The Journal of Extension

Manuscript 5789

Community-Based Well Testing and Outreach to Mitigate Human Health Risk from Unsafe Drinking Water

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Abstract:
Twenty two percent of groundwater wells tested nationally have one or more contaminants above a health threshold, and many private well owners are unaware of risks because they have not tested their water. Researchers piloted a community well testing clinic for education/outreach and surveyed participants about outcomes. Two months afterwards, 75% of participants with high or intermediate health risk water quality results had taken action or intended to, indicating that community private well testing clinics can be effective in mitigating human health risk from contaminated drinking water.

Introduction:

Access to clean drinking water is a hallmark public health indicator. Unclean water consumption can cause short-term health impacts such as diarrhea, dysentery and cholera, and long-term impacts such as liver, kidney, autoimmune and neurological damage, as well as increased risk for various cancers (Eggers et al., 2018; US, EPA 2024; WHO, 2022). While public water systems use water treatment technology and monitoring to protect consumers, private wells do not receive the same government services. Well owners are neither mandated to test nor to maintain their systems and financial support is limited or non-existent (Seltenrich, 2017). Nationwide research indicates 22% of private wells have at least one contaminant above a health threshold (DeSimone et al., 2015), but in some cases more than half of well owners have never tested (George et al., 2023). Water testing must, however, be accompanied by results interpretation and audience-tailored education because linkage to health issues and mitigation options can be confusing and inaccessible (Doria et al., 2009; Eggers et al., 2018; Fizer et al., 2018; Fox et al., 2016).

To assist the 30% of Montana on private wells (Dieter et al., 2018) the Montana State University (MSU) Cooperative Extension *Well Educated* program was developed in 2005. This program was inspired by MSU Extension programming from the 1980s (Bauder et al., 1991), and provides well-owners reduced cost well water testing, easy-to-understand results, and information on drinking water related health risks and mitigation options. The program has served over 10,000 participants (MSU Extension, 2024a).

Previous research and *Well Educated* program results indicate that groundwater contaminants above human health thresholds (US EPA 2024) are present in every Montana county (MSU Extension, 2024a), and in most cases cannot be detected without testing. 25% of well water samples contained Total Coliform bacteria, which should not be present in groundwater, indicating action is necessary to reduce risk of contamination by pathogens. Arsenic was the top ranked analyte of health concern with 10% of samples exceeding the 0.01 mg/L public health standard, indicating widespread risk of cancer and numerous other health risks with lifetime consumption of the water.

In the Fall of 2023, the *Well Educated* program team piloted two community-based well testing and outreach events to increase access to a more comprehensive set of health related parameters for members of rural communities. The purpose of this *Ideas at Work* paper is threefold: 1) to describe the four steps of these community-based well-water testing and outreach pilot events, 2) to share participant feedback on the process, and 3) to present preliminary data regarding community members' perceptions of potential well-water risks and their willingness to take mitigation action.

Pilot Project: A Community Based Private Well Testing and Outreach Event

Based on a successful model developed by colleagues at Virginia State Extension (Benham et al., 2016), our team organized two separate community-based, private well testing and outreach events (MSU Extension, 2023). Each pilot clinic involved: 1) water sample collection, 2) water quality analysis, 3) delivery of results and interpretation, and 4) two community events, as detailed below:

Part 1) Test Kit Dissemination and Sample Drop-Off

Participants in two rural locations were invited to pick up test kits (bottles and instructions) between August 21 and September 1, 2023 at their local library or Cooperative Extension office. Recruitment involved advertising in the local newspaper, hanging fliers at community establishments (e.g. local health departments, conservation districts and Extension county offices), via social media posts, and through word of mouth. The Extension agent for the counties and staff from the local conservation district were primary recruiters.

The testing panel cost at a commercial lab was over $500, reduced by ~50% through competitive bid. Cost to participants was further reduced to $185 with funding from the MSU Institute on Ecosystems. Participants dropped off their water samples on the morning of September 6, at one of two locations. At drop-off, participants filled out a short Qualtrics registration form either online or hardcopy (or online in advance). The form collected contact information for delivering results and information about the water source and uses (Appendix 1). Samples were stored on ice in coolers, paperwork was collated, and samples were delivered to the contracted lab the same day.

Part 2) Sample analysis by an EPA-certified commercial lab

To accommodate the university procurement process, the partner lab was selected through a competitive bid process initiated months prior to the start of sample kit distribution. Analytical results were provided by the lab on September 28th, three weeks after sample submission. Results were provided in both a PDF format for delivery to the participant, and in a comma separated value file with a format prearranged to be compatible with *Well Educated* program's existing R scripts for results interpretation.

Part 3) Dissemination of results to well owners

Results were disseminated to participants by email. Each email included a lab report PDF, a home use interpretation comparing individual analytes to thresholds, and an assessment of cumulative human health risk across analytes (Appendix 2). The interpretation split results into two clear categories: 1) human health related – parameters of concern (e.g. arsenic) and, 2) non-human-health related – parameters of note (e.g. hardness or alkalinity). For human health related parameters, links to contaminant factsheets were included. The cumulative risk value was calculated by taking the ratio of each contaminant concentration to the health threshold and summing that ratio across analytes (MSU Extension, 2024b), following the approach of Bradley et al. (2022). This is a relatively new approach for assessing drinking water quality and has very limited past application in private well owner education. Participants also received links to educational videos on the *Well Educated* program website about well and septic systems.

Part 4) Hosting the community outreach/education events

Two evening community events were held to bring people together to learn about water quality in their own wells, the wells of the broader community, and to hear from professionals. Both events were social in nature and included refreshments and time to mingle, talk, and ask questions of the speakers. Speakers included the founder and director of the *Well Educated* program, a Montana Bureau of Mines and Geology hydrogeologist, a local county health department sanitarian, and an environmental health

professor. At the end of the event, time was allotted for participants to ask specific questions about their test results.

Survey Methods

Fifty well owners participated in the community-based well water testing clinic (Parts 1-3). Of those, 27 participated in the feedback survey, and 13 of those respondents also participated in one of the community events. On the Qualtrics registration form (Appendix 1) participants were asked questions such as the age and depth of their well, while the post-event Qualtrics survey (Appendix 3) asked them to reflect on the level of risk of their well water (based on the lab analysis and cumulative risk calculation), and whether they intend to mitigate the risk. Human subjects data collection associated with this project was reviewed and approved by the MSU Institutional Review Board (IRB#: 2023-916).

Demographics and Survey Results

One third of participants had never tested their well water, even though 82% of the participants owned the home and well (Table 1). 100% of participants utilized their well water for drinking, cooking, bathing and general household uses.

Table 1.

Participant demographics & private well information

Characteristic	n	(%)
Age of well	22	
1-10 years	5	18.2%
11-20 years	4	22.7%
21-30 years	8	36.4%
31-40 years	2	9.1%
41+ years	3	13.6%
Depth of well (feet)	24	
1 – 100	9	37.5%
101-200	3	12.5%
201-300	6	25.0%
301-400	4	16.7%
401+	2	8.3%
Uses of well water	26	
Drinking	26	100%
Cooking	26	100%
Bathing	26	100%
General household uses	26	100%
Yard and garden	24	92%
Agricultural Irrigation	1	4%
Livestock water	3	12%

Other (please specify)	1	4%
Frequency of testing	27	
Never tested	9	33.3%
Tested once	10	37.0%
Tested more than once	6	22.2%
Tested at least every three years	2	7.4%
Property owner status	27	
Owner and live there more than half the year	22	81.5%
Owner and live there less than half the year	3	11.1
Owner but do not live there	1	3.7%
Renter	1	3.7%
Length of time at property (years)	27	
1-10	7	26.0%
11-20	10	37.0%
21-30	4	14.8%
31-40	4	14.8%
41+	2	7.4%
Acreage	27	
Less than 1 acre	5	18.5%
1-10 acres	13	48.1%
10-50 acres	8	29.6%
50-250 acres	1	3.7%
Age of septic system (years)	27	
1-10	5	20.8%
11-20	7	29.2%
21-30	9	37.5%
31-40	1	4.2%
41+	2	8.3%
Frequency of septic tank pumping	24	
Never pumped	3	12.5%
Pumped within the last 5 years	19	79.2%
Pumped but more than 5 years ago	2	8.3%

Via the registration form, participants were asked to report on their perceptions of the importance of specific water issues. Most participants indicated water availability and water quality were very important, with some variability in concern based on sources of water quality impacts (Table 2).

Table 2

Participant rating of water issue importance

Characteristic	Not at all important		Slightly Important		Moderately Important		Very Important	
	n	(%)	n	(%)	n	(%)	n	(%)
Water availability with increasing development in area (n=24)	1	4.2%	3	12.5%	3	12.5%	17	70.8%
Water quality with increasing # of septic systems in area (n=24)	1	4.2%	4	16.7%	3	12.5%	16	66.6%
Water quality related to agricultural land use (n=24)	5	20.8%	4	16.7%	7	29.2%	8	33.3%
Water quality related to natural sources of contaminants (n=26)	2	7.7%	3	11.5%	3	11.5%	18	69.2%
Water quality related to other sources; please specify (n=13)	4	30.8%	2	15.4%	2	15.4%	5	38.5%

When participants were asked why they were interested in attending a community-based well-water testing and outreach event, 23.8% noted concern about their water quality due to color/taste/smell, while 18.2% had learned that there were contaminated wells in their community. ‘Other’ reasons for attending included ‘concern about maintaining quality water’ and ‘reduced cost’ of testing (Table 3).

Table 3

Motivating factors for participation in testing, ordered by importance

Motivating Factors	Not at all important		Slightly important		Moderately important		Very important	
	n	(%)	n	(%)	n	(%)	n	(%)
I saw the flyer or an advertisement for the program (n=26)	1	3.8%	1	3.8%	4	15.4%	20	77.0%
Concerned about water quality due to color/taste/smell (n=21)	9	42.9%	3	14.3%	4	19.0%	5	23.8%
I learned that there are contaminated wells in my area (n=22)	12	54.5%	4	18.2%	2	9.1%	4	18.2%
Someone suggested I participate in the clinic (n=20)	11	55.0%	2	10.0%	5	25.0%	2	10.0%
I test my well regularly (n=21)	11	52.4%	9	42.9%	1	4.8%	0	0%
Other (n=8)	3	37.5%	0	0	1	12.5%	4	50.0%

The water quality results of highest concern are those for participants at “intermediate” or “high risk” based on the cumulative risk categories. 75% of participants in these two categories had never tested their well water, or only had tested it once prior (Table 4). On the other hand, it is notable that the two participants who had tested at least every three years were at very low or low risk levels.

Table 4

Water quality risk level versus participant frequency of water testing (N = 26)

	Testing Frequency			
Risk Level	Never tested (9)	Tested once (9)	Tested more than once (6)	Tested at least every three years (2)
Very low risk (7)	3	2	1	1
Low risk (11)	2	5	3	1
Intermediate risk (6)	2	2	2	-
High risk (2)	2	-	-	-

In terms of mitigating risk to human health, a critical variable is whether this pilot program encouraged participants to take action. By the time of the follow-up survey in December-January 2023, 75% of participants (6/8) with water classified as "high risk" or "intermediate risk" had either already taken action or intended to – (Table 5). The type of action varied from changing their water source, to shock chlorinating their well, to inspecting the well head. Most participants who had not taken any action to mitigate their risk were in the low or very low risk category.

Table 5

Indication of whether participants took action to mitigate risk, organized by risk level (N = 26)

	Did participant take action to mitigate risk			
Risk Level	Yes [a] (4)	Intend to (4)	Considering (3)	No[b] (15)
High (2)	1	1	-	-
Intermediate (6)	2	2	1	1
Low (11)	-	1	2	8
Very low (7)	1	-	-	6

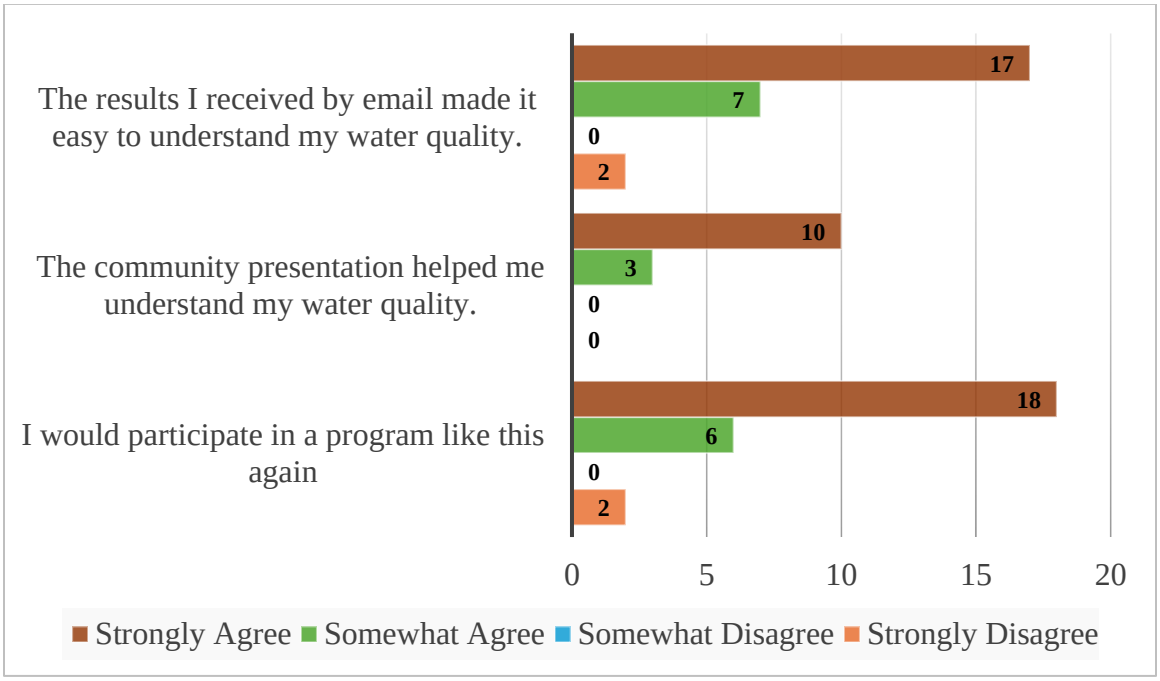
[a] Participants who answered "Yes" that they had mitigated risk indicated actions including: changed water source, e.g. using bottled or delivered water; bleached well; evaluated filter size; inspected well head and/or took protective action; flushed line from spring box to cabin

[b] Participants who answered "No" that they had not mitigated risk indicated reasons including: others in the household did not think it is worthwhile; lack of time; lack of knowledge on how to proceed

65% of participants strongly agreed that the water quality results they received by email were easy to understand (Figure 1). 77% of participants indicated that the community presentation helped them understand their water quality, which underscores the value of hosting an in-person event at the culmination of such a community-based program to ensure participants fully understand what their water quality test results mean for them and their family's health.

Figure 1

Feedback on the Well Educated Community Based Pilot Program (N=26)



* note that only 13 people who filled out the survey attended the community meeting.

At the in-person event, the director of the *Well Educated* program spoke about what participants can do to mitigate the adverse effects of their drinking water. This how-to component was well received, as evidenced by anecdotal comments after the presentations as well as the following survey comments, "*I am happy to know what is in our water and what I can do to make it safer; I understand the info."* and "*I feel like the information is comprehensive and there are clear instructions on how to mitigate the issue with our well.*"

Of the 27 participants who completed the follow-up survey, 63% indicated that they have already shared some of the information that they had learned through this *Well Educated* program with someone else. 30% of participants shared with 2 or more people which demonstrates that information sharing across the community is occurring.

Discussion and Implications

Follow up survey data confirmed the *Well Educated* program Community Based Private Well Testing and Outreach Events pilot was a success. Considering that one-third of participants had never before tested their well water (Table 1), this project introduced numerous people to this facet of health promotion. Part of the project's appeal was the fact that *Well Educated* program was able to subsidize the cost of these private lab tests for numerous individuals. Opportunities to reduce future testing costs include: 1) omitting non-health related analytes, 2) leveraging existing groundwater quality data to eliminate contaminants with very low risk of occurrence, and/or 3) facilitating sample analysis in a university lab.

This pilot involved producing materials to interpret lab results in an easy-to-understand format (Appendix 2), which, according to participants, increased their understanding of their water quality results, and the potential implications for their health. Anecdotally, this increased understanding became a catalyst for individuals to prioritize taking action to mitigate their risk from consuming contaminated water. This was evidenced by the fact that 75% of individuals whose well water was classified as either 'high' or 'intermediate' risk have either already taken action to mitigate that risk, or intend to (Table 5). Lastly, anecdotal evidence supports that the community presentations not only helped to foster a sense of community among the participants (Grocke-Dewey, 2023), but also allowed individuals to hear from a variety of professionals about topics that help to contextualize well water testing and why it is such an important protective health measure. Participants noted that they greatly appreciated that these events were held at their local community centers, were informal in nature, and involved ample time to ask questions about their individual well water results. 92% of participants agreed (69% strongly agreed) that they would participate in such an event again.

Conclusion

75% of participants with high or intermediate risk water quality results had taken action or intended to when they filled out the follow-up survey a few months after the program. Based on this high rate of risk mitigation and positive feedback on the clinic approach, our results indicate additional clinics would be beneficial for mitigating health risks in rural communities.

Supplemental Material

Appendix 1 – Registration sheet question list.

Appendix 2 – Example of results sent to participants.

Appendix 3 – Follow up survey question list.

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