Journal of Amish and Plain Anabaptist Studies

Volume 11
Issue 2 *Health and Healthcare among the Plain Anabaptist People*

Article 3

2023

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Recommended Citation

Kumar Chaudhary, Anil, Parmveer Singh, and Sharmistha Basak. 2023. "Perceptions Regarding Drinking Water Quality and Its Effects on Human and Animal Health among Plain-Sect Community Members." *Journal of Amish and Plain Anabaptist Studies* 11(2):123-36.

Perceptions Regarding Drinking Water Quality and Its Effects on Human and Animal Health among Plain-Sect Community Members

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Abstract: The quality of drinking water can affect human and animal health, and plain-sect populations may be more susceptible than other rural populations due to their use of traditional farm management practices and their reliance on well water. Therefore, an interdisciplinary team conducted a pilot study to understand the status of existing drinking water quality, community perceptions regarding causes of water deterioration, its associated effect on human and animal health, and solutions to address such challenges. The study included water testing and a focus group discussion with plain-sect community members. The findings revealed that participants perceived the drinking water quality as potable and free from contamination which contradicted water testing reports, where 92% of water samples violated the standard drinking water quality parameters. Perceived causes of water deterioration included sulfate leaching, changes in farming practices, and commercial development. The participants also revealed human health (e.g., cancer, stomach ailments) and animal health (e.g., changes in milk production and conception rates) concerns but expressed no association of these health concerns with drinking water quality. This pilot study's findings indicate that there exists a gap between perceptions of and actual drinking water quality and its relationship to health. More efforts are needed by health and conservation professionals to narrow the existing knowledge gaps by considering socio-cultural factors and appropriate scientific interventions related to best management practices of drinking water quality, and human and animal health, to achieve desired goals in plain-sect communities. [Abstract by authors.]

Keywords: focus group; human health; Old Order Mennonite; Lancaster County, PA; Groffdale Old Order Mennonite Conference

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Recommended citation: Kumar Chaudhary, Anil, Parmveer Singh, and Sharmistha Basak. 2023. "Perceptions Regarding Drinking Water Quality and Its Effects on Human and Animal Health among Plain-Sect Community Members." *Journal of Amish and Plain Anabaptist Studies* 11(2):123-36.

Publication type: Original research (peer reviewed), open access (may be distributed freely). *JAPAS* is published by the Amish & Plain Anabaptist Studies Association (http://amishstudies.org) and the University of Akron.

Funding: This work was supported by funding from the Penn State Institute of Energy and Environment. This work was partially supported by the United States Department of Agriculture National Institute for Food and Agriculture multistate Hatch project, NC1190 – Catalysts for Water Resources Protection and Restoration: Applied Social Science Research.

Acknowledgements: Special thanks to Greg Heigel for leveraging his trusting relationships to work with the plain-sect community; transdisciplinary project team members (Adrian Barragan, Kristin Sznajder, Eugene Lengerich, Leon Ressler, Cibin Raj, Kurt Wagner, Greg Heigel) for supporting project research activities and assistance during focus group discussion; plain-sect community members for participation in the focus group discussion; and graduate students (Farhan Sadique, Elsie Assan) who supported the research efforts. We also want to acknowledge *JAPAS* guest editors, Drs. Rosanna Hess and Braxton Mitchell, and anonymous reviewers for providing constructive feedback..

INTRODUCTION

Groundwater is the main source of drinking water for about half of the population of the United States (U.S.) (Nolan and Hitt 2006) and especially for plain populations such as Amish and Old Order Mennonites living in agricultural regions. In fact, approximately 23 million people depend on private wells for drinking water (Murray, et al. 2021). Specifically, out of the 12.96 million people in Pennsylvania (U. S. Census Bureau 2022), 12% of them rely on well water (Pennsylvania Public Water System Compliance Report 2021).

Both point (e.g., sewage systems) and non-point (e.g., agriculture) sources pose a risk to drinking water quality (The British Geological Survey 2022). Among non-point sources, agricultural production activities in the U.S. remain the largest source of water quality contamination (Stuart and Gillon 2013). For instance, the mishandling of agricultural chemicals during storage or accidental spills exacerbates contamination (Leu, et al. 2004). Several agricultural contaminants related to water quality include bacteria, organic materials, algae, and total suspended solids (Brew, Carter, and Maddox 2008; Pfost, Fulhage, and Casteel n.d.). Livestock manure from cattle ranches also adds bacteria to groundwater through leaching and water runoff (Hrudey, et al. 2003; Reiff 2016). Moreover, a range of activities including grazing livestock, deep plowing of farmland, and manure application have been identified as potential sources of surface and groundwater pollution (Sommers and Napier 1993; Widner 2010; Perry-Hill and Prokopy 2014; Brock, Ulrich-Schad, and Prokopy 2018).

Agriculture is an integral part of plain people's lives. Despite plain people's efforts to protect their land through careful farm management practices, an injudicious application of agricultural inputs, such as pesticides, fertilizers, pasturing practices, and contamination of wells has been observed on plain-sect farms (Hoorman 2002). Farmers openly spread manure on farms exposing it to the rigors of the weather (Blake, et al. 1997; Widner 2010). Manure management practices followed by some plain-sect farmers pose a significant threat to both surface and groundwater quality (Hockman-Wert 1998, 2021; Brock, Ulrich-Schad, and Prokopy 2018).

WATER QUALITY AND HEALTH

Miller et al. (2019) identified that plain people in Lancaster County self-reported their exposure to agriculture chemicals, and some of their health concerns including anemia, thyroid dysfunction, vaginal yeast infections, high cholesterol, and obesity. Some contaminants not only alter the appearance, odor, palatability, and physical and chemical composition of water but also lead to infections and diseases (Brew, et al. 2008). Comparative analysis (1998-2008) of coliform contamination in non-municipal water consumption revealed higher gastrointestinal risks and water pollution between Mennonite and non-Mennonite populations (Amraotkar, et al. 2015). Moreover, research has shown a potential relationship between drinking water quality and cancer, especially due to the

presence of nitrates in drinking water (Ward, et al. 2018). Evidence from Wisconsin shows that the emergence of colorectal, ovarian, thyroid, bladder, and kidney cancers caused by elevated nitrate concentration in drinking water is a public health concern (Mathewson, et al. 2020). The presence of nitrates and nitrites in drinking water could pose risks to the health of infants and pregnant women (Ward, et al. 2018).

Regarding animal health, research has also shown that contaminated water possessing elevated levels of total dissolved solids (TDS), algae, nitrates, sulfate, and phosphorus adversely affects the performance and health of livestock (Patterson, et al. 2004). Other bacteria, when ingested by farm animals through contaminated water, affect animals' performance and productivity. The reduction in feed and water intake are symptoms of drinking poor quality water (Wright 2007). In particular, *Leptospirosis,* a disease transmitted through contaminated water, can inflict animals with conditions such as infertility, low milk production, and late-term abortion (Brew, et al. 2008; Pfost, et al. n.d.). There is also an association between drinking water quality and the reproductive and production performance of dairy herds (Ensley 2000). The elevated levels of nitrogen in cattle's drinking water were negatively associated with calving interval, milk, and protein production. Nitrates in livestock drinking water could lead to "methemoglobinemia, severe gastritis, poor growth, infertility, spontaneous abortions, reduced thyroid function, decreased feed consumption, interference with vitamins A and E metabolism and birth defects" in livestock (Olkowski 2013, 100-01).

Considering the potential relationship between contaminated drinking water and human and animal health, the Environmental Protection Agency (n.d.) has calibrated standard limits for over 90 chemical and microbial contaminants (e.g., *E.Coli, Cryptosporidium*, and metals such as lead). The factors behind water contamination could be industrial and agricultural. However, a high percentage of plain-sect farmers do not consider animal manure, soil erosion, and fertilizers as water pollutants (Ulrich-Schad, Brock, and Prokopy 2017) In addition, plain-sect populations are reported to adopt limited conservation practices (Ulrich-Schad, Brock, and Prokopy 2017). Amish and Old Order Mennonites are not open to government subsidies to install conservation practices because of fear that the government could impose unacceptable regulations (Bhanoo 2010).

COMMUNITY-BASED PARTICIPATORY RESEARCH (CBPR) APPROACH

Guided by extant literature, we have been able to learn about the multiple interlinked factors related to drinking water quality, the health of humans and animals, and the role of community beliefs on the adoption of certain technologies/interventions. This implies that before designing and implementing any educational and outreach efforts for culturally closed or sensitive communities, i.e., the plain-sect population, there needs to be a substantial amount of familiarity with community norms and practices. In addition, researchers need to report drinking water quality parameters and share them with community members (Segev, et al. 2021), to confirm the existing situation of the drinking water quality and create awareness and adoption of research-based recommendations.

The involvement of communities in shared learning promotes capacity and increases trust and opportunities for collective action (Ajith, et al. 2022). The focus includes the understanding of local knowledge, the relationship of the communities with their resources, and generating information useful for communities (Cummins, et al. 2010). This type of research is known as a community-based participatory research (CBPR) approach. The motivation for developing a CBPR design for this study was to engage the communities and produce mutually beneficial knowledge and foster long-term trust and relationships (Israel, et al. 2012). There is a felt need to develop educational and outreach programs for sharing information with well owners (Caffrey, et al. 2020; Mulhern, et al. 2022). Moreover, the difficulties related to the adoption of a new behavior should be reduced (Hexemer, et al. 2008).

Considering the above discussion, a CBPR approach that allows the active involvement of community members to produce knowledge and actions that are locally generated and are a suitable fit was required (Strand, et al. 2003). Based on the nature and type of water contaminants and their effect on human and animal health, it is imperative to conduct a study that could fill research gaps related to the perceptions of the plain-sect

population about drinking water quality issues and its relationship to human and animal health.

PURPOSE AND RESEARCH QUESTIONS

The purpose of this study was to describe the perceptions of plain-sect community members as related to drinking water quality and its potential effect on human and animal health. The specific research questions which guided this study were:

1. What is the status of existing drinking water quality based on the perception of plain-sect sect community members and by testing water samples?
2. What is the perception of plain-sect community members regarding causes of drinking water quality deterioration, if any?
3. What are human and animal health concerns existing among plain-sect community members related to drinking water quality?
4. What is the perception of plain-sect community members regarding potential solutions to address drinking water quality issues, if any?

METHODOLOGY

This study was part of a larger project focusing on drinking water quality and its effects on human and animal health among plain-sect community members. Here in this paper, we are presenting the results from the initial exploratory focus group discussion that we conducted with several plain people along with the results of water sample testing done on those same participants and some other members' well water.

Study Design

To answer this study's research questions, we used a qualitative descriptive design (Sandelowski 2000; Doyle, et al. 2020) because we were interested in providing a straightforward description of plain-people's perceptions and experiences related to drinking water quality and its effect on human and animal health. The selected design is most appropriate when there is limited research conducted on the topic under study, which fits well with our study (Sandelowski 2010; Doyle, et al. 2020). Additionally, qualitative descriptive research is most appropriate for the current study because it considers the subjective nature of the research problem under investigation, the different experiences study participants bring to the discussion, along with presenting the findings in a way that directly reflects the voice of participants and "closely resembles the terminology used in the initial research question" (Doyle, et al. 2020, 444).

Even though qualitative descriptive research is criticized as being less explanatory than other types of qualitative research approaches (e.g., grounded theory) and production of findings that are close to data (Sandelowski 2010), "many of the analytic techniques recommended by Sandelowski, such as the use of codes and thematic analysis, overlap with other philosophical approaches such as grounded theory and phenomenology" (Pelentsov, Fielder, and Esterman 2016, e208). During our design of the study, data collection, and data analysis, we maintained scientific rigor to correctly represent the perceptions and experiences of participants. We selected a focus group as our method to collect data to provide the plain-sect community members an opportunity to engage with each other's thoughts, stimulate more thoughtful discussion, and create a more comfortable environment for discussion by the presence of multiple members from the same community.

Target Population, Sampling, and Recruitment

The target population for this research was the plain-sect (Amish and Old Order Mennonites) population residing in Lancaster County, PA. The study specifically focused on the eastern part of the Lancaster County due to anecdotal evidence suggesting a high concentration of nitrates and bacteria in the eastern part of Lancaster County's drinking water wells (A. Gibson, personal communication, December 4, 2018). One of the biggest challenges working with plain people is access to the community, as it takes time to build relationships (Stoltzfus 2022). Since 2019, the lead author of this paper has been working with multiple conservation professionals and organizations promoting the conservation of natural resources specifically ground and surface water quality (e.g., Lancaster County Conservation District, Eastern

Lancaster County Source Water Collaborative) among agricultural plain-sect communities in Lancaster County. As a result of this collaboration, the lead researcher was able to connect with an interested neighborhood in the eastern part of the county.

We used non-probability sampling methods including a combination of purposive and snowball sampling to recruit enough participants for the focus group discussion. The participants were included in the focus group discussion if they were plain-sect community members who were 18 years and older, lived in eastern Lancaster County, were engaged in farming operations, or had knowledge of farming and had a working knowledge of community water and health-related issues. We first visited our initial contacts in the community and invited them for the focus group discussion. During the invitation, we shared the focus group discussion flyer that we had created for the discussion and asked for names of additional community members whom we could invite. Using snowball sampling, we identified additional community members. In total, we invited 15 community members including Amish, Old Order Mennonites, and one non-Anabaptist farmer to participate in the discussion. The non-Anabaptist farmer was invited because of his acquaintance with the plain-sect community and was a neighbor of plain-sect participants whom we invited. Additionally, the non-Anabaptist farmer provided a comfortable environment to plain-sect community members as they were not used to formal focus group discussion.

Eventually, seven people (six Old Order Mennonites and one non-Anabaptist farmer) indicated consent by participation in the focus group discussion in August 2022, representing an optimum sample size for a focus group discussion to obtain meaningful findings (Bloor, et al. 2001). Even though several Amish community members agreed to be part of the focus group discussion, none of them were able to join the discussion due to last-minute family or farm commitments. As compensation for community members' time for the focus group discussion, we provided lunch during the discussion, and we tested their well water samples. This study was approved by the Institutional Review Board at the Pennsylvania State University.

Data Collection

The data were collected using a focus group discussion and well water samples from the community members. The focus group interview protocol was developed by the authors of the paper in consultation with interdisciplinary project team members by considering the purpose of the study and review of relevant literature. To establish the validity of interview questions, the interview protocol was reviewed by a panel of experts with expertise in social science research, public health, animal health, and hydrology. The panel also included conservation professionals working with plain-sect community members. The panelists provided feedback related to clarifying the language and flow of the questions. For example, one question focused on health concerns because of drinking water quality, and panelists suggested it would be difficult to link health concerns to drinking water quality. The interview questions were revised based on the feedback from panelists.

The interview protocol was comprised of four sections. The first section focused on general questions related to drinking water and its quality, e.g., "What is the primary source of drinking water in the community," and "What are the community guidelines to access water in the community?" The second section of the interview was comprised of questions related to identifying causes of drinking water contamination and the effect of agricultural practices and climate change on drinking water quality deterioration, e.g., "What causes do you perceive as reasons for the deterioration of drinking water quality?" The third section explored risks associated with human and animal health due to drinking contaminated water, e.g., "What health concerns (if any) have you observed in the community?" and "What animal health-related issues (if any) have you observed in the community?" Lastly, the fourth section questions focused on identifying practices used by plain-sect community members to maintain good drinking water quality, e.g., "According to your understanding, what are the possible ways to maintain good drinking water quality in the community?"

In addition to the focus group discussion, we collected 12 well water samples, testing water for E. Coli, total coliform bacteria, total dissolved solids, Nitrate N, and pH, to compare the participants' perceptions with actual drinking water quality.

The 12 water samples came from the seven focus group participants' wells and five additional wells belonging to plain-sect community members in the study area.

Data Analysis

Qualitative descriptive research designs are exploratory; a data-driven that hones a research question across thestudy instead of starting with a pre-developed philosophical perspectives (Doyle, et al. 2020). We analyzed focus group data using qualitative content analysis where we first transcribed the focus group's responses using a professional transcription service. After transcription, we read the transcript a few times to familiarize ourselves with the data and then used our research questions to code the data. We later reviewed the codes to make an interpretation to answer our research questions while keeping the findings "data-near" (Sandelowski 2000; Doyle 2020). In this regard, the term "data-near" means that the interpretation of the findings is close to the original data as provided by the focus group participants (Sandelowski 2010). Upon interpretation of codes, we presented the findings in the form of a summarized narrative along with direct quotations from focus group participants. We used descriptive statistics to report the results of the well water sample analysis.

Trustworthiness and Dependability of Findings

We established the trustworthiness of qualitative findings using the four indicator criteria outlined by Lincoln and Guba (1985), i.e., transferability, dependability, confirmability, and credibility. To establish the transferability of findings, we used purposive and snowball sampling to enhance generalizability and provided a thick description of data supplemented with actual quotes from the participants. In the case of dependability, we have provided a clear description of data collection procedures and kept audit trails to systematically report the data analysis and reasoning to obtain final themes (Lincoln and Guba 1985; Dooley 2007). To establish confirmability, we employed methodological triangulation (Lincoln and Guba 1985) where we compared the findings of the focus group discussion with well water sample testing reports and more than one coder coded the data to establish inter-coder reliability. Finally, to establish the credibility of the findings, we had a panel of experts review the interview protocol to confirm the validity of interview questions prior to conducting a focus group discussion. Additionally, we shared the findings with project team members who attended the focus group discussion and did member checking by sharing the draft findings with participants to confirm the interpretation of discussion data by the research team (Lincoln and Guba 1985).

RESULTS

In the results section, first, we will provide sample demographics as a context for research findings and later we will present findings from our content analysis along with well water test results relevant to each research question of the study.

Sample Demographics

Six Old Order Mennonites and one non-Anabaptist farmer participated in the focus group discussion. The average age of respondents was 43.71 years (SD = 6.45), and 100% of the Old Order Mennonite participants were educated through eighth grade while the non-Anabaptist participant had completed high school. All participants used well water for drinking. The average depth of the well was found to be 412.14 feet (SD = 118.20). On average, participants were living in the community for 43.14 years (SD = 6.47) and were engaged in agriculture for an average of 21.14 years (SD = 7.86). In terms of animals, most of the participants had milking cows, with an average herd size of 65.6 (SD = 17.98). The average land holdings owned by the participants was 77.57 acres (SD =13.79) followed by rented land of 32.33 acres (SD =13.27) and cash-rent of 14.00 acres. In terms of income, six participants were dependent on land for more than 75% of their income, while one participant was dependent on his land for 25% of his income.

General Water-Related Aspects

Prior to focusing on the questions guiding the study, we inquired about sources of water and if

Table 1: Prevalence of Different Contaminants in the Water Samples (N =12)

Analysis	Drinking water standards		Samples failed to meet standards	
	Standard	Type	Min–max values	% (n)
Total Coliform Bacteria (MPN/100 mL)	0	Health	2-201	83.3% (10)
E. Coli Bacteria (MPN/100 mL)	0	Health	1	25.0% (3)
pH	6.5-8.5	Aesthetics	6.03-6.45	16.7% (2)
Total Dissolved Solids (mg/L)	500	Aesthetics	504-841	50.0% (6)
Nitrate as N (mg/L)	10	Health	11.9-30.1	16.7% (2)

there were any community-level guidelines for accessing their water. The participants mentioned that wells and springs are the two major sources of drinking water in the community. The well water is considered safe for drinking, agricultural, and dairying purposes as it undergoes periodic testing, especially when it is intended for production use. Additionally, the spring water is not widely used for drinking. Consequently, dairy operators prefer to rely heavily on well water for daily dairy operations. To probe deeper into the use of water, we expanded our inquiry to know whether community members rely on any other sources such as bottled water. The participants mentioned that they have neither purchased bottled water nor are acquainted with any fellow community members who are presently relying on bottled water for drinking. When asked about any community protocols to access water, the participants indicated a lack of awareness regarding any existing community-level guidelines. Among these responses, one participant voiced that there is a need for concerted efforts to deepen wells to recharge aquifers during periods of water scarcity.

Existing Drinking Water Quality

The results from the 12 well water samples—seven from focus group participants and five additional ones from plain people in the study area (Table 1)—indicate that 11 samples failed to meet the standard drinking water quality criteria. Out of 12 samples, 83.3% (n = 10) had colonies of total coliform bacteria (MPN/100 mL). Moreover, 50% (n = 6) of the water samples had high total dissolved solids (mg/L) compared to drinking water standard; 25% (n = 3) of water samples had colonies of *E. coli bacteria* (MPN/100 mL). Lastly, 16.7% (n = 2) of water samples had high levels of nitrates and pH compared to drinking water standards.

When asked about the prevailing quality of their drinking water, the participants stressed the good quality of well water as the main reason for more reliance on it. The participants stated that drinking water quality exhibits some variations across different locations, but the quality on their farms was considered fine. Contrasting to this, one participant voiced that the quality of the water is declining. Regarding the changes or deterioration in water quality, some participants were uncertain or unaware of any changes. They proposed studying historic trends through dialogues with their older generations, particularly grandparents, to glean information regarding the past state of the drinking water quality. One community member voiced, "You probably have to ask our grandpas."

Our investigation focused on quality but identified the quantity aspect of the water as well. One community member shared his actual experience. He said, "We ran out of water; water quantity was running short … go deeper."

Causes of Deterioration of Drinking Water Quality

Regarding perceptions of causes of drinking water quality deterioration, most of the participants stressed again that their water is good. Some participants mentioned that bacterial contamination, elevated nitrates and pH, and limestone in groundwater could be potential sources of water contamination, if there were any. The participants emphasized that agricultural practices and management strategies have noticeably changed. In the realm of agricultural practices, community

members have shifted towards growing multiple crops, cover crops, and double cropping. The multiple and double cropping styles require substantial doses of nitrogen application. However, it is still a question for further investigation whether these agricultural practices have impacted the drinking water quality. To respond to this question, a participant mentioned,

> We're double cropping, cover crop, no-till, whatever, maybe that hasn't even really made any difference to the wells, at this point. But, in 20 years from now, maybe it does, and I don't know.

Additionally, a participant highlighted an important aspect; substantial amounts of nitrogen, calcium, and phosphorus are utilized for corn cultivation. Some unutilized portions of these fertilizers eventually mix with soil and water resources. The unabsorbed nitrogen leaches down to the groundwater and elevates the nitrate levels of the water. Apart from the application of fertilizers to crops, residential lawn fertilization was also discussed as a cause of drinking water quality deterioration. However, lawn management activities are also considered economically unrewarding. The participant explicitly stated, "That is a way bigger issue than anybody realizes, it's because my wife … She comes in there and gets spraying … grass, nothing gets taken off."

When we delved into understanding the role of excessive manure in the area due to high animal population and improper management of the manure to water deterioration, the participants mentioned that a lot of crops are grown in the area and the manure is all used on their farms or sold to their neighbors. Moreover, the spread of calcium salts on roads during winter was also described as a cause of deteriorating water quality. One participant attributed the poor city sewer system in the area as a potential cause. The discussion with the community members also alluded to how commercial developments impact water quality. The establishment of golf courses, housing developments, and storm water management were identified as key components that impair water quality. Participants pointed out that not only agricultural practices but also different aspects of development contribute to the decline of overall water quality. One man said,

> You take like golf courses, all residential buildings, development, you see it all the time. You see these crews going around spreading fertilizer. What is it? That's nitrates.

Furthermore, additional concerns were related to landfills in the community that pollute water resources, and in this regard, the corporations and city government were directly blamed. As one participant articulated, "The trash is not coming from the Lancaster County, that's being dumped in our backyards. So, we've got more pollution being done by corporations."

Probing deeper to explore how community members perceive climate change influencing drinking water quality, a participant expressed that water quality has remained relatively stable and has shown no demarcated changes in the past decade. One participant remarked,

> We got dry years, we got wet years, we get cold winters, we got snowy winters, and we get some winters where we [hardly] start to get any snow, but I think that's how it's always been.

Climate change and its implications for drinking water quality warrants further exploration.

Concerns about Human and Animal Health

When asked about community health concerns, our findings revealed that there were some cases of cancer (leukemia and neuroblastoma), thyroid dysfunction, and mental illness in the community. One of the participants said, "We would've had a case of one of our children had cancer too, two and a half years old, back in 2012." However, whether these diseases in the community could be attributed to drinking water quality remained unanswered. One of the community members said,

> My wife has overactive thyroid, but that's been in her family. And, I guess they say that can be hereditary too … since she has a family history, that could be more a genetic problem.

Moreover, another participant recalled an incident related to drinking inferior quality water:

> One of my nephews … was probably three-four years ago … had severe stomach pains … I'm not sure what all they thought, might be appendicitis … they finally connected that to maybe something through water; and, I'm not sure, like I said, it was a number of years ago. I'm not sure

> if they tested their water at that time and found out that something was high or anything.

Regarding health concerns related to animals, there is a predominance of dairy animals, poultry, and some pigs in the community. On enquiring about the performance of these animals, the participants stated that they believed that livestock health concerns are more likely due to weather conditions than drinking water quality. With excessive heat, milk quantity and conception rate are marginally affected, but the regular reproductive cycle remains unaffected during elevated temperatures. Amidst these concerns, bacterial infection among the duck population was also discussed. One participant mentioned that these minor issues could not be attributed to drinking water quality. Another community member mentioned, "I've never seen any problems with the cows that I could relate to water quality."

Well Water Quality Management Strategies

From the discussion about potential strategies related to the management of well water quality, the participants expressed their sentiments "[We're] blessed with good water in the area" and the only way to manage it is to take care of it. One community member said that he does not see any issue with well water quality and does not know of any practice that is better than what is already being done to maintain drinking water quality. They emphasized the significance of the use of common sense to protect groundwater quality. In the same direction, the participants mentioned that they are following good farming practices and are not aware of what improvements they should make. The community members believe that how they manage farm practices is relevant to water management. Furthermore, participants felt that digging deeper wells is a plausible way to improve water quality.

> As far as bettering the water or getting better water quality is simply by drilling deeper wells. Is how I see it. I don't know. I guess I can't pinpoint what we're actually doing to make our water better.

The participants also mentioned that adherence to good farming practices such as a nutrient management plan is a plausible way for water management. Moreover, water treatment professionals, veterinarians, and representatives of milk companies could be involved in collective efforts to improve the groundwater quality. In addition, sinkholes were discussed as potential sources of water contamination, which could be controlled by covering the sinkholes to avoid the contact between the water and potential contaminants. On being asked about which practices community members usually follow to manage water quality, they mentioned that there is surplus manure resulting from livestock activities. However, community members adhere to nutrient management plans, particularly for crop cultivation. This way, excessive manure is well managed by selling it to neighboring farmers, particularly those operating on large farms.

DISCUSSION

Results from both quantitative (i.e., water tests) and qualitative (i.e., focus group discussion) research exhibited that well water is a common source of drinking water for community members. This finding is consistent with a previous study (Miller, et al. 2017) within another plain-sect community in Lancaster County. A discrepancy was observed between the water test reports, i.e., samples failed on standard drinking water quality parameters, and community members' perceptions that their drinking water quality is good. The community members did perceive changes in agricultural practices, an increase in application of fertilizers, lawn fertilization, and commercial activities (e.g., golf courses, housing developments) has occurred over time. The participants' perception of good drinking water quality may be guided by limited knowledge of drinking water quality standards and positive community norms toward water quality. Therefore, it is important to first understand beliefs when seeking to bring about change in the community, e.g., the introduction and adoption of culturally acceptable scientific practices. Even though community members mentioned changes in agricultural practices including nutrient management practices (e.g., cover crops adoption in recent years), whether these practices are associated with well water quality needs further investigation. Not only is there a lack of evidence of an association with agricultural practices but

there is also no conformity to whether livestock management impacts groundwater quality.

We also observed that plain-sect community members stressed that the farming community is not the only one to blame for groundwater quality deterioration, as they are stewards of land and do their best to protect the land and water. This observation is consistent with findings of Dutcher and colleagues (2004). For example, they mentioned that cities (storm water management), corporations (e.g., landfill in the community), housing development, and other developments (e.g., golf courses) are equal contributors to groundwater quality deterioration. Additionally, the community members also indirectly raised questions about environmental justice (Mohai, Pellow, and Roberts 2009) since it was the city government who decided to establish a landfill in their community.

As far as health is concerned, the participants discussed some diseases within the family and community, both in the case of humans and animals. In the case of human health, diseases (e.g., cancer) were attributed to hereditary whilst it was perceived that regular change in the performance of animals was due to change in temperature rather than drinking water quality. Participants listed several diseases or illnesses in the community in the present and from the past, but they do not perceive that these illnesses would be related waterborne diseases in the community. Moreover, these community members did not confirm that groundwater quality in the area is impaired or that there is anything related to well water quality that needs attention by research and practice. The findings exhibit a critical gap between community members' knowledge regarding diseases and a connection to poor quality drinking water. In another study, it was found that the Mennonite population is more susceptible to diseases due to reliance on traditional practices, non-utilization of sewage systems, and poor management of waste (Valcour, et al. 2002). Even from solutions or remedies for improving the groundwater quality, the research findings do not capture much from our discussion, as the community members do not perceive drinking water quality deterioration as a challenge.

As shown by water test reports and the focus group discussion, we observed a need for actionable research that could narrow these gaps and promote action toward adopting best management practices related to drinking water quality and health. The participants felt that they are following a nutrient management plan, testing the water through a federal inspector, as it is mandatory for dairy operations, and are aware of good practices. In this scenario, the participants don't feel the need to know what could be done better.

STRENGTHS AND LIMITATIONS

The present research has several strengths and limitations that might affect the research findings. To the best of the authors' knowledge, the current study is one of very few pilot efforts to understand the perceptions of plain-sect community members regarding drinking water quality, its effect on human and animal health, and the role of agriculture in impacting drinking water quality. Moreover, the study employs triangulation by comparing the perception of the participants with water test reports. The study has the potential for informing research and educational programs for community members on various social and environmental issues in the future. Additionally, the study has the potential to leverage healthy relationships to promote mutual learning among community members, researchers, and other stakeholders.

Every effort was made to capture the data with utmost reliability and trustworthiness. Still, possible limitations could include the following:

- A small sample size and only one focus group session. The study has limitations in fully capturing a deeper understanding of the topic under investigation. Therefore, the application of the findings to broader research contexts representing broader plain-sect communities needs critical caution.
- Due to the qualitative focus and use of purposive sampling, the study findings cannot be generalized to the thousands of Old Order Mennonites in the region.
- Even though we tried to include both Amish and Old Order Mennonites in our focus group, the non-attendance of Amish due to last minute farm/family obligations limit the findings from representing the broader plain-sect community and are restricted to Old Order Mennonites. Additionally, we acknowledge that there may not have been a

strong enough trust relationship for the Amish farmers, at least some, to prioritize attendance at the focus group.
- The focus group discussion in a formal setting is uncommon for the plain-sect population. Therefore, we assume that it could be a latent factor behind the distortion of research data or receiving in-depth responses from the participants.
- Although the participants were assured of the confidentiality and anonymity of the data, the use of audio recording for the research purpose could have had a confounding effect on the quality, quantity, and comfort level of the respondents to freely express their views.
- There was also the presence of influential community members in the focus group. We observed that most of the participants agreed with what was mentioned by those influential ones. Therefore, we suspect that this might have skewed participants' responses in a certain direction (e.g., agreeing to what was already said by one influential community member) and affected the data quality.

Considering the strengths and limitations of the research findings, we recommend that the study be replicated among other plain-sect communities to enhance the reliability and validity of this research.

RECOMMENDATIONS FOR PRACTICE AND RESEARCH

Based on research findings, there is a need for more collaborative research and outreach efforts including agricultural and livestock farmers, corporations, and various stakeholders to develop potential solutions to address drinking water quality issues and human and animal health challenges. Community trust building and networking are two ways of engaging with the plain-sect population for designing and implementing research, education, and outreach efforts in the long term.

We found a discrepancy between community perceptions of drinking water quality and the results of the well water tests. This discrepancy can be attributed to positive plain-sect community norms towards natural resources, e.g., water, which requires further investigations on community norms and their relationship to water quality beliefs. Additionally, the gaps in understanding can only be addressed if the socio-cultural dynamics of the community are well understood.

Based on the findings related to drinking water quality, we recommend longitudinal studies to measure the quality of the water, scanning for emerging contaminants, and assessing whether community members are adopting recommended drinking water best management practices. From the health care perspective, we also recommend in-depth studies assessing the correlation of drinking water quality and waterborne diseases among human and animals. Thus, information pertaining to health status, the historical pattern of health, and future estimates could be ascertained. There is also a need to estimate the effect of agricultural and manure management practices on the groundwater quality among plain-sect populations. Future studies conducting cross-community comparisons between plain-sect populations and non-Anabaptist farmers residing in adjacent or neighboring farms would demonstrate the regional, cultural, social, or other factors that may govern preferences for the adoption of specific management practices.

CONCLUSIONS

The findings of this study shed light on the perception of a few plain-sect community members regarding existing drinking water quality, causes of drinking water quality deterioration, and the impact of agricultural and livestock management practices on water quality. The study also delved into concerns related to human and animal health emerging from drinking water quality. Limited education and minimal outside contacts hinder the utilization of available information and resources to address issues affecting human or animal health. Guided by the water test reports and focus group discussion, a discrepancy between actual drinking water quality and perceived drinking water quality was found. Moreover, the presence of diseases in the community and lack of relationship of these diseases to drinking water quality requires further research. Efforts are needed to enhance educational opportunities for community members to adopt best management practices related to well water management, agricultural and livestock management, and human and animal health.

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