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Health and Nitrate-Contaminated Drinking Water in the Lower Yakima River Valley

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Abstract

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MPH, Oregon Health and Sciences University, 2012

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Dissertation Submitted in Partial Fulfillment

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Abstract

In the United States, many private wells are used as the only source of potable water. These wells, under current federal and state regulations, are neither monitored nor checked for water purity. The purpose of qualitative case study was to gain an understanding about how the documented nitrate contamination problem in the Lower Yakima Valley River Valley is perceived by members of the community and to measure their willingness to engage in collective action for social change. Purposive samples of 6 participants were interviewed using 10 questions derived from the drinking water disparities framework by Balazs and Ray. Additional historical information and data were reviewed. While analyzing the data, themes and patters emerged and were identified. According to the study results, the community was not actively engaged in any communication regarding the nitrate contamination. This community, if engaged in a collective action to deal with the nitrate contamination problem, could be successful in influencing larger organizations, such as state and federal governmental entities, to work toward nitrate contamination source identification and remediation. Private well owners hold beliefs about the safety of their individual water supply, but had no knowledge of the water quality being used by their friends, neighbors, and families.

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Chapter 1: Introduction to the Study

Introduction

Over 42 million people in the United States use unregulated private wells for their primary drinking water supply (Shortle, Ribaudo, Horan, & Blandford, 2012; U.S. Geological Survey [USGS], 2009). The use of these unregulated wells can place consumers at risk for exposure to water-borne illnesses from chemical contaminants. Anthropogenic sources of nitrate, such as fertilizers, animals waste, and septic systems, are considered the most common contaminants found in drinking water supplies throughout the United States (Lockhart, King, & Harter, 2013; Swistock, Clemens, Sharpe, & Rummel, 2013; White, Ruble, & Lane, 2013). High levels of nitrate have been linked to human health effects, such as methemoglobinemia, anencephaly, and other illnesses (Centers for Disease Control and Prevention [CDC], 2013; Environmental Protection Agency [EPA], 2012a).

In groundwater studies conducted in the Lower Yakima River Valley in Washington State, scholars have shown high levels of nitrate; therefore, it is likely that nitrate is found in the private water supplies in many of the homes in this rural area (Washington State Department of Ecology, 2013). A qualitative study design, as described and outlined by Creswell (2013), was used to conduct interviews with the English-speaking Latino and Hispanic populations in the Lower Yakima River Valley who were using private water wells as their primary drinking water supply. Currently, there is a gap in the literature about the health impacts the Latino/Hispanic population in the Lower Yakima River Valley may be experiencing by the ongoing exposure to nitrate

in the drinking water supply. This study was designed to fill in the gap in the current literature about the health conditions the Latino/Hispanic population was experiencing in the Lower Yakima River Valley that may be attributable to the use of nitrate-contaminated drinking water.

Background

The Lower Yakima River Valley area in Washington State is experiencing a pressing environmental public health issue. The area is located in south-central Washington state, with the City of Yakima at the center of the valley. According to the U.S. Census Bureau (2014), the population of Yakima County is 247,000, with a mix of White (64%), Hispanic\Latino (30%), and American Indian (6%). The top three economic engines of the area are the apple, dairy, and cattle industries. The area is bucolic and agricultural-based. Yakima County is the eighth largest county and is the second largest county in terms of size (in square miles) in Washington State (OFM, 2013).

Yakima County has 14 incorporated cities, and the majority of that population is in the City of Yakima, with 93,000 people (OFM, 2013). The vast majority of people in the county are employed in agribusiness. As of 2013, 26% of the population was employed by agribusiness (dairy, cattle, fruit, vegetables, etc.) with nearly 11,000 employees accounting for over $650 million in wages (OFM, 2013). This is, by far, the largest percentage of the economy in terms of employment numbers in the Yakima Valley. The highest paying sector of the economy is the government sector, accounting for over 16% of the economy and nearly $750 million in wages paid (OFM, 2013).

Over 39% of the population in Yakima County speaks Spanish (U.S. Census Bureau, 2014). This is over double the Washington average of 18% (U.S. Census Bureau, 2014). Only 71% of the population over the age of 25 in Yakima County has a high school diploma, as opposed to over 90% of the population over the age of 25 in Washington State that has attained a high school diploma (U.S. Census Bureau, 2014). Only about 16% of the population has a bachelor's degree in Yakima County, versus over 30% for the entire State of Washington (U.S. Census Bureau, 2014).

According to the Washington State Department of Ecology (2013), nearly 20% of the private drinking water wells have nitrate levels at or above the drinking water standard as established by the Clean Water Act of 1986. Nitrate is a form of nitrogen consisting of a single atom of nitrogen (N) and three oxygen atoms (O_3) that combines to become nitrate (NO_3) formed through ionic bonding. There are several common sources of nitrate, including plant decay, fertilizers, and naturally occurring nitrate. Nitrate in drinking water, at levels above 10 mg/L, can cause methemoglobinemia, or blue-baby syndrome (CDC, 2014). Nitrate interferes with hemoglobin affecting cells in a way that they cannot release oxygen (CDC, 2014). Hence, infants who ingest nitrate at these levels literally turn blue in color.

One of the most common anthropogenic sources of nitrate is fertilizer (Lockhart et al., 2013; Swistock et al., 2013; White et al., 2013). Nitrate fertilizer promotes growth in agricultural products and is defined as an acute contaminant in water resources with demonstrated health effects (CDC, 1996; EPA, 2012). When nitrate fertilizers are applied to agricultural fields above agronomic rates, nitrate can leach through soil layers and

enter groundwater supplies (EPA, 2013; Washington State Department of Ecology, 2013). Nitrate is highly pervasive in the environment and is regularly detected in drinking water supplies (Nolan & Hitt, 2006; Rivett, Buss, Morgan, Smith, & Bemment, 2008). When nitrate concentrations are greater than 3.0 mg/L in groundwater, that level is linked with anthropogenic sources (EPA, 2012). These anthropogenic sources include fertilizers and animal wastes applied to agricultural fields above agronomic rates (EPA, 2012). EPA researchers found that a concentration of nitrate that is less than 0.2 mg/L usually originates from natural sources while concentrations of nitrate between 0.21mg/L and 3.0 mg/L are attributable to either natural or anthropogenic sources (EPA, 2012).

Problem Statement

Little is known or published about the chronic health impacts or perceptions of risk of drinking nitrate-contaminated water for the Hispanic/Latino population who live, work, and consume the contaminated water in the Lower Yakima River Valley. This project helped fill the gap in understanding the health and health risk perceptions of consuming nitrate-contaminated drinking water on the Latino/Hispanic populations in the Lower Yakima River Valley.

Purpose of the Study

The purpose of this project was to gain an understanding about how the documented nitrate contamination problem in the Lower Yakima Valley River Valley is affecting the Hispanic/Latino community. In the Lower Yakima River Valley, nitrate contamination has been found in over 21% of the private and public drinking water wells that serve over 212,000 people (U. S. Census Bureau, 2014). Sampling results showed

elevated nitrate levels in the range of 5-19.9% in the wells identified as contaminated while 67% of wells were found to have nitrate levels below 5 mg/l (Washington State Department of Ecology, 2013). Sources of the contamination include nitrogen-based fertilizers and animal wastes being applied to agricultural growing areas above agronomic rates (Washington State Department of Ecology, 2013).

Nitrate contamination of drinking water supplies in the Lower Yakima River Valley is a growing problem (Washington State Department of Ecology, 2013). Infants are most susceptible to the contaminant if they ingest water with nitrate concentrations over the 10 mg/L standard (CDC, 2014). Consumption of nitrate through drinking water above the 10 mg/l standard have been linked to neural tube defects, such as anencephaly and spina bifida (Croen, Todoroff, & Shaw, 2001).

Research Questions

Three research questions guided this study. They were as follows:

RQ1: To what degree does the Hispanic/Latino population in the Lower Yakima River Valley perceive they may be at risk for health effects by drinking water contaminated with nitrate?

RQ2: What acute and chronic health effects are the Hispanic/Latino population in the Lower Yakima River Valley experiencing?

RQ3: To what degree is the Hispanic/Latino population in the Lower Yakima River Valley ready to move forward with nitrate risk-reduction activities in their communities?

Conceptual Framework

The conceptual framework used for this study was based on the socioecological model. The socioecological model, as described by Glanz, Rimer, and Lewis (2002), has been used to explore relationships between individuals and the environment. According to this model, associations may be found between the environment in which a person lives and his or her health status (Glanz et al., 2002). The environment may not only act as a potential source of toxins, hazards, and pathogens, but may also be responsible for the health information and influences that are used by people to achieve a better wellbeing (Glanz et al., 2002). For these reasons, the socioecological model has been used in public health studies to identify environmental causes of health conditions and social mediation that can be used to better protect human health (Glanz et al., 2002; Stokols, 1996).

Balazs and Ray (2014) examined the role of socioecological factors as they relate to drinking water contamination issues in communities throughout the San Joaquin Valley in California. Using the socioecological model (and a qualitative research design), Balazs and Ray developed a framework that traces the development of a composite burden that comprises the exposure and coping costs that many water systems and households face. The framework, known as the drinking water disparities framework (DWDF), uncovers the processes that have an impact on access to safe water (Balazs & Ray, 2014). Balazs and Ray found that the framework can be tailored to contexts (i.e., communities that are suffering from drinking water contamination—like the Lower Yakima River Valley in Washington State).

Balazs and Ray (2014) found that there is no direct causal path between race, class, and disproportionate health burdens; rather, race and class are implicated in almost every factor that have historically combined, and still combine, to produce this composite health burden. Balazs and Ray argued that the framework reveals how, alongside a baseline of contaminated source water, a series of planning policies have constrained access to physical and financial resources that restrict community members from finding ways to properly solve unintended exposure to the contamination. Balazs and Ray found that it is in these decisions, in conjunction with regulatory failures, that explain the origins of environmental injustice in the context of drinking water. Balazs and Ray also noted that these forces influence coping capacities of individuals in the community that may lead only to partial protection. This, in turn, exacerbates the impacts of drinking water contamination communitywide (Balazs & Ray, 2014).

Balazs and Ray (2014), building on social epidemiology approaches and using empirical data from the San Joaquin Valley, found that the framework makes central the interactions between environmental factors (sociopolitical, natural, and built) and their multiple levels of operation. Balazs and Ray also argued that the framework reveals how, alongside a baseline of contaminates in the drinking water, a series of planning policies have constrained access to physical and financial resources that restrict community members to finding ways to properly solve their exposure to the contamination. Balazs and Ray stated that it is in regulatory failures and a lack of community resources to mitigate contamination and political disenfranchisement of local residents that delineate the origins of environmental injustice in the context of drinking water contamination.

The framework described by Balazs and Ray (2014) was adopted for this project because of the following: (a) the framework describes a range of political actors and socioecological factors that may determine both exposure and coping capacity, (b) the framework demonstrates that that there is a complexity in isolating the cause of drinking water pollution, and (c) the composite burden of exposure and coping costs can create environmental injustices in a community regardless of whether there is a statically significant link between poor water quality and community demographics (Balazs & Ray, 2014). This project combined a qualitative approach with a phenomenological model and the socioecological framework (Balazs & Ray, 2014).

Nature of the Study

This study was qualitative in nature. Qualitative researchers attempt to understand how a participant thinks and feels about a phenomenon; it also allows for the researcher to delve deeper into the understanding through the participant's own words (Creswell, 2008). By focusing on the participant's thoughts and feelings about a phenomenon, I provided deeper insight for future researchers and possible intervention development. I focused on the participants' thoughts and feelings through open-ended questions that allowed for free-form narratives.

Only one strategy was used to collect data for this study: one-to-one interviews. The interviews were conducted using a survey tool approved by the institutional review board (IRB) and the dissertation committee. Data analysis consisted of identifying themes from the collected responses. The research design for this study is explained in greater detail in Chapter 3.

Definition of Terms

Contamination: In drinking water supplies, contamination is defined by the EPA (2012a) as the maximum contaminant level (MCL). For nitrate, the MCL is 10mg/L.

Domestic or private well: May either be drilled or dug. In essence, a hole in the ground that allows for the collection of groundwater to be pumped vertically for domestic uses, such as drinking. Wells are often used in rural areas due to lack of infrastructure outside of city limits (EPA, 2012d).

Epidemiology: The study related to health and diseases (Dixon & Dixon, 2002). In this study, health effects were examined as population-based risk factors.

Groundwater: Water that travels through soil and rock layers (Goss & Barry, 1995).

Nitrate: A naturally occurring and the most common occurring chemical found in groundwater supplies in the United States (EPA, 2012a). Nitrate exposure, when ingested by infants, can cause acute and chronic illnesses. The chemical is also commonly used as a fertilizer (Agency for Toxic Substances and Disease Registry, 2011).

Regulations: Administrative rules adopted and enforced by governmental agencies–including drinking water (EPA, 2012b).

Risk: The probability that human health will be impacted when exposed to harmful hazards, such as nitrate. Risk can be measured through many methodological approaches (Kasperson, Kasperson, Pidgeon, & Slovic, 2003).

Risk perception: The term refers to the judgments and evaluations that people have of potential hazards. It is one of the main components in the decision-making process and accepting risk (Sjoberg et al., 2004).

Safe Drinking Water Act (SDWA): The SDWA of 1974 is a federal law promulgated to protect drinking water supplies in the United States. The EPA (2012) found that under the SDWA, "EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards" (p. 1).

Assumptions

The principle assumption of this study was that the interviewees who participated in the study spoke their minds and answered the interview questions honestly. Another assumption was that the research design, methodology, and instrument met all of the requirements for study validity and reliability. It was further assumed that all participants interviewed during this study used private water wells for their drinking water supply and lived in the study area.

Scope and Delimitations

The study included interviews and an unobstructed document review involving the private wells in the Lower Yakima River Valley where nitrate contamination in the groundwater has been found by state and local regulatory agencies. The focus of the study was on private wells constructed prior to 2000 because of the age of the community and limited documentation of domestic well construction and water quality sampling results prior to 2000 (Washington State Department of Ecology, 2013).

Participants were interviewed until saturation was reached (i.e., when no new information could have been gleaned from additional time interviewing the participant; (Nossiter, 2007). In the Lower Yakima River Valley, private wells are the main source of drinking water for most of the community outside the city limits of the City of Yakima; other options are either nonexistent or unavailable (Washington State Department of Ecology, 2013). Improper construction and maintenance of private wells may impact the quality of the drinking water, which can, in turn, influence perceptions and behaviors.

Limitations

The conversation between the interviewee and me must be accurately interpreted and relayed. Therefore, it was paramount that I report the findings of the interviews accurately. Other limitations included the health literacy of the population and that the interviewee understood the nature and hazards nitrate contamination in their water supply can produce. Another limitation was the hesitation interviewees had when it came to dealing with questions relating to government actions. This limitation was buffered using my credentials as a Walden University PhD student and not a government agent. To counteract these potential limitations of the interviews, unfettered reviews of government documents which, according to Patton (2002), strengthen validity reduced these limitations. By following Walden University's guidelines and protocols for interviewing study participants, credibility and validity of the results were ensured (Walden University, 2013).

Significance and Social Impact

This project may result in being the catalyst that leads state and local decision makers, community leaders, and the at-risk population to develop short- and long-term harm and risk-reduction strategies and interventions that may prevent the unnecessary and inequitable exposure to nitrate contamination through the consumption of drinking nitrate-contaminated well water by the minority Hispanic/Latino population. In this project, I focused on the nexus between the chronic physical health effects of nitrate contaminated drinking water supplies and the understudied minority population of the Lower Yakima River Valley.

The project area's minority population was comprised of Hispanics/Latinos who were primarily employed by the agricultural businesses that were the dominant economic force in the community. This target population was most at-risk for nitrate contamination because they generally relied on private, untreated wells as their primary drinking water supply (Washington State Department of Ecology, 2013). Therefore, they were exposed and were susceptible to the acute and chronic effects of nitrate (Washington State Department of Ecology, 2013). Additionally, this population was impacted by several socioeconomic factors that have created disparities in terms of income, language, education, and culture (Yakima Valley Memorial Hospital, 2013) that leads to misunderstanding and misperceptions of the nitrate contamination problem in the community.

Summary

In this chapter, background information about this study was provided through the focus on private well-water contamination by nitrate and the associated perceived health risks of the minority population most at risk for this source of drinking water. The problem statement and research questions guiding the study were presented and described. The conceptual framework and a discussion of the assumptions and potential limitations were also presented. In this chapter, I provided definitions of the terms that were frequently used in this study. Finally, an explanation of the study's significance and potential for positive social change by better protecting the health of the minority population in the Lower Yakima River Valley from the deleterious health effects of nitrate contaminated drinking water was presented.

Chapter 2 contains a review of the literature regarding health risk perceptions and the power of collective action. I also show where gaps exist in the literature.

Chapter 2: Literature Review

Introduction

Over 42 million people in the United States use unregulated private wells for their primary drinking water supply (Shortle et al., 2012; USGS, 2009). The use of these unregulated wells can place consumers at risk for exposure to water-borne illnesses from chemical contaminants. Anthropogenic sources of nitrate, such as fertilizers, animals waste, and septic systems, are considered the most common contaminants found in drinking water supplies throughout the United States (Lockhart et al., 2013; Swistock et al., 2013; White et al., 2013). High levels of nitrate have been linked to human health effects such as methemoglobinemia, anencephaly, and other illnesses (CDC, 2013; EPA, 2012).

In groundwater studies conducted in the Lower Yakima River Valley in Washington State, scholars have found high levels of nitrate; therefore, it is likely that nitrates are found in the private water supply in many of the homes in this rural area (Washington State Department of Ecology, 2013). I used a qualitative study design, as outlined by Creswell (2013), to interview members of the Latino/Hispanic population in the Lower Yakima River Valley who were identified as using private water wells as their primary water supply. This study fills the identified gap in knowledge about the health conditions the Latino/Hispanic population was experiencing in the Lower Yakima River Valley that may be attributable to the use of nitrate-contaminated drinking water.

In this chapter, I provide an exhaustive examination of the literature that describes the sources of nitrate in drinking water, the regulatory framework at the federal and state

levels that govern drinking water, and the potential human health effects of consuming nitrate in drinking water. In this chapter, I also explore the theoretical and conceptual framework that defined the parameters of the project and how the nitrate continuation problem in the Lower Yakima River Valley may be perceived by the community. Great numbers of the U.S. population rely on private wells for household needs, but the quality of this water cannot be guaranteed (EPA, 2012).

Literature Search Strategy

To find literature for this study, I conducted searches using the following keywords: *nitrate, groundwater, minority, Lower Yakima River Valley, human health, stakeholders, knowledge,* and *perception*. I also used the following databases: MEDLINE, CINAHL, Google Scholar, EPA, National Institutes of Health (NIH), Academic Search EBSCO, and the CDC. I restricted the scope to articles published within the last 5 years, unless the piece of literature or reference was pertinent to the study and was recognized as seminal in the field of study.

Theoretical and Conceptual Framework

The theoretical framework I used for this study was based upon the social-ecological model. The social-ecological model, as described by Glanz et al. (2002), is used to explore relationships between individuals and the environment. According to this model, associations can be found between the environment in which a person lives and his or her health (Glanz et al., 2002). The environment may not only act as a potential source of toxins, hazards, and pathogens, but also may be responsible for the health information and influences that are used by people to achieve better wellbeing (Glanz et

al., 2002). The social-ecological model has been used in public health studies to identify environmental causes of health conditions and to design social mediations that can be used to better protect human health (Glanz et al., 2002; Stokols, 1996).

Balazs and Ray (2014) examined the role of socioecological factors related to drinking water contamination issues in communities throughout the San Joaquin Valley in California. Using the socioecological model and a qualitative research design, Balazs and Ray developed a framework that traced the development of a composite burden that comprises the exposure and coping costs that many water systems and households face. The framework, known as the DWDF, can be used to uncover the processes that have an impact on access to safe water. Balazs and Ray found that the framework could be tailored by researchers to contexts such as communities that are suffering from drinking water contamination–much like those the Lower Yakima River Valley in Washington State.

Balazs and Ray (2014) found that there is no direct causal path between race, class, and disproportionate health burdens; rather, race and class are implicated in almost every factor that have historically combined, and still combine, to produce this composite health burden. Balazs and Ray also argued that the framework reveals how, alongside a baseline of contaminated source water, a series of planning policies have constrained access to physical and financial resources that restrict community members from finding ways to properly deal with exposure to the contamination. Balazs and Ray argued that the origins of environmental injustice in the context of drinking water can be found in these planning decisions, in conjunction with regulatory failures, a lack of community

resources to mitigate contamination, and political disenfranchisement of local residents. These forces also influence coping capacities of individuals and the community, which may lead only to partial protection that, in turn, exacerbates the impacts of drinking water contamination community-wide (Balazs & Ray, 2014).

I adopted the DWDF, as described by Balazs and Ray (2014), for this project because (a) the framework describes a range of political actors and socioecological factors that may determine both exposure and coping capacity, (b) the framework demonstrates that that there is a complexity in isolating the cause of drinking water pollution, and (c) the composite burden of exposure and coping costs can create environmental injustices in a community regardless of whether there is a statically significant link between poor water quality and community demographics (Balazs & Ray, 2014). In this project, I combined a qualitative approach with a phenomenological model and the ecological framework.

Review of the Literature

Nitrate is a form of nitrogen consisting of a single atom of nitrogen (N) and three oxygen atoms (O_3) that combine through ionic bonding to become nitrate (NO_3). There are several common sources of nitrate, including plant decay, fertilizers, and naturally occurring nitrate. Of these, one of the most common anthropogenic sources of nitrate is fertilizer (Lockhart et al., 2013; Swistock et al., 2013; White et al., 2013). Nitrate fertilizer promotes growth in agricultural products and is defined as an acute contaminant in water resources with demonstrated health effects (CDC, 1996; EPA, 2012).

When nitrate fertilizers are applied to agricultural fields above agronomic rates, nitrate can leach through soil layers and enter groundwater supplies (EPA 2013; Washington State Department of Ecology, 2013). Nitrate is highly pervasive in the environment and is regularly detected in drinking water supplies (Nolan & Hitt, 2006; Rivett et al., 2008). Researchers have found that a nitrate concentration greater than 3.0 mg/L in groundwater is linked with anthropogenic sources including fertilizers and animal wastes applied to agricultural fields above agronomic rates (EPA, 2012). The EPA (2012) found that a concentration of nitrate that is less than 0.2 mg/L likely originates from natural sources, while concentrations of nitrate between 0.21 and 3.0 mg/L are attributable to either natural or anthropogenic sources.

Regulatory Framework for Drinking Water Protection

The SDWA of 1974 was promulgated to ensure that drinking water is safe for consumption. The SDWA achieved this goal by defining and restricting the number and concentration of contaminants that may be present in the drinking water supply. These contaminant levels are noted by the acronym MCL-or maximum contaminant level. The MCL represents the amount of contaminate that is allowable under the SDWA to be in drinking water and that is presumed safe for human consumption. The SDWA is executed by the U.S. EPA (2012). The MCL for nitrate in drinking water is 10 mg/L. However, this MCL is enforceable for public water supplies only-private wells are not regulated by the SDWA (EPA, 2012). Private drinking water wells are exempt from regulatory oversight by the EPA; therefore, these wells are not routinely monitored for contaminants. This leaves approximately 37 to 42 million residents of the U.S. population

that uses nonregulated private wells for drinking water (EPA, 2012). Because private well users are not protected under the SDWA, most of the residents who have private wells in the Lower Yakima River Valley are vulnerable to drinking-water-borne diseases and chemical contaminants such as nitrate. Environmental education tailored to private well owners, especially those who live in rural areas, could help stakeholders to make informed decisions that reflect good environmental stewardship.

Human Health Effects of Nitrate in Drinking Water

The MCL for nitrate in drinking water is 10 mg/L (CDC, 2014). As noted by Greer and Shannon (2010), methemoglobinemia (also known as blue baby syndrome) is still a problem that affects infants in the United States. Greer and Shannon noted that breast-fed infants do not present with methemoglobinemia, even when the mothers are exposed to and ingest nitrate through their diet at rates above the 10 mg/L standard established by the EPA. Greer and Shannon demonstrated that there is a link between infants who drink formula mixed with nitrate-contaminated drinking water and methemoglobinemia. Greer and Shannon described how infants are still presenting in U.S. hospitals with methemoglobinemia, especially in areas where there are known concentrations of nitrate in the groundwater above the maximum contaminant level.

Greer and Shannon (2010) noted that there is positive link between methemoglobinemia and nitrate levels for children above the age of 6 months who consume foods known to contain naturally occurring high level of nitrate including beets, carrots, spinach, squash, and green beans. Greer and Shannon concluded that healthcare providers should ask parents about the source of drinking water during every well-baby

check-in at their physician's office. Finally, Greer and Shannon posited that drinking water supplied by private wells should be checked yearly for nitrate. Scholars have not examined if there are chronic health effects on children and adults who are exposed to nitrate contamination through ingestion of drinking water. Greer and Shannon noted that nitrate contamination can be prevented by using point-of-use reverse osmosis or ion-exchange methods. However, these methods are often expensive to obtain and maintain; thus, low-income populations cannot afford these treatment options.

Richard, Diaz, and Kaye (2014) posited that the link between infant methemoglobinemia and ingestion of nitrate contaminated water and other sources should be considered a higher priority in the field of public health research. Richard et al. reported that early epidemiological scholars have demonstrated significant associations between high groundwater nitrate and elevated methemoglobin levels in infants fed drinking-water-diluted formulas. Richard et al. noted that, in epidemiological investigations, researchers have indicated other sources of nitrogenous substance exposures in infants that must also be considered as a cause of methemoglobinemia, including protein-based formulas and foods and the production of nitric acid by bacterial action in the infant's gastrointestinal system as a response to inflammation and infection. Richard et al. concluded that the best prevention method for methemoglobinemia is limiting nitrate exposure in infants less than 6 months of age. The limitations should include restricting ingestion of well water and restricting high nitrate and nitrite foods and medications that can produce the potent oxidizer nitric oxide in the gastrointestinal tract (Richard et al., 2014).

In several epidemiological studies conducted over the past 20 years, researchers have demonstrated a link between nitrate exposure and intrauterine growth retardation (Bukowski et al., 2001), increased incidence of sudden infant death syndrome (Croen et al., 2001), and increased risk of central nervous system defects (Arbuckle, Sherman, Corey, Walters, & Lo. 1988; Brender et al., 2004; Croen et al., 2001). Researchers have documented long-term and short-term health effects—all of which are dependent on level of exposure. Exposure to nitrate at a concentration above the 10 mg/L MCL has been associated with increased risk for anencephaly, a developmental disorder that occurs during pregnancy and is always fatal for infants (CDC, 2012). Croen et al. (2001) concluded that exposure to nitrate in drinking water at concentrations above the MCL of 10 mg/L has adverse health outcomes.

The Washington State Department of Health (2006) determined the extent of the nitrate contamination problem as it related to methemoglobinemia by reviewing the health records of over 500 infants aged 2 weeks to 9 months who resided in the target area. The Washington State Department of Health identified infants whose households relied on private wells for their water supply. The Washington State Department of Health found that almost two-thirds of the infants (63%) were given tap water, regardless of the household's water source, while only one-fifth of the respondents remember receiving advice about feeding their infant well water. The Washington State Department of Health found that 16% of the households with private wells had tap water nitrate levels above 45 mg/l nitrate, or over 4 times the maximum contaminant level. The Washington

State Department of Health noted that the major risk factors for infant methemoglobinemia were prevalent in this population.

Several other researchers (Arbuckle et al., 1988; Brender et al., 2004; Croen et al. 2001) have reported statistically significant findings linking drinking water nitrate levels to neural tube defects. These researchers also compared the dietary intake of nitrate to health implications related to neural tube defects and found minimal or no effect on risk (Arbuckle et al., 1988; Brender et al., 2004; Croen et al. 2001). These findings on the adverse health effects of nitrate exposure are significant to the users of private wells; however, because private well users are not required to test the water in their wells for nitrate, it is difficult to identify the actual source of nitrate in order to mitigate the risk factors.

In a study of Hispanic women and/Latinas, Brender et al. (2004) examined nitrate-related drug exposure and neural tube defects (NTDs) in relation to dietary nitrites and nitrate. Brender et al. compared 184 cases of NTD-affected pregnancies to 225 pregnancies of women with normal live births from the Texas Neural Tube Defects Project. Brender et al. concluded that because the level of nitrate in the water sampled was relatively low and women were not asked about frequency and amount of water consumed, the amount of nitrate in the water directly contributed to the increased risk observed among women who used prescription drugs containing nitrate.

Croen et al. (2001) investigated the potential association between maternal exposure to nitrate in drinking water, diet before pregnancy, and the risk of NTDs in their infants. Case infants (538) with NTDs (both live and stillborn single births) born from

1989 through 1991 were selected from California's birth defects program. Control infants (539) were live births with no NTDs selected from each area birth hospital for the same time period. Croen et al. found an increased risk for NTDs among babies born to mothers living in areas where the drinking water nitrate level was above the MCL as compared to those living and drinking water in areas with nitrate concentrations below the MCL.

Summary and Transition

In Chapter 2, I discussed the literature on the sources of nitrate in drinking water, the regulatory framework at the federal and state levels that govern drinking water, and the potential human health effects of consuming nitrate in drinking water. Additionally, the theoretical and conceptual framework that defines the parameters of the project and how the nitrate contamination problem in the Lower Yakima River Valley may be perceived by the community were described. Great numbers of the U.S. population rely on private wells for household needs, but the quality of this water cannot be guaranteed (EPA, 2012). The hazards of nitrate in drinking water are not well understood by the general public, especially private well users. The EPA (2012) noted that poor well maintenance by private well owners who lack the knowledge needed to ensure proper well maintenance, plus the inconvenience of spending time conducting maintenance and sampling on their water supply, are likely contributors to private well water contamination.

Because private wells are unregulated, the number of private wells and the types of contaminants are not known. This issue presents a problem in terms of understanding the scope of the public health problem of nitrate in drinking water. Researchers have

conducted few studies evaluating minority community members' perceptions of health threats posed by nitrate in private well water sources (Jones et al., 2006). Developing an understanding of this issue from the perspectives of Hispanic and Latino private well owners who might have different levels of interest, knowledge, and exposure to nitrate in their well water is the first step toward environmental awareness about a potentially significant health problem.

In Chapter 3, I describe the study design, target population, study sample, setting, data collection and analysis protocols, and ethical treatment of project participants.

Chapter 3: Research Method

Introduction

Public health researchers have documented several health risks for individuals who are exposed to nitrate-contaminated water. These risks include methemoglobinemia, anencephaly, spina bifida, and other neural tube defects (Brender et al., 2004; Croen et al., 2001; Greer & Shannon, 2010; Richard et al., 2014). Scholars studying the human health effects of consuming nitrate-contaminated water have also found that health risk perception and the collective action it inspires can lead to positive social change (Balazs & Ray, 2014). The purpose of this study was to gain an understanding about how the documented nitrate contamination problem in the Lower Yakima Valley River Valley was affecting the Hispanic/Latino, English-speaking community.

In this chapter, I discuss the research methods that I used to learn how Hispanic/Latino residents of the Lower Yakima River Valley in Washington State perceived the nitrate contamination problem and subsequent human health effects. I also provide detail on how the target population perceives health risks associated with consuming contaminated water. The chapter includes an overview of the procedures followed while I conducted the face-to-face interviews and while reviewing project-related documents to answer my research questions.

Research Design and Rationale

Three research questions guided this study. They were as follows:

RQ1: To what degree does the Hispanic/Latino population in the Lower Yakima River Valley perceive they may be at risk for health effects by drinking water contaminated with nitrate?

RQ2: What acute and chronic health effects are the Hispanic/Latino population in the Lower Yakima River Valley experiencing?

RQ3: To what degree is the Hispanic/Latino population in the Lower Yakima River Valley ready to move forward with nitrate risk-reduction activities in their communities

Descriptive Qualitative Case Study

The conceptual framework for this study was based upon Glanz et al.'s (2002) socioecological model that public health researchers use to explore relationships between individuals and the environment. According Glanz et al., associations can be found between the environment in which a person lives and his or her health status. The environment may not only be a potential source of toxins, hazards, and pathogens but may also be responsible for the health information and influences that are used by people to achieve a better wellbeing (Glanz et al., 2002). The socioecological model has been used by public health researchers to identify environmental causes of health conditions and social mediation that can be used to better protect human health (Stokols, 1996).

Balazs and Ray (2014) examined the role of socioecological factors as they relate to drinking water contamination issues in communities throughout the San Joaquin Valley in California. Using the socioecological model and a qualitative research design, Balazs and Ray traced the composite burden comprised of the exposure and coping costs

that many water systems and households face. The DWDF they developed uncovers the processes that have an impact on individuals' access to safe water. Balazs and Ray noted that the framework can be tailored by researchers to study contexts. For this reason, it was appropriate to use the framework for studying communities such as those along the Lower Yakima River Valley in Washington State that may be exposed to drinking water contamination.

Balazs and Ray (2014) found that there is no direct causal path between race, class, and disproportionate health burdens. Rather, race and class are implicated in almost every factor that has historically combined to produce this composite health burden (Balazs & Ray, 2014). Balazs and Ray found that the framework reveals how planning policies have often constrained access to physical and financial resources. This restriction affects community members' ability to find ways to solve unintended exposure to contamination (Balazs & Ray, 2014). Balazs and Ray stated that it is these planning decisions, in conjunction with regulatory failures, a lack of community resources to mitigate contamination, and political disenfranchisement of local residents, that explains the origins of environmental injustice in the context of drinking water. Balazs and Ray found that these forces also influence coping capacities of individuals and the community; this combination may exacerbate the impacts of drinking water contamination community-wide (Balazs & Ray, 2014).

The framework described by Balazs and Ray (2014) was adopted for this project for several reasons. Namely, Balazs and Ray found that the framework describes a range of political and socioecological factors that may determine both exposure and coping

capacity and that the framework demonstrates that that there is a complexity in isolating the cause of drinking water pollution. Additionally, the composite burden of exposure and coping costs can create environmental injustices in a community regardless of whether there is a statically significant link between poor water quality and community demographics (Balazs & Ray, 2014). I combined a qualitative approach with a phenomenological model within an ecological framework (see Balazs & Ray, 2014).

Role of Researcher

My role in this study was as an interviewer. The interviewer role is created by generating a relationship with participants in the study while remaining professional and personally focused. Intellectual discussions, in English. between the participants and I were initiated, and I listened intently to personal experiences. To retrieve detailed information about the community and the participants, a variety of reliable and credible sources were used to validate the information. Both Creswell (2009) and Patton (2002) found that an interview protocol is essential in helping a researcher to gather data through organized documentation.

Potential Threats to Validity

To limit threats to validity, guidelines put forth by the IRB of Walden University (2013) were followed. The purpose of the IRB review is to ensure participant protection from harm and to keep the focus of the study on the data. The goal of the researcher is to ensure the safety of the participants, maintain research integrity, and ensure research objectivity. The research design was selected, and appropriate questions to gather information and maintain the safety of participant information were developed for this

study (see Creswell, 2009; Creswell & Plano Clark, 2011; Patton, 2002). The informed consent form offered a full disclosure of the study variables to potential interviewees, as well as the benefits and risks for participating in the study.

Research Methods

For this study, interviews were conducted through the use of a purposive sampling strategy. In accordance with the qualitative case study design, potential participants were selected to assure validity and the potential for yielding relevant information (see Creswell, 2013); participants were chosen for the study based on inclusion criteria and availability.

Sampling

As noted by Palinkas et al. (2015), purposeful sampling is used in qualitative research for the identification and selection of information-rich cases related to the phenomenon of interest. The method was used based on the research questions, available resources, IRB recommendations, and time frame to explore unaccountable facts. Baker and Edwards (2012) recommended that a sample size for qualitative research projects consists of about 30. For this study, a sample size of five was considered adequate per the IRB recommendations. Normally, during data collection, a point of saturation is reached when continued data collection produces no new information, and this was the case in this study.

Participants' responses were captured, and all themes were defined, signifying that saturation had occurred. A sample size of five offers an advantage for the researcher, especially when researchers are faced with time constraints and small sample sizes

(Baker & Edwards, 2012). Mason (2010) also noted that a number of issues can affect sample size in qualitative research; however, the guiding principle was the concept of saturation.

In the Lower Yakima River Valley, nitrate contamination has been found in over 21% of the private and public drinking water wells that serve over 212,000 people (U. S. Census Bureau, 2014). Based on available data, sampling results indicated elevated nitrate levels in the range of 5-20% of the sampled wells were contaminated (Washington State Department of Ecology, 2013).

Instrumentation

Only one strategy was used to collect data. One-to-one interviews were conducted with participants, and a survey tool was used that was approved by the IRB. Data analyses consisted of identifying themes and patterns of the data collected. Data were collected and stored on paper, and interviews were recorded to assure fidelity to the participants' responses. Safety and security of the materials was paramount.

As suggested by qualitative researchers, interviews were conducted following IRB-approved questions and interview protocol (Creswell, 2009; Patton, 2002). In addition, a secondary data search was conducted by reviewing written documents such as well logs, water quality data, community newsletters, and other available information. Ten questions were developed and vetted to explore personal health risks, perceived community risk, and willingness to work toward corrective action (See Appendix A for the IRB-approved questionnaire). The face-to-face interviews provided a deeper

understanding of the community and offered detailed information regarding relationships in the community.

As the researcher, I purposefully followed proper note taking and audio-taping procedures while interviewing participants. Historical documents such as community health assessments, well log data, well testing data, and other data were examined to analyze the integrity and credibility of the study, as suggested by Creswell (2009) and Creswell and Plano Clark (2011). Exploring these documents without obstruction yielded background information that could be useful for the community.

Pilot Test of Survey Instrument

The survey tool was pilot-tested prior to use in the field. As noted by Palinkas et al. (2015), pilot testing (or pretesting) means that a small-scale trial run of the use of the survey tool should be conducted prior to use of the tool in the field. Palinkas et al. found that pilot testing a survey tool is not only an established practice for determining errors in the tool but also provides a suitable way to practice using the tool. Palinkas et al. stated that it is vital to test the survey tool to ensure that the questions are understood by the participants and to determine if there are any issues with the words or meaning of the questions.

In this study, pilot-testing involved the use of a small number of respondents to test the questions. As noted by Palinkas et al. (2015), scholars use a pilot test to identify problems with the methods and logistics of the interview process, as well as the questionnaire itself. The pilot test included cognitive interviewing to ensure that the questions in the instrument were understood by the interviewees. The ability of the

project researcher to interview and record requests for additional explanation by participants is vital. The project researcher must register comments indicating respondents' difficulty with a question or with the sequence of questions or other factors **(**Palinkas et al., 2015).

Validity of the Instrument

The interview questions were developed through an iterative process with a focus on discerning contamination sensitivity, causes of illness, acceptance, and individual and collective environmental action. Works by Creswell (1998, 2013), Patton (2002), and Morse (1994) served as the basis for the development of qualitative questions for the interview instrument. The content and context of the interview instrument were based on exploring private well owners' feelings and thoughts about nitrate contamination in their drinking water supply. Approximately 25 notes/items collected during an interview were reduced to approximately 15 items. These items were placed in categories such as knowledge, action, and concern. Individual interviews corroborated the development of the structured questions for the study.

Recruitment

Private well owners with nitrate levels above 10 mg/L were contacted by creating and disseminating a letter that identified the reason for contact, the problem being studied, my role as the researcher, and an informed consent form. The disseminated letters included self-addressed stamped envelopes to encourage return. The initial letter was mailed to prospective participants 3 weeks before a second introductory letter and informed consent form was sent. The initial contact letter also served as notification of

further mailings. The initial contact letter was in English and requested that the participant be able to speak English as a part of the study requirements.

The second introductory letter and another copy of the informed consent form was sent to those addresses that did not return the materials. This introductory letter requested that the participant agree to a 30-minute interview. The purpose of the interview was outlined in the letter: to discuss health risk perceptions due to nitrate contamination of their well water. The participants were asked to return the informed consent form within 10 days of receiving the letter. Participants who return a signed informed consent form, within the given timeframe, were scheduled for an interview.

Interviews were scheduled by using the contact information provided by the signed consent forms. Interviews were conducted in participants' homes, if possible, and only if the participants felt safe. A microtape recorder was used to capture the verbal portion of the interviews. Each tape was labeled to identify the number of the participant by the coding system for later retrieval. Patton (2002) found that using field notes to capture verbal and nonverbal communications vital to ensure validity of the data. Creswell (2009) stated that coding the contact information is a way to ensure safety of the interviewing and participant information. In this manner, the integrity of the study was assured.

Creswell and Plano Clark (2011) recommended using a large number of resources and documents to gain information related to the study. Historical documents are secondary data sources that can provide evidence in qualitative studies. The use of secondary data potentially minimizes problems associated with researcher bias. Creswell

and Plano Clark added that these types of data can save the researcher time and money because the data already exist. Patton (2002) indicated that it is inexpensive to use secondary data; they are easy to analyze and can be used to corroborate new data.

Data Analysis

Qualitative research, as noted by Johnson, Dunlap, and Benoit (2010), generally creates a large volume of words to organize, document, track, and record. Johnson et al. stated that qualitative methodology depends primarily upon eliciting self-reports from subjects or observations made in the field that are transcribed into field notes. The field notes generated during this project created hundreds of words that required proper management. At every step along the way, the researcher is faced with the question about how best to organize, collect, manage, store, retrieve, analyze, and give meaning to the information obtained during qualitative research (Johnson et al., 2010).

Reliability and Validity

Patton (2002) found that by incorporating more than one strategy, a researcher can increase credibility in a study. In this s**t**udy, the data collected from the natural environment within the participants' community were used to conduct interviews and review secondary data sources to explain themes. The methodological strategies employed in this study were used to magnify and strengthen reliability and internal validity as suggested by Creswell Plano and Clark (2011). As noted by Creswell (1998) and Morse (1994), a small number of responses, between five-25, is enough to gain insight into the mindset of the target population.

Through participant cross checking, the veracity and accuracy of the reporting of participants' responses was ensured. Creswell (2009) indicated that member checking provides a base to establish credibility. Patton (2002) posited that the strategy of longer-term engagement with the participant helps to build trust and allows the researcher more time to garner facts in a field setting. By following these strategies with fidelity, credibility of the data was increased.

Patton (2002) found that "thick" descriptions are a simple way to clarify interpretations of the study. The descriptions not only of the findings but of the intricate components of the study were inclusive and considered other disciplines in reading the study. Patton also found that proper documentation and auditing of the records increases trustworthiness. Keeping Patton's advice in mind, field notes, daily accounts of the process, and a journal to ensure proper documentation was kept to increase trustworthiness.

Ethical Procedures

The paramount concern for any social research project is to not cause harm. Harm can come in many forms. In this project, harm could have come in the form of accidental release of personal private information without permission after the interviews were completed. The importance of maintaining confidentiality was paramount in this project. Informed consent, as outlined in the Walden University guidelines (2013), protected the participants of this study. The guidelines indicated that the informed consent form should include information regarding benefits and risks associated with the study, integrity

issues such as confidentiality, and assurances that participation is voluntary in nature and without coercion.

Creswell (2009) stated that information obtained during a project must be kept completely secured. Creswell suggested that participant information should be available under an identifiable folder and subfolder on a personal secured computer. For this study, informed consent forms, interview responses, and observation notes were kept in separate boxes secured by lock and key. Identification codes were used to identify participants in the study, and participant responses will be destroyed by shredding.

The informed consent form describes the benefits of the study and how the participant can withdraw from the study. The form also stated that the data on health risk perceptions and study may be shared with decision makers to deal with the issues. Participants who signed the informed consent form were assumed to agree to participate in the research prior to the interviews (Walden University, 2013).

Exit Strategy

To close out interviews with participants, closure negotiations were used. Creswell (2009) and Patton (2009) suggested closure negotiations and reframing the relationship between researcher and participants at the end of the study. In this study, all participants were provided a signed copy of their informed consent and a handout about the human health effects of nitrate contamination in drinking water.

Summary

In this chapter, the research design, reliability and validity, and data collection and data analysis strategies for use in a descriptive qualitative case study were described

in detail. An analysis of the data was conducted to discover emerging themes in order to answer research questions.

In Chapter 4, I will present the results of the study.

Chapter 4: Results

Introduction

The purpose of this project was to gain an understanding about how the documented nitrate contamination problem in the Lower Yakima Valley River Valley was affecting the local community. In the Lower Yakima River Valley, contamination has been found in over 21% of the private and public drinking water wells that serve over 212,000 people (U. S. Census Bureau, 2014). Based on available data, sampling results showed elevated nitrate levels in the range of 5-19.9% in the wells identified as contaminated while 67% of wells were found to have nitrate levels below 5 mg/l (Washington State Department of Ecology, 2013). Sources of the contamination include nitrogen-based fertilizers and animal wastes being applied to agricultural growing areas above agronomic rates (Washington State Department of Ecology, 2013).

Nitrate contamination of drinking water supplies in the Lower Yakima River Valley is a growing problem (Washington State Department of Ecology, 2013). Infants are most susceptible to the contaminant if they ingest water with nitrate concentrations over the 10 mg/L standard (CDC, 2014). Consumption of nitrate through drinking water above the 10 mg/l standard have been linked to neural tube defects such as anencephaly and spina bifida (Croen et al., 2011). Through the use of 11 interview questions and unobstructed documents reviews significant results were obtained. The following three research questions guided the study.

To what degree does the Hispanic/Latino population in the Lower Yakima River Valley perceive they may be at risk for health effects by drinking water contaminated with nitrate?

What acute and chronic health effects is the Hispanic/Latino population in the Lower Yakima River Valley experiencing?

To what degree is the Hispanic/Latino population in the Lower Yakima River Valley ready to move forward with nitrate risk-reduction activities in their communities?

Sample Demographics

During a 2-month period in the spring of 2018, the Lower Yakima River Valley community was provided with informational letters and informed consent forms that asked for their consent to participate in a study to determine the health risks of consuming nitrate-contaminated drinking water. I interviewed private well owners with nitrate results over the EPA standard of 10 mg/L. I explored their perceptions and understanding about the nitrate continuation problems in their community, as well as their interest and willingness to participate in collective action to advance change to correct the water quality problems.

Of the 220 private well owners in the target community, 40 (or 18%) of the private drinking water wells were identified as contaminated by nitrate through a review of water quality reports generated by Yakima County Health Department (2018). Informational letters and consent forms were sent to all 40 of these private well owners seeking their consent to participate in the study.

Of the 40 initial informational letters and consent forms delivered, five community members returned signed consent forms with their contact information included. A second mailing containing an informational letter and consent form was sent to the remaining 35 non-responders. One additional community member agreed to participate in the study from that effort, for a total of six (or 15%) consenting participants of the possible 40 participants targeted for this study. These six participants provided the results of this study.

Data Collection

I interviewed all six participants who provided me with signed consent forms agreeing to participate in the study to gain understanding about how the documented nitrate contamination problem in the Lower Yakima Valley River Valley was affecting their community. The interviews were audio-recorded, and hand-written notes were taken during the 25-35 minutes sessions conducted at either the participants' home or via the phone; four of the six participants were interviewed in their home while two of the six were interviewed over the phone. Table 1 shows the interview schedule and location where the interview took place for each participant. After each interview was conducted, I transcribed the interviews and used member-checking to ensure accuracy of the transcriptions. Following the transcription, major themes and patterns were identified through a close examination of the interview responses.

Table 1

Interview Schedule

Participant #	Interview Date	In Home or By Phone
Participant 1	June 8, 2018	On Phone
Participant 2	June 8, 2018	In Home
Participant 3	June 9, 2018	In Home
Participant 4	June 9, 2018	In Home
Participant 5	June 9, 2018	In Home
Participant 6	June 10, 2018	On Phone

Table 2 displays the unobstructed document review schedule, including the type of document reviewed, the dates of the review, and whether the review was conducted in person or online. The unobstructed document review consisted of three documents with approximately 5-7 days of review time per document. The documents were spreadsheets and database queries obtained through a Freedom of Information request to the Yakima

County Department of Health and to the Washington State Department of Health. Those official requests produced the private well testing results that were otherwise unavailable for viewing.

Table 2

Unobstructed Documents Review

Documents Reviewed	Review date	In Person or Online
Yakima County Health Department – Private Well Testing Results	March 4-10, 2018	Online
Washington State Department of Health – Public Well Testing Results	April 2-6, 2018	Online
Yakima County Health Department – Private Well Testing Results	April 15-21, 2018	Online

Data Analysis

I analyzed all interview responses, observations, and documents to understand how the documented nitrate contamination problem in the Lower Yakima Valley River Valley was affecting the Hispanic/Latino community. The participant responses reflected the information captured during the document review process. Passages from the interviews focused on the research questions. Balazs and Ray's (2014) DWDF uncovers

the broad processes that have an impact on access to safe water. The DWDF is illustrated below in Figure 1.

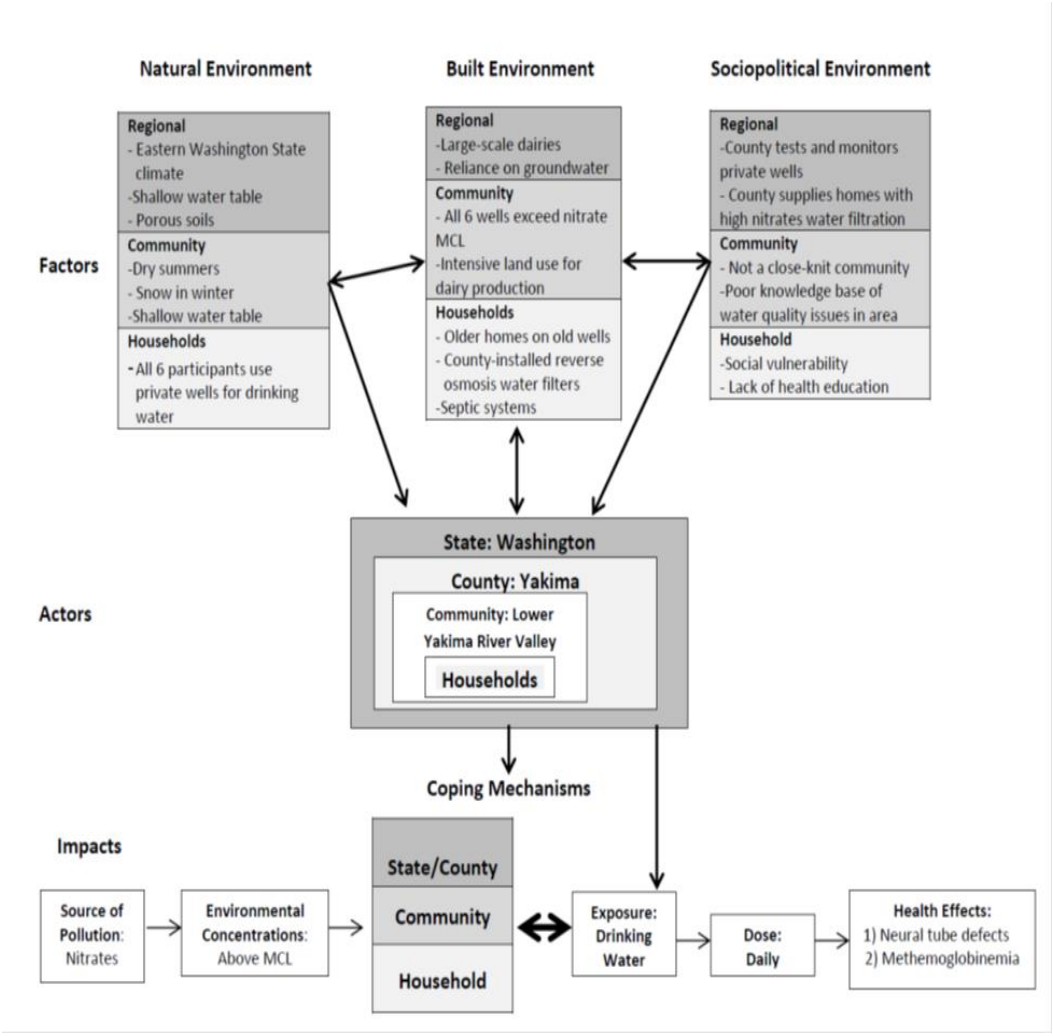

Figure 1. Drinking water disparities framework for Lower Yakima River Valley. Adapted from C. A. Balazs & I. Ray, 2014, *American Journal of Public Health*, 104, pages 603–611.

With the context of the DWDF in mind, the following are the interpretations of the health risks from nitrate contamination by the private well owners interviewed for this project. One of the key questions of the interview was to determine whether there was a willingness to respond individually and collectively to achieve water quality improvements. The interview questionnaire used for this study is provided in Appendix A.

Interview Themes

In an analysis of the questionnaires, I identified five major themes. The first theme, coded as AIWQ, refers to the participants who were aware of their individual drinking water quality issues. The second theme, participants' awareness of their neighbors, families, or friends drinking water quality issues, was coded as ANFFWQ. The third theme, drinking water quality testing is important, was coded as TII. The fourth theme, water quality issues have led to illnesses, was coded as WQLI. The final theme, participants would participate in political action individually and collectively in order to resolve water quality problems in their community, was coded as PARWQP. Table 3 shows the themes that participants shared with one another, while Table 4 shows the themes participants shared by percentage.

Table 3

Themes of Shared Interview Responses

Participant #	AIWQ	ANFFWQ	TII	WQLI	PARWQP
1	X	X	X	X	X
2	X		X		X
3	X		X		X
4	X	X	X	X	X
5	X		X		X
6	X	X	X	X	X

Note. AIWQ = **A**ware of **I**ndividual **W**ater **Q**uality, ANFFWQ = **A**ware of **N**eighbors **F**riends or **F**amilies **W**ater **Q**uality, TII = **T**esting **I**s **I**mportant, WQLI = **W**ater **Q**uality has **L**ed to **I**llnesses PARWQP = **P**olitical **A**ction to **R**esolve **W**ater **Q**uality **P**roblems

Table 4

Themes of Interviewee Responses by Percentage

Theme Codes	# of Participants with Positive Response	Percentage (%)
AIWQ	6	100%
ANFFWQ	3	50%
TII	6	100%
WQLI	3	50%
PARWQP	6	100%

Note. AIWQ = **A**ware of **I**ndividual **W**ater **Q**ualityANFFWQ = **A**ware of **N**eighbors **F**riends or **F**amilies **W**ater **Q**uality
TII = Testing Is Important WQLI = **W**ater **Q**uality has **L**ed to **I**llnesses PARWQP = **P**olitical **A**ction to **R**esolve **W**ater **Q**uality **P**roblems

Interviews

The interview sessions began with the IRB-approved protocol where I explained the reason for the interview, the participants' rights before and during the interview, and a copy of the questionnaire to the participant. I explained the goal of the study, and I stated that I appreciated their time and candor in discussing the local water quality problems from a public health perspective. At the end of the interview, I thanked the participants for their assistance and told the participant that they would receive a copy of the completed dissertation in the near future.

Participant 1

The first interview took place on June 8, 2018. The participant and I had scheduled an in-person interview, but the participant had a conflict arise, so we conducted the interview by phone. The participant said that he had "grown up in the house" where the drinking water well was known to be contaminated with nitrate. He said that he did not notice much of a change in the water quality of the water in this home, but that the water supply that was connected to his office was "very turbid." He said that his first real knowledge of a water quality problem was when the county tested the well in 2014, and the nitrate levels were at about 11 mg/l. He then noted that there was an expansion done at his business recently, and the water was tested again and the nitrate levels were 14 mg/l. He noted that a couple of his family members were given water filtration equipment by the state because of the water contamination, but was not aware of a community-wide contamination problem. However, his family did not have the filtration system so he was exposed to the "pure stuff."

He said that was was "absolutely" important for people to test their drinking water because it is the one thing the people put in their body the most. With the amount of water consumed by people, real health problems could arise if contamination is present in the water. The participant did say that both his father and his grandfather suffered from cancer during the time they lived in the house with the high nitrate, so there could be a connection between the contamination and health outcomes. However, he did say that none of his family or friends were told by a health care provider that their illness presentations were due to water contamination. He did say that he felt that his company

may be responsible for the nitrate in their own well due to the intensive agricultural activities that take place on the property. He finished up the interview by saying that having safe drinking water was important.

Participant 2

The second interview took place on June 8, 2018, in the participant's home. He started the conversation by stating that the county had tested his well, and he knew there was a problem. He then stated he had lived in the area for over 50 years. He stated that he did not notice any change in the water quality of the years, and the county installed a "reverse osmosis" system and the water was supposed to be "good." He said that the reason they installed the reverse osmosis system was for the "really high nitrate," and because the water was hard as well. He then noted that the water had not been tested for "at least 7 years." He stated that he was not aware of the water quality issues his neighbors may be facing as "we don't really talk about that" issue. He did think that testing water was important for the children, but not so much for the "old timers." He did not know anyone who had become ill from drinking the water in the area. He also did not know anyone in his family or community who had been told by a health care provider that their illness was related to poor water quality.

Participant 2 told a story about his neighbor needing a water filtration system on his irrigation well because of the "large number of frog eggs" that was being dispersed by the well. The frog eggs were so numerous in the irrigation well that they "plug up the drip irrigation lines" and prevented the water from getting to the crops. That is about the only time he ever spoke to a neighbor or community member about water quality issues. He

did say he would take part in a community action if there was a reason to in regards to poor water quality, but with his reverse osmosis system in place, he did not have any worries.

Participant 3

The third interview took place on June 9, 2018, inside the participant's home. He said he had lived in the same house for over 44 years. He said that the county had come by about 3-4 years ago and tested the well, and due to the high nitrate, they do not use the well water for drinking anymore. He said that because he does not use the water anymore for drinking, and it did not need to be tested. He said he knew his neighbors used wells, but he did not know if there was a water quality problem with them. He did note that "It's all the same water." He said that his son, who lived a mile up the road, had good drinking water in his well. He thought that people may get sick by the water if it was contaminated, but said he did not know anyone in his family or any of his friends who had become ill due to the water. He was also unaware of anyone being diagnosed by a healthcare provider that they were ill as a result of drinking the water in the area. He noted that he does not talk to many folks in the area, but he would join forces with others in the community if there was a water contamination problem.

Participant 4

The fourth interview took place on June 9, 2018, inside the participant's home. She said she had lived in the area since 1948 and the same house since 1960. She said that she had not noticed any changes in the drinking water over the years. She said that her water quality was "better than others" and was unaware if her well had any problems.

She said that someone had come by a couple of years ago and tested the water and said that it was "ok." She said she did not know whether others in her neighborhood had problems with their drinking water supply. However, she said she was aware that the community had water quality problems from information she heard on the local radio station. She agreed that that it was important for people to have their drinking water supply tested. She then asked me to define nitrate and what it does to the body. I responded by explaining how nitrate binds to red blood cells so that they cannot absorb oxygen, thus creating "blue baby syndrome" in infants. I also explained how important it is to have the water tested if a home has children because there is some evidence of long-term nervous system problems that can occur from ingestion of nitrate.

She stated that she did not know of anyone in her family or community who had become ill from the drinking water supply, nor did she know of anyone receiving a diagnosis from a healthcare provider linking water quality to their illness. She also mentioned that she did not know whether her friends and neighbors had water quality issues. She claimed that everyone was working so hard in the community that there "isn't time to talk" about water quality problems. She did say, however, that if there was a problem with the water quality, she would take part in a community effort to address the issue.

Participant 5

The fifth interview took place on June 9, 2018, inside the participant's home. She had lived in the area for nearly 40 years. She said that she had not noticed any changes in the water quality since she has lived in the house. She noted that, although her water was

not affected, people in the area had high nitrate because "of the number of dairies in the area." She said that the county had tested the water several years ago and made them use filters on their water supply due to the levels of nitrate in the water. Upon clarification, she said that the filtering system in use was reverse osmosis.

She said that there were "probably a lot" of her neighbors and community members with poor water quality and high nitrate. She said that was due to the number of dairies in the area. She stated that the county allowed the dairy across the street to "irrigate the fields with dairy waste." She did know that there was a problem with the water quality in the area and that a major issue was high nitrate. She said that the only reason her well was not contaminated was because of the depth of the well, which protected it from the nitrate. She said it was important for people in the community to have their water tested and that people may be getting ill from their water, but it would be hard to tell unless the water was tested. She did say that she did not know any friends or family who had become ill from the drinking water supply and that she does not talk to neighbors about their drinking water quality. Finally, she said that she would participate in community action if there was a problem with the water quality on a community-scale.

Participant 6

The sixth interview took place on June 9, 2018, on the phone. She said she had lived in the area for over 30 years. She said that she had not noticed any changes in color, texture, or flavor of the water. However, the county tested the well in 2009, and the nitrate level was 27.4 mg/L. Due to that high value, the county said the family should "drink bottled water." In 2010, the county tested it again, and the level was 20.4 mg/L.

The county then installed a reverse-osmosis system that allowed them to drink the water again. She said she was not aware of anyone in the neighborhood or community who had high nitrate in their drinking water, but she would not be surprised if there were.

She said it was important that people test their drinking water supply. She was not sure if there was a direct link between the drinking water quality in the area and contamination, and she did not know anyone who was diagnosed by a healthcare provider that their illness was due to their water quality. She also noted that she had not spoken to neighbors, friends or family members about their drinking water quality. She did say that she would engage in community or political action to deal with the water quality problems. She said that is how the county became involved in testing well water throughout the area and providing reverse osmosis systems on water supplies with high nitrate.

Document Review

In order to review the water testing results from the various governmental authorities that govern water quality in drinking water, I sent letters to the Washington State Department of Health, Washington State Department of Ecology, and Yakima County Health Department in March, 2018, requesting access to the results of all well water quality tests conducted in the Lower Yakima River Valley since 2007. I was informed by both the Washington State Department of Ecology and the Washington State Department of Health that I would need to request these results strictly from Yakima County as they did not create nor have access to these results. I did receive an e-mail from Yakima County Health Department that I would need to go to their website and

make a request through their Public Records Request Portal and the link to that site was as follows: https://yakimacountywa.mycusthelp.com/WEBAPP. On that website, I create a username and password. From there, I made a request to have access to all drinking water tests in the Lower Yakima River valley. In less than 48 hours, Yakima County sent me an e-mail stating my record request was complete. I logged back into the website and found my request had been fulfilled.

The request was sent in the form of an Excel spreadsheet. The data were displayed by address, owner name, and nitrate test result. Of the 220 well owners listed on the Excel spreadsheet, 40 (or 18%) of the private drinking water wells were identified as contaminated by nitrate through a review of water quality reports generated by the Yakima County Health Department (2018). I used this document to send letters to the 40 private well owners identified on the spreadsheet as having high nitrate in their drinking water well.

Results

The results of the collected data allowed me to draw several conclusions about the findings of the study. For the first research question, I found that all of the participants did not see that they were at risk for illness from drinking water contaminated by nitrate. This response was likely because every participant knew that their water was tested at some point in the past. For those participants who had high nitrate identified in their drinking water, the county installed a reverse-osmosis system to purify the water.

There also appeared to be a low interest or awareness of the water quality problems affecting their neighbors and the community. The responses indicated a “closed

community" that did not seem to discuss or share information amongst themselves about their own water quality problems. There was only one participant who linked the local dairies to the high nitrate values in the water supply and another who linked agriculture to the high nitrate. This may indicate that there is lack of knowledge about the impact that dairies and agriculture may have on the water quality in the area. However, there was agreement among all participants that people in the area should have their well water tested to make sure it is safe.

For second research question I found that no participants said that they knew of anyone who had experienced an illness from the high nitrate in the drinking water, and none of the participants had heard a healthcare provider linking an illness to the water quality in the area. Because there was little community conversation occurring about water quality issues, this result was not surprising.

For the third research question, I found that all participants responded to this question by saying they would be ready to move forward as an individual as a member of a group to force political action on the water contamination issue, if necessary. However, because the county had already conducted tests and installed reverse-osmosis systems on water wells, there did not seem to be much interest in exploring that avenue at this point. One participant noted that the county did respond to the community when the nitrate issue was first raised in 2009 and 2010. At that time, the county tested 220 wells and identified those well with high nitrate. From there, the county installed reverse-osmosis on those systems, hence "resolving" the drinking water issue. However, what was not

addressed by the county action was the underlying cause of high nitrate in the water supply.

Much debate has occurred in the area about the source(s) of nitrate: septic systems, agriculture, and the commercial dairies. Only one participant identified the diaries as the cause for the high nitrate, while another noted it was agriculture. Without identifying and understanding the nature and scope of what is causing the high nitrate problem in the water supply in this area, the only remedy that can be implemented is at the tap, not the source.

Summary

In this study, I examined the perceptions and beliefs of participants who lived in the Lower Yakima River Valley, used a private well as a source of potable water, and had high nitrate in their drinking water supply. Qualitative data were collected from six out of 40 potential participants willing to be interviewed for this study. Overall, participants understood the importance of having their well tested due to high nitrate values in the ground water supply. None of the participants had first-hand knowledge about any illnesses in their immediate families or friends that have been caused by the nitrate contamination of the drinking water supply. An over-arching theme in this community was that members seem to be closed to one-another, and drinking water quality issues were not discussed. However, there was a general agreement among participants that they would engage in political action to solve the water quality problem if it were ever necessary.

In Chapter 5, I discuss recommendations for future research.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this project was to gain an understanding about how the documented nitrate contamination problem in the Lower Yakima Valley River Valley was affecting the local community. I explored the acceptance, concerns, and beliefs experienced by members of the community in regards to nitrate contamination of their drinking water supply. I wanted to understand whether community members were aware of, and had interest in, the potential health effects of nitrate contamination. I also wanted to determine if community members would engage in a political action individually and collectively to deal with nitrate continuation of their drinking water supply. I found that there was a lack of awareness about the severity of the nitrate contamination of the drinking water supply in their community. However, there was an interest in engaging in political action, as both individuals and as a group, to affect change.

Interpretations of the Findings

Private drinking water wells have been exempt from the quality standards promulgated in the SDWA of 1974, but some states and local governments have made provisions in their comprehensive plans to monitor groundwater used as drinking water. However, drinking water consumed through private wells is not required to be tested or monitored by the federal or state governments; this leaves private well owners exposed to nitrate contamination (Baban & Cracium, 2007; Backer & Toasta, 2011; Burrow et al., 2008; Daniels et al., 2008; EPA, 81 2012d; Hynds et al., 2013; Imgrund et al., 2011).

Based on the interview responses, the private well owners appeared to have certain beliefs that the local government had fixed the nitrate problem on an individual (each private well) basis, but not on a community-wide basis. There was a sense that if there was a community-wide problem, that both the community as a group (and as individuals) would join forces and work toward change. What that change entails would likely include remediation at the source(s) of contamination, but that is unclear at this time.

As demonstrated in the literature review, there is a positive correlation between health risk perception and behavior changes, for both individual and group action (Baban & Cracium, 2007; Doria, 2011; Iyer & van Zomeren, 2009; Sjoberg et al., 2004). I found a similar mix of health risk perceptions due to nitrate contamination in drinking water and changes in behavior and attitude. I confirmed earlier study findings that indicated that private well owners incur more health risks than those who consume publicly-supplied water. This is due to the water quality standards that publicly-operated water purveyors must adhere to in the SDWA (Backer & Toasta, 2011; Goss & Barry, 1995; Hynds et al., 2013).

In this study, participants were aware of the water quality of their individual wells, including the nitrate levels. However, they did not notice changes in appearance, smell, or color of the water over time. This may have been, in part, due to the addition of reverse-osmosis water purifiers that were installed in homes with water quality results with high nitrate values. This intervention by the local government contributed to an

increase in knowledge about the risks of nitrate contamination for the individual, but masks the overall groundwater quality for the area and related health risk perceptions.

As noted by Doria (2010), it is possible that the human senses of taste, smell, and sight are factors that influence health risk perceptions regarding water. Because the participants in this study had reverse-osmosis purifiers installed on their water supply, the water would be clear, odor-free, and have no taste. Therefore, the health perception that the water was unsafe to drink is lessened by the inability to sense the contaminant of concern. Health risk perceptions influence behaviors and attitudes that alter societal systems designed as a barrier for disadvantaged groups (Sjoberg et al., 2004; Slovic, 1999).

The results of this study were supported by the results found in the literature review; individuals are motivated to respond when the (health) effects may be either immediate or delayed, and the consequences are either severe or facile. This is especially true when the risk is in the form of an unfamiliar substance and if the events that may be caused by that substance are catastrophic and beyond their control (Baban & Cranciun, 2007; Canter et al., 1992; Huddy et al., 2005; Kasperson et al., 2003; McDaniels et al., 1999; Sjoberg et al., 2004).

I found that the participants were willing to work as individuals and collectively to deal with the contamination problem if it was demonstrated as a real threat. However, the barrier to work collectively would be hampered by the lack of awareness of the community's water quality problems. There was also a noticeable lack of knowledge about the water quality of their nearby neighbor's water. Iyer and van Zomeren (2009)

found that social and psychological factors stem from empowerment and mobilization of individuals within a group to move beyond fear and transition into response. Increased and concern regarding nitrate contamination of a drinking water supply can subsequently increase health risk perception. This increase in health risk perception may result in both individual and collective behavior changes. Many authors have noted similar results (Corning & Myers, 2002; Heinmiller, 2009; Hynds et al., 2013; Imgrund et al., 2011; Larsson et al., 2006).

The nexus between the source(s) of the contamination in the participants drinking water supply and human activities that have been attributed contribute to water contamination was not realized by the majority of the participants. There was recognition by one participant that the animal manure being spread "all over the fields" was a likely source, while other participants either mentioned fertilizers as the cause or made no mention of any cause whatsoever. I found that all of participants in this study do not believe that water contamination was a problem in their community. Most importantly, participants did not believe that the drinking water in their community caused illnesses. Although the nitrate contamination of the groundwater in the study area had nitrate levels above the state and federal standards, there was no evidence that the drinking water supply was making residents sick.

All of the participants have had their well tested in the last 3 years, and at least one had it tested within the last few months. Because health risk perceptions are commonly influenced by many factors, the number of occurrences with which an individual encounters a risk may change their view of the risk. The study area has

experienced a number of area-wide studies from federal state and local authorities conducting water quality assessments. This level of scrutiny has been observed (and experienced) by the local population. Therefore, as the perceived health risk transitions from being unknown to know, and the health consequences move from acute to chronic, the impetus to change behavior or work collectively to solve community-wide issues is reduced accordingly.

Another finding was that the participants did not believe they were at risk for health problems because they believed that no risk existed. The participants believed that, even if there was a problem with the groundwater, their drinking water was safe because of the water purification equipment added to their water supply. This acceptance of technology as a remedy to solve an underlying environmental problem is not unusual. However, it does allow for the local, state, and federal governments to ignore the underlying water quality problems by treating water at every tap. The willingness by local, state, and federal agencies to engage in masking the health risks associated with nitrate contaminated drinking water through the use of individual interventions, rather than conducting a thorough identification and remediation of nitrate sources, is subverting the spirit of the SDWA. Individual interventions (i.e., adding reverse-osmosis purification systems to individual drinking water supplies) allows local, state, and federal government agencies to delay the expensive and unpopular option to identify and remediate nitrate sources in this community.

The participants did indicate a willingness to work collectively with other residents in the community if a water quality problem was identified. However, most of

the participants said they would only participate in collective action if the water quality problem in the community concerned their health. Based on the document review and interview responses, it appeared that the community lacked organization and leadership around the nitrate contamination issue. This lack of leadership and organization ensures that collective community action may not occur. As the level of sensitivity and awareness is increased about a potential health risk, their acceptance of that health risk is decreased. This finding was also found in the study. All of the participants said that their individual drinking water supply was safe, without offering any solid evidence. The participants' sensitivity (or lack of knowledge) about the true nature of their water supply was reliant upon the reverse-osmosis system. Their belief that the purification system keeps their water quality safe bolstered their confidence about the safety of the water overall. The participants showed a belief and reliance on technology to reduce the sensitivity (i.e., knowledge) about the underlying water quality problem. This reliance on technology to mask an underlying water quality problem can be dangerous to the health of the community.

All of the participants said they had engaged with the local government entities to in ensuring that their water quality was safe. This engagement was usually in the form of periodic checking and maintaining the reverse-osmosis systems. This willingness to trust the local water quality authorities indicated a possible window for local and state government entities to engage in a public health campaign addressing the underlying water quality issues. This may also indicate a willingness to engage in community-wide forums to identify, collectively, the sources and remedies to the ongoing nitrate

contamination problem. The participant indicated that their concerns reached beyond their own water supplies, and all of the participants indicated a willingness to work together.

Limitations of the Study

I experienced several limitations in the first phase of data collection. The criteria for participant selection was limited because the number of wells identified as having high nitrate was lower than the 40 out of the 220 wells in the target area. The number of participants, six, was somewhat limiting, but the criteria for inclusion still resulted in a 15% participation rate, which is considered reasonable for an external survey (see Creswell, 1998). I also worked with English-speaking people only who were of Hispanic/Latino descent as the added complication of having to need to hire a professional translator for this project was fraught with technical and financial difficulties that were beyond my ability to overcome for this study. I also addressed many concerns identified by participants regarding their anonymity and assured them that their identification on the informed consent form would not result in unwanted government involvement in their private affairs.

The lack of communication with dairy owners was an unforeseen limitation. The dairy owners in the community did not respond to the first or second contact letters. The owners of the dairies could have provided insight and perspective for the study. However, this lack of communication fit with the controversy regarding the importance of nitrate-contaminated drinking water as a cause of methemoglobinemia. Many arguments against

nitrate has been that fecal contamination of wells by agricultural waste frequently cooccurs with nitrate contamination, which is cause of methemoglobinemia.

Another limitation of this study was that cases of methemoglobinemia were rare in the United States including the Lower Yakima River Valley. As noted by VanDerslice (2006), methemoglobinemia is a transient condition, thus making it nearly impossible to perform a study that assesses the importance of risk factors on the rare clinically-observed cases of methemoglobinemia. VanDerslice also stated that methemoglobinemia is complex and multifactorial. Because nitrate is present in the drinking water of many of the water wells in the target area, infant food prepared with that water can contribute to nitrate exposure.

Vanderslice (2006) did find that there were at least 10% of the 500 infants who participated in the study had elevated methemoglobin levels; specifically, 10% of the infants were above normal, while 3% had physiologically significant levels. Knowing that the groundwater levels in the area continue to have elevated levels of nitrate, the number of infants who experienced methemoglobinemia has not significantly changed since the conclusion of the study. Therefore, there are a number of infants who present methemoglobinemia in a clinical setting, but because the condition is not a reportable or tracked by the state, the exact number of cases is unknown.

Recommendations

This study contributes to the body of research on health risk perceptions of private well owners affected by nitrate contamination by indicating the limitations of the outreach efforts in the community to inform and educate property owners about the

nitrate contamination. I also showed that the reliance and belief in water purification technology creates a false sense of security about health risks of the underlying water contamination. I also found that participants were not aware of any health problems being caused by the water contamination. However, all of the participants said they would engage in a collective effort to deal with a water quality issue if it were demonstrated to be of concern.

Sjoberg et al. (2004) indicated that beliefs about a health risk influences behavior and decision making. In this study, the factors considered included existing beliefs, concerns, and actions that the individual considered in context of the nitrate contamination problem. A participant's knowledge, attitude, and fear of a health risk and subsequent health effects are critical in both decision and behavior change. There was a lack of understanding and knowledge about the nitrate contamination problem on a macro scale. This lack of knowledge about the scale of the nitrate contamination problem may be a contributing factor in what appeared to be a disinterest in discussing water quality problems with friends, family, and neighbors. There was also a lack of organization and leadership in the community as it related to nitrate contamination.

The need for leadership and organization is vital to help engage the community for action. Iyer and van Zomeren (2009) noted that power rests with the people in the community, and they must act collectively to engage decision makers in creating positive social change. The shared goal could lead to effective coordination of response. Heinmiller (2009) found that that community mobilization is a component of collective coordination; however, resistance from a group may result in internal strife over shared

goals. With this study, I identified the health risk perceptions of private well owners in the Lower Yakima River Valley and demonstrated how risk perceptions influence individual and collective action.

However, I did not collect and test drinking water samples for nitrate contamination, nor did I examine health records for possible adverse consequences of exposure to nitrate. There is a gap in the literature on the nitrate contamination in the study from a longitudinal viewpoint and a close examination of medical records of people who use nitrate contaminated water. There is also an issue about the need to report nitrate contamination-related illnesses to local public health authorities. This gap can only be addressed through local and state governmental action. There is also a gap in the literature about the long-term use of reverse-osmosis purification system for individual water supplies in small, bucolic areas with high rates of poverty.

This study does, however, provide data points related to health risk perceptions and nitrate contamination in the drinking water. I found that individual drinking water well testing and health risk assessment should be promulgated for communities with known nitrate contamination in the drinking water supply. I suggested that there is a need for ongoing private well testing for nitrate in this community. There is also a need for increased knowledge and awareness of community health risks from nitrate contamination. Finally, I showed that this community would engage in collective action, if needed, to deal with the nitrate contamination problem.

Social Impact Implications

The potential impact of this study comes from a better understanding of private well owners' knowledge about nitrate contamination, as well as of their beliefs and actions in this regard. I also validated previous research findings. Health risk perception, tied to awareness and education about the health threats, is a key factor in moving toward behavioral change. This community, if engaged in a collective action to deal with the nitrate contamination problem, could be successful in influencing larger systems, such as state and federal governmental entities, to work toward nitrate contamination source identification and remediation. I found that private well owners hold strong beliefs about the safety of their individual water supply, but had no knowledge of the water quality being used by their friends, neighbors, and families. Their belief in the safety of their water was tied to a reliance on the purification technology used to treat the nitrate in the water. Further research would be useful to determine whether a belief in the safety of the water quality in their homes is directly related to a strong belief in water purification technology as a fail-safe option to reduce the health threat of nitrate-contaminated water. Additional research should include a quantitative study on patterns of nitrate contamination through the community's water supply that can be accessed by the entire community via a web portal. This would be followed by a survey designed to gauge participants' belief in the need for collective action based on the water quality data shown on the web.

Positive Social Change

This study has the potential to drive social change in the community by allowing decision makers to understand that there has been a gap in the flow of information being provided to the community about the nitrate contamination of the drinking water supply. By conducting a more thorough and inclusive outreach effort, governmental agency staff could improve the overall level of knowledge about the nitrate contamination, as well as provide events where community members could learn what they can do to help in making a change. I found that all of the participants agreed that if there was evidence of a problem with their drinking water supply, they would be willing to act to fix the problem. However, it was clear that the participant did not know the extent of the nitrate contamination, nor were they aware of the potential health impacts drinking nitrate-contaminated water could have on their health. Therefore, there is a potential for the community to come together to create a positive social change if they have evidence of the nitrate contamination issue in hand.

Conclusion

In this study, I explored participants' health risk perceptions about nitrate contamination and their willingness to participate in collective action, if needed, to address nitrate contamination in their drinking water supply. The information was collected exclusively from six participants who resided in the Lower Yakima River Valley, located in the southeast portion of Washington State. The results of this study may be replicated in other areas that are similar in geography and demography as the Lower Yakima River Valley. This study provides an underpinning for future researchers

to examine health risk perceptions of private well owners as it relates to risk perception and community education about potential health threats.

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Appendix A: Interview Questions

Lower Yakima River Valley Nitrate Study

Interview Questions

Study Name: The Health Impacts of Nitrate Contaminated Drinking Water on Minority Residents in the Lower Yakima River Valley

Introduction: Hi, my name is Michael McNickle. Please call me Mike. I am a doctoral candidate performing research on your local drinking water supply. I am interested in this issue from a public health perspective. Do you mind answering a few questions? This will take approximately 30 minutes. If not, a phone interview can be scheduled in place of the face-to-face interview.

Questions:

1. How long have you lived in this area?
2. During this time, have you had changes in your drinking water quality? Smell? Taste? Appearance? Texture?
3. What do you know about the quality of your drinking water supply?
4. Have you had your water supply tested recently, and if so, what were the results?
5. Are you aware whether any other residents in this community with private drinking water wells who test their water for nitrates?
6. Are you aware that some tests of private wells in the community have unsafe levels of nitrate?
7. Do you think it is important that people test their drinking water supply?
8. Do you feel that, when people get sick, it is because of contamination of the drinking water supply?
9. Have you or any of your friends or family been told by a health care provider that they were sick because of their drinking water?
10. Do you ever talk to other residents, family, or friends about their drinking water quality?

11. If you knew that you and other residents had issues with the water quality, would you participate in political action as an individual or with others to resolve the water issue? Why or why not?