor at University of Michigan that did quite a bit of study on it you know, or focused on nitrogen and phosphorus and so he did some studies with the drawdown of, you know, where they draw the water from, and you know really reduce the phosphorus levels in the lake so that helped, and you know you've got the Huron River coming upstream that kind of affects it too... "* (Participant 14). How they learned about HABs: *"I learned about HABs through word of mouth and my own personal experience of just visually seeing it but then obviously living in Belleville my whole life I have met people that have been on the lake for like 70 years or whatever so I've talked to a lot of different people in this area because I've lived here for so long, there's some algae that grow around some areas in the lake but like you gotta have kind of like stationary water that doesn't move…" (*Participant 10). Describing the water using negative description and based on their understanding from what they: "*Oh yeah it was nasty the water it had a weird color even when you looked across from the bridge or the shore you didn't see a clean watery reflection, you'd see this weird color to it and like a fungus on it. It was gross. They did some cleanup years ago, some repairs, they did something that they were dropping in the water they never quite made it known what it was but you could see these surf boats and the DNR boats are out on the lake testing water and did some things in different spots and I'm sure it had to do with the current because it was sitting along those spots where you knew the main current was and so it started to*

improve at that point and then there was a lot of construction going on and then things deteriorated for a while then and then it started to get a little bit better and now it's kind of at a point where you just waiting to see exactly which way it's going to go it's not exactly what it was but it's not exactly good like it once was either so I'm just kind of waiting…" (Participant 13), and HABs causes such as: *"Caused by pollution, you know, that fertilizer in the water definitely accelerates all that, I don't think there's any doubt… but I think that in urban situations they can happen anywhere…"* (Participant 15).

III. Lake experiences:

Participants in Belleville and Ford Lake expressed having more negative experiences than Lake Erie. Besides presence of algae, in Belleville and Ford Lake many participants expressed polluted water, dead fish floating around the area, heavy current and several drownings occurring. For those that mainly attended Belleville Lake expressed it was cleaner than Ford Lake. However, for both lakes, the repeated words attending these two small inland lakes consisted of "yucky, smelly, gross.", and example of several experience are shown below: "*I'm unsure if its Belleville or Ford Lake, I've seen dead fish, and a lot of trash that will wash up, and stuff like that*." (Participant 6), "*They have fishing tournaments on the lake but not if they put in the notice, now how can you at one point have a fishing tournament and a month or two before or a month or two afterward quietly the word spread don't eat the fish 'cause they have high contamination right now and they discourage people from swimming, they will even close down Belleville park beach so it's not acceptable, if you're on the lake on a boat of course they're not going to drive by and say, "get out of the water", but on the beach they say "No swimming" (*Participant 13),*"In more recent years, yes, there has been here on Belleville Lake, there have been a few incidents where the water would get green and yucky and those, you know,*

we read that there's those algae blooms going on. I know they say not to swim really, and honestly, we don't really swim in the lake that much, but our grandsons do, we take them to like more shallow parts, a lot of times and they will swim, and our kids swim grew up swimming in the lake and so did we, we water skied and we'd fall in the lake the whole bit" (Participant 7). ***"****Yeah, somebody from the state, somebody from the Watershed Ann Harbor. Remember that, uh, I don't remember it was brought up about Ann Harbor every now and then when the rain come in and it's so heavy there overloaded, they dumped their sewage into the river. You know back in the day, there's been a few times where Belleville Lake was shut down and they didn't want people swimming in it." (Participant 1). "I spend most of the time, 90% of the time, I am fishing in Belleville Lake. I don't do too much boating. I don't have a boat on the water, so its mostly bass fishing." (Participant 2).*

Some participants reported willing to travel to Lake Erie to take their kids to swim rather than Belleville and Ford Lake due to its bad reputation of having contaminants and drownings. An example is a quote: *"I prefer going to Lake Erie because it's bigger the under current it's much less strong, I don't hear people dying in Lake Erie or not as nearly as often as Belleville Lake, although the lake itself (Lake Erie) is still pretty dirty it's nothing like Belleville Lake…" (Participant 9)*. A negative experience attending Lake Erie regarding HABs and how they learned about them is explained was repeated in several interviews, an example: "*Some days we would go (Lake Erie) and there will be an algae booms and we were told not to go into water, some days there would be huge amount of mayflies that would just like cover the beach and cover the surface of the water and I don't know they were just wash in or I don't know how many the fly production works but it was gross but there would be tons of it everywhere and it would be gross and we wouldn't be able to swim …*" (Participant 9).

IV. Fish consumption:

A key distinguishing finding between those attending Belleville and Ford Lake than those in Lake Erie was the fish consumption. Due to the 'Do Not Eat the Fish' Health Advisory by EGLE in 2018, many people expressed their worry and concern about consuming fish in Belleville and Ford Lake, whereas consuming fish caught in Lake Erie was generally accepted. Within Belleville and Ford Lake, due to mistrust in government agencies there was a controversy of whether trusting if the fish consumption was safe. The following quote explains different attitudes towards consuming fish: "*I do not eat the fish I've thrown back after I've caught them. There is an advisory that says 'do not eat the fish' back at the boat launch, so I don't know anybody that eats the fish from Belleville or Ford leak I'm sure there are because I've seen people with stringers and stuff boat launch but nobody I know…"(*Participant 14), another participant expressed consuming fish at a young age but now expressing his change of perception given the advisory notice: "*Oh yeah we used to eat them when we were growing up I thought we'd eat we used to bring home a bucket of fish clean them up and eat them. Now you're scared to eat any you don't know if they are telling you that just to not eat them or what I don't know…"(*Participant 23). Other examples of fish consumption in Belleville lake where participants expressed never to eat the fish: "*I've never tried it fish in Belleville Lake because of the health department and the DNR had stuff coming out and made articles about why you shouldn't, which was all the more reason not to and if you were to, you really got to make sure that you're boiling the fish or you are cooking at 100% because if you're not then you could get really sick because of the bacteria. I never – to my knowledge eaten fish of Belleville Lake and I love fish and seafood…*" (Participant 12). *"We used to fish, we would never eat the fish that we'd get out of the lake (Belleville) ever in the 20 something years, we would just fish for pleasure and*

throw them back, our son would do that too, we basically when we were younger we were water-skiers, just boating and tubing and take our grandsons tubing and you know have people over and do all that but mainly that kind of stuff…"(Participant 7). Although some have expressed avoiding eating the fish in Belleville lake, others such as the following participant expressed they have eaten the fish all of their life: *"There's a lot of people that eat and catch the fish, you know, now that we have this stock, we don't know, like we were just talking (trustworthiness about government), now we don't know what to believe, I've been eating the fish out of Belleville Lake all of my life. Even though I don't really have too many problems, doesn't mean I won't have any problems in ten years…" (*Participant 2). Avoiding fish consumption out of Belleville Lake was rumored for many years, the following was a participant between the age of 70-80 years old that expressed the following: "*Younger years when I lived in school I didn't live on Belleville Lake but you might as well think I did because we used to fish, go out in jet skis and swim in the water constantly. And then as I got older, I realized what a lot of the green stuff was appearing more and more and was all about and first time that they put up notices that don't eat the fish that you're catching even though they step the lake constantly. They come in they dropped those uh, twist bundles, or whatever you call them, for nesting for the fish and then they pour fish into it.." (*Participant 13). Other ways people found it acceptable to eat the fish was because their family members also consumed the fish out of Belleville Lake: *"When I was small, I'm sure my dad caught fish and we ate them then, but I'm sure a lot of people eat them, but I'm not really not a fish eater and I would never want to clean them anyway… But basically, if someone told me, "here's a fish it's from Belleville Lake", just in my head with no knowledge about it and just rumors, I wouldn't eat it…"* (Participant 17).

In Lake Erie, because there is no "Do Not Eat the Fish" Health advisory, there was more positive attitudes towards consuming the fish however the worry of the safety remains: *"It's crossed my mind you know like this is weird eating it and I'll check the reports online more worried about feeding it (fish) to the kids because they love eating it but I don't want to give them anything because they're small wouldn't want any issues in them, but the Huron river has contaminants and the spill and it pretty close to us so that's something that we that's kind of concerned me a little bit but this year it's been a lot better I haven't seen any algae blooms the water is clear there's less seaweed. I got little kids, so we eat a good amount of walleye, I clean them, I clean walleye and perch to where I waste a little bit of meat and basically like cut the tenderloins* out of them and catch a lot of them to make sure there's no silver skid no belly meat just like the prime cut…" (Participant 19).

*V. Other con*cerns:

PFAS and E. coli were other concerns expressed throughout the interview. The "Do Not Eat the Fish" Health advisory was due to the PFAS. Based on the findings conducted during the interview, participants mentioned PFAS occurred by a company that immediately left after dumping fire retardant contaminants near Lake Huron watershed. An example of this regarding PFAS and fish consumption can be seen below: *"I think there'd be a lot of interest in you know they told us we can fish but we can't eat the fish and that was because of whatever we were talking about the fire retardant, but we don't really know the reason behind it…it would be nice to know for sure, 'cause the fishing is good in the lake most of the time and I don't know if they're still restocking with walleye or whatever but there's a lot of recreational fishing and a lot of people I like catch and release and occasionally if I catch walleye its something I would like to*

*eat and I wouldn't mind eating it but I haven't in the last couple of years because they're not sure if it's safe to do so…"(*Participant 8).

RESULTS: PHASE 2

Online survey

Addressing research question #2: "How are the public's behavioral beliefs (attitude, knowledge, subjective norms, and perceived behavior control) shaping their risk perception towards HABs?", the objective of this phase was determining what behavioral beliefs could influence public's perception of risk when engaging with recreational activities during a HABs event. Although a total of 4,228 participants accessed the online survey, and 2,360 (55%) claimed they had fully completed the survey. However, the survey was attacked by bots, identified for the repeated patterns of time, same consistent answers, and duration of the study. To identify logic of error, using an elimination process was developed and among the criteria, survey needed to be completely answered. After a through elimination process, a total of 158 participants were selected (66 emotional, 49 cognitive, and 44 control). Potential respondents were invited to complete the online survey via Qualtrics in July 2022, those eligible to take the survey must be 18 years or older. The survey was voluntary and anonymous. The IRB ID: 007642, and project IDs: NIH 1P01ES028939-01 and NSF OCE-1840715. High level of priority was given for those that attended at least one of the selected lakes; Lake Erie, Belleville Lake, and/or Ford Lake.

Addressing research question #2: "How are the public's behavioral beliefs (attitude, knowledge, subjective norms, and perceived behavior control) shaping their risk perception towards HABs?". The objective of this phase was focused on answering is determining which behavioral beliefs (attitude, subjective norm, perceived behavior control, knowledge) shape risk perception. Within our results, the study performed a Cronbach alpha and a multiple regression analysis

where risk perception was analyzed as the independent variable and behavioral beliefs represented the dependent variables.

Demographic characteristics of respondents

A total of 158 respondents fully answered the survey (see Table 7). More than half of the respondents were male (n=88, 55.6%), following female (n=67, 42.4%), and prefer not to say (n=3, 1.2%). Majority were either within the age range of 25-34 years old (n=63, 40%), or 35-44 years old (n=60, 37%). In education background, most respondent reported with some college 31% (n=49) or having a 2-year degree (n=37, 23%). Lastly, more than half of the respondents were white (n=117, 74%). Out of 158 participants, 122 (77%) reported having previous experiences with blue-green algae blooms, whereas 36 participants (23%) did not. The two recreational activities participants performed the most during a blue-green algae event included boating (n=77, 49%) fishing (n=33, 20%). Majority of the respondents (n=90, 57%) experienced seeing blue-green algae in Ford Lake, Lake Erie, and Belleville Lake. Out of the three lakes, Belleville Lake was the most with a total of 37% (n=60), following Ford Lake 24% (n=39), and Lake Erie 22% (n=36).

Vulnerable populations

A total of 32 (20%) respondents reported having at least one of the following health conditions; asthma, pregnant / nursing, respiratory complications, conditions requiring dialysis, hemophilia, heart disease, coronary artery, bypass surgery, epilepsy, diabetes, kidney / liver complications, paraplegia, cerebral palsy, or cancer. Within the health conditions, based on the EPA criteria of selected vulnerable populations if directly exposed to HABs, consisted of a total of 23% (n= 36).

Demographic characteristics of respondents		
Characteristic	**Frequency**	**Percent (%)**
Gender		
Male	88	55.7
Female	67	42.4
Prefer not to say	3	1.9
Age		
18 - 24	19	12.0
25 - 34	63	39.9
35 - 44	60	38.0
45 - 54	12	7.6
65 - 74	4	2.5
Education		
2 year degree	37	23.4
4 year degree	35	22.2
Doctorate	1	0.6
High school graduate	12	7.6
Less than high school	1	0.6
Masters or professional degree	23	14.6
Some college	49	31.0
2 year degree	37	23.4
4 year degree	35	22.2
Doctorate	1	0.6
High school graduate	12	7.6
Race/Ethnicity		
American Indian or Alaska Native	4	2.5
Asian	2	1.3
Black or African American	20	12.7
Hispanic or Latino	3	1.9
Native Hawaiian or Pacific Islander	4	2.5
Native Hawaiian or Pacific Islander,Asian	1	0.6
Prefer not to disclose	3	1.9
White	117	74.1
White,American Indian or Alaska Native	2	1.3
White,Hispanic or Latino	2	1.3
American Indian or Alaska Native	158	100.0
Asian	4	2.5

Table 7. Demographic characteristics of respondents

HABs knowledge based on survey response

The correct answers based on four questions with a total score of knowledge of 16, the mean total score is 8 (50%). When asked if participants knew where to report any suspicious looking blue-green algae (EGLE), 64% (n=101) responded “Yes”, and 36% (n=57) responded

"No". When asking about the health conditions associated with blue-green algae blooms if directly exposed, 58% (n=92) answered at least three correct symptoms that were mentioned in the factsheet, only 26% (n=42) fully answered all 5 associated health symptoms. When asking about who the selected vulnerable populations are, 71% (n=112) respondents mentioned at least three types of vulnerable populations that were also displayed within our virtual factsheet administered, and 15% fully answered all 9 selected vulnerable populations.

Reliability scale: Cronbach's alpha

The Cronbach alpha values (see Table 8) are greater than 0.70 for all the constructs indicating attitude, subjective norm, perceived behavior control, and intention scales. For attitude, the maximum score was a total of 21. And the mean across the 3 items constituted the attitude score $\alpha = 0.796$. For subjective norm, the maximum score was a total of 84. The descriptive norm items (see Table 9) were combined to produce an overall subjective norm measure, the coefficient alpha of $\alpha = 0.933$. For perceived behavior control, the coefficient alpha for this scale was $\alpha = 0.706$. For knowledge, the coefficient alpha for this scale was $\alpha = 0.525$. For intentional behavior, the coefficient alpha for this scale was $\alpha = 0.855$. Lastly, for risk perception, the average alpha coefficient $\alpha = 0.705$.

N of items per variables and its Cronbach alpha
Attitude (Cronbach alpha of 0.796)
Item 1: From "0" being "Not negative", to "7" being "Very negative", how would blue-green algae blooms impact your recreational experience?
Item 2: Imagine you just went for a swim, but later found out there were blue-green algae blooms in the lake, from "0" being "Not worried at all", to "7" being "Very worried", how worried would you be from contracting any potential health symptoms?
Item 3: From "0" being "Not concerned" to "7" being "Very concerned", how concerned are you regarding the presence of blue-green algae blooms in your lake?
Subjective Norm (Cronbach alpha of 0.933)
Item 1: How likely are your family members, friends, and the people in your community to swim in the lake(s) when visible blue-green algae are present?
Item 2: 16-B. How likely are your family members, friends, and the people in your community to go boating on the lake(s) when visible blue-green algae are present?
Item 3: How likely are your family members, friends, and the people in your community to go fishing on the lake(s) when visible blue-green algae are present?
Perceived Behavior Control (Cronbach alpha of 0. 706)
Item 1: For me, the decision to avoid getting in the water when blue-green algae blooms are present is easy.
Item 2: It is entirely up to me whether I decide to perform any lake activities when blue-green algae blooms are present. For example, my job does not require me to attend the lake.

Table 8. Number of variables per behavioral belief and Cronbach alpha

Measuring reliability using Cronbach alpha for each behavioral belief						
Behavioral Belief:	Cronbach alpha	N of items	Inter item correlation	Mean	Variance	Std. Deviation
Attitude	.796	3	.565	14.49	15.65	3.956
Subjective Norm	.933	4	.536	57.33	256.6	16.01
Perceived Behavior Control	.706	3	.445	15.75	14.58	3.81
Knowledge	.525	4	.216	.49631	.059	.242
Intentional Behavior	.855	4	.595	18.96	38.92	6.23
Risk Perception	.705	3	.210	37.49	84.56	9.19

Table 9. Measuring the reliability of behavioral beliefs using Cronbach alpha

Multinomial regression analysis

A multinomial regression analysis was conducted to explore the relationship between risk perception (dependent variable) and attitude, knowledge, subjective norm, and perceived behavior control (independent variables). The first model summary is used to determine how well the data fits in a regression model. Based on Table 10., the adjusted R square, the data indicates 27.6% of the variance of the dependent variable (risk perception) is explained by the independent variables (behavioral beliefs). Based on Table 11 ANOVA is used to ensure that the independent variables are statistically significant to predict the dependent variable. Out of all behavioral beliefs, Attitude was statistically significant by having a value less than 0.01. The unstandardized coefficients indicate how much the dependent variable varies with independent variable. For every risk perception score (see Table 12), the more likely a higher attitude score is calculated (.362). A unit increase of the mean value of attitude leads to 0.4% increase in risk perception given its significant value. However, a negative value such as perceived behavior control indicates having a lower risk perception. For every risk perception score, a decrease in perceived behavior control (-.039).

Pearson correlation of Risk Perception							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.542[a]	.294	.276	.83246371 4430503	.294	15.946	4

Table 10. Model Summary Risk Perception and Behavioral Beliefs

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	44.202	4	11.050	15.946	<.001[b]
	Residual	106.028	153	.693		
	Total	150.230	157			

a. Dependent Variable: Risk Perception
b. Predictors: (Constant), Total Mean of Intentional Behavior, Perceived Behavior, Attitude, Subjective Norm

Table 11. ANOVA Summary Risk Perception and Behavioral Beliefs

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.102	.364		5.779	<.001
	Attitude	.362	.062	.484	5.842	<.001
	Subjective Norm	.036	.064	.049	.557	.578
	Perceived Behavior	-.039	.067	-.047	-.580	.563
	Total Mean of Intentional Behavior	.071	.060	.113	1.177	.241

Table 12. Coefficients Summary Risk Perception and Behavioral Beliefs

DISCUSSION: PHASE 1

Addressing research question #1: "How are communication preferences of vulnerable populations' attending Belleville Lake, Ford Lake, and Lake Erie shaping their knowledge about HABs and its health risks?" The study found a knowledge gap between existing information from government agencies about HABs and its human health effects vs. the public's general understanding about HABs. Based on the interviews, fieldwork, and existing physical messages

we were able to not only understand selected vulnerable populations' lived experiences but comprehend how current messages are shaping selected vulnerable populations' knowledge. By integrating a community outreach and engagement approach, such as participating in community lake events, receiving input from community members regarding communication preferences, and listening to community members health concerns regarding the lake and its conditions, allowed us to gain a better understanding relationship between how the users attending these lakes are learning about HABs versus how HABs are currently being communicated in the selected communities. In addition, it allowed us to explore communication preferences, lake experiences, thus developing potential gaps of what the users would like to know about HABs health effects. This phase was essential to design a communication product (virtual factsheet) tailored to our findings.

Based on our results, none of the participants were aware about HABs health effects, and those that were aware, learned about HABs through word of mouth, working for government agencies such as EGLE, or through personal experiences attending the lake. In addition, a lack of mistrust and low confidence in relation to past negative experiences on "sugarcoating" or how the messenger (representative) of the message is portrayed in town hall meetings could influence people's perception. Among Belleville and Ford Lake vs. Lake Erie, many of those that attended Lake Erie were aware about HABs due to the Toledo water crisis that occurred in 2014, and because most of the sources of communication they used to obtain information about HABs came from government agencies or news such as Detroit Press and the Toledo Blade. Based on our findings, participants in Belleville and Ford Lake, trusted sources at a communal level; word of mouth, private Facebook groups, and local clubs and organizations including the Belleville Yacht Club, and events hosted in their public library. Low level of knowledge about HABs can

be related with the mistrust toward government agencies. By having less trust on government agencies, the less likely individuals will use the resource to learn about hazards in lake conditions.

The goal for effectively communication environmental health hazards such as HABs is to avoid having public learning about them through direct and personal experiences and impacts. Potential strategies to better communicate HABs health risks include incorporating more public engagement and adapting to the existing sources community members use. Throughout our research, limited media and health information from government agencies identified who are the vulnerable populations' who is at stake if exposed to HABs and its cyanobacterial toxins. There is very few research conducted in understanding public's communication preferences vs. how existing government agencies are communicating about HABs. This calls for a need to develop better communication strategies to effectively provide the essential information for the public, especially for selected vulnerable populations who are more likely to have greater health risks if exposed to HABs.

The information is out there, but how do we reach the public? Effective risk communication can be very challenging. From the government, scientists, and representatives from industries there is an existing gap between both, providing a shallow area of how to effectively communicate the technical risk information (environmental and health-related issues) and avoid having inaccurate perceptions of risk towards the hazardous event (Covello et al., 1986; Peters 2013). Poor communication can lead to bigger problems between the public and those in charge of divulging such risks (health/communication experts), such as the public (nonexperts) being accused of ignoring existing information, and experts being perceived as secretive, containing technical jargon and complex objective analysis, and known not to be

trusted (Bennett et al., 2010; Porat et al., 2020). According to the National Research Council (US) Committee on Risk Perception and Communication (1989), if nonexperts are not able to understand the selected information, it can lead to more challenges to receiving inaccurate and incomplete information from these experts. Trustworthiness, credibility, and accessibility are among the few challenges and concerns academia has expressed when discussing scientific information within the field of risk communication (Van der Meer and Jin, 2019; Hyland et al., 2021). Among the problems and challenges risk communication faces, it can be criticized as "technical, complex and uncertain" (Covello et al., 1986). Some challenges include government agencies lacking the public's trust (Covello et al., 1986; van der Meer and Jin, 2019), and relying on sources found in social media for accurate information (Abrams et al., 2022). According to Covello et al. (1986), several origins of risk communication problems derive from the message (government or industry data), the source (who is the messenger), the channel (what type of media), and the receiver (individual citizens). Although media disinformation has been a concurring issue in the past (Marwick & Lewis 2017), the spread of incorrect information has gained momentum in the field of science and it can be very challenging in correcting (Waisbord 2015; van der Meer and Jin, 2019).

When it comes to public health and environmental-health related issues, the root of some challenges and risks communication faces can be tied to broader and unique social and cultural issues, including misinformation in social media platforms and mistrust toward health and government agencies (Covello et al., 1986; Frewer 2004; van der Meer and Jin, 2019). There is no 'one size fits all" strategy to effectively communicate risk (Hyland-wood et al., 2021) however drawing fundamental strategies and scholarships essential to obtain effective risk communication (in the realm of environmental-health related topics) we can explore challenges

between existing information provided by government agencies vs. the public's understanding, and highlight the importance of incorporating risk perception as a key variable to better understand public's health behaviors towards the risk, and including more public engagement methods, creating a more effective way to bridge the existing gap between existing scientific information and public's understanding (Bennett et al., 2010).

Using concepts learned from SARF (Kasperson et al., 1988) allowed us to address better potential strategies to understand how to effectively communicate these risks better. SARF helps explore how communication shape perception of risk based on how selected vulnerable populations' communication preferences. There are four information mechanisms that SARF proposes contribute to the amplification of risk perception: volume of information about a risk event, ambiguity of information, dramatization of facts and potential consequences, and symbolic connotations communicated in the process of sharing information (Strekalova 2016; Kasperson et al., 1988). This can be seen through the information channels, social stations, and individual stations that the framework proposes (see Fig. 3). Risk attenuation and amplification processes proposed by Kasperson et al. (1998) allow to understand the basic risk communication processes, that can lead to improved health environmental policies (Pidgeon and Henwood 2010). Integrating these concepts through our semi-structured phone interviews were essential component to better understand selected vulnerable populations' communication preferences, knowledge, and experiences. It helped explore behaviors, opinions/values, feelings, towards HABs, among other lake conditions, concerns, hazards and/or incidents they have experienced. This allowed unexpected data to emerge, such as fish consumption, and PFAS and E. coli concerns. By learning how selected vulnerable population awareness about HABs health effects, how they were communicated, what they feel and their experiences, using these factors can

contribute to social and cultural concepts, allowing us to design an effective communication product, and contributing to gaining more knowledge.

Limitations (Phase 1):

Possible reasons for environmental-health communications to not be effectively concentrating on communicating HABs during 2021-22 could be due to limited employees, budget cuts, and the high peak season of COVID-19. However, the call to involve more effective risk communicators is urgent. This calls for an urgent action for communication experts, among government workers involved in HABs communication campaigns to involve better effective communication strategies.

DISCUSSION: PHASE 2

Addressing research question #2: "How are the public's behavioral beliefs (attitude, knowledge, subjective norms, and perceived behavior control) shaping their risk perception towards HABs?". Based on our results and SPSS data analysis attitude was reported as the strongest behavioral belief associated with risk perception and intentional behavior. Attitude is defined as "relatively enduring organization of beliefs, feelings, and behavioral tendencies towards socially significant objects, groups, events or symbols" (Hogg & Vaughan 2005), it is also a "mental and neural representation organized through experience, asserting a dynamic influence on behavior" (Pratkanis et al. 1989). Attitude towards the behavior of avoiding HABs is mainly associated with feelings of concern, worry and safety regarding individuals' perception of risk. The more negative the attitude, in this case having no safety concerns or worry towards HABs when engaging with them directly, the lower the risk perception. The positive attitude included having better safety behavior, thus having a higher level of risk perception towards HABs. Hypothetically by having a more positive attitude, thus having higher level of risk

perception, we expected the individual to have a better intentional behavior to avoid HABs. In addition to risk perception being measured with behavioral beliefs, the study also ran a multiple regression line in relation to intentional behavior, and attitude was also the most significant value. Using this information, we can better incorporate messages and strategies keeping public's attitude as one determining factor to increase risk perception when it comes to discussing HABs and its potential health effects.

Measuring risk perception and its behavioral beliefs:

Risk perception is defined as an individual's risk assessment and beliefs about potential harm or the possibility of a loss (Slovic 1987). It is an assertion people make about the characteristics and severity towards a risk (Gellman & Turner 2013). One of the most important paradoxes mentioned throughout different studies include how risks that harm people are often very different from the risks that concern, worry, and upset people (Slovic 1987; Covello 2011). The nature of human perception permits a differentiation between the real-world threats and what is subjective based on the individual's perceptual experience of those threats (Pidgeon, Kasperson & Slovic 2003), highlighting a key challenge when measuring an individual's perception. There is a large body of literature about how risk information can be effectively communicated (Siegrist et al. 2005; Fischoff 2009; Lundgren & McMakin 2009; Covello 2011; Malecki and Keating 2020). Limited literature focuses on the relationship between risk and sources of communication influence risk perception (Covello 2011). A challenging component to study is understanding how better educate the public and what specific factors to consider in order to increase risk perception. There are two broad risk models that are commonly utilized to study people's perception as well as communicate risk. The first approach risk are seen as an objective and are independent of social context, they call this approach "the realist". The second

approach is when risk are interrelated with sociocultural context, referring this approach as "the constructionist" (Smith 2006; Abrams and Greenhawt, 2020). The more studies are learning about risk, the more they have recognized the importance of its social constructionist approach within society, and communities (Smith 2006; Abrams and Greenhawt, 2020).

Using other studies and literature allows us to understand how different behavioral beliefs, specifically attitude is included within theories and frameworks of risk perception. One of the models used to characterize public risk perception is the Climate Change Risk Perception Model (CCRPM, Van der Linden, 2015). This risk perception model allows to understand perception of risk within a social context. The theory integrates the cognitive factors (knowledge), the emotions such as the affect, and the socio-cultural factors such as their norms and values (Van der Linden, 2015). *Affect* is defined as an instinctive emotional state that people experience, which can be related to an individual's attitude. It is an experience that individuals associate with perception about the object and its negative or positive feelings attached to them (Árvai & Rivers III 2014). By learning about the risk perception model sociocultural context, we are able to understand the essence of attitude in relation to risk, such as how the sources of communication and experiences can shape attitudes, and how they may be embedded within their social action and human behaviors. Among other studies, the Extended Parallel Processing Model (EPPM) (Witte, 1994) and (Witte 1994) and Risk Perception Attitude (RPA) framework (Rimal & Real, 2003) help understand the type of beliefs that drive risk perception. The EPPM is a methodology used to study efficacy beliefs and emotional reactions to determine behavioral decisions, threat or fear management use this model to better understand health behaviors. Witte (1994) uses this model to study AIDS prevention, underlying cognitive and emotional mechanisms of success and failure appeals. Within Witte's findings, risk perception about the response that was

recommended as prevention was associated with danger control responses however unrelated to fear control responses. Meaning, when efficacy beliefs are strong, perceived risk can become a mediation correlation between emotional fear and behavior. In relation to efficacy beliefs and emotions, feelings (pleasant or unpleasant) tend to derive from wanting to approach or avoid an object (Barret and Bliss-Moreau 2010). It is an experience that individuals associate with perception about the object and its negative or positive feelings attached to them (Árvai & Rivers III 2014). In response to Witte's EPPM, Rimal and Real (2003) use concepts derived from EPPM and introduce RPA framework integrating attitude. Categorizing individuals in four groups: responsive, avoidance, proactive, and indifference. Both EPPM (Whitte, 1994) and RPA Framework (Rimal & Real, 2003) mention risk perception consists of perceived susceptibility (individual's beliefs about its vulnerability towards the risk), and perceived severity (seriousness of the risk or effects the harm may cause, if exposed). EPPM theory focuses on how individuals process messages, RPA framework theorizes how individuals' perception of risk can influence them to act (Turner et al., 2006). Using these concepts, we've learned how feelings, experiences, and affective measurements can influence how individuals perceive risk.

CONCLUSION

Risk communication needs to involve structuring more decision-making processes that accommodate societal concerns and provide forms within the institutions that can listen and discuss. Understanding the public's perception of the risk, needs, and concerns, and integrating public engagement such as searching for more community engagement and community intermediators can allow risk communication about environmental-health risks to become more effective, improve mistrust toward media information, obtain a better health behavior, and even a higher level of knowledge towards the risk. Finding new and engaging ways to incorporate

effective risk communication we would not only be helping prevent future incidents, or events, but share common knowledge to better communicate environmental health risks in the future. The need for better effective communication about HABs requires integrating community engaged methods such as listening to public's concern and exploring ways on how to better develop trust. Attitudes are based on feelings, thus by becoming more empathic, we are not only increasing better level of understanding of potential risks caused by HABs but potentially minimizing incidents and exercising better health behaviors in the future.

CHAPTER 2: EVALUATING COMMUNICATION FRAMES, ITS EFFICACY AND RISK PERCEPTION

INTRODUCTION

When it comes to distributing environmental and health risks, how one communicates the information to the public is vital. Risk communication can be seen through the lens of risk information. It is a process where people exchange information, these exchanges usually consist transferring risk messages from experts to non-experts (Árvai & Rivers III 2014). Risk communication can be referred to as the act of conveying or transmitting information about health and environmental risks (Covello et al., 1986). It can be defined as an exchange of real-time advice and opinions between experts and people facing threats to their health, economic, or social well-being (Abrams and Greenhawt 2020; World Health Organization [WHO], 2020). The goal of risk communication is bidirectional, it is meant to be collaborative and not a simple didactic message from an institution or physician to public (Siegrist et al. 2005). However, it is often criticized as a "one-way" passage from experts to non-experts. In addition, risk messages and risk communication processes are two different concepts requiring better understanding on how one differentiates from the other (National Research Council (US) Committee on Risk Perception and Communication 1989). Risk communication is also known as a "source of frustration" for both risk communicators and their intended audience (Covello et al., 1986). Psychological, sociological, and cultural factors create public misperceptions and misunderstandings about risks (Covello 2011). For risk communication to become effective, the audience must find the communication organization credible and trustworthy (Lundgren & McMakin 2009). A significant part of effective risk communication involves the identification and management of rumors and misinformation (Árvai & Rivers III 2014; WHO 2014). The principles of risk communication are supported by a large group of behavior and social science

research (Covello et al., 1989; Covello 1992; Slovic and Peters 2006; Lundgren & McMakin 2009; Fischoff 2009; Heath and O'Hair 2010). Poor risk communication may cause serious detrimental effects to people's health and severe environmental threats (Lundgren & McMakin 2009; Covello 2011). Having effective ways to communicate risk can help prevent potential accidents or harm in the future (Covello 2011).

According to one of the world's leading experts and practitioners of risk, Covello (2011) there are seven cardinal rules for effective risk communication. These rules were later applied for EPA's rules of effective risk communication. First, people have the right to have a voice and participate in decisions that affect their lives. Learning about what people have to say about the risk itself will not only help build effective risk communication but will allow you to learn more about your whom this message is targeted to. Learning about your audience and including their voice allows you to increase participation, engagement, and learn more information about their perception of the risk (Lundgren & McMakin 2009). Second, plan and tailor risk communication strategies. This can be done by setting goals, learning more about your audience and their communication channels, which require different risk communication strategies (Covello 2011). Third, listen to your audience. By listening to your audience, it is possible to obtain a better understanding on how to effectively tailor communication strategies to the intended audience, as well as gain a better understanding how they perceive risk. In addition, listening to your audience can also help to learn about the intended audience's personal experiences, attitudes, and awareness of the risk event. Fourth, being honest and transparent allows one to have an effective message come across and decrease the level of doubt regarding the risk event. To communicate honestly one must differentiate between opinions and facts. Any risk communication message can be questioned by the audience, hence the importance of listening to audiences' concerns

(Lundgren & McMakin 2009). Another way that one can make communication more credible is by learning what factors influence trust for the audience member, as well as sources they would consider trustworthy for health and risk-related news. Fifth, coordinate and collaborate with credible sources of information and trusted voices. By receiving information that is credible, and unbiased can permit the communication about risk to have validation (Covello 2011). Sixth, plan for media influence. Social media and cultural factors influence uncertainty, trust and shape perceptions and response to risk messaging in institutions and audience members (Malecki and Keating 2020). Lastly, speak clearly and with compassion. A factor that falls within communicating honestly and transparency is taking into consideration the audience's level of understanding (Lundgren & McMakin 2009). Technical language and jargon are major barriers to effective risk communication. Abstract and unfeeling language often offend and confuse people (Covello 2011). Learning about your target audience allows you to implement a language that is accessible and understandable for the message to be transferred. When developing a communication project, event, or product, one can use The National Center for Food Protection and Defense (NCFPD)'s tactics for best practices when developing risk communications and messages: (1) keep in mind risks and crises are an ongoing process, (2) conduct pre-event planning and preparedness activities, (3) foster partnerships with publics; (4) collaborate and coordinate with credible sources, (5) meet the needs of media and remain accessible, (6) listen to public's concerns and understand the audience, (7) communicate with compassion, concern, and empathy, (8) demonstrate honesty, candor, and openness, (9) accept uncertainty and ambiguity, and lastly, (10) give people meaningful actions to do self-efficacy (NCFPD, 2009).

The purpose of risk communication is to form a better alignment between the public perceptions of risk and how the risk is being measured (Lundgren 1994; Árvai & Rivers III 2014). Risk

communication is more than just distributing a cautionary message, it should understand its audience members, social and cultural values, as well as utilizing trustworthy communication sources. In doing so, risk communication will gain more importance for an effective and efficient risk management (Hampel 2006). Effective risk communication can be narrowed down to four main types; the first is information and education, the second is behavior change and protection action, the third consists of disaster warnings and emergency information, and the last is a joint problem and conflict resolution (Covello et al., 1986). The deficit model by Hiltgartner (1990) emphasizes how to align between non-experts and experts. A key goal of risk communication focuses on rectifying the knowledge gap between the scientists and those receiving the information (Frewer 2004). Risk communication can be known as effective when the nonexpert (recipient) accepts the view / information provided (by the expert). However, a successful risk communication can also be considered effective when it raises a higher level of understanding or action regarding the environmental-health issue (National Research Council (US) Committee on Risk Perception and Communication 1989).

Risk communication should not be studied as a "passive, one-way procedure" (Heydari et al., 2021). It is a two-way process that involves a clear message, using multiple platforms to reach a diverse audience, integrating trusted and accessible resources (Hyland-Wood et al., 2021). Strategies and recommendations for effective risk communication from Hyland-Wood et al. (2021) include having a clear message and desired action, minimizing cognitive messages, and focusing on having clear instructions of what behavior the expert wants to achieve and why. Having credibility entails using intermediaries between non-experts and experts such as public-health experts or medical experts to communicate such risks. Ways to better engage include using empathy towards the public and using public engagement strategies such as listening to

nonexperts' needs and concerns, and communicating with frankness, honesty, and openness, becoming transparent and acknowledge uncertainty could lead to having less mistrust towards government agencies (Porat et al., 2020). Among the strategies of effective risk communication, public engagement is a key approach to improving better health behavior and more likely a higher level of trust towards receiving risk information from government and health agencies (Hyland-Wood et al., 2021, Frewer et al., 2004).

Good risk communication can inform, support, educate, calm a nervous public, build trust, encourage cooperative behaviors, and can potentially help save lives (Covello 2011). There is a large body of literature on how risk information can be effectively communicated (Siegrist et al. 2005; Fischoff 2009; Lundgren & McMakin 2009; Covello 2011; Malecki and Keating 2020) however there is a gap between how effective existing health-risk information are being communicated, and if it achieves the goal to reduce hazard behaviors and levels of harm (Alaszewski 2005). Using Hyland-Wood et al., (2021) towards recommendations of effective strategies to communicate risk, the objective of the study includes using multiple strategies to understand the gap between communication experts and non-experts when it comes to public health and environmental-health-related issues.

The study focuses in understanding how using different communication frames can influence the level of risk perception. Using preliminary data from our exploratory work in the first phase (mentioned in Chapter 1) through interviews, fieldwork and attending local events, the study was able to design two factsheets about the detrimental human health effects caused by HABs. The objective of the study is to understand and compare between existing health and government agencies communicating human health risk caused by HABs, and if using a different communication frame with emotional appeal could influence a higher level of risk perception

towards HABs. A mixed method approach including community-engaged strategies such as conducting fieldwork attending local and state parks near the selected lakes to talk with community members, attending local events around the lake, and listening to community members, help better understand public's preference towards the different communication frames. Through an online survey and a focus group, the research aims to determine which intervention exposure using different communication frames can achieve a desired level of risk perception towards HABs. Although the survey was open to the public, a higher preference was given to those who attend one of the selected lakes; Belleville Lake, Ford Lake, and/or Lake Erie for recreational purposes. To obtain more participants with the desired population preference, it was specifically sponsored through associated local organizations such as Lake Huron Watershed Council located between Ford and Belleville Lake, private FB groups associated in communicating news and recreational activities near the selected lakes, pasting, and handing out flyers in local and state parks and attending community events near the selected lakes. The research aims to develop a model for others to use with the goal of designing a risk communication project by implementing community-engaged strategy to obtain a desired sample population. In this section, we will be focusing on answering the following research question (#3), how do different communication frames (emotional vs. cognitive) influence public's risk perception to avoid engaging in recreational water activities when HABs are visibly present?

METHODS

Study design

Using different communication frames and how it could influence public's perception of risk towards HABs, the study designed two factsheets about the detrimental human health effects caused by HABs. The two communication frames consisted of a cognitive and emotional style.

Although both factsheets had the same content, they were advertised differently. The cognitive factsheet included existing information about HABs sponsored by government and health agencies; Environment, Great Lakes, and Energy (EGLE), Centers for Disease Control and Prevention (CDC), and Environmental Protection Agency (EPA). Whereas emotional factsheet involved images of loved ones such as dogs, kids, elderly, and phrases associated with emotions aiming to increase emotions affiliated with sadness, fear, and worry. Both factsheets were designed using preliminary results from phase 1 (Chapter 1), in addition to using different imagery, color was another integration of our design asking participants what color came into their mind when they thought of the word: "risk" and "health" (Phase 1). In this chapter, we focus on discussing phase 2, to better understand the efficacy between both communication frames displayed in each factsheet, an online survey and a small focus group was conducted. The two factsheets were presented to research participants in the online survey through a randomization process using Qualtrics. The virtual factsheets served as a methodological tool to evaluate the efficacy of different communication frames. The efficacy was evaluated by comparing how each communication frames influenced the public's perception of health risk of HABs and its intentional behavior to avoid engaging directly with HABs. The online survey (described in Chapter 1) was also administered to understand how behavioral beliefs can influence the desired risk perception. A fieldwork was conducted in June 2022 to promote the online survey, attending state, and local parks nearby the selected lakes (Belleville Lake, Ford Lake, and Lake Erie), and attending a three-day lake fest near Belleville Lake. Individually approaching people during these events generated more insight on how the general public attending selected lakes feel towards HABs and the lake. Introducing the project and the research objectives allowed more people to share their personal opinions and stories about HABs. After

closing the survey, an additional method the study conducted was a small in-person focus group held in Belleville District Library with Belleville Rotaract Club members. The objective of the focus group was to learn about community members preferred factsheet (cognitive or emotional). Following an informal discussion where community members shared their personal opinions, and concerns about HABs. Hard-copy format of each factsheet was distributed, and on a blank piece of paper, participants were encouraged to answer open-ended questions discussed in more detail later in this section.

Online survey

The cross-sectional online survey was administered from June to July 2022 and approved through IRB (IRB ID: 007642; project IDs: NIH 1P01ES028939-01 and NSF OCE-1840715). The online survey was anonymous, and for those who completed the survey, a $5 Amazon e-gift card was offered as an incentive and sent via email. Those eligible to participate in the study must be 18 years or older, willing to share their lake experience with HABs (if any), knowledge about HABs, and attitudes towards engaging in the lake with HABs. Although the survey was open to the public, a higher preference was given to those who attend one of the selected lakes; Belleville Lake, Ford Lake, and/or Lake Erie for recreational purposes. Data from those who had seen HABs in Michigan lakes before taking the survey, and those who had not. Although distributing the survey online reaches a large audience with a bias towards those who have access to the online platform (Kim & Song 2017), an advantage can be creating a larger random sample population that share the same interest, recreational activities in Belleville Lake, Ford Lake, and/or Lake Erie.

Using Ajzen's (1985) Theory of Planned Behavior (TPB) the study was able to design the online survey to determine which behavioral beliefs (factors) can predict risk perception. TPB's

behavioral beliefs include attitude, subjective norm, and perceived behavioral control. Integrating TPB in our survey help measure public's attitudes towards avoiding engaging directly with HABs while conducting recreational activities, subjective norm, based on other's behaviors and acceptability when it comes to engaging with HABs, and perceived behavior control, understanding the participant's level of difficulty to avoid engaging with HABs. The purpose of the survey served for two main objectives, the first included understanding which behavioral beliefs influence public's risk perception to avoid performing recreational activities when HABs are present (discussed in Chapter 1), and the second objective aims to determine which communication frames (emotional and cognitive) influences achieved desired risk perception. Within the survey, the two factsheets were presented to research participants in an online survey. Although the online survey used the same set of questions, using a randomization process, each participant was categorized as one of the three groups: those receiving the emotional factsheet, cognitive factsheet or the control group (no-factsheet). Their efficacy was evaluated by comparing how each communication frames influenced the public's perception of health risk of HABs and its intentional behavior to avoid engaging directly with HABs.

Focus group

To better understand community members' opinion about the different communication frames, a brief focus group (n=12) was conducted in the Belleville Area District Library. Participants were recruited during the Belleville Lake fest in June 2022 and focus group was held during a Belleville Rotary Club meeting with volunteered community members in Belleville. Focus groups are an excellent method to engage with community members and learn more about their perceptions and opinions. They are considered an efficient method to collect qualitative data (Onwuegbuzie et al., 2009). Through engaging in small number of people in an informal

discussion, it can allow new data to emerge as well as discuss and provide additional findings on a specific topic (Onwuegbuzie et al., 2009). Using CDC's Evaluation Brief manual on conducting focus groups (2018), focus groups are held with approximately six to twelve people, consisted of a series of questions and prompts. Focus groups can be used to gather attitudes, experiences, and beliefs through qualitative data, serves as adjunct to quantitative data collection method to receive additional information and lastly also utilized through mixed-method evaluation approach (CDC 2018). Two key concepts essential to plan a focus group consist of developing a questionnaire guide and deciding the number and type of participants.

The focus group was held in the Belleville Area District Library during the Belleville Rotaract Club meeting. A printed version of each factsheet was handed out and in a blank piece of paper, participants were asked to mention what they like/dislike of each factsheet, what information they found helpful (if any), what information was new to them and what did they already know, and overall, which factsheet did they personally prefer and why. Following up was an open discussion for the participants to express any general comment, interest, and concerns. Although there was no incentive, or audio recording, the informal discussion brought more participants to openly share their thoughts and preferences towards the two factsheets. After having the focus group, the meeting consisted of presenting a PowerPoint of the research and fieldwork experience conducted during Phase 1 of the project. Sharing preliminary results of the exploratory findings created a space for community members to share and express their opinions and concerns about HABs in Belleville and Ford Lake.

Data collection and recruitment strategy for the online survey and focus group

A mixed-recruitment strategy was designed to promote the online survey. It included snowball sampling, flyers, and conducting fieldwork to recruit people face-to-face during community events. Snowball sampling is a random sample of individuals drawn from a finite population, helping the study make statistical inferences about various aspects in the given population (Goodman, 1961). The objective of snowball sampling is growing sample size hence described as a rolling snowball (Kirchherr and Charles 2018, Goodman, 1961). Hard-copy and digital flyers were designed to promote the online survey. To increase public's attention and number of participants to take the online survey, multiple flyers were created using different imagery of HABs, colors, and messages. A brief pilot test was administered with ten community members to receive feedback on the recruitment flyers and for the online survey before final distribution. The online flyer was sponsored through private Facebook groups that focused on discussing recreational activities in Belleville Lake, Ford Lake and Lake Erie, and Listerv emails from Michigan Sea Grant and Lake Huron Watershed Council. The digital flyer including the survey link and a QR Code. The hard-copy version of the flyer included the QR code. If unable to retrieve QR code, the researcher's email was provided and link to the survey was sent via email for those who directly contacted the researcher. Attending the Belleville Lake fest, hard-copy flyers were pasted in the local library, local shops, and public bathrooms near Belleville Lake, and were personally handed out to local artists, owners of local shops, and the public present during the event. By individually approaching people during the lake fest allowed to gain more insight of people's awareness of HABs and concern within Belleville Lake. Introducing the project and the research objectives, allowed more people to casually share their personal opinions and stories about HABs. This data consisted of qualitative work, note-taking was the

main method to collect general attitudes or expressions people shared. While recruiting participants for the survey during Belleville Lake fest, a booth sponsored by the Belleville Rotary Club caught interest in learning more about the study. Throughout discussing study's objective, the Belleville Rotary club directly contacted the study and took interest in voluntarily participating in a focus group to learn more about the existing project.

Data analysis of the online survey

To understand the efficacy of each communication frames how it can influence research participant's risk perception towards engaging in recreational water activities when HABs are present, the study administered a mixed method approach consisted of online survey and a focus group. Although the online survey used the same set of questions, using a randomization process, each participant was categorized as one of the three groups: those who received an emotional factsheet (Group A), cognitive factsheet (Group B) or those who did not receive a factsheet, serving as a control group (Group C). Their efficacy was evaluated by comparing how each communication frames influenced the public's perception of risk towards HABs. For participants those who received a factsheet in the online survey, a pre/post method was included measuring risk perception and intentional behavior before and after exposure the virtual factsheet. The change in risk perception (CRP) was calculated by subtracting between the before (Pre-RP) and after (Post-RP) to obtain a true measure of efficacy and value of risk perception for each group.

$$CRP = Post\text{-}RP - Pre\text{-}RP$$

To determine the significance of risk perception between each of the communication frames, and those who did not receive a factsheet (research question 3), the study used Statistical Package for Social Sciences (SPSS), to perform several descriptive statistics and multiple paired t-test analysis. Descriptive statistics is mainly used to understand the mean and standard

deviation of each variable. Using the average one can determine its significant value. The t-test is known as a statistical test of difference between a set of two groups or sets of data (Pallant 2007; Gerald 2018). It is a procedure that allows the analysis to determine the probability level of rejecting the null hypothesis that two means are the same (McMillan and Schumacher 2010; Gerald 2018). Using this t-test is known to compare the two groups and its scores and means and measure which participants are more meaningfully related to the participants in the other group (University of Arizona Military Reach 2009). There are three different types of t-tests: independent, dependent (paired), and one-sample t-test. The dependent t-test, also known as paired sample t-test was selected for this study to better understand the relationship and significance of risk perception and intentional behavior before and after they received the factsheet. This sample is a common practice to apply the dependent t-test when using pre- and post- methods (Gerald 2018). A dependent t-test is commonly used when two populations are collected in pairs (Douglas and George, 2003; Gerald 2018). For our study, the first t-test measures the change of risk perception of those who received the cognitive and emotional factsheets (Group A+B) versus those who did not, represented as the control group (Group C). The second paired t-test consisted of comparing the change of risk perception (CRP) between both communication frames with each other: emotional (Group A) and cognitive (Group B). The last paired t-test conducted focused on the pre/post-test of the risk perception between those receiving cognitive and emotional factsheet. In this case because it is the same participants conducting the pre-test and pos-test scores within a group (emotional or cognitive), they are meaningfully related and dependent on each other (Gerald 2018).

For our focus group, qualitative data analysis was conducted and consisted of notetaking and memory-based analysis, meaning the researcher would recall the past events occurring in the

focus group (Onwuegbuzie et al., 2009). There are three types of ways to collect data; individual, group and/or group interaction data (Duggleby, 2005; Onwuegbuzie et al., 2009). Most focus group researchers use the group as a unit of analysis (Morgan, 1997; Onwuegbuzie et al., 2009). Because most of the answers were inclined to one specific communication style, it was easier to determine public's preferences towards the different communication frames. The pages written on a blank page were collected, helping us identify what specific elements the participants appreciated from each flyer.

RESULTS

Demographic characteristics of respondents

A total of 158 respondents fully answered the survey (see Table 8 in Chapter 1). More than half of the respondents were male (n=88, 55.6%), following female (n=67, 42.4%), and prefer not to say (n=3, 1.2%). Majority were either within the age range of 25-34 years old (n=63, 40%), or 35-44 years old (n=60, 37%). In education background, most respondent reported with some college 31% (n=49) or having a 2-year degree (n=37, 23%). Lastly, more than half of the respondents were white (n=117, 74%). Out of 158 participants, 122 (77%) reported having previous experiences with blue-green algae blooms, whereas 36 participants (23%) did not. The two recreational activities participants performed the most during a blue-green algae event included boating (n=77, 49%) fishing (n=33, 20%). Majority of the respondents (n=90, 57%) experienced seeing blue-green algae in Ford Lake, Lake Erie, and Belleville Lake. Out of the three lakes, Belleville Lake was the most with a total of 37% (n=60), following Ford Lake 24% (n=39), and Lake Erie 22% (n=36).

Descriptive statistics

A total of four descriptive statistic tables were designed comparing among the significant value of risk perceptions towards the different exposures of information and communication frames. The descriptive statistics on Table 14 measures the risk perception for each group. The Post-risk perception variable is the calculated score after being exposed to the factsheet throughout the survey. With a total of 66 participants, those who received the emotional factsheet (Group A), held a mean (M) of 37.38, and a standard deviation (SD) of 8.263. With a total of 49 participants, those who received the cognitive factsheet (Group B), held a M of 37.10, and a SD of 9.692. For those who did not receive a factsheet serving as our control group, with a total of 43 participants, the M= 33.91, and SD= 8.002. The second descriptive statistics (Table 15) measures the changed risk perception (CRP) for only those who received a factsheet (Group A and B). SPSS randomized and analyzed a total of 49 participants on each group. Group A had a M= 24.96, and SD= 12.235, whereas group B had a M= 5.29 and SD= 9.463. For the third descriptive statistics (Table 17), it measures those receiving factsheet (Group A +B) and who did not (Group C). For those who received a factsheet, M= 24.44 and SD= 12.853, whereas those who did receive a factsheet, M= 37.58, and SD= 8.827. For the last descriptive statistics (Table 19), focused on group A and B, measuring pre/post of risk perception. For group A before being exposed to the factsheet consisted of a M= 36.38 and a SD=7.444. After being exposed to the factsheet, M= 62.83, and a SD= 14.328. For group B, before being exposed to the factsheet, M= 31.82, and a SD= 5.943. After being exposed to the factsheet, M= 37.10, and a SD= 9.692.

Paired t-test analysis

A total of three different paired t-test were conducted measuring the overall significant p-value for those who received and/or did not receive a communication factsheet. The first paired t-test

analysis (Table 16), using the CRP between group A and B, M=19.67, SD=15.7, with a p-value <.001. The second paired t-test analysis (Table 18), focused in comparing between those receiving a factsheet (Group A+ B), and those who did not (Group C). The paired-test analysis using CRP is M=19.67, SD=15.7, with a p-value <.001. For the last paired t-test analysis, a Pre/Posttest between group A and B was conducted, for group A, consisted of M=-26.455, SD=14.48, and a p-value <.001. For group B, M= =5.286, SD=9.463, and a p-value <.001.

Focus group

Out of the twelve participants, ten openly expressed they preferred the emotional factsheet. When asked in detail about the elements that they liked, participants mentioned red, imagery of dogs and children, and visual way mouth, nose and eyes were presented. Among those that preferred the cognitive factsheet (n=2) mentioned they liked the slogan "If it's green, don't go in", and the images of the different HABs. From someone who disliked the cognitive factsheet mentioned it was "too wordy", and from someone who disliked the emotional factsheet said it was "too much going on the title", referring to the colors and images being "too loud".

Out of the twelve participants, none were aware about HABs human health effects, and less than three participants openly mentioned they aware of the environmental effects HABs may cause associating it with fertilizers and pesticides. Information they found helpful included learning about the symptoms HABs may cause, routes of exposure and the phone number of where to contact if they see HABs. Although all the participants were aware of HABs human health effects, seven participants openly shared seeing HABs in Belleville Lake before. Personal stories of participants attending the lake emerged, one participant expressed negative experience attending a small dock area connected to Belleville Lake saying it had an awful smell and never went back due to the experience. Another participant shared she had seen HABs happening in

Belleville Lake since 1970s and that they never do anything about it, it continues to appear. In response to that story, someone asked “What can we do about it?” In response among each other, the participants started brainstorming ways to advertise Belleville community members to avoid using pesticide. Part of the focus group involves me listening to ways they would like to communicate about HABs in their community, by sharing my preliminary results brought more attention to better communicate and address HABs. In September 2022, the community held a meeting in Belleville District Library, open for all community members, the Belleville Independent, the local newspaper wrote an article about addressing the issue about HABs in Belleville Lake.

Descriptive Statistics of Risk Perception for Group A, B, and C

	N	Mean	Std. Deviation	Std. Error Mean
Group A (Post)	66	37.38	8.263	1.017
Group B (Post)	49	37.10	9.692	1.385
Group C	43	33.91	8.002	1.220

Table 13. Descriptive statistics of risk perception per each group using post-risk perception

A. Emotional vs. Cognitive group using the changed risk perception (CRP)

Descriptive Statistics of the CRP for Group A and B				
Group	Mean	N	Std. Deviation	Std. Error Mean
Group A (CRP)	24.96	49	12.235	1.748
Group B (CRP)	5.29	49	9.463	1.352

Table 14. Descriptive statistics between emotional (group A) and cognitive group (group B)

Paired t-test statistics of CRP between Group A and B								
Paired Differences					t	df	Significance	
Mean	Std. Deviation	Std. Error Mean	95% C.I. of the Difference				One-Sided p	Two-Sided p
			Lower	Upper				
19.673	15.7	2.243	15.164	24.183	8.772	48	<.001	<.001

Table 15. Paired t-test of the CRP between emotional (group A) and cognitive group (group B)

B. Factsheet vs. Control

Descriptive Statistics for Group A+B and C				
Group	Mean	N	Std. Deviation	Std. Error Mean
Group A+B	24.44	43	12.853	1.960
Group C	37.58	43	8.827	1.346

Table 16. Descriptive statistics of those receiving factsheet (Group A +B) and who did not (Group C)

Paired t-test statistics between group A and B								
Paired Differences					t	df	Significance	
Mean	Std. Deviation	Std. Error Mean	95% C.I. of the Difference				One-Sided p	Two-Sided p
			Lower	Upper				
-13.140	14.939	2.278	-17.737	-8.542	-5.768	42	<.001	<.001

Table 17. Paired t-test of CRP of those receiving factsheet (Group A +B) and who did not (Group C)

C. Comparison of Risk Perception, Pre/Post-test Emotional and Cognitive factsheets

Descriptive Statistics for Group A and B				
Group	Mean	N	Std. Deviation	Std. Error Mean
Group A (Pre)	36.38	66	7.444	.916
Group A (Post)	62.83	66	14.328	1.764
Group B (Pre)	31.82	49	5.943	.849
Group B (Post)	37.10	49	9.692	1.385

Table 18. Descriptive statistics of pre/post risk perception of those receiving a factsheet

Paired t-test statistics between group A and B									
Paired Differences						t	df	Significance	
Group	Mean	Std. Deviation	Std. Error Mean	95% C.I. of the Difference				One-Sided p	Two-Sided p
				Lower	Upper				
Group A (Pre/Post)	-26.455	14.489	1.784	-30.016	-22.893	-14.833	65	<.001	<.001
Group B (Pre/Post)	-5.286	9.463	1.352	-8.004	-2.568	-3.910	48	<.001	<.001

Table 19. Paired t-test of pre/post risk perception of those receiving factsheet

DISCUSSION

Addressing research question #3: "How do different communication frames (emotional vs. cognitive) influence public's risk perception to avoid engaging in recreational water activities when HABs are visibly present?" based on our t-test results we were able to determine all had significant values. Based on our descriptive statistics (Table 13) comparing risk perception between all three groups, a similar mean (M=37) of risk perception was found between those receiving a factsheet, whereas those who did not had a lower average score (M=33). For the second analysis (Table 14 and 15) the study compared only between the groups that received a factsheet. Using the change in risk perception (CRP), obtained by subtracting the value of risk perception before and after being exposed to the factsheet, the mean was significantly higher for those who received the emotional factsheet that those who received the cognitive factsheet. Through the paired t-test, we can determine significant value of participant's risk perception when receiving factsheet. In Table 18 and 19 we analyzed those who received factsheet and compared to those who did not. According to our descriptive statistics (Table 16), a higher mean (M=37.58) was shown for those who did not receive a factsheet (Group C) than those who did (M=24.44). A possible interpretation can be that for those who did not receive factsheet, perceived risk higher than those informed and already aware of the potential human health symptoms. Risk perception was measured twice and calculated as a change for those receiving a

factsheet, whereas those who did not receive a factsheet had a direct measurement of risk perception, this could be the reason the mean value sets was higher for group C than those receiving factsheets (group A+B). Lastly a comparison of emotional and cognitive was conducted focusing on the pre/posttest of risk perception (Table 18 and 19). Dependent paired test is commonly used for pre/posttest results, shown on Table 18, group A had a greater average of risk perception than group B. Before receiving the emotional factsheet, the mean for group, A was 36.38, whereas after receiving the factsheet, the mean nearly doubled with a value 63.83. Before receiving the cognitive factsheet, the mean for group B was 31.82, after receiving the factsheet the risk perception increased by 37.10. When conducting the last analysis pre/posttest between emotional and cognitive communications, both demonstrated significant values. Using Covello's (2011) seven cardinal rules for effective risk communication, by listening to the audiences' concerns, in addition to their general understanding and experiences with HABs. By learning about what people have to say about the risk itself will help build an effective risk communication and learn more about your whom this message is targeted to. Having this said, to compare communication frames, the study designed factsheets based on preliminary findings from our first phase (see Chapter 1). The first phase consisted of exploring populations' socio-cultural values, lake experiences and sources, using this information help design the two factsheets. For the emotional factsheet, narrative messaging and imageries including dogs, children, and elderly were shown to obtain feelings of empathy, love and/or worry when discussing the potential risks. For cognitive factsheet, it represented existing messages about HABs sponsored by EGLE, NOAA CDC, and EPA agencies. After administering fieldwork during the first phase of the study, we found the slogan "If it's green don't go in" commonly advertised by EGLE and NOAA near the selected lakes. For this reason, the slogan was

incorporated in the cognitive factsheet, and instead of demonstrating images of people like the emotional factsheet, different images of HABs were incorporated. Throughout our exploratory findings, color was an additional element that help design our factsheets. Using a distinction of color was another exploratory finding that was not initially part of our design. Although the question was not originally part of our recollected data, based on our sample population it allowed to customize and incorporate more of how community members in Belleville Lake, Ford Lake, and Lake Erie associate risk with colors. As mentioned by Covello (2011) listening to your audience can allow new data to emerge. Conducting a focus group during our study allowed for community members in Belleville Lake to share what communication frames they preferred, as well as opening a discussion for more people to express their concerns and personal opinions. Between cognitive and emotional, based on the descriptive results shown on Table 18, the emotional factsheet had a higher level of risk perception after receiving the factsheet than those who received cognitive factsheet. Based on the results of the focus groups the public chose the emotional communication frames over the cognitive style, strengthening our results the paired t-test on Table 19. Using different communication frames to communicate risks can increase the chances of achieving a higher level of risk perception, thus a higher likelihood to obtain a better health behavior when engaging directly with the risk. In addition, emotional elements within communication can be suggested within government agencies when communicating about HABs potential risks.

CONCLUSION

Although government and health agencies already communicate health risks about HABs using clear messages, there is a need to strategize and build more community engagement methods to effectively communicate these risks. Implementing more community engagement

tools can help customize the information for the desired public to learn about the health risks. By customizing the information and engaging with the community about the potential risks HABs may cause can increase public's level of perception, and potentially increase better health behaviors when engaging towards the risk. Based on our findings, emotional factsheets resonated more with the public based on using narrative messaging and images including dogs, elderly, and kids can bring more feelings of love and/or worry when talking about the potential risks. The way the study designed the emotional factsheet was based on conducting interviews exploring community member's communication preferences, knowledge, lake experiences, opinions about the selected lakes and other risks and concern they may have. Administering fieldwork and focus groups allowed to learn more about public's preferences towards the different communication frames.

Poor risk communications may cause serious detrimental effects to people's health, using effective strategic methods engaging with community members to become co-creators of knowledge can lead to better health behaviors and potentially prevent individuals to experience direct effects and impacts from the risk and/or hazard that is being communicated. Listening to audiences' concerns, being honest and transparent, coordinate and collaborate with credible sources of information and trusted voices, and lastly avoiding technical language including jargon can help have more effective message.

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