"We are all here to learn": A qualitative study on private well stewardship within a rural, agricultural Latino community

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Abstract

Background: Nitrate contamination in groundwater disproportionately impacts agricultural Latino communities, creating a significant hazard for Latinos that rely on private wells. Private well users must conduct water testing and other well stewardship behaviors to ensure their well water is safe to drink. This study sought to identify the barriers and facilitators of private well water testing in rural, agricultural Latino communities.

Methods: We conducted four focus groups with private well users, two in Spanish and two in English. We recruited 37 participants from the Lower Yakima Valley, Washington State, a rural, agricultural community with a large Latino population and elevated nitrate concentrations in groundwater. A semi-structured interview guide was developed to capture testing barriers and facilitators guided by the Risk, Attitudes, Norms, Ability, and Self-Regulation (RANAS) model. Inductive thematic analysis was conducted by two coders to identify common themes.

Results: Themes emerged around barriers and facilitators to well stewardship behaviors, including well testing, treatment, and maintenance. Barriers included limited actionable information, economic limitations, lack of technical support, and challenges related to landlords and neighbors. Facilitators of well stewardship included concerns about well water contamination, knowledge of agricultural sources of contamination, do-it-yourself (DIY) home repair experience, and responsibility to protect family.

Conclusions: Well stewardship programs in rural, agricultural Latino communities may want to prioritize communication that provides actionable information on well water testing, treatment, and maintenance and emphasizes the responsibility to protect family in its messaging. Additionally, programs that provide financial and technical assistance and well maintenance education that builds on DIY home repair experience may be effective in these communities.

Background

The US Safe Drinking Water Act does not regulate private wells, leaving over 42 million US residents with little regulatory oversight of their water quality [1]. Private well users are responsible for ensuring that their water is safe to drink. According to a survey of domestic wells conducted by the US Geological Survey (USGS) in 48 states, 23% of domestic wells in the US contained one or more contaminants at a concentration exceeding a human health standard [2]. Nitrate is the most common anthropogenic contaminant in private wells [2], originating from synthetic fertilizers, fossil fuel combustion, animal waste, and wastewater [3]. The maximum contaminant level for nitrate in regulated drinking water sources is 10 mg/L NO$_3$-N [4]. Consuming water above this concentration may lead to developmental effects, gastrointestinal cancer, and methemoglobinemia, which can be fatal in infants if not treated [5].

Nitrate contamination in drinking water supplies disproportionately impacts Latino communities [6, 7]. Public water systems in the top quartile of percent Latino residents served are nearly three times more likely to exceed 5 mg/L of nitrate than public water systems in the bottom quartile [7]. These disparities
may occur because agriculture is the largest input of nitrogen in US water resources [3], and 83% of farm workers are Latino [8]. Public water systems with groundwater sources have higher nitrate concentrations than those with surface water sources [7], suggesting that Latino communities relying on private wells may also be disproportionately impacted by nitrate contamination. The Lower Yakima Valley (LYV) in Central Washington is one such community. LYV is home to a rural, agricultural Latino community where approximately 34% of residents rely on private well water [9]. A 2017 USGS survey found that 26% of private wells in LYV had a nitrate concentration that exceeded the maximum contaminant level at least once over the sampling period in a 2017 USGS survey [10]. Given the extensive well water contamination in this community, it is critical to understand how private well users ensure that their water is safe to drink.

Private well users must conduct a number of activities to keep their water safe, including proper construction, well maintenance, periodic well water testing, and water treatment as necessary. Altogether, these behaviors are referred to as well stewardship. Literature on the barriers and facilitators of well stewardship is extensive. Research shows that private well users are often satisfied with the quality of their well water and confident that it is safe to drink [11–13]. Many note its good taste, smell, and clarity [12, 13] and may not see the need for testing and treatment due to low perceived risk of water contamination and related health effects [12]. Other barriers to testing and treatment include cost, inconvenience, not knowing how to test, and lack of social norms [11, 12, 14–16]. However, the majority of these studies were conducted in regions with primarily non-Latino White populations.

A key component of well stewardship is well water testing, but some private well users do not test their wells [17] and few test at recommended frequencies [14, 18]. In a recent policy statement, the American Academy of Pediatrics recommended that well water users test for nitrate every year [19]. Agricultural communities with large Latino populations appear to have low testing frequencies compared to AAP recommendations. In one of the few studies on well water testing in majority Latino communities, only 52% of survey respondents reported never testing their wells despite the prevalence of high nitrate concentrations in the study area. Although testing rates appear to be low in rural, agricultural Latino communities, there is inadequate research examining the barriers and facilitators of well water testing within this population. Guided by the Risk, Attitudes, Norms, Ability, and Self-Regulation (RANAS) model [20], this study examined the barriers and facilitators of private well water testing among well water users residing in predominantly Latino communities in rural, agricultural areas.

**Methods**

We conducted four focus groups between November 2018 and January 2019 with private well users in LYV, WA: two in Spanish and two in English. We used purposive sampling to recruit participants, sampling for both Spanish and English speakers based on self-reported language preference for focus group discussion. Individuals were eligible for participation if they reported using a private well, were 18 years or older, and had one of the following individuals in their household: a child, a pregnant individual, or an adult 65 years or older as they are highly susceptible to health effects related to nitrate and total coliform,
which are common well water contaminants in LYV. We included non-Latinos to capture perceptions of well stewardship in the broader community, recognizing that many Latinos in rural, agricultural areas do not live in racially/ethnically homogenous communities. We excluded individuals who had attended a meeting of the local groundwater management committee as their perceptions may differ from the general LYV population. Individuals received $25 for participating in the focus groups. The University of Washington Human Subjects Division determined that this study was exempt from federal human subject regulations.

**Setting**

LYV is a rural, agricultural region where residents live in small cities and unincorporated communities across the valley. As reported by the 2013–2017 American Community Survey, the region has a total population of 60,958, of which 71.4% is Latino and 26.4% is non-Latino White [21]. LYV is home to a large immigrant community: 24.6% of the population is foreign born [22], of which 94.3% were born in Mexico [23].

**Recruitment**

We used multiple methods to recruit participants including radio, flyers, door-to-door canvassing, community meetings and participant referrals in partnership with community-based organizations. We supplemented with cold-calls, calling individuals who had participated in a free well water testing program organized by the county. Two research team members (KV and ET) recruited the focus group participants. ET, an English/Spanish bilingual and bicultural research team member, recruited all Spanish speaking participants. Before the focus groups, participants completed a ten-minute phone questionnaire on demographics and well stewardship behavior. Verbal consent was obtained from all participants at the start of the focus group sessions.

**Focus Group Guide**

Focus group questions were informed by the Risk, Attitudes, Norms, Ability and Self-Regulation (RANAS) model for water-related health behaviors [20], which has been applied in well stewardship studies previously [14, 15, 24]. The model is composed of five concepts, which are listed in the model name and are drawn from health behavior theories such as the Health Belief Model, Integrated Behavioral Model, and Social Cognitive Theory. In the first segment of the moderator guide, questions covered participants’ perceptions of well water quality, water-related health risks, and well water testing. In the second segment, participants read about well water testing from fact sheet developed by a health agency (see Additional File 1). The portions of the fact sheet read with participants included the agency’s recommendations for nitrate and coliform bacteria testing; cost, procedures, and recommended frequencies for testing; and blue baby syndrome resulting from the consumption of water with elevated nitrate concentrations. After reading the fact sheet, focus group questions focused on barriers and facilitators of well water testing.
and intentions to test. All focus group questions were reviewed for cultural appropriateness by all research team members, where three team members were bicultural and bilingual in English and Spanish and one person was a member of the community.

Data Collection

Focus groups lasted 1.5 to 2 hours and were convened at a local community center. ET, moderated all four sessions and has prior experience moderating focus groups. Focus group discussions were audio recorded, transcribed verbatim, and checked for accuracy. Translation from Spanish to English was performed by a certified translator.

Analysis

The transcripts were analyzed using inductive thematic analysis and ATLAS.ti Version 8 software. KV developed an initial codebook by identifying main ideas in the four transcripts, clustering similar ideas into groups, and naming and defining the groups. All other members of the research team reviewed the codebook and provided feedback. KV and DD used the final codebook to independently code the transcripts and met regularly to reconcile discrepancies. ET, a member of the community, attended reconciliation meetings to provide contextual information and resolve coding disagreements. Following the methods outlined by Braun and Clark [25], we used thematic mapping to identify themes across codes. We constructed an initial map illustrating the relationships between codes. Then we revisited the transcripts, revising the maps until the concepts formed a clear and succinct pattern that accurately represented the data.

Results

A total of 37 individuals participated in four focus groups, with 20 participants in the Spanish focus groups and 17 in the English focus groups. Each focus group had 7 to 11 participants. Table 1 lists the participants’ demographics and well stewardship characteristics. All the Spanish focus group participants and 65% of English focus group participants were Latino. The remaining participants were non-Latino White. The mean age among the Spanish and English focus group participants was 43 and 54 years, respectively. The percentage of Spanish and English focus group participants who reported a household income in the top bracket (> $50,000) was 0% and 59%, respectively. The percentage of Spanish and English focus group participants who reported having pursued trade school, an associate's degree, college, or graduate school was 11% and 65%, respectively. Half of the Spanish participants worked in agriculture compared to 7% of English participants. Forty-four percent of Spanish participants reported ever testing their well water compared to 70% of English participants. Bottled water was purchased for in-home use by 59% of English focus group participants and 78% of Spanish focus group participants. Only two participants reported using water treatment systems capable of removing nitrate; both reported using reverse osmosis systems.
Participants across all four focus groups had lively discussions about well stewardship. Eight themes emerged around the barriers and facilitators of well maintenance, treatment, and bottled water use in addition to testing, the study's original focus. Barriers included limited actionable information, economic limitations, lack of technical support, and barriers related to landlords and neighbors. Facilitators of well stewardship included concerns about well water contamination, knowledge of agricultural sources of contamination, do-it-yourself (DIY) home repair experience, and responsibility to protect family.

Concerns about water contamination

Participants had extended and dynamic discussions about well water contamination in which many spoke with a sense of concern, worry, or suspicion. Many stated that they did not drink their well water, but did use it for cooking, cleaning, or gardening. Participants across all focus groups expressed concern about contamination from nearby agricultural activities or water that looked, tasted, or smell bad. Participants asked many questions and one male participant in a Spanish focus group explained, “I think we are here for the same purpose, because I also have no certainty that the water from the well is good [...] and for that reason we’re here because we want to know.” At the end of the focus groups, several participants expressed gratitude for information they had received.

Knowledge of agricultural sources

Conversations between participants, particularly in the English focus groups, demonstrated a knowledge of agricultural practices as major source of well water contamination in the area. English focus group participants described the nuanced processes that transport nitrate through the environment, discussing manure lagoons at industrial dairies, the use of manure to fertilize crop fields, infiltration into groundwater, and the impact of well depth and water table height on water quality. When discussing potential sickness from well water, one English focus group participant relied on her knowledge of the sources and transport of contamination.

“Our water doesn't taste horrible if we bypass the filter. However, we know that our water table is really high and we're virtually surrounded by dairies. And so it crosses your mind. You think how much of what's being sprayed right next door is infiltrating the ground around us and then seeping into the water table.”

Participants in both the English and Spanish focus groups also expressed concern about contamination from pesticide application on crop fields and stated that well water should be tested for pesticides and other agricultural chemicals. Spanish focus group participants shared concerns about pesticides more frequently than English focus group participants, who discussed dairies and manure fertilizer more frequently. For example, one Spanish focus group participant was more worried about pesticide use near her property than cattle:
“Where I live there is a property that only had some cows, but the neighbor rented it out to them, for the hops, and now I feel that they are going to use pesticides. Maybe they did not use them before, so I had no pesticide danger, but now I do.”

DIY home repair experience

Spanish focus group participants shared their experiences investigating well water issues and asked questions about how to make repairs on their own. Several Spanish focus group participants raised concerns about discolored or foul-smelling water and deposits left on faucets, pipes, and appliances, as did several English focus group participants. Several participants in the Spanish focus groups identified aging piping components as a potential source of contamination. Concerned about the look and smell of their water, these participants described the actions they had taken to address these issues: opening pipes, discovering extensive corrosion, consulting neighbors, flushing water lines with chlorine, and researching anti-corrosion pipes online. Additionally, one Spanish focus group participant shared detailed observations of his employer’s well renovation project:

“I saw when they took out the steel pipes [...] [and] put in another type of material. Since then I was thinking, because if we [live] about half a mile from where he has his well and I could see the tubes that are about this thick, they are like 7 tubes deep and each is about 15 or 20 feet long. [...] we can see that although they are made of steel they are falling apart, they are very rusty. That’s why I get the idea that it’s necessary to do that.”

Spanish focus group participants asked questions about how to replace corroded pipes and seek financial support for well renovations. Spanish focus group participants also discussed septic tanks as a potential source of contamination in their wells, reflecting on the proximity of their well to neighboring septic tanks and the need for regular maintenance.

Lack of actionable information

Throughout each focus group, participants raised questions about how to prevent and mitigate well water contamination. For example, one female participant in an English focus group described her need for general well stewardship education:

“My father, he is the one that did the maintenance on [the well], put whatever he had to do to make sure that the water was good. He passed away two years ago on [DATE]. Now, I’m new. I saw what he, you know, certain things that he used to do. I don’t know anything else, so how do I know if it’s good?”

Spanish focus group participants sought information to address the deposits, discoloration, and foul smells they observed in their well water. Some asked questions about basic well water treatment, describing situations that could be resolved with particle filters and water softeners. Participants across
all focus groups often used the word “filter” to describe many types of water treatment systems and some expressed confusion about the purpose of different treatment systems.

Some participants shared that their wells had been tested once or twice in the past. Some reported satisfactory results and others learned that they had elevated nitrate levels or bacterial contamination. Those who had received satisfactory results still sought information about future contamination or contaminants that had not been tested. Before reading the fact sheet on testing, participants were asked specifics about the testing procedure, including recommended contaminants and testing frequency. Most participants across the four focus groups were unaware of government recommendations to test every year for nitrate and total coliform. One participant reported testing his well water for nitrate every year, but not for total coliform. Many participants did not know testing costs or who to contact for testing. Even participants who had tested their wells in the past admitted that they had little knowledge of these specifics. Many had their wells tested by government agencies during groundwater monitoring studies, and so had little knowledge of how to test on their own. One female participant in a Spanish focus group explained this when the moderator asked if participants knew how to test their well water:

“No. We do not know, and like when the lady, one day they were doing it for free. But it is to just to know and they said [the water] was fine, but no, we do not know how to do it.”

Lastly, participants who had not tested previously were unfamiliar with the testing process itself, asking if they could purchase a home testing kit or if an inspector would conduct the test at their house.

Participants reflected on the need for more well stewardship information in different ways. Several described their lack of knowledge as a deficit, while others emphasized it as an opportunity for community learning. For example, one male Spanish focus group participant expressed regret for not knowing more, stating, “I can send my family and myself to the hospital for not paying a little bit of attention.” One female participant responded to this participant with an alternate perspective:

“[…] I can say that maybe one in 100 people knows this about the water, so do not feel bad saying that you do not know much about water because I think […] that I do not know much either, so do not feel bad. We are all here to learn.”

**Responsibility to protect family**

Many participants expressed worry or fear of sickness from contaminated well water and discussed the need to protect children, pregnant women and older adults from contaminated well water. Many participants described testing, buying filters, being aware of contamination, and renovating wells as ways to protect their family’s health. Participants across all four focus groups discussed protecting their families with a sense of responsibility, but this theme was particularly strong in one Spanish focus group. When discussing the need for information on well water contamination, a female participant in this focus group said,
“The responsibility always ends with us. We are the owners of our family, of our children, and we are the ones who have to look for what we should do.”

Although participants correctly identified vulnerable family members, they rarely discussed specific health effects unprompted. This worry about sickness seemed to be based on what could happen, rather than knowledge of specific water-related health effects. An older male participant in an English focus group shared,

“I tried to monitor my health yet not be paranoid. I just went through a nasty gallbladder operation. Anything that happens to me, I wonder is it just getting old or is there something hurting me? […] I’m not sixteen anymore.”

In contrast, several participants stated their well water had positive or neutral effects on their health. Several said that when a family member gets sick, they drink more well water. These and several other participants reported that their water looked and tasted good. Despite positive perceptions of their well water, these participants described water contamination as a concern that “sits in the back of your mind” (from an English focus group) and emphasized the need to be aware of well contamination issues.

**Economic limitations**

After reading the fact sheet and learning about well water testing, participants were asked what makes it difficult to test well water. The most common response from participants across all focus groups was financial cost. Additionally, several English focus group participants described the installation and maintenance costs of water treatment systems as burdensome, particularly for community members with limited financial means. In contrast, two English focus group participants stated that the costs of yearly testing and reverse osmosis installation were worthwhile in order to protect their families. Participants in three focus groups stated that taking time off work is also a major barrier to testing. One female Spanish focus group participant described how substantial socioeconomic challenges take priority over water quality for community members who have immigrated from Mexico.

“When you arrive here all you do is to think about tomorrow: ‘Tomorrow I have to work, I have to do so much and what to eat,’ or ‘I only have so much,’ but [water] is the least you think about.”

Many participants stated that they drank bottled water, but few compared the value of testing and treatment to that of bottled water. One Spanish focus group participant stated that well water testing was important in areas where water is said to be good and residents drink their well water. Another participant described how his family tended to purchase bottled water because it was cheaper and more convenient than replacing the filters in his reverse osmosis system. Participants also mentioned other challenges with their treatment systems, including reduced pressure, changes in taste, and doubts about filter effectiveness.
Lack of technical support

Several English focus group participants described difficulties accessing adequate technical support and navigating services during well water testing and treatment. Participants who had tested their wells stated that it was difficult to understand their water quality test results, sharing that they did not know the water quality standards and whether those standards were protective of infants and children. After reading the fact sheet on nitrate and coliform bacterial testing, several participants asked how they could use contaminated water (e.g. cooking, bathing) and how to improve their water quality. Participants expressed that testing laboratories provided insufficient guidance on how to address contaminated well water and water treatment companies often recommended expensive treatment options. Others did not know who to contact for help on water treatment. Greatly frustrated, one English focus group participant described her difficulties treating E. coli in her well, “playing phone tag” with treatment companies, implementing various treatment methods, and still not being satisfied with the quality of her well water. She concluded, “I [am] literally thinking of selling my house and getting out of here.”

Landlords and neighbors

Finally, participants described significant barriers to good water quality that related to their landlords and neighbors. At the start of one Spanish focus group, a renter asked with great concern whether she or her landlord was responsible for ensuring the safety of her water. Another participant, one who knew the renter outside of the study, commented that the renter’s water smells terrible. The renter explained that her landlord “doesn’t want to help.” The renter was grateful to hear that she could test her well water quality independent of her landlord. An English focus group participant who shared her well with her neighbor asked whether her neighbor’s cattle, which he kept near the well, could contaminate the well water. She also described barriers to treating her well for bacterial contamination, explaining that she did not treat the well because her neighbor drank bottled water and was not interested in treatment. Recalling her thought process at the time, she said, “Well, I’m not doing anything if the neighbor’s not doing it.”

Discussion

The purpose of this study was to identify the barriers and facilitators of private well water testing within predominantly Latino communities in rural, agricultural areas. Emergent themes extended beyond the topic of testing and included barriers and facilitators of other well stewardship behaviors, such as well maintenance and treatment. Participants in this Latino community reported barriers to well stewardship that are commonly reported in other rural communities, such as a lack of actionable information, economic limitations, and a lack of technical support [11, 12, 14–16]. They also described barriers related to landlords and neighbors, which have not been reported previously. Additionally, participants reported facilitators that have been observed in other communities, including concerns about (perceived risk of) water contamination, knowledge of agricultural sources of contamination, and a responsibility to protect
family [13, 14]. DIY home repair experience also emerged as a facilitator, which has been previously reported in well stewardship literature.

The responsibility to protect family and DIY home repair experience emerged as notable facilitators within the Spanish focus groups. Previous studies on well water testing have also observed that the obligation to protect vulnerable family members and the belief that testing is useful to protect family facilitates testing behavior [13, 14]. Messages around the responsibility to protect family may be particularly resonant among Latino communities as family and a sense of collectivism are commonly noted as critical aspects of Latino culture [26]. Additionally, Spanish focus group participants demonstrated a drive to understand the source of their well water issues and take action using their experience in DIY home repair. These individuals may be quick adopters of well maintenance behaviors because they have foundational skills needed to make maintain their homes. In combination with well maintenance knowledge, these home repair skills may help build self-efficacy, which is a significant predictor of well maintenance behaviors such as visual well inspection [18]. Educational resources geared towards well users with DIY home repair experience may improve rates of well stewardship behaviors in communities like this one.

Our participants had limited information on how to conduct well stewardship activities, yet they demonstrated abundant knowledge and concern about agricultural sources of contamination. This knowledge imbalance may be influenced by local media, which has focused heavily on agricultural groundwater contamination and government responses to the issue. Spanish and English-language media in the region have covered local groundwater issues since 2008, reporting on topics such as a lawsuit against local dairies and the actions of the local groundwater management committee [9, 27]. Studies have shown a strong correlation between media coverage of issues and the public’s opinion on the importance of those issues [28]. This and related coverage may have increased community knowledge and concern about agricultural contamination. Interestingly, prevention and mitigation actions may not have received similar coverage. A study on media coverage during Hurricane Katrina showed that 35.7% of newspaper articles on the topic focused on government response while only 8.9% emphasized prevention and mitigation efforts [29]. Researchers need to recognize the importance of media outlets as critical avenues for raising awareness of groundwater contamination, and develop media partnerships to share actionable information on prevention and mitigation actions.

Focus group participants reported economic limitations as a major barrier to well stewardship. This finding corroborates studies that have observed lower rates of testing and treatment among lower income communities [17, 24]. In this study, bottled water was described as a cheaper and more convenient option than treatment systems. Similarly, Flanagan et al. observed an association between lower income and drinking bottled water as opposed to using treatment systems [15]. Although treatment for contaminants such as arsenic is more cost-effective than purchased water for households with more than one person [30], our focus group results suggest that water treatment is burdensome - involving vigilant maintenance, recurring costs, and uncertainty about treatment effectiveness. Bottled water, in comparison, may be a more sensible choice for private well users who are pressured to prioritize short-term costs and benefits.
due to limited socioeconomic means. Therefore, interventions that increase affordability and convenience for well water testing and treatment are particularly important in low-income rural communities.

This study observed barriers around landlords and neighbors, which has received little attention in well stewardship literature. These barriers included limited information about landlord and renter responsibilities, lack of landlord support, disagreements between shared well users, and limited control over neighbors’ practices. The landlord-related barriers reported by study participants help explain the observed association between rentership and lower testing rates [17]. Clear communication on the rights and responsibilities of renters and landlords is needed in well stewardship outreach. Additionally, Krieger et al. observed that landlords are more responsive to renters’ requests when public health staff encourage them to correct hazardous housing conditions [31]. This type of negotiation assistance could be an impactful way to resolve well stewardship conflicts between renters, landlords and shared well users. As recommended by Krieger et al., negotiation assistance for housing-related health issues could be incorporated into the duties of public health nurses, environmental health professionals, and community health workers.

Although focus group questions focused on well water testing, participant discussions often shifted to well water treatment and prevention of contamination. These observations suggest that private well users do not artificially separate testing from other aspects of well stewardship, as researchers and environmental health practitioners may be inclined to do. It also suggests that private well users prioritize solutions to contamination issues when seeking information on well stewardship. Well stewardship programs that promote well water testing may also want to include actionable information on prevention and treatment.

Research within this region could play an important role in promoting well stewardship behaviors and advancing knowledge on the development and implementation of well stewardship interventions. Numerous groundwater monitoring studies have been conducted in this region since the 1970s [9], and several studies have explored interventions to reduce other environmental exposures in the area [32], but there is inadequate research on interventions that promote well stewardship. The barriers and facilitators identified in this study could be used to adapt existing strategies for well stewardship outreach [33] for rural, agricultural Latino communities and develop interventions on previously unexplored topics, such as well stewardship among renters and shared well users.

This study had several limitations and strengths. The perspectives shared by focus group participants may not be representative of rural, agricultural Latino communities due to purposive sampling methods and inclusion of non-Latino participants. Additionally, previous media coverage and public outreach may increase awareness of groundwater contamination among the study participants. Regardless, results suggest that even highly engaged and knowledgeable private well users face significant barriers to well stewardship, which may be common in other rural communities. To our knowledge, this was the first study to explore private well stewardship in a rural, agricultural Latino community. Another strength of this study is a strong collaboration with a bilingual and bicultural team member from the community
whose knowledge of Latino culture and historical groundwater issues in the region increases the validity of the study results.

Conclusion

Private well users in this rural, agricultural community with a predominantly Latino population have unique barriers and facilitators of well stewardship. Well stewardship programs in rural, agricultural Latino communities may want to prioritize communications with actionable information and messages around family protection, programs that provide financial and technical assistance, and well maintenance education that builds on home repair experience. Additionally, this study highlights the barriers private well users face with their landlords and neighbors, underscoring the need for negotiation assistance and clear communication on legal responsibilities. This study can inform well stewardship programs in this and other rural, agricultural Latino communities.

Abbreviations

AAP: American Academy of Pediatrics; CDC-NIOSH: Centers for Disease Control National Institute for Occupational Safety and Health; DIY: do-it-yourself; NIH: National Institutes of Health; NWCPHP: Northwest Center for Public Health Practice; LYV: Lower Yakima Valley; SD: standard deviation; and USGS: United States Geological Survey.

Declarations

Ethics approval and consent to participate

The University of Washington Human Subjects Division determined that this study was exempt from federal human subject regulations. Verbal consent was obtained from all participants.

Consent for publication

Not applicable.

Availability of data and materials

Data files and materials pertaining to this publication are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.
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Authors’ contributions

KV, EA, LK, CK, and ET contributed to study design. ET, KV, and DD collected and analyzed the data. EA, LK and CK also contributed to the interpretation of the data. KAV wrote the manuscript. All authors contributed to critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.

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**Tables**

Table 1. Participant demographics and well stewardship characteristics (n=37)
| Characteristic                              | Total n (%) | English focus groups n (%) | Spanish focus groups n (%) |
|--------------------------------------------|-------------|----------------------------|---------------------------|
| Number of participants                     | 37 (100)    | 17 (46)                    | 20 (54)                   |
| Gender                                     |             |                            |                           |
| Female                                     | 19 (54)     | 10 (59)                    | 9 (50)                    |
| Male                                       | 16 (46)     | 7 (41)                     | 9 (50)                    |
| Age (in years), mean (SD)                  | 49 (14)\(^a\) | 54 (16)\(^a\)              | 43 (10)\(^a\)             |
| Race                                       |             |                            |                           |
| Latino                                     | 29 (83)     | 11 (65)                    | 18 (100)                  |
| Non-Latino White                           | 6 (17)      | 6 (35)                     | 0 (0)                     |
| Household Income                           |             |                            |                           |
| < $25,000                                  | 11 (31)     | 2 (12)                     | 9 (50)                    |
| $25,000 to $50,000                         | 13 (37)     | 5 (29)                     | 8 (44)                    |
| > $50,000                                  | 10 (29)     | 10 (59)                    | 0 (0)                     |
| Declined to answer                         | 1 (3)       | 0 (0)                      | 1 (6)                     |
| Education                                  |             |                            |                           |
| Grade school or junior high                | 11 (31)     | 1 (6)                      | 10 (56)                   |
| High school or GED                         | 11 (31)     | 5 (29)                     | 6 (33)                    |
| Trade school, associate's degree, college  | 10 (29)     | 9 (53)                     | 1 (6)                     |
| Graduate school                            | 3 (9)       | 2 (12)                     | 1 (6)                     |
| Home ownership                             |             |                            |                           |
| Owner                                      | 32 (91)     | 17 (100)                   | 15 (83)                   |
| Renter                                     | 3 (9)       | 0 (0)                      | 3 (17)                    |
| Employment status                          |             |                            |                           |
| Full time                                  | 16 (46)     | 9 (53)                     | 7 (39)                    |
| Part time                                  | 10 (29)     | 5 (29)                     | 5 (28)                    |
| Not employed                               | 9 (26)      | 3 (18)                     | 6 (33)                    |
| Occupation                                 |             |                            |                           |
| Agriculture                                | 7 (27)      | 1 (7)                      | 6 (50)                    |
| Non-agriculture                            | 19 (73)     | 13 (93)                    | 6 (50)                    |
| Have ever tested well water\(^b\)         | 20 (57)     | 12 (70)                    | 8 (44)                    |
| Water Treatment                            |             |                            |                           |
| Purchase water                             | 24 (69)     | 10 (59)                    | 14 (78)                   |
| Water softener                             | 6 (17)      | 4 (24)                     | 2 (11)                    |
| Particle filter                            | 5 (14)      | 5 (29)                     | 0 (0)                     |
| Boil                                       | 3 (9)       | 2 (12)                     | 1 (6)                     |
| Carbon filtration                          | 15 (43)     | 3 (18)                     | 12 (67)                   |
| Reverse osmosis                            | 2 (6)       | 1 (6)                      | 1 (6)                     |
| Unknown                                    | 2 (6)       | 0 (0)                      | 2 (11)                    |

\(^a\)Mean and standard deviation (SD)  
\(^b\)Fifty-nine percent of English participants were recruited from a list of participants in a county private well water testing program  
Demographic data missing for two participants

**Supplementary Files**

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