CHARACTERIZING LEAD EXPOSURE IN HOUSEHOLDS THAT DEPEND ON PRIVATE WELLS FOR DRINKING WATER

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Evidence accumulated over the past several decades indicates that there is no safe level of exposure to lead for young children. Although the Safe Drinking Water Act has safety measures in place to maintain the safety of municipal water supplies, no such protection exists for private wells. Recent research suggests U.S. children relying on private well water may be at increased risk from lead exposure compared to those with access to a regulated community water supply. However, no prior studies have investigated this risk through concurrent collection of water and blood samples to test for associations between lead in water and lead in blood. To assess these associations, we collected blood and water samples from 89 participants in North Carolina homes relying on private wells for their drinking water. We also collected dust samples to account for the potential risk of exposure to lead from paint and from lead-containing dirt tracked into the home. All environmental samples were analyzed for lead using inductively coupled plasma mass spectrometry. A multivariable regression was performed to examine the association between well water and blood lead, controlling for lead in dust and other factors that may be associated with lead exposure risk. We found that although water lead levels were not directly associated with blood lead, use of a water filter was associated with a decrease of 32% in blood lead ($p<0.05$). Additionally, use of a filter was significantly associated with a decreased risk of the occurrence of high lead levels drinking water ($p=0.01$). Furthermore, we found significant racial disparities in access to water filters. Among participants identifying as African American or Native American, 38% had a water filter, compared to 83% of those identifying as other races ($p<0.001$). This study highlights that those who get their drinking water from a private well and do not filter their water may be at increased risk of exposure to lead. Further research will be required to understand the association more fully between lead exposure and well water, with a focus on communities who do not have access to water filters.

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1 Introduction

Lead is a neurotoxicant that has been proven to have no safe level of exposure.[1] Once ingested or inhaled, it can cross the blood-brain barrier, where it can interfere with normal brain development and functioning. Because children's organs are still developing, they are most vulnerable to lead's neurotoxic effects. [2] Additionally, due to behavioral characteristics and metabolism, children are at a greatest risk for lead exposure and absorption.[2] Many studies over the last several decades have linked early-life lead exposure to decreased academic achievement[3], attention-related behaviors,[4] and problematic behaviors at home and school.[4]Additionally, these effects can be carried into adulthood[5]. Evidence also is mounting that lead exposure poses health risks in adults[1,6–9]. Multiple studies have found associations between chronic lead exposure and increased risk of heart disease, kidney disease and high blood pressure.[1,7–9] Currently, research is exploring an association between lead exposure and degenerative diseases such as cataracts and dementia.[8] This research includes exploring a possible causal relationship between chronic lead exposure in adulthood and accelerated cognitive decline.[6] Furthermore, research suggests adults exposed to lead may be at risk for infertility.[7] Pregnant people exposed to lead during their pregnancy are at a higher risk for miscarriage, still birth, premature birth, and low birthweight.[7] Although a causal relationship has yet to be defined, research is exploring the association between lead exposure and a number of types of cancers.[7] Additionally, community surveys have found an association between increased mortality and lead exposure.[8]

At the population level, blood lead levels have decreased significantly over time in the United States. For example, in 2018, the CDC reported that an estimated 2.6% of U.S. children 6 and under have BLL at or above 5 µg/dL—half the prevalence reported in 2012.[10] In the United

States, these decreases reflect several decades of legislation that has been passed at the national level to decrease use of lead in industrial and consumer products.[11] The use of lead paint was banned in 1978,[11] and leaded gasoline was officially phased out in 1996.[12] The Safe Drinking Water Act was introduced in 1974, but it did not include lead exposure prevention policy until 1986.[13] In 1986, Congress prohibited the use of pipes, fittings, solder, and flux that were not "lead free".[14] In this amendment, "lead free" allowed solder and flux to contain up to 0.2% lead, and pipes to contain to contain up to 8% lead.[14] In 2011, the Reduction of Lead in Drinking Water Act was passed.[14] This act adjusted the definition of "lead free" by reducing the weighted average of lead in all wetted plumbing structures to not exceed 0.25% of the total weight of the plumbing features.[14] Despite the decreases in U.S. blood lead levels over time, in 2022, exposure to environmental lead is still a public health issue. In response to the growing evidence of lead's neurotoxic effects in even the smallest doses, the CDC adjusted the reference level for elevated blood lead from 5 µg/dL to 3.5 µg/dL in November of 2021.[10] An estimated 600,000 U.S. children have blood lead levels above this new threshold.[15]

One important remaining source of environmental lead exposure is drinking water. Lead contamination of water usually occurs from the dissolution of lead from pipes and fixtures.[15] To prevent lead contamination through this route, municipal water systems monitor control the corrosivity of the water they distribute.[15] This lead prevention strategy gained public attention due to the Flint, Michigan Water Crisis. Studies have determined that the primary cause for lead contaminated drinking water during this crisis was due to the corrosivity of the water from the Flint River.[16] When the city transitioned from sourcing their water supply from the Detroit Water and Sewerage Department to the Karegnondi Water Authority, they used the Flint River as their temporary water source.[17] Because the city did not take the proper precautions to control the

water's corrosivity, thousands of families were exposed to lead from their drinking water as lead was released from lead-bearing water service lines and household plumbing and fixtures.[17]

Although the tragedy of the Flint, Michigan Water crisis gained the attention of the public eye, there is a possibility the approximate 13% of Americans who rely on private wells for their drinking water could be exposed to lead from their water.[18] Although municipal water systems are regulated, there is no policy that requires private wells to be tested regularly for safety. The EPA recognizes a drinking water system as a public when it has at least 15 service connections or when it provides drinking water for at least 25 people for at least 60 days a year.[19] Because private wells do not meet this criterion, it is up to the household to monitor the safety—including the corrosivity and potential for release of lead--of the drinking water.

A few states require testing of well water for lead upon initial construction of the well and/or when property is transferred. However, no state requires routine testing of private well water.[20] Multiple studies have shown that households relying on private well water generally do not test their water quality on a regular basis, if ever.[21] This lack of testing is alarming because recent studies in multiple U.S. communities have found elevated concentrations of lead in private well water.[21–26] These studies suggest that children relying on a private well for their drinking water may be at increased risk for lead exposure, compared to those in homes served by a community water system.[27] Despite the potential risks from lead exposure, limited research has been done to examine blood lead levels in children or adults who get their drinking water from private wells. A 2020 study in Wake County, NC, reported that children who get their drinking water from a private well have a 25% increased risk of elevated blood lead levels when compared to children who get their drinking water from municipal sources.[28] This study matched data about household water sources in the county to blood lead surveillance data but did

not collect concurrent measurements of lead in blood and lead in water, limiting the ability to draw causal conclusions about the effects of lead in private well water on children's health. The gap in knowledge about the impacts of lead in private well water on blood lead may contribute to the lack of awareness of this potential risk, which in turn could increase the risk of lead exposure for the millions of families relying on private well water.

To the best of our knowledge, this is the first U.S. study to analyze concentrations of lead in blood and well water simultaneously. This project aims to begin to fill the knowledge gap of understanding lead exposure in people who get their drinking water from private wells. Specifically, the study seeks to assess whether there is an association between lead in tap water in houses relying on private wells and the blood lead levels of household residents.

2 Methods and Materials

To characterize blood lead levels in people who get their drinking water from private wells, this study used a cross-sectional design. We recruited 89 participants in North Carolina who rely on private wells for drinking water to test household tap water and participants' blood samples for lead. Dust samples were also collected as control to represent other potential routes of exposure. A household questionnaire was conducted to understand household and behavioral characteristics. This study was approved by the Indiana University IRB # 2003976342.

2.1 Sample Population and Recruitment

Participants were eligible for this study if they (1) lived in a household that obtained their primary source of drinking water from a private well and (2) lived in North Carolina. To identify eligible participants, we used a variety of recruitment strategies. We partnered with several community organizations – American Indian Mothers, Robeson County Department of Health,

and the Robeson County Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) office. These organizations helped us identify eligible households, posted flyers in their offices and on their social media pages, and mailed flyers to their organization's members and participants. Additionally, we mailed letters to households from lists of private well owners developed in our prior research[29,30], relied on word-of-mouth strategies from current and previous participants, went door-to-door, and created a website for potential participants to visit and sign up. All participants received a $75 Visa gift card. Participants who recruited a household received an additional $25 visa gift card.

2.2 Sample Collection

To characterize the relationship between blood lead levels and drinking water sourced from a private well, three types of samples were collected: water, dust, and blood. In addition, a household questionnaire was conducted determine characteristics of the home and well, demographic information, and behaviors of participants that might be associated with lead exposure. The research team went to the homes of the participants for sample collection and survey administration.

2.3 Blood Sample Collection and Analysis

For 59 participants, blood samples were collected by a trained phlebotomist during the initial visit. The phlebotomist collected two 5 mL samples from the antecubital region using a 6.0 mL vacutainer K2 EDTA 10.8 mg tubes. After collection, tubes were stored in a refrigerator until ready for analysis. All samples were analyzed within 30 days of collection. Lead and other toxic heavy metals were analyzed at RTI International laboratories via inductively coupled plasms mass spectrometry (ICPMS) using RTI's published laboratory procedures.[31]

Due to barriers from the hesitation of participants to participate in a venous blood draw, the research team transitioned to a capillary sample part-way through the study. 30 samples were capillary samples. Blood was collected by a trained member of the research team using the Tasso-SST device. Prior to use on participants, RTI International laboratories verified the devices were lead-free. The Tasso-SST device collected approximately 250 µg/L of blood from the deltoid region of the arm. All samples were analyzed within 30 days of collection. Lead was analyzed at RTI International laboratories via ICPMS using previously mentioned procedures.

2.4 Water Sample Collection and Analysis

Participants collected water samples in the morning after an overnight stagnation period of at least six hours. Such "first flush" samples are intended to capture the maximum potential for lead exposure due to extended release of lead from plumbing and fixtures as water stagnates in the household water system overnight. Participants were provided with detailed oral and written instructions and two 500 mL water bottles. Participants were directed to collect the water before anyone in the household used the water. They were directed to collect cold water, and to only open the bottle for collection to reduce the risk of potential lead contamination. Once the water was collected, participants placed the water bottles in a sealed bag and set them in a safe, shaded location. Later that day, a member of the research team came by the house to pick up the samples.

During the initial household visit, a member of the research team used a Hanna Instruments, Model HI 8130 Combo pH/Conductivity/TDS Tester to test the pH, conductivity, and temperature of the water. Lead and other toxic heavy metals were analyzed at RTI International laboratories via ICPMS using EPA Method 200.8.[32]

2.5 Dust Sample Collecting and Analysis

A member of the research team collected up to five dust samples at the initial home visit: 1. the floor of the entry way, 2. the floor of the room the participant uses most, 3. the floor of the room where the participant sleeps, 4. the windowsill of the room where the participant sleeps, 5. the window trough of the room where the participant sleeps. Where possible, a 1 meter by 1 meter area was measured a taped off. When this area was not possible, the research team member measured and documented the area. Ghost Wipes® were used for dust sample collection on all surfaces. The area was completely wiped in an up-and-down motion until the full area had been sampled. When collection was complete, the researcher placed the wipe in a collection tube. Researchers wore gloves for sample collection and changed gloves between areas.

Lead and other toxic heavy metals were analyzed at RTI International laboratories via ICPMS with procedures the American Industrial Hygiene Association's environmental lead program at RTI[33].

2.6 Questionnaire

To understand demographic and behavioral characteristics of the participant and characteristics of the home, well, and water, a research staff member administered a questionnaire. To understand the characteristics of the well, data on the well age and depth were obtained. To understand home characteristics, data regarding the home age and length of time in residence was collected. Understanding the year the home and well were built allows us to better characterize lead exposure through plumbing materials and lead-based paint. To understand potential sources of lead exposure outside of the home, data on participants' occupation and/or

the school they attend was also collected. Additionally, research staff obtained information about each area of the house where a dust sample was collected, including the last time the area was cleaned and the method used to clean the area. Participants self-reported their age, date of birth, height, and weight. The complete questionnaire can be found the appendix.

2.7 Statistical Analysis

All statistical analyses was conducted using R. A multivariable regression was performed to analyze the association between blood lead concentration and water lead concentration while controlling for other potential sources of lead exposure and for behavioral and demographic factors potentially associated with lead exposure. Chi-square tests were used to assess differences in categorical variables among participant subgroups.

3 Results

3.1 Participant and Household Characteristics

The total sample size was 89 participants in 75 households. See Figure 1 for a map of household locations. Approximately 89% of participants reported regularly drinking water from their tap, with an average of 80% of water consumed at home coming from the tap. 70% of participants reported using a water filter. The mean age of participants was 21. The majority of participants were in the age category 0 years old – 8 years old, followed by the >30 age group. Approximately 61% of participants identified as white, 15% identified as American Indian, 10% identified as African American or Black, 10% identified with more than one race, 2% identified as Hispanic or Latino/a/x, and 2.3% did not report their race or ethnicity. 38% of participants reported having a master's degree or higher, 26% reported having a 4 year degree, 24% reported having some college, and 12% reported having a high

school education or less. 79% of homes were built after the lead paint was banned in 1978. See Table 1 for further detail on participant and household characteristics.

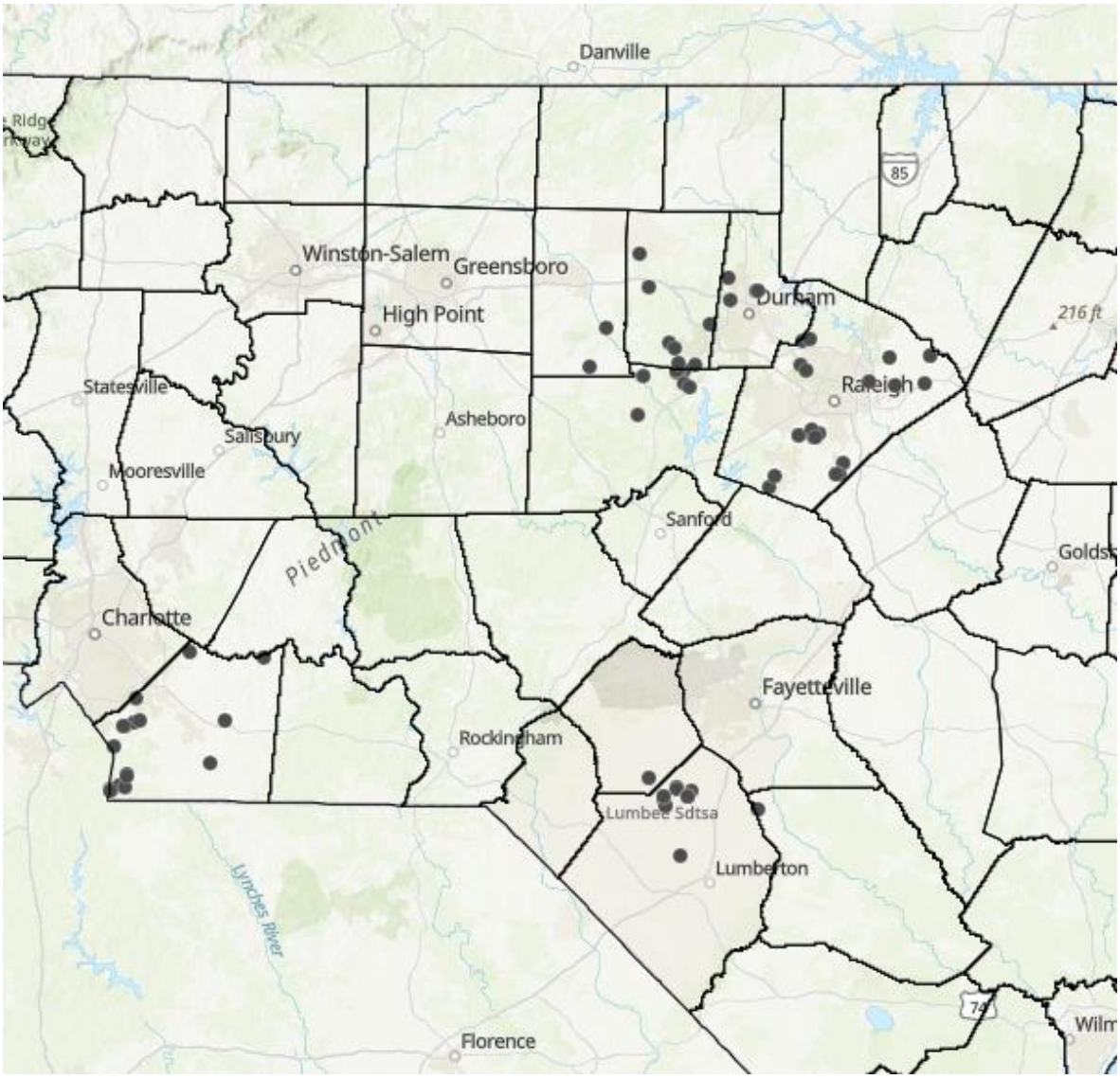


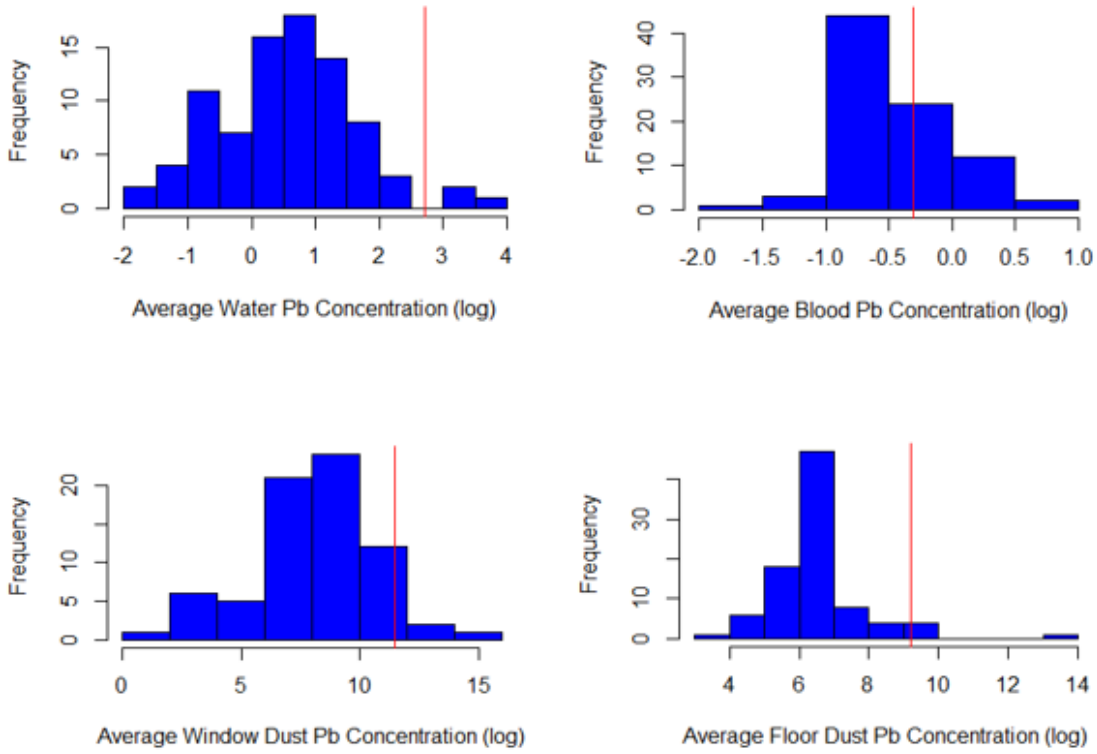
Figure 1: Locations of study participants

Table 1: Participant/parental, and environmental characteristics

Characteristics of participant	
Gender	(N)(%)
Female	45 (51)
Male	44 (49)
Race	
American Indian or Alaskan Native	13 (15)
Black	9 (10)
Hispanic Latino/a	2 (2.3)
More than one race	9 (10)
White	54 (61)
na	2 (2.3)
Age group	
0 to 8	56 (63)
9 to 14	5 (5.6)
15 to 19	1 (1.1)
20 to 29	3 (3.4)
>30	24 (27)
na	1 (1.1)
Age (mean) (SD)	21 (25)
Characteristics of home	
County	
Alamance	2 (2.3)
Chatham	10 (11)
Durham	4 (4.5)
Orange	7 (7.9)
Robeson	14 (16)
Union	31 (35)
Wake	21 (24)
Year home was built	
Before 1950	3 (3.4)
1950 - 1977	5 (5.6)
1978 - 1987	17 (19)
1988 - 1997	21 (24)
1998 - 2002	11 (12)
2003 or later	21 (24)
na	11 (12)
Water filter?	
yes	62 (70)
no	18 (20)
na	9 (10)
Behavioral characteristics of participant	
Drink water from the tap?	
yes	79 (89)
no	9 (10)
na	1(1.1)
Percent of the time drink water from the tap	80 (36)
Months participant has lived in the home (mean) (SD)	90 (111)
Smoke cigarettes inside the home?	
yes	13 (15)
no	76 (85)
Education of adult participant or parent of child participant	
High school or less	11 (12)
Some college	21 (24)
4-year college/University Degree	23 (26)
Graduate degree (e.g., M.D., J.D., Ph.D.)	34 (38)

3.2 Sample Results

The mean blood lead level for the study sample was 0.68 µg/dL, SD 0.4, maximum 2.3 µg/dL (Table 5). No participants had a blood lead level above the CDC blood lead reference level of concern of 3.5 µg/L. The mean water lead level was 3.5 µg/L, SD 6.5, maximum 50. Three participants had an average water sample that exceeded the EPA's action level of 15 µg/L. The mean floor lead dust concentration was 13 µg/M^2,SD 111, maximum 1051 µg/M^2. One participant had a lead dust concentration that exceeded the EPA's clearance level of 108 µg/M^2 (10 µg/ft^2). The mean window lead dust concentration was 151 µg/M^2, SD 1020, maximum 8639 µg/M^2. One participant had a mean window lead dust concentration that exceed the EPA's clearance level of 1076 µg/M^2 (100 µg/ft^2). See Figure 2 and Table 2 for more information on lead concentrations of samples.



Pb = lead

Figure 2: Logarithmic histograms of lead concentrations for average water, blood, window, and floor lead concentrations from study population. For water, window, and floor histograms, the redline represents the EPA's clearance level. The red line on the blood histogram represents the U.S. 50th percentile of blood lead concentrations. A log scale was used on the graphs to allow for a more detailed visual representation of the lead concentrations.

Table 2 Lead Concentrations in Collected Samples				
	Blood (n=89)	Water (n=75)	Window Dust (n=75)	Floor Dust (n=75)
Maximum	2.26 µg/dL	50.2 µg/dL	8639 µg/M^2	1052 µg/M^2
Mean(SD)	0.68(0.41) µg/dL	3.49 µg/dL	151.33 (1020) µg/M^2	13.3 (111.3) µg/M^2
Relevant Guideline Value or Standard	3.5 µg/dL	15 µg/L	1076 µg/M^2	108 µg/M^2

Results from averages of samples within each household

CDC guidelines used for blood guideline. EPA guidelines for water and dust EPA[29]

3.2 Regression Analysis Results

Blood lead was not directly associated with lead in water. However, those who filtered their well water had significantly lower blood lead compared with those who did not use water filters ($p<0.05$). Use of a water filter was associated with a decrease of 32% in blood lead, when controlling for age, sex, average lead in floor dust, and whether the participant reported drinking their tap water at home. Use of a filter significantly decreased the chance of having higher levels of lead in tap water. See table 3. In addition, use of a filter was significantly associated with a decreased risk of the occurrence of high levels of lead in drinking water. 50% of participants who did not use a filter had levels of lead in their water above the seventy-fifth percentile of our data set (3.52 µg/L), compared to only 16% of those who did not use a filter ($p=0.01$) (Figure 3). There are significant racial disparities in access to water filters. Among participants identifying as African American or Native American, 38% had a water filter, compared to 83% of those identifying as other races ($p<0.001$) (Figure 4).

Table 3: Influence of demographic, household, and environmental factors on participant blood lead levels (log transformed)

	Coefficient	Exponentiated Coefficient	SE	*t*	*p*
(Intercept)	-1.06	0.35	0.315	-3.364	0.0012
Age	**0.0075**	**1.0**	**0.002**	**3.601**	**0.00056**
SexMale	0.11	1.1	0.100	1.142	0.26
RaceWhite, Asian, Latino/a, or Other	-0.075	0.93	0.136	-0.551	0.58
log(Floor_Pb)	0.070	1.1	0.038	1.829	0.071
FilterUnknown	-0.15	0.86	0.226	-0.656	0.51
FilterYes	**-0.38**	**0.68**	**0.148**	**-2.591**	**0.011**
Drink_TapYes	0.21	1.2	0.177	1.210	0.23

Regression results are based on data from 84 participants with complete data for all included variables.

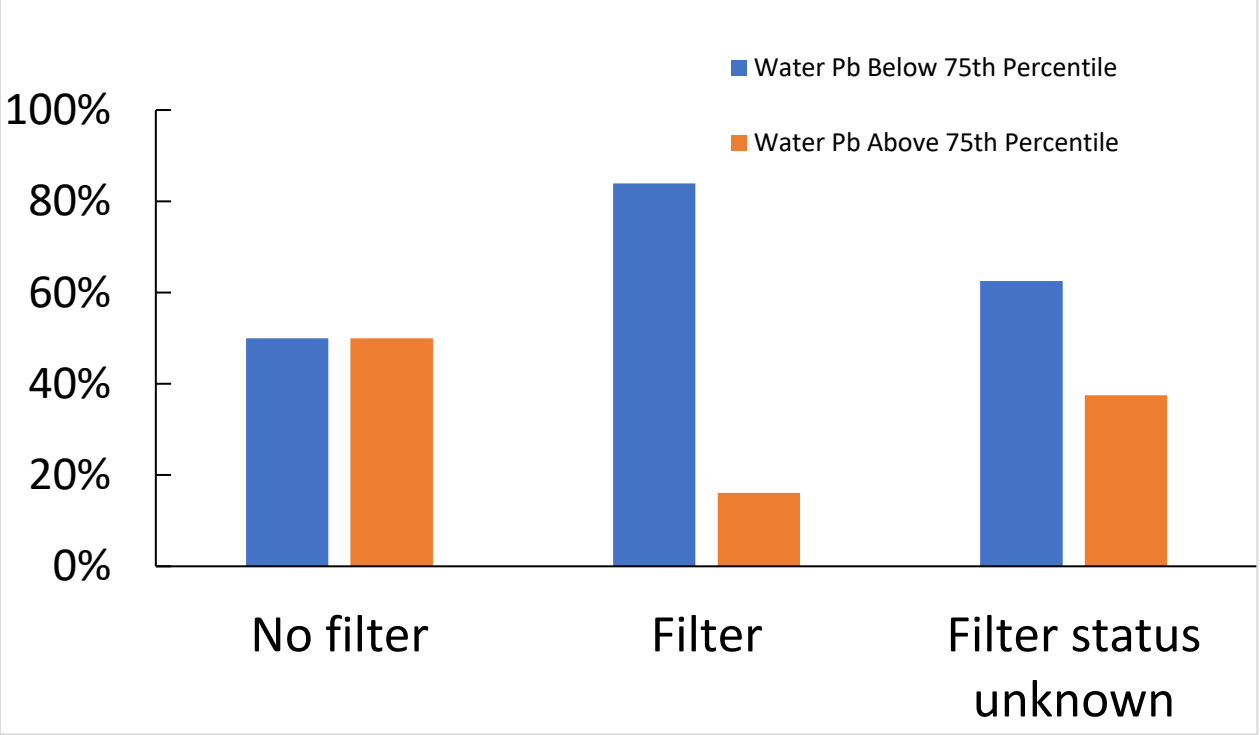


Figure 3: Fraction of participants with water lead above or below the 75th percentile of water lead in this study (3.5 µg/L).

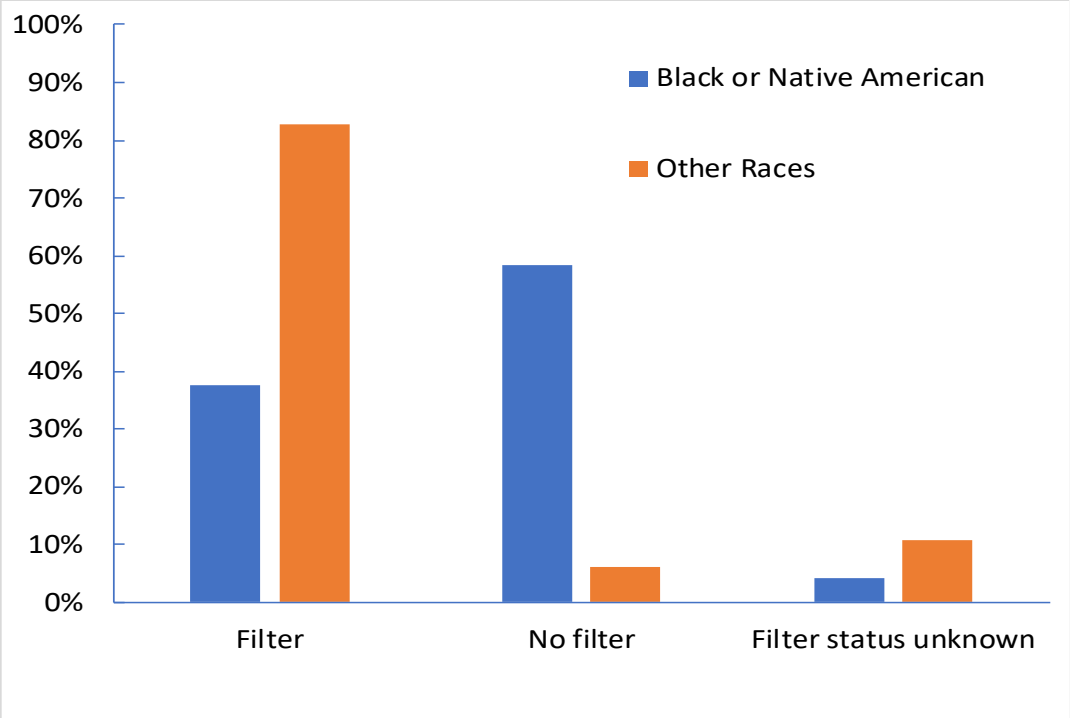


Figure 4: Water filter use by race

4. Discussion

In this study, we examined blood lead levels in people who get their drinking water from a private well. Although we did not find a significant association between blood lead and water lead, our results show that use of a water filter is associated with decreased blood lead levels and decreased water lead levels. We also found that those who filtered their water (70% of the study participants) were significantly less likely to be exposed to high levels of lead (above the third quartile of the water lead concentration, 3.5 µg/dL) in their drinking water. Together, these results suggest that water filters remove lead from the water and therefore can effectively break the link between lead in drinking water and lead in blood. However, we found significant racial disparities in use of water filters. Among Black and Native American participants, 38% had water filters, compared to 83% of participants from other racial groups.

4.2 Comparison to Previous Studies

The results of this study are consistent with previous studies suggesting that U.S. households relying on private well water are at risk from exposure to lead in drinking water unless they

install a corrosion control system (such as a whole-house acid neutralizer) or filter their water to remove lead.

Studies have found that high levels of lead are relatively common in tap water in houses relying on private wells.[21,22] Related research has found that children who live in households that rely on a private well for their drinking water have a 25% increased risk for elevated blood lead levels when compared to their counterparts who have access to regulated, municipal water systems.[28] Additionally, research has found that water filtration devices were able to significantly reduce lead concentrations in water sourced from private wells[34]. Although this study did not find an association between blood lead levels and water lead levels, it is recommended that the association between well water and blood lead levels to still be an active area of research.

4.1 Limitations

Limitations of this study include difficulty in recruiting participants from our target population. This limits generalizability of our results as the majority of our participants were white and highly educated, and used water filters. Additionally, 37% of participants in this study were above the age of 8. Because young children have yet to develop mature mechanisms to rid their bodies of lead quickly, our results are likely not generalizable to young children. Because water lead concentrations and blood lead concentrations may fluctuate over time, another limitation is that samples were collected at just one point in time. The widespread use of filters also limits our ability to make inferences about associations between lead in water and lead in blood.

5 Conclusion

To the best of our knowledge, this study is the first U.S. study to investigate the blood lead levels in people who rely on private wells for their drinking water while simultaneously measuring blood, water, and household dust samples. We found that use of a water filter helped prevent high levels. The majority of participants were white, highly educated, and had access to water filters. Education and race are each factors that have been shown to impact blood lead levels.[35,36] It is recommended that future studies that aim to examine the association between blood lead and water lead focus recruitment strategies to include participants with a more diverse racial and ethnic background. Additionally, it is recommended that more households that do not use a filter are included. More broadly, steps are needed to provide equitable access to water filters for households relying on private wells.

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6 Supporting Information

6.1 Instructions for collecting water

Instructions for Collecting Your Water Sample

Please read carefully before collecting your sample.

To collect your water sample, please follow the instructions below. Then, sign and date the form. The research team will collect the sample tomorrow.

If you have any questions, please call Dr. Jackie MacDonald Gibson at 919-208-0816 or Alyson Alde at 217-273-1544.

Results should be available within 30 days but may take up to 90 days due to lab queue.

1. If you recently disinfected your well, be sure all chlorine is gone; the lab will not accept samples with chlorine.
2. Select an indoor faucet, preferably your kitchen tap. Avoid leaky faucets that allow water to seep around the valve.
3. It is important not to contaminate the sample bottles or their caps. Keep the bottles closed until ready to use. Do not touch the inside of the cap.
4. **Allow the water in your household to sit undisturbed in the water pipes for at least 6 hours (overnight is best).** It is most important that you let the water stand in the pipes to allow for the most accurate results. This means not running any water within the house or using the toilets.
5. Turn on the cold water faucet, and **immediately** fill the sample collection bottle. Please do not allow the water to run before filling the bottle. Replace the bottle cap, being careful to close it tightly.
6. Date this form and indicate the time when you collected your sample, below.
7. Place the filled bottle and this form in a bag with handles. Hang the bag on your front door knob or leave it on your front porch. The research team will collect your sample tomorrow.

SAMPLE COLLECTION DATE AND TIME:

Date_____
Time_____

Sample ID _____

6.2 Household questionnaire

Household Questionnaire

Name of Research Team Member:

_____

Household ID: _____

#	**Metadata**	Response options
1	Date	
2	Address	
3	Start Time	
4	GPS coordinates (Lat)	
5	GPS coordinates (Lon)	
6	Home type	____Single-family home
		____multi-family home/apartment
		____Manufactured home/trailer
		____Other:
	Adult Respondent	
7	What is your full name?	
8	Gender of adult respondent	_____Male
		_____Female
		_____Other:
9	Race/Ethnicity of adult respondent (mark all that apply)	_____Black
		_____White
		_____American Indian or Alaskan Native
		_____Asian
		_____Pacific Islander or Native Hawaiian
		_____Hispanic Latino/a
		_____Other:
		_____Don't Know
		_____Decline to state
10	How old are you (years)?	
11	What is your relationship to [child]?	_____Mother
		_____Father
		_____Grandmother
		_____Grandfather
		_____Aunt

		_____Uncle
		_____Other:
12	Are you the child's primary caregiver?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
13	Are you currently working outside the home?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
14	What is your current occupation?	_____
15	What is the highest level of education that you completed?	_____Never attended school
		_____Primary school (Through 6th Grade)
		_____Middle school (Through 8th Grade)
		_____High school (Through 12th Grade)
		_____Technical/vocational school
		_____Associates Degree
		_____4-year college/University Degree
		_____ Graduate degree (e.g., M.D., J.D., Ph.D.)
16	How long have you lived at this address (years)?	
17	What is your main source of water in this home?	_____Piped network
		_____Private well
		_____Other:
18	When was this well constructed (year)?	
19	How deep is this well (feet)?	
20	Does this house have a septic system or municipal sewer connection?	_____Sewer
		_____Septic
		_____Other:
21	Do you drink tap water when you are at home?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
22	The last time you drank water at home, was it from the tap?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state

23	What % of the time do you drink tap water when you are at home (vs water from another source)	
24	Do you own or rent this home?	_____Own
		_____Rent
		_____Other:
25	When was this home built (year)?	
Only ask Q 26 if the answer to Q13 was "Yes"		
26	Are you exposed to lead at your job?	Yes
		No
		Don't Know
27	[Refer to dust collection site near entrance to home]: When was the last time this area was cleaned? (days ago)	
28	[Refer to dust collection site near entrance to home]: What cleaning method was used the last time this area was cleaned? (mark all that apply)	_____Sweep
		_____Vacuum
		_____Mop
		_____Swiffer
		_____Clean with rag or paper towel
		_____Other:
29	[Refer to dust collection site in child's room/area]: When was the last time this area was cleaned? (days ago)	
30	[Refer to dust collection site in child's area]: What cleaning method was used the last time this area was cleaned? (mark all that apply)	_____Sweep
		_____Vacuum
		_____Mop
		_____Swiffer
		_____Clean with rag or paper towel
		_____Other:
31	[Refer to other dust collection site where child spends time]: When was the last time this area was cleaned? (days ago)	
32	[Refer to other dust collection site where child spends time]: What cleaning method was used the last time this area was cleaned? (mark all that apply)	_____Sweep
		_____Vacuum
		_____Mop
		_____Swiffer
		_____Clean with rag or paper towel
		_____Other:

Only answer Q33-35 if the survey respondent is not the child's mother		
	Child's Mother (If different from Respondent)	
33	Is the child's mother currently working?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
34	What is [child's] mother's current occupation?	
35	What is the highest level of education that [child's] mother completed?	_____Never attended school
		_____Primary school (Through 6th Grade)
		_____Middle school (Through 8th Grade)
		_____High school (Through 12th Grade)
		_____Technical/vocational school
		_____Associates Degree
		_____4-year college/University Degree
		_____ Graduate degree (e.g., M.D., J.D., Ph.D.)
	Child Characteristics	
36	Name of [child]	
37	Gender of [child]	_____Male
		_____Female
		_____Other:
38	Child's birth date (month, day, year)	
39	Was [child] in school last year?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
Only answer Q40 if the answer to Q39 was "Yes"		
40	Name of school [child] attends	
41	Was [child] in day care outside the home last week?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
Only answer Q42 if the answer to Q41 was "Yes"		
42	How many days per week was [child] in day care outside the home last week?	
43	How long has child lived in this home? (months)	
44	Does [Child] stay at this home every day of the week?	_____Yes
		_____No

		_____Don't Know
		_____Decline to state
45	How many days per week does child stay at this home?	
46	Race/Ethnicity of [child] (mark all that apply)	_____Black
		_____White
		_____American Indian or Alaskan Native
		_____Asian
		_____Pacific Islander or Native Hawaiian
		_____Hispanic Latino/a
		_____Other:
		_____Don't Know
		_____Decline to state
47	Was [child] ever breastfed?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
Only answer Q48 if the answer to Q47 was “Yes”		
48	For how long was [child] breastfed? (Months)	
49	Does [Child] drink tap water when [child] is at home?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
50	The last time [child] drank water at home, was it from the tap?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
51	What % of the time does [child] drink tap water when [child] is at home (vs water from another source)	
	Household	
52	Does anyone in this household smoke cigarettes?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
53	Does anyone in this household smoke cigarettes inside the home?	_____Yes

		_____No
		_____Don't Know
		_____Decline to state
54	How many packs per day do people in this household smoke?	
55	Does anyone in this household smoke electronic cigarettes?	_____Yes
		_____No
		_____Don't Know
		_____Decline to state
	Environmental Sampling	
56	Floor dust sample ID	
57	Windowsill sample ID	
58	Paint sample collected?	_____Yes
		_____No
		_____N/A
59	Paint sample ID	
60	Water sample collected?	_____Yes
		_____No
		_____N/A
61	Water sample ID	
62	Water temperature (C)	

6.3 Informed consent

Indiana University, Bloomington
Parental Permission for a Minor Child to Participate in a Research Study

Consent Form Version Date: 7/13/20
Title of Study: Water Infrastructure to Improve Childhood Health and Decrease Childhood Lead Exposure
Principal Investigator: Jacqueline MacDonald Gibson
Principal Investigator Department: Department of Environmental and Occupational Health
Principal Investigator Phone number: 812-856-2448
Principal Investigator Email Address: jacmgibs@iu.edu
Funding Source and/or Sponsor: U.S. Environmental Protection Agency
Study Contact Telephone Number: 812-856-2448
Study Contact Email: jacmgibs@iu.edu

What are some general things you and you child should know about research studies?
You are being asked to take part and/or allow your child to take part in a research study. Joining the study is voluntary for you and your child. You may decide to not allow your child to participate, or you may withdraw your permission for you or your child to be in the study, for any reason, without penalty. Even if you give your permission, your child can decide not to be in the study or to leave the study early.

Research studies are designed to obtain new knowledge. This new information may help people in the future. You and/or your child may not receive any direct benefit from being in the research study. There also may be risks to being in research studies. Deciding not to be in the study or leaving the study before it is done will not affect you or your child's relationship with the researcher or Indiana University, Bloomington.

Details about this study are discussed below. It is important that you and your child understand this information so that you and your child can make an informed choice about being in this research study.

You will be given a copy of this consent form. You and your child should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

What is the purpose of this study?
The purpose of this research study is to inform you about toxic metals in private well water and you and/or your children's blood lead levels. We want to estimate how lead in well water affects children's developmental outcomes. Also we want to assess the association between lead in private well water and adult's and children's blood lead. Participants are being invited from households in Indiana and North Carolina who obtain their water from a private well. You and your child are being asked to be in the study because the researchers are studying the relationship

between private well water quality and blood lead. Lead exposure is especially harmful for children under 7 years old.

Are there any reasons you or your child should not be in this study?
You or your child should not be in this study if you get your drinking water from a city water supply or drink mainly bottled water.

How many people will take part in this study?
There will be approximately 300 people in this research study.

How long will you and/or your child's part in this study last?
For this study, you and/ or your child's active involvement will only include the time it takes for the research team to collect a blood sample at your home. In addition, the child's parent or guardian will be asked to complete a survey and collect a water sample on the morning of your appointment, and the research team will collect dust samples from around your home. We estimate the total time to be about 1 hour. Once you and/or your child's blood specimen is tested for lead, it will be destroyed.

Water and blood testing results will be mailed to you within about one month of sample collection. We will provide you with information about how to interpret the water and blood lead test results and what to do if you are concerned about these results.

What will happen if your child takes part in the study?
We are targeting residents of Indiana and North Carolina who get their drinking water from a private well. We plan to recruit 300 households to participate. If you agree to participate, we will collect a tap water sample from your kitchen sink and will test it for lead and other metals. We will also collect a blood sample to test your and/or your child's blood for lead. Environmental samples of dust will be taken from 5 areas of your floor or windowsills and tested for lead. Lastly, we will inspect paint at windowsills and any locations where you and/or your child interacts the most for peeling or chipping paint.

No special preparations are needed for this test. It may help to have you and/or your child wear a T-shirt or short-sleeved shirt on the day of the test.

A trained research staff will collect a capillary blood sample from the deltoid region of the arm. Beforehand, the skin surface will be cleaned with antiseptic. A blood collection device called "Tasso-SST" will be placed on the cleaned portion of the arm. The research staff will press a button on the device. This will initiate the blood collection process. This process will last no more than three minutes, and it will collect approximately 250 microliters of blood (approximately 1 teaspoon). After blood collection is complete, the trained research staff with apply a bandage to the blood collection area.

Specimens will be stored at the laboratories of RTI International until testing (up to four weeks) and then destroyed.

Lastly, a survey asking questions about your water and you will be given during environmental sampling.

What are the possible benefits from being in this study?
Research is designed to benefit society by gaining new knowledge. The benefits to your and/ or your child from being in this study will include receiving a free lead blood test that could potentially detect elevated blood lead levels associated with negative health outcomes. In addition, your household tap water will be tested for lead and other metals.

What are the possible risks or discomforts involved from being in this study?
There may be uncommon or previously unknown risks. You should report any problems to the researcher. Collecting a sample of blood is only temporarily uncomfortable and can feel like a quick pinprick. Afterward, there may be some mild bruising, which should go away in a few days. If your home is found to have high levels of lead or other toxic metals, that could decrease its property value.

What if we learn about new findings or information during the study?
You and your child will be given any new information gained during the course of the study that might affect your willingness to continue your child's participation in the study.

How will information about your child be protected?
Participants will not be identified in any report or publication about this study. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, Indiana University, Bloomington, will take steps allowable by law to protect the privacy of personal information. In some cases, you and/or your child's information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies (for example the Office for Human Research Protections (OHRP)) for purposes such as quality control or safety.

All data will be coded on a secure server with access limited to only research personnel who have the password and have been granted access. All data will be delinked from personal information (i.e. names and addresses) and given a random identifying number. The key to the delinked dataset will be kept in a separate location on the secure server with access only by senior researchers.

Will my information be used for research in the future?
Information or specimens collected from you or your child for this study may be used for future research studies or shared with other researchers for future research. If this happens, information which could identify you will be removed before any information or specimens are shared. Since identifying information will be removed, we will not ask for your additional consent.

What will happen if your child is injured by this research?
All research involves a chance that something bad might happen. This may include the risk of personal injury. In spite of all safety measures, you and/or your child might develop a reaction or injury from being in this study. If such problems occur, the researchers will help you and your

child get medical care, but any costs for the medical care will be billed to you and/or your insurance company. Indiana University, Bloomington, has not set aside funds to pay you for any such reactions or injuries, or for the related medical care. However, by signing this form, you and your child do not give up any of your legal rights.

What if you or your child wants to stop before your child's part in the study is complete?
You can withdraw your child from this study at any time, without penalty. The investigators also have the right to stop your child's participation at any time. This could be because your child has had an unexpected reaction, or has failed to follow instructions, or because the entire study has been stopped.

Will you and/or your child receive anything for being in this study?
Upon study completion, parents will receive a $75 gift card. Furthermore, we offer a $25 gift card to you for each referral of a participant who completes our study.

Will it cost you anything for your child to be in this study?
It will not cost anything to be in this study.

Who is sponsoring this study?
This research is funded by the U.S. Environmental Protection Agency. This means that the research team is being paid by the sponsor for doing the study. The researchers do not, however, have a direct financial interest with the sponsor or in the final results of the study.

What if you or your child has questions about this study?
You and your child have the right to ask, and have answered, any questions you may have about this research. If there are questions about the study (including payments), complaints, concerns, or if a research-related injury occurs, contact the researchers listed on the first page of this form**.**

What if there are questions about your child's rights as a research participant?
All research on human volunteers is reviewed by a committee that works to protect your child's rights and welfare. If there are questions or concerns about your child's rights as a research subject, or if you would like to obtain information or offer input, you may contact the Institutional Review Board at (812) 855-1741or by email to IRB office (irb@iu.edu) .

Parent's Agreement:

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily give permission to allow my child to participate in this research study.

_____

Printed Name of Research Participant (child)

_____ _____

Signature of Parent Date

_____

Printed Name of Parent

_____ _____

Signature of Research Team Member Obtaining Permission Date

_____

Printed Name of Research Team Member Obtaining Permission

6.4 Blood collection form

Participant ID:	Type: _____Adult _____Child
Height (ft., in.):	Weight (lbs.):
Cleaned the arm area with D-wipe and alcohol pad: _____Yes _____No	Collected Blood Sample: _____Yes _____No
Notes:	

Participant #2

Participant ID:	Type: _____Adult _____Child
Height (ft., in.):	Weight (lbs.):
Cleaned the arm area with D-wipe and alcohol pad: _____Yes _____No	Collected Blood Sample: _____Yes _____No
Notes:	

Participant #3

Participant ID:	Type: _____Adult _____Child
Height (ft., in.):	Weight (lbs.):
Cleaned the arm area with D-wipe and alcohol pad: _____Yes _____No	Collected Blood Sample: _____Yes _____No
Notes:	

Participant #4

Participant ID:	Type: _____Adult _____Child
Height (ft., in.):	Weight (lbs.):
Cleaned the arm area with D-wipe and alcohol pad: _____Yes _____No	Collected Blood Sample: _____Yes _____No
Notes:	

6.5 Dust Collection Form

I. Dust Wipe Sampling		
1	Household ID	
2	Collection Date	
3	Person(s) collecting sample	
4	Sample Description (if needed):	

Sample ID	Participant ID(s)	Room (Circle options)	Sample Location	Dimensions of sample area (inches)	
				Length	Width
		(1) Home Entrance	Floor		
		(2) Room frequented by participant Location:	Floor		
		(3) Participant's bedroom	Floor		
		(4) Participant's bedroom	Windowsill		
		(5) Participant's bedroom	Trough		
		(6) Kitchen	Floor		
		Other:			
		Other:			
		Blank Sample Wipe	N/A	N/A	N/A

Notes:

6.6 Water Collection Form

II. Water Sampling		
1	Household ID	
2	Collection date	
3	Person(s) collecting sample/data	
4	Sample Description (if needed):	
5	Sample ID of First Flush	
	Sample ID of Second Flush	
6	Sample Location	___Kitchen Faucet ___Other:
7	Was cold water collected?	___Yes ____No
8	pH: _____ Conductivity: _____ Temperature: _____	

Notes:

Alyson Alde

PROFESSIONAL RESEARCH EXPERIENCE

Research Assistant *Indiana University – Bloomington, Indiana* 5/2021– 5/2022

- Co-managed project that examined blood lead levels in individuals who get their drinking water from private wells
- Utilized Excel, SharePoint and R to organize, code, and analyze data
- Scheduled to present thesis findings at conference – Break the Cycle of Childhood Environmental Health Disparities
- Identified blood collection device that increased sample collection and decreased cost
- Collaborated with community organizations, graphic designers, and mailing services for participant recruitment
- Managed research team to coordinate collection of biological and environmental samples
- Informed families of sample results and educated households on lead exposure prevention strategies

Project Coordinator *IU Center for Survey Research – Bloomington, Indiana* 8/2020–5/2021

- Received and delivered biological and environmental samples for study examining relationship between obesity and
  environmental factors
- Performed quality checks for survey data including audio recordings, interviewer comments, and inconsistent documentation
- Supported supply delivery for up to 14 field interviewers and phlebotomists throughout the state of Indiana
- Managed medical supply inventory for three projects simultaneously

Covid-19 Response Coordinator *Indiana University – Bloomington, Indiana* 8/2020-5/2021

- Analyzed positive Covid-19 cases within IU campuses to detect transmission patterns daily
- Performed twice daily school reports to ensure positive tests performed outside of IU were accurately reflected in IU's database
- Communicated with chief medical officer and other medical staff to report inconsistencies with testing information
- Supervised, trained, and assisted in biological specimen packaging

Research Assistant - CoVPN 3006 *Indiana University – Bloomington, Indiana* 1/2021-6/2021

- Conducted informed consent with individuals participating in Covid-19 vaccine and transmission study
- Fully discussed the study's requirements and applied "teach back" methods to ensure participants' understanding
- Discussed participants' medical history to ensure safety and eligibility
- Worked closely with principal investigator to address concerns and communicate updates

COMMUNITY OUTREACH AND TEACHING EXPERIENCE

Health Center Manager and Trainer *Planned Parenthood – Bloomington, Indiana* 12/2018-9/2020

- Immediately communicated, adapted, and implemented Covid-19 policies throughout entire health center
- Created weekly schedule for up to 10 medical staff including MDs, NPs, RNs, and MAs
- Managed medical supply inventory for entire health center
- Submitted weekly state-mandated medical forms
- Preformed phlebotomy for STI testing and pregnancy testing
- Handled and prepared blood, urine, and histology samples to ship to labs for STI and cancer screening
- Preformed and trained staff to preform ultrasounds to determine gestational age

Healthy Relationships Class Cofacilitator *Milestones – Bloomington, Indiana* 1/2018-12/2018

- Presented medically accurate information on sexual and reproductive health to up to 20 adult women with intellectual and developmental disabilities to promote healthy relationships
- Collaborated with therapists and direct care staff to ensure individuals received information relevant to them
- Created a safe space for the women to ask questions about sexual and reproductive health
- Documented detailed, accurate notes after each class session

EDUCATION

Indiana University – Bloomington, Indiana 8/2020-5/2022
Master of Science – Environmental and Occupational Health

University of Missouri- St. Louis —St. Louis, MO 8/2012-5/2014
Bachelor of Science - Psychology

Lake Land College — Mattoon, Illinois 8/2010-5/2012
Associates - Psychology