Biological sampling for GenX and other Per- and Polyfluoroalkyl Substances (PFAS)—North Carolina, 2018

Summary

What is the purpose of this report?
This report presents results of an investigation conducted to improve understanding of exposure to GenX and other PFAS among people living near a manufacturing facility in Bladen County, NC. It describes concentrations of 17 PFAS in the blood and urine of 30 people with evidence of exposure to GenX through their private drinking water wells.

What were the key findings?

- GenX was not detected in blood or urine from any of the 30 participants.
- Only one PFAS was detected in one participant's urine.
- Nine of 17 PFAS tested for were detected in blood samples of at least one of the 30 participants. The other eight were not detected in any of the blood samples. Four PFAS were detected in blood samples from all participants (PFHxS, n-PFOA, Sm-PFOS and n-PFOS).
- The median, or middle, levels of PFHxS and n-PFOS detected in participants were higher than the median levels found in the US population. Most PFAS were either not detected in blood or were detected at levels similar to available US population levels.

What do these findings mean?
These results help scientists better understand what is detectable in the blood and urine of North Carolina residents in this area and provide information that can be used to guide human exposure and health studies in the future.

Scientists do not know how long many of these chemicals stay in the body. We do not know how much of each chemical was in people's bodies a year ago or what may be there in the future.

While scientific research on PFAS is growing, these blood and urine test results cannot tell us:

- If a past or current health problem that an individual is experiencing is related to the PFAS levels found in their body.
- If the PFAS levels in an individual's body will make them sick now or later in life.
- How or where participants were exposed.
- Whether participants were exposed to other PFAS or other chemicals we did not test for.

What are the next steps?
The North Carolina Department of Health and Human Services (NCDHHS) is sharing this information with researchers who can use it to plan studies that can help us better understand PFAS exposures and health effects among North Carolina communities. NCDHHS will continue to update participants and the public as better information about health effects of these chemicals becomes available. Based on information shared during this investigation, NCDHHS will be administering a community survey to better understand how the community has been affected during the past year. NCDHHS plans to use information from the survey to better respond to the community's needs.

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Background

In June 2017, the North Carolina Department of Environmental Quality (NCDEQ) began investigating contamination of the Cape Fear River with "GenX" (perfluoro-2-propoxypropanoic acid) and other similar chemicals referred to as per- and polyfluoroalkyl substances (PFAS). The source of these chemicals is the Chemours (formerly DuPont) Fayetteville Works facility, a manufacturing facility located in Bladen County, NC. Although GenX has only been produced at this location since 2009, it may have been discharged into the Cape Fear River since 1980 as a byproduct of other processes.

Through their investigation, NCDEQ identified PFAS in surface water, groundwater, and air close to the Chemours facility and coordinated with Chemours to test private wells at homes close to the plant for GenX and other PFAS. As of April 2018, 837 private wells had been tested; 207 (25%) had GenX levels exceeding the North Carolina Department of Health and Human Services (NCDHHS) provisional drinking water health goal of 140 parts per trillion (ppt), with a maximum measured GenX concentration of 4,000 ppt.[1] Chemours began providing bottled water to residents living in homes with a well that exceeds the NCDHHS provisional drinking water health goal.

Following detection of these chemicals in their drinking water, residents raised questions about whether these chemicals were present in their bodies. In August of 2018, NCDHHS conducted a small exposure investigation to measure GenX and other PFAS in the blood[1] and urine of North Carolina residents whose private wells were found to contain the highest concentrations of GenX. This exposure investigation was conducted to better understand what is detectable in the blood and urine of North Carolina residents and provide information that can be used to guide human exposure and health studies in the future.

Methods

NCDHHS, the lead agency for this investigation, collaborated with the federal Agency for Toxic Substances and Disease Registry (ATSDR) and the Centers for Disease Control and Prevention (CDC); the Bladen and Cumberland County health departments; and NCDEQ to complete this investigation. NCDHHS worked with ATSDR and CDC staff to design this investigation and complete the laboratory analysis. NCDEQ provided a list of private wells that had been tested for GenX and the results. NCDHHS worked with the local health departments to interview participants and collect and process blood and urine samples according to CDC protocols.

Participant Recruitment

Thirty residents from Bladen and Cumberland Counties were invited to participate in this investigation. Using NCDEQ's list of private drinking water wells tested for GenX and other PFAS, NCDHHS identified households with the highest concentrations of GenX in their private wells. Up to two people, one adult and one child, living in each household were invited to participate. All participants had to be:

- at least 12 years of age or older;
- a full-time resident of the selected household since at least September 2016;
- able to provide written informed consent/parental permission to participate;
- able to safely provide a blood and urine sample; and,
- able to understand English.

[1]Blood serum was measured as part of this investigation and is referred to as "blood" throughout this report.

Previous or current employees of the Chemours Fayetteville Works facility or a facility known to use or manufacture PFAS were excluded from this investigation. Although occupational exposure to these chemicals is important to understand, this investigation focused specifically on environmental PFAS exposures.

Trained NCDHHS staff called potential participants to invite them to participate. NCDHHS staff made three attempts on different days and times to reach each household; one voicemail message was left when possible. If no contact was made after three attempts, NCDHHS staff moved to the next household. Eligible participants who were reached scheduled an appointment at their local health department to participate in the investigation.

Only NCDHHS project staff have access to information that can identify participants, and all private information is kept secured. All participants' personal identifying information (such as name, address, date of birth) is protected by North Carolina and federal law.

Informed Consent/Assent

Participants provided their consent (for adults) or assent (for minors) to participate by signing a form which described the procedures for participating, benefits and risks of participation, and provided contact information for health department staff (**Appendix A: Consent Form**). Participants also had the option to provide consent to have extra blood and urine from this investigation stored at the NC State Laboratory of Public Health (NC SLPH) to use in future investigations of PFAS exposure.

Questionnaire

NCDHHS staff interviewed all participants using a questionnaire to gather information about drinking water consumption and sources, length of time living in the area, and demographic information (e.g., age). Participants were also asked about their occupational or school history; the frequency with which they work or play in the soil; and consumption of local fruits, vegetables, or fish (**Appendix B: Adult & Minor Questionnaires**).

Blood & Urine Sampling

Participants allowed health department staff to collect approximately 10 milliliters (mL) of blood. Blood samples were labeled and processed in accordance with CDC protocols. Samples were allowed to clot for 30 minutes–1 hour at room temperature and then were centrifuged for 15 minutes at 1000–1300 g-force to separate the serum. Laboratory staff transferred approximately 1.8 mL of serum from each participant's tube into a 2 mL cryovial or tube provided by CDC; this was done twice to create two blood serum specimens per person.

Participants also provided a urine sample. Urine collection containers were labeled, capped, and sealed in a plastic bag. Local health department laboratory staff processed samples according to CDC guidance and transferred approximately 1.8 mL of urine from each participant's collection container into a 2 mL cryovial or tube; this was done twice to create two urine specimens per person

All cryovials and the leftover urine samples were stored in a freezer at or below -20°C and transported on dry ice from the local health departments to the NC SLPH through the state courier system. At the conclusion of the investigation, blood and urine samples were shipped to the laboratory at the National Center for Environmental Health, part of CDC, in Atlanta, Georgia.

For those who provided permission, NC SLPH continues to store leftover blood and urine samples.

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Laboratory Analysis

CDC tested blood samples for 17 PFAS (Table 2) that they have validated methods for. Urine samples were tested for all the PFAS listed in Table 2 except for MeFOSAA, which there is no available laboratory method to measure in urine. Urine was also tested for creatinine, which is a measure of how concentrated the urine is. PFAS test results were reported as micrograms of the analyte per liter of blood or urine (µg/L). All laboratory analysis was conducted using described CDC laboratory methods and established procedures for quality assurance and control.[3] CDC will dispose of any leftover blood and urine sent to them within one year of the end of this investigation.

Table 2. List of measured PFAS and their abbreviations.

PFAS	Abbreviation[‡]
2,3,3,3,-tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoate	GenX
perfluorobutane sulfonic acid	PFBS
perfluorohexanoic acid	PFHxA
perfluorobutanoic acid	PFBA
perfluoroheptanoic acid	PFHpA
perfluoropentanoic acid	PFPeA
4,8-dioxa-3H-perfluorononanoate	ADONA
9-chlorohexadecafluoro-3-oxanonane-1-sulfonate	9Cl-PF3ONS
2-(N-methyl-perfluorooctane sulfonamido) acetic acid	MeFOSAA
perfluorohexane sulfonic acid	PFHxS
n-perfluorooctanoic acid	n-PFOA
branched perfluorooctanoic acids	Sb-PFOA
perfluorodecanoic acid	PFDA
perfluoroundecanoic acid	PFUnDA
perfluoromethylheptane sulfonic acids (methyl branched PFOS)	Sm-PFOS
n-perfluorooctane sulfonic acid	n-PFOS
perfluorononanoic acid	PFNA

[‡]Abbreviations listed here are those commonly used by scientists. Six of these abbreviations differ from those reported in results letters sent to participants. Abbreviations used in results letters were taken directly from CDC results files. Differences include: PFBUS → PFBS; NADONA → ADONA; 9Cl-PF → 9Cl-PF3ONS; Me-PFOSA-ACOH2 → MeFOSAA; PFDEA → PFDA; PFUA → PFUnDA.

Data and Statistical Analysis

NCDHHS staff calculated median (middle), minimum, and maximum PFAS levels found among all participants. These estimates were compared to PFAS levels found in the general US population during 2013–2014 when available. Levels for the general US population were determined as part of the National Health and Nutrition Examination Survey (NHANES), a CDC program that collects information from a nationally representative sample of about 5,000 persons (age 12 and over) each year. Levels of PFAS in urine of the general US population are not available as PFAS were not measured in urine in the 2013–2014 NHANES.

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NCDHHS staff also examined participants' current drinking water source and the number of participants reporting activities such as playing or working in soil; gardening; hunting; and eating local produce, meat, and eggs.

Results

Participant Characteristics

Among the 30 participants, half were male, 25 were adults, and all had lived in the county for at least 10 years (Table 3). Participant's private wells had an average GenX concentration of 680 ppt. All participants reported using bottled water as their current main source of drinking water; the average length of time relying on bottled water was approximately 9 months.

Table 3. Characteristics of investigation participants—North Carolina, 2018

	n=30	%
Gender		
Male	15	50
Female	15	50
Age		
<18 years old	5	17
18-64 years old	15	50
≥65 years old	10	33
Years living in county		
10-19 years	8	27
20-29 years	5	17
30-39 years	4	13
≥40 years	13	43

During the interviews, few people reported consuming locally sourced fish (n=7; 23%) or eggs, poultry, meat or wild game (n=10; 33%) (Table 4). Most people reported eating vegetables or fruit grown in their home garden or a garden close to their home (n=20; 67%). Seven participants reported that they either did not have a garden this year or lessened their consumption of local fruits and vegetables—many attributed those changes to their concerns about GenX. Most people also reported spending time working or playing outdoors around their homes (n=24; 80%).

Table 4. Selected questionnaire results of participants in North Carolina (n=30)

	n	%
Bottled water as current drinking water source	30	100
Consumed locally sourced products		
Fish	7	23
Eggs, poultry, meat or wild game	10	33
Fruits and Vegetables	20	67
Spent time working or playing outdoors	24	80

PFAS Levels

GenX and 7 other PFAS were not detected in blood or urine of participants (Table 5). The following 9 PFAS were detected in blood from at least one participant: PFHpA, MeFOSAA, PFHxS, n-PFOA, PFDA, PFUnDA, Sm-PFOS, n-PFOS, and PFNA. Four PFAS were detected in blood from all participants: PFHxS, n-

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PFOA, Sm-PFOS, and n-PFOS. The median, or middle, blood concentrations of n-PFOA, PFDA, Sm-PFOS, and PFNA were similar to or lower than the US general population. Median blood concentrations of PFHxS and n-PFOS were higher than the median concentrations in the general US population. However, most participants' PFHxS and n-PFOS levels were lower than the 95th percentile found in the general US population (Figure 1).

Appendix C shows the distribution of all PFAS detected in the blood of participants. PFAS levels did not appear to differ among participants by gender, age, or length of time living in the county.

One PFAS, PFHxA, was detected in one participant's urine sample at a level close to the lowest level able to be detected, or limit of detection (LOD); otherwise the 16 PFAS tested in urine were not detected (Table 5).

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Table 5. Summary of PFAS levels found in blood of investigation participants in North Carolina (n=30) and in the US population.

		North Carolina Residents (n = 30)			US population[a]	
PFAS	**LOD**	**Median**	**Minimum**	**Maximum**	**Median**	**95th Percentile[b]**
Blood	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
GenX	0.1		Not detected		Not measured	
PFBS	0.1		Not detected		—	—
PFHxA	0.1		Not detected		Not measured	
PFBA	0.1		Not detected		Not measured	
PFHpA	0.1	—	—	0.6	—	0.2
PFPeA	0.1		Not detected		Not measured	
ADONA	0.1		Not detected		Not measured	
9Cl-PF3ONS	0.1		Not detected		Not measured	
MeFOSAA	0.1	—	—	0.6	—	0.6
PFHxS	0.1	2.1	0.7	6.7	1.4	5.6
n-PFOA	0.1	1.75	0.4	7.3	1.9	5.3
Sb-PFOA	0.1		Not detected		—	0.2
PFDA	0.1	0.15	—	1.3	0.2	0.7
PFUnDA	0.1	—	—	0.5	—	0.5
Sm-PFOS	0.1	1.2	0.2	7.4	1.5	5.1
n-PFOS	0.1	5.4	1.4	34.6	3.5	14
PFNA	0.1	0.6	—	2.1	0.7	2.0
Urine						
GenX	0.1		Not detected		Not measured	
PFBS	0.1		Not detected			
PFHxA	0.1	—	—	0.4		
PFBA	0.1		Not detected			
PFHpA	0.1		Not detected			
PFPeA	0.1		Not detected			
ADONA	0.1		Not detected			
9Cl-PF3ONS	0.1		Not detected			
PFHxS	0.1		Not detected			
n-PFOA	0.1		Not detected			
Sb-PFOA	0.1		Not detected			
PFDA	0.1		Not detected			
PFUnDA	0.1		Not detected			
Sm-PFOS	0.1		Not detected			
n-PFOS	0.1		Not detected			
PFNA	0.1		Not detected			

Dashed line (—) = less than the limit of detection; µg/L = micrograms per liter of urine; LOD = limit of detection

[a] Source: CDC. The National Report on Human Exposure to Environmental Chemicals, Updated Tables, March 2018. Available at: https://www.cdc.gov/exposurereport.

[b]The 95th percentile is the level that 95% of people tested were at or below.

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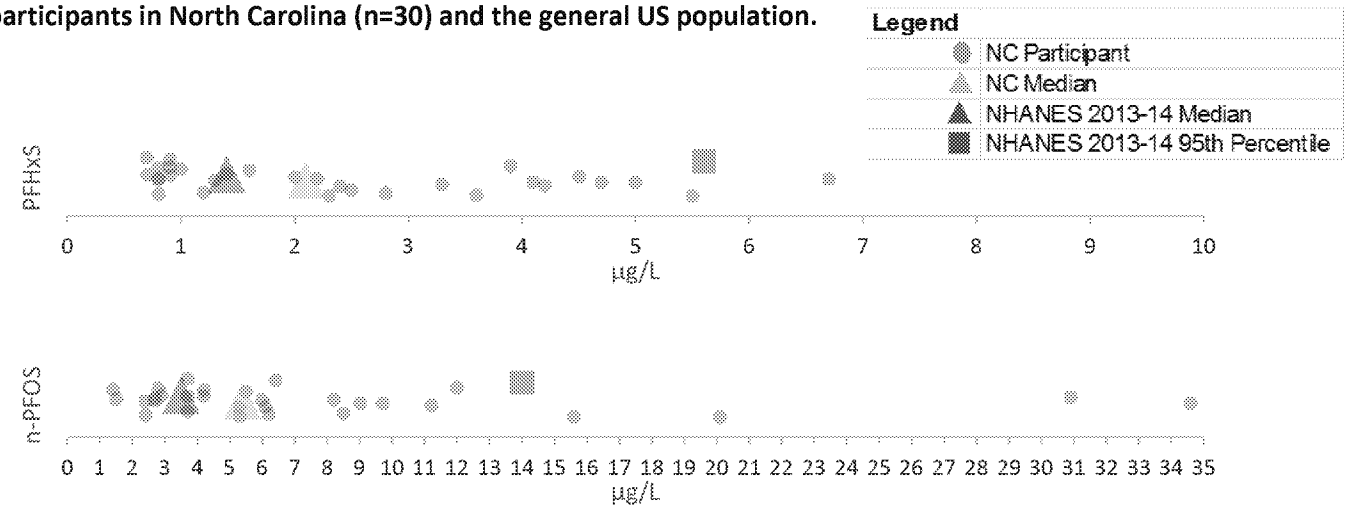
Figure 1. Distribution of PFHxS (top) and n-PFOS (bottom) levels found in blood of investigation participants in North Carolina (n=30) and the general US population.



Conclusions

In this limited exposure investigation, most of the PFAS measured were either not detected or were detected at levels similar to available US population levels. Importantly, GenX was not detected in blood or urine from any of the 30 participants. Although GenX was not detected, people have still been exposed in the past through drinking water from private wells. These results may indicate that GenX doesn't stay in the body for a long period of time since all participants had stopped using their well water for drinking.

Nine older, or legacy, PFAS were detected in participants' blood and one older PFAS was detected in one participant's urine. Most of these PFAS were at levels similar to those found in the general US population. Median levels of PFHxS and n-PFOS were higher in participants than the US population. These PFAS tend to stay in people's bodies for a long period of time. Therefore, it is unclear if this indicates there is an ongoing source of exposure to these PFAS or if people were exposed in the past.

Most people in the general US population have measurable levels of some PFAS in their body because these PFAS have been used in many consumer products. However, levels have been going down over time in the US based on NHANES data collected since 1999.[4]

The levels of PFAS detected in blood and urine in this investigation cannot be directly compared to drinking water health advisories or goals or levels found in participant's drinking water. Relating drinking water concentrations to levels found in the body requires complex modeling of how these compounds move through the body, which is not available for most PFAS.

There are four main limitations to this investigation.

- We did not have the ability to test for all PFAS that people may be exposed to in these communities.
- PFAS concentrations measured in this investigation are only representative of the levels in people's blood and urine at the time of sampling. They cannot tell us what may have been in people's blood or urine in the past.

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- PFAS concentrations measured in this investigation cannot be used to predict the occurrence of disease in the community or for an individual and cannot explain an individual's current or future health problems.
- The results of this investigation are applicable only to the individuals tested and may not be representative of levels of PFAS in people throughout the entire community or in other populations.

Despite these limitations, these results improve our understanding of PFAS exposure in this community. The results of this investigation help scientists describe PFAS exposure and pathways of exposure among these participants and provide information needed for human exposure and health studies to be done in the future. NCDHHS will continue to update participants and the public as new reference levels for these chemicals become available. NCDHHS is aware of and continuing to follow the ongoing GenX Exposure Study led by North Carolina State University.

This investigation was an important step in helping answer questions from the affected communities in North Carolina. As part of the interview process, participants indicated how learning of GenX and other PFAS in their community had impacted their daily lives, including no longer gardening. To better understand these impacts across the entire community, NCDHHS plans to administer a community survey. This survey will provide NCDHHS with information about how the community has been affected during the past year and the community's concerns. Information from this survey will allow NCDHHS to better respond to the community's needs.

References

1. North Carolina Department of Environmental Quality. GenX Investigation. Accessed at: https://deq.nc.gov/news/hot-topics/genx-investigation.

2. Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention. Perfluoroalkyl and polyfluoroalkyl substances exposure assessment technical tools. May 2017.

3. Kato K, Kalathil A, Patel A, Ye X, and Calafat A. Per- and polyfluoroalkyl substances and fluorinated alternatives in urine and serum by on-line solid phase extraction—liquid chromatography—tandem mass spectrometry. *Chemosphere*. 2018. 209: 338–345.

4. CDC. The National Report on Human Exposure to Environmental Chemicals, Updated Tables, March 2018. Available at: https://www.cdc.gov/exposurereport.

Where Can I Learn More?

To learn more about PFAS and NC DHHS' activities:
https://epi.publichealth.nc.gov/oee/a_z/pfas.html

To learn more about NC DEQ's ongoing investigation at the Chemours' Fayetteville Works Facility:
https://deq.nc.gov/news/hot-topics/genx-investigation

To learn more about PFAS:
https://www.atsdr.cdc.gov/pfas/index.html
https://www.epa.gov/pfas

To learn more about biomonitoring in general, watch this short video:
"What is biomonitoring?": https://vimeo.com/280827005

Who Can I Contact if I Have Questions?

- For questions about your health, we recommend that you contact your healthcare provider.
- For questions about this report or about PFAS and your health, please contact the Occupational and Environmental Epidemiology Branch at (919) 707-5900.

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Appendix A
Consent Form

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NC DEPARTMENT OF
HEALTH AND
HUMAN SERVICES

ROY COOPER • Governor
MANDY COHEN, MD, MPH • Secretary
DANNY STALEY • Director, Division of Public Health

Project Name: Biological Sampling for GenX and other Per- and Polyfluoroalkyl Substances (PFAS) — Cumberland and Bladen Counties, North Carolina

Adult Consent Form

The North Carolina Department of Health and Human Services (DHHS) is doing an investigation of exposures to chemicals called PFAS. That stands for per- and polyfluoroalkyl substances. PFAS are chemicals that are used in many ways in the United States and are found in the environment (in the air, soil, and water). Some PFAS can stay in the human body for years. Scientists are still learning how PFAS may affect people's health.

This investigation is being done following detection of PFAS chemicals in the drinking water supply where you live. The main goal for this investigation is to find out how much GenX and other PFAS is in the blood and urine of people in your community who may have drunk water that had GenX and other PFAS in it, and to see how these levels compare to people in other parts of the country. The North Carolina Department of Health and Human Services (DHHS) will conduct this investigation during Summer 2018.

This form contains information about this investigation and what will happen if you decide to participate. If you agree to take part in this investigation, please sign at the end of the form. If you have any questions about this form, please don't hesitate to ask. Thank you for considering participating.

Who is conducting this investigation?

The NC DHHS will conduct this exposure investigation along with the Bladen and Cumberland County Health Departments during Summer 2018. The Centers for Disease Control and Prevention (CDC) will test the blood and urine samples at their laboratory.

What will I have to do to participate?

Participation in this exposure investigation is completely voluntary. If you decide to participate, you are free to quit the investigation at any time. There is no penalty if you choose not to participate or if you want to stop participating at any time. If project staff decide it is in your best interest, or if you fail to meet the investigation requirements, you may be removed from the exposure investigation without your consent.

To participate, we will ask you to give us a blood sample. A phlebotomist or nurse will draw a small amount of your blood for testing (about 2 teaspoons). We will also ask you to give us a urine sample. We will label your samples with a code and date of collection. Only the project team will be able to identify which samples are yours. We will then ask you to answer a few questions about yourself, where you live, and your drinking water; the questionnaire should take less than 20 minutes to complete. And, you can skip any questions you do not want to answer.

What will you test my blood and urine for?

We will send your blood and urine samples to the CDC to measure the levels of 17 PFAS including GenX. Your urine sample will be tested for 8 PFAS (including GenX), and your blood sample will be tested for 9 PFAS (not including GenX). Blood and urine samples will be tested for different PFAS because scientists developing these laboratory methods have found that some PFAS are more likely to be found in blood and some in urine. The type of sample a PFAS is likely to be found in is dependent on each PFAS's chemical structure and how quickly it is eliminated from the body. Because of the chemical structure of GenX it is thought to be eliminated from the body through urine more quickly than other PFAS. Therefore, CDC plans to test urine samples for GenX. Some of the other PFAS are thought to stay in the body longer, and because of this are more likely to show up in blood. Based on the initial results of blood and urine testing, CDC may decide to test both samples for any of the 17 PFAS.

Your urine sample will also be tested for creatinine, a measure of how concentrated your urine is. Blood samples will not be tested for anything other than PFAS; urine samples will not be tested for anything other than PFAS and creatinine. There will be no charge to you for the blood draw, urine collection, or the laboratory analysis. Any blood and urine that is not needed for the measurements will be kept for up to one year after the exposure investigation is over. CDC will keep the extra blood and urine during this time in case the laboratory needs to repeat the test to check your results. Your blood and urine samples will be destroyed after the investigation is over unless you give us permission to save them longer.

What will NC DHHS do with the results of this investigation?

At the end of the exposure investigation, we will send you your blood and urine test results by mail and be available to answer questions. If you would like to talk with a physician about your results, one working on the exposure investigation will be available to you free of charge. The NC DHHS will summarize the blood and urine levels of GenX and other PFAS from all investigation participants. NC DHHS will share the summary of GenX and other PFAS results with the public through presentations and written materials. NC DHHS will also share summary results with the scientific community through publications. Upon request, NC DHHS may share de-identified data from this investigation with other state and federal partners involved in investigating PFAS exposures. Your personal information will not be shared publicly or with other agencies.

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What are the risks of participating?
This exposure investigation requires you to give a small amount of blood. You may feel a sharp sting from the needle used to draw your blood. Sometimes a bruise or small blood clot appears at the site. These bruises or clots usually go away on their own. Putting heat on the site can also help the bruise or clot to go away. Although it is not common, the needle could cause temporary damage to a nerve. This nerve damage can cause numbness in part of the arm.

Risk of injury from the blood draw is higher for people with bleeding disorders, and for anyone on blood thinning medications (such as Coumadin) and other therapies. If you have a bleeding disorder or are taking blood thinning medication, we recommend that you talk to your doctor before participating. Infection could also develop because of the puncture through the skin. You or your health insurance company would be responsible for any follow-up care if you are injured while participating in this investigation.

If you participate in this investigation, you will receive information about the levels of GenX and other PFAS in your blood and urine along with how your levels compare to levels in other people. Some people may feel worried or anxious about their results. There is little we can tell you about what your results mean for your individual health. Exposure investigation of PFAS and how they relate to health in people is not clear at this time, and we do not yet know enough to say whether there are levels in the body that are safe or unsafe.

What are the benefits of participating?
Your participation in this investigation will provide you with information about levels of GenX and other PFAS in your body, help us understand the levels of GenX and other PFAS in the blood and urine of people in your community, and see how your levels compare to other communities that have been tested. Your participation will also help us better understand possible exposure sources in your community. This information will help advance research about PFAS exposure and associated health effects.

From this investigation, we will not be able to tell you if the PFAS levels in your blood will make you sick now or later in life. You will be able to call project staff during and after the investigation if you have questions about your results. If your doctor has questions about GenX or other PFAS, he or she may also call project staff or the physician working on the investigation. The names and phone numbers of people to call are listed below.

What about my privacy?
All personal identifying information (such as name, address, date of birth) gathered for the exposure investigation is private. This information is protected by North Carolina and federal law. Only project staff will have access to information that can identify you, and we will keep private information in a secure, locked database or file at all times. Aside from the NC DHHS exposure investigation team, you are the only one who will receive your individual results.

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What if I have questions later?
We will give you a copy of this form to keep. If you have questions, concerns, or complaints about this investigation, please contact:

Jess Rinsky, PhD, MPH
Epidemiologist
Division of Public Health
NC Department of Health and Human Services
P: 919-707-5900
Email: jess.rinsky@dhhs.nc.gov

Rick Langley, MD, MPH
Physician
Division of Public Health
NC Department of Health and Human Services
P: 919-707-5900
Email: rick.langley@dhhs.nc.gov

If you are interested in participating in this investigation, please complete the following form.

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Project Name: Biological Sampling for GenX and other Per- and Polyfluoroalkyl Substances (PFAS) — Cumberland and Bladen Counties, North Carolina

By marking the check boxes below and signing this form, you are confirming that you understand the goals of the exposure investigation, and that you agree, of your own free will, to participate. You are also confirming you will allow the project staff to collect, store, and share the information gathered for the exposure investigation as described above. You will receive a copy of this form for your records.

I agree to participate in the NC DHHS Exposure Investigation.
☐ Yes ☐ No

I understand that I will receive my blood and urine test results by mail.
☐ Yes ☐ No

I understand that project staff will not be able to determine if the PFAS levels in my blood will impact my health.
☐ Yes ☐ No

I agree that project staff can contact me in the future with updates about this investigation.
☐ Yes ☐ No

Project Coordinator's Name:_____
(Printed)

Project Coordinator's Signature:_____

Participant's Name:_____
(Printed)

Participant's Signature:_____

Date Signed: _ _ / _ _ / _ _ _ _

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Are you interested in supporting additional exposure investigations in your community?
It is possible that your blood and urine samples may be useful in other exposure investigations conducted in your community. By marking the check boxes and signing below, you give us permission to save any leftover blood and urine collected as part of this investigation to use in future investigations of PFAS exposure, and to contact you to ask your permission to test your sample for other PFAS in the future. The leftover blood and urine will be saved at the North Carolina State Laboratory of Public Health until no longer viable. We will contact you before testing your samples for other PFAS. And, we will not test your samples for anything other than PFAS.

I give permission for my blood and urine samples to be saved for additional testing in the future.
☐ Yes ☐ No

I give permission for the NC DHHS investigation team to contact me to ask permission to analyze my specimens for PFAS in the future.
☐ Yes ☐ No

Project Coordinator's Name:_____
(Printed)

Project Coordinator's Signature:_____

Participant's Name:_____
(Printed)

Participant's Signature:_____

Date Signed: _ _ / _ _ / _ _ _ _

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Appendix B
Adult & Minor Questionnaires

ED_005565_00003709-00018

NC DHHS PFAS EXPOSURE QUESTIONNAIRE – ADULT PARTICIPANT

LABEL

Interviewer: _____

Date: _ _/_ _/_ _ _ _

Time: _ _:_ _ am / pm

Good Morning/Afternoon.

Thank you for talking with me today.

I would like to ask you some questions about you and where you live. The questions will take about 20 minutes to answer. Your individual answers will be confidential and will not be shared with anyone. We will combine your answers with those of other participants to more accurately interpret levels of GenX and other PFAS detected in blood and urine among all participants.

You are not required to participate in this interview. If you chose to participate, you can skip any questions you do not want to answer. Again, all of your answers will be kept confidential; no one else will see your individual answers.

Are you willing to participate in this interview? *(circle one)*

- ☐ Yes
- ☐ No

If no, ask the person why they do not wish to participate and record the reason, if they provide one, in the space below. Whether they provide a reason or not, thank them for their time.

Notes:

_____

_____

_____

_____

_____

Section A: Demographic Information

First, I will ask you some questions about you. Please remember you can chose not to answer any questions you do not want to answer.

1. Do you consider yourself… (*Interviewer: Read the choices aloud)*
   - ☐ Male
   - ☐ Female
   - ☐ Other *Please specify:* _____
   - ☐ Refused

2. Do you consider yourself to be Hispanic, Latino, or of Spanish origin?
   - ☐ Yes
   - ☐ No
   - ☐ Part (e.g., one parent)
   - ☐ Don't know
   - ☐ Refused

3. How would you describe your race? (*select all that apply*)
   - ☐ American Indian or Alaska Native
   - ☐ Asian
   - ☐ Black/African American
   - ☐ Native Hawaiian/Pacific Islander
   - ☐ White
   - ☐ Other _____
   - ☐ Don't know
   - ☐ Refused

4. How old are you? _____

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Section B: Exposure Assessment

The following questions will be about your home and drinking water. You might need time to think about some of your answers. Take your time and feel free to let me know if you need me to explain the question or open a calendar for you to look at.

5. How long have you lived in {Bladen/Cumberland} County?

   _ _ years _ _ months ☐ Don't know ☐ Refused

6. How long have you lived at your current home in {Bladen/Cumberland} County (the home where your well was tested for GenX)?

   _ _ years _ _ months ☐ Don't know ☐ Refused

7. What is your current, main source of drinking water at home?
   - ☐ Private well
   - ☐ Community well
   - ☐ Bottled water
   - ☐ Other *(Please describe)* _____
   - ☐ Don't know
   - ☐ Refused

8. When did you begin using this drinking water source? _ _ (month) _ _ _ _ (year)

9. Have you previously used another main source of drinking water at home?
   - ☐ Yes
   - ☐ No → *Skip to Q12*
   - ☐ Don't know → *Skip to Q12*
   - ☐ Refused → *Skip to Q12*

10. What was your previous source of drinking water at home?
    - ☐ Private well
    - ☐ Community well
    - ☐ Bottled water
    - ☐ Other *(Please describe)* _____
    - ☐ Don't know → *Skip to Q12*
    - ☐ Refused → *Skip to Q12*

11. When did you begin using your previous main drinking water source?

    _ _ (month) _ _ _ _ (year) ☐ Don't know ☐ Refused

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12. On average, how many 8 oz cups of water or beverages prepared with water do you drink per day (e.g., coffee, tea)?

    _ _ 8 oz cups ☐ Didn't drink ☐ Refused

    NOTE: 1 cup = 8 oz; 2 cups = 1 pint (16 oz); 4 cups = 1 quart (32 oz); 16 cups = 1 gallon (128 oz)

13. Are you currently using water filters or treatment device(s) for your tap water?
    - ☐ Yes
    - ☐ No → *Skip to Q16*
    - ☐ Don't know → *Skip to Q16*
    - ☐ Refused → *Skip to Q16*

14. What type of water filter or treatment device(s) are you currently using to filter or treat the water you drink? (*Select all that apply*)
    - ☐ Whole house carbon filter
    - ☐ Faucet filter
    - ☐ Refrigerator filter
    - ☐ Under the sink carbon filter
    - ☐ Pitcher filter
    - ☐ Reverse osmosis (RO) system
    - ☐ Other, specify: _____
    - ☐ Don't know
    - ☐ Refused
    - ☐ Not applicable

15. How long have you been using water filters or treatment device(s) for your tap water?

    _ _ (month) _ _ _ _ (year) ☐ Don't know ☐ Refused

16. What source of water do you currently use to make ice in your home?
    a. Private well
    b. Community well
    c. Bottled water
    d. Other *(Please describe)* _____
    e. Don't know
    f. Refused

Now, I am going to ask you a few questions about other activities you may do in your community or around your home. It's important to note that, at this time, we do not know if any of the following activities are sources of exposure to GenX or other PFAS in your community.

17. How frequently do you work or play in the soil (e.g., gardening, digging, farming, building, repairing) at or close to your home?
    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never → *Skip to Q19*
    - ☐ Don't know → *Skip to Q19*
    - ☐ Refused → *Skip to Q19*

18. Where do you work or play in soil? (*Interviewer: list all locations; please provide addresses if possible*)

    _____

    _____

    _____

    ☐ Don't know ☐ Refused

19. During the summer, how often do you eat vegetables or fruit grown in your home garden, or a garden close to your home?
    - ☐ Every day
    - ☐ Several times per week
    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never → *Skip to Q21*
    - ☐ Don't know → *Skip to Q21*
    - ☐ Refused → *Skip to Q21*

20. What types of locally-grown vegetables or fruits do you typically eat (list all types)?

_____

_____

_____

☐ Don't know ☐ Refused

21. How often do you eat fish locally caught from ponds, lakes, or rivers in Bladen or Cumberland Counties or the Lower Cape Fear Region?
    - ☐ Every day
    - ☐ Several times per week
    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never
    - ☐ Don't know
    - ☐ Refused

22. How often do you consume milk from animals raised on or near your property?
    - ☐ Every day
    - ☐ Several times per week
    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never
    - ☐ Don't know
    - ☐ Refused

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23. How often do you consume eggs, poultry, meat or wild game raised or hunted on or near your property?
    - ☐ Every day
    - ☐ Several times per week
    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never
    - ☐ Don't know
    - ☐ Refused

Section C: Adult Females Only

In this section, I am going to ask you questions about pregnancy and breast feeding. We are asking about these events in your life because pregnancy and breast feeding can affect the amount of water you drink and may affect the amount of GenX and other PFAS that are detectable in your blood or urine. You might need time to think about some of your answers. Take your time and let me know if you need me to explain the question or open a calendar for you to look at. Please remember you can chose not to answer any questions you do not want to answer.

24. Are you currently pregnant?
    - ☐ Yes
    - ☐ No
    - ☐ Don't know
    - ☐ Refused

25. How many total pregnancies have you carried to term?
    Interviewer: a pregnancy carried to term would be one that ended in either a live or still birth. This includes babies that were born preterm or premature. Miscarriages and abortions are not included as a pregnancy carried to term.

    _ _ total pregnancies carried to term

    - ☐ Never been pregnant → *Skip to Q30*
    - ☐ Don't know →*Skip to Q27*
    - ☐ Refused →*Skip to Q27*

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26. Please tell me the following information about each of your pregnancies carried to term.

Pregnancy	Month ended	Year ended
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

27. Are you currently breastfeeding or expressing breast milk?
    - ☐ Yes
    - ☐ No
    - ☐ Don't know
    - ☐ Refused

28. Have you ever breastfed or expressed breast milk?
    - ☐ Yes
    - ☐ No → *Skip to Q30*
    - ☐ Don't know → *Skip to Q30*
    - ☐ Refused → *Skip to Q30*

29. During your lifetime, how many months total have you breastfed or expressed breast milk?

    _ _ months

    - ☐ Don't know
    - ☐ Refused

30. Have you completed menopause?
    - ☐ Yes
    - ☐ No → *Skip to Section D*
    - ☐ Don't know → *Skip to Section D*
    - ☐ Refused → *Skip to Section D*

31. If yes, how old were you when you completed menopause? _ _ years
    - ☐ Don't know
    - ☐ Refused
    - ☐ Not applicable

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Section D: Occupational History

Now, I will ask you some questions about where you work or have worked in the past.

32. Have you ever worked in any of the following industries? *(Read and select all that apply)*
    - ☐ Manufacturing of nonstick cookware such as Teflon® coated pots/pans
    - ☐ Manufacturing of stain resistant coatings (e.g., Scotchguard®) used on carpets, upholstery, and other fabrics
    - ☐ Manufacturing of water resistant clothing (e.g., Gore-Tex®)
    - ☐ Never worked in the industries listed above

33. Have you ever worked as a firefighter?
    - ☐ Yes
    - ☐ No
    - ☐ Don't know
    - ☐ Refused

34. What kind of work do you currently do, for example, registered nurse, janitor, cashier, auto mechanic?

_____

35. Where do you currently work? *You can tell us the county, city, or name of your place of work.*

_____

If the participant never worked in the industries listed in Q30 and was not a firefighter, skip to Section E.

36. Please tell me the following information about the time you worked in the industries you mentioned above, or when you were a firefighter.

Company Name	Job Title	Brief Description	Year Started	Year Ended

Section E: Comments/Questions

37. We have reached the end of the survey. Do you have any comments or questions you would like to share with me today?
    Record any comments or questions in the space below.

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    Thank you for your time. If you have questions after you leave here, please use the information on your consent form to contact us and we will do our best to answer them.

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NC DHHS PFAS EXPOSURE QUESTIONNAIRE – MINOR PARTICIPANT

Interviewer: _____

Date: _ _/_ _/_ _ _ _

Time: _ _:_ _ am / pm

LABEL

Good Morning/Afternoon.

Thank you for talking with me today.

I would like to ask you some questions about you and where you live. The questions will take about 20 minutes to answer. Your answers will be kept private and will not be shared with anyone. We will combine your answers with answers from other participants to help understand levels of GenX and other PFAS found in the blood and urine samples you are giving us today.

You do not have to talk to me today if you don't want to. If you agree to talk to me, you can skip any questions you do not want to answer. Again, all of your answers will be kept private; no one else will see your individual answers.

Are you willing to talk with me today? *(circle one)*

- ☐ Yes
- ☐ No

If no, please ask the person why they do not wish to participate and record the reason, if they provide one, in the space below. Whether they provide a reason or not, thank them for their time.

Notes:

_____

_____

_____

_____

_____

Section A: Demographic Information

First, I will ask you some questions about you. Please remember you can chose not to answer any questions you do not want to answer.

1. Do you consider yourself/your child… (*Interviewer: Read the choices aloud)*
   - ☐ Male
   - ☐ Female
   - ☐ Other *Please specify:* _____
   - ☐ Refused

2. Do you consider yourself/your child to be Hispanic, Latino, or of Spanish origin?
   - ☐ Yes
   - ☐ No
   - ☐ Part (e.g., one parent)
   - ☐ Don't know
   - ☐ Refused

3. Which one or more of the following would you say is your/your child's race? (*select all that apply*)
   - ☐ American Indian or Alaska Native
   - ☐ Asian
   - ☐ Black/African American
   - ☐ Native Hawaiian/Pacific Islander
   - ☐ White
   - ☐ Don't know
   - ☐ Refused

4. How old are you/is your child? _____

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Section B: Exposure Assessment

The following questions will be about the water you drink at home. You might need time to think about some of your answers. Take your time and feel free to let me know if you need me to explain the question or open a calendar for you to look at.

5. How long have you/has your child lived in {Bladen/Cumberland} County?

   _ _ years _ _ months ☐ Don't know ☐ Refused

6. How long have you/has your child lived at your current home in {Bladen/Cumberland} County, the home where GenX was found in your well?

   _ _ years _ _ months ☐ Don't know ☐ Refused

7. What is your/your child's current, main source of drinking water at home?
   - ☐ Private well
   - ☐ Community well
   - ☐ Bottled water
   - ☐ Other *(Please describe)* _____
   - ☐ Don't know
   - ☐ Refused

8. When did you/your child begin using this drinking water source?

   _ _ (month) _ _ _ _ (year)

9. Have you/your child previously used another source of drinking water at home?
   - ☐ Yes
   - ☐ No → *Skip to Q12*
   - ☐ Don't know → *Skip to Q12*
   - ☐ Refused → *Skip to Q12*

10. What was you/your child's previous source of drinking water at home?
    - ☐ Private well
    - ☐ Community well
    - ☐ Bottled water
    - ☐ *(Please describe)* _____
    - ☐ Don't know → *Skip to Q12*
    - ☐ Refused → *Skip to Q12*

11. When did you/your child begin using your previous drinking water source?

    _ _ (month) _ _ _ _ (year) ☐ Don't know ☐ Refused

12. On average, how many 8 oz cups of water or beverages prepared with water did you/your child drink per day?

    _ _ 8 oz cups ☐ Didn't drink ☐ Refused

    NOTE: 1 cup = 8 oz; 2 cups = 1 pint (16 oz); 4 cups = 1 quart (32 oz); 16 cups = 1 gallon (128 oz)

13. Are you/Is your child currently using water filters or treatment device(s) for your tap water?
    - ☐ Yes
    - ☐ No → *Skip to Q16*
    - ☐ Don't know → *Skip to Q16*
    - ☐ Refused → *Skip to Q16*

14. Which water filter or treatment device(s) are you/is your child currently using to filter or treat the water you drink? (*Select all that apply*)
    - ☐ Whole house carbon filter
    - ☐ Faucet filter
    - ☐ Refrigerator filter
    - ☐ Under the sink carbon filter
    - ☐ Pitcher filter
    - ☐ Reverse osmosis (RO) system
    - ☐ Other, specify: _____
    - ☐ Don't know
    - ☐ Refused
    - ☐ Not applicable

15. How long have you/has your child been using water filters or treatment device(s) for your tap water?

    _ _ (month) _ _ _ _ (year) ☐ Don't know ☐ Refused

16. What source of water do you currently use to make ice in your home?
    - ☐ Private well
    - ☐ Community well
    - ☐ Bottled water
    - ☐ Other *(Please describe)* _____
    - ☐ Don't know
    - ☐ Refused

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Now, I am going to ask you a few questions about other activities you may do in your community or around your home. It's important to note that, right now, we do not know if any of the following activities are sources of exposure to GenX or other PFAS in your community.

17. How frequently do you/does your child work or play in the soil (e.g., gardening, digging, farming, building, repairing) at or close to your home?

    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never → *Skip to Q19*
    - ☐ Don't know → *Skip to Q19*
    - ☐ Refused → *Skip to Q19*

18. Where do you/does your child work or play (list all locations; please provide addresses if possible)?

    _____

    _____

    _____

    ☐ Don't know ☐ Refused

19. During the summer, how often do you/does your child eat vegetables or fruit grown in your home garden, or a garden close to your home?

    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never → *Skip to Q21*
    - ☐ Don't know → *Skip to Q21*
    - ☐ Refused → *Skip to Q21*

20. What types of locally-grown vegetables or fruits do you/does your child typically eat (list all types)?

_____

_____

_____

☐ Don't know ☐ Refused

21. How often do you/does your child eat fish locally caught from ponds, lakes, or rivers in Bladen or Cumberland Counties or the Lower Cape Fear Region?
    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never
    - ☐ Don't know
    - ☐ Refused

22. How often do you/does your child consume milk from animals raised on or near your property?
    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never
    - ☐ Don't know
    - ☐ Refused

23. How often do you/does your child consume eggs, poultry, meat or wild game raised or hunted on or near your property?
    - ☐ Every day
    - ☐ Several times per week
    - ☐ Several times per month
    - ☐ Once per month
    - ☐ A few times per year
    - ☐ Once per year
    - ☐ Rarely
    - ☐ Never
    - ☐ Don't know
    - ☐ Refused

Section D: Activities outside your home

Now, I will ask you some questions about what you do when you are not at your house.

24. Do you/does your child currently attend or did you/your child attend a school in Bladen or Cumberland Counties or the Cape Fear River Region?
    - ☐ Yes, currently attending
    - ☐ Yes, used to attend
    - ☐ No
    - ☐ Don't know
    - ☐ Refused

25. Please tell me about the schools you/your child has attended. For each school, please tell me the following information?

School Name	Address	Duration Attended		Affected Area *Interviewer: this can be filled in later if name is available*	
		Start Year	End Year	Yes	No

26. What is/was the main source of drinking water you/your child used at your current or previous schools or daycares?
    - ☐ Public water system (city or county)
    - ☐ Community well
    - ☐ Private well
    - ☐ Spring
    - ☐ Pond
    - ☐ Cistern
    - ☐ Bottled water
    - ☐ Water brought from home
    - ☐ Don't know
    - ☐ Refused

ED_005565_00003709-00035

Section E: Females Only

In this section, I am going to ask you questions about pregnancy. We are asking about these events in your life because pregnancy and breast feeding can affect the amount of water you drink and may affect the amount of GenX and other PFAS that are detectable in your blood or urine. Please remember you can chose not to answer any questions you do not want to answer.

27. Are you/Is your child currently pregnant or have you ever been pregnant?
    - ☐ Yes
    - ☐ No →*Skip to Q33*
    - ☐ Don't know →*Skip to Q33*
    - ☐ Refused →*Skip to Q33*

28. How many total pregnancies have you/your child carried to term?
    Interviewer: a pregnancy carried to term would be one that ended in either a live or still birth. This includes babies that were born preterm or premature. Miscarriages and abortions are not included as a pregnancy carried to term.

    _ _ total pregnancies carried to term

    - ☐ Don't know →*Skip to Q33*
    - ☐ Refused →*Skip to Q33*

29. Please tell me the following information about each of your/your child's pregnancies carried to term.

Pregnancy	Month ended	Year ended
1		
2		
3		
4		
5		

30. Are you/Is your child currently breastfeeding or expressing milk?
    - ☐ Yes
    - ☐ No
    - ☐ Don't know
    - ☐ Refused

31. Have you/Has your child ever breastfed or expressed milk?
    - ☐ Yes
    - ☐ No → *Skip to Q33*
    - ☐ Don't know → *Skip to Q33*
    - ☐ Refused → *Skip to Q33*

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32. During your/your child's lifetime, how many months total have you/your child breastfed or expressed milk?

    _ _ months

    - ☐ Don't know
    - ☐ Refused

Section F: Comments/Questions

33. We have reached the end of the survey. Do you/does your child have any comments or questions to share with me today?
    Record any comments or questions in the space below.

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    Thank you for your time today. If you have questions after you leave here, please use the information on your assent and parental permission form to contact us and we will do our best to answer them.

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Appendix C
Distributions of PFAS Detected in Blood

ED_005565_00003709-00038
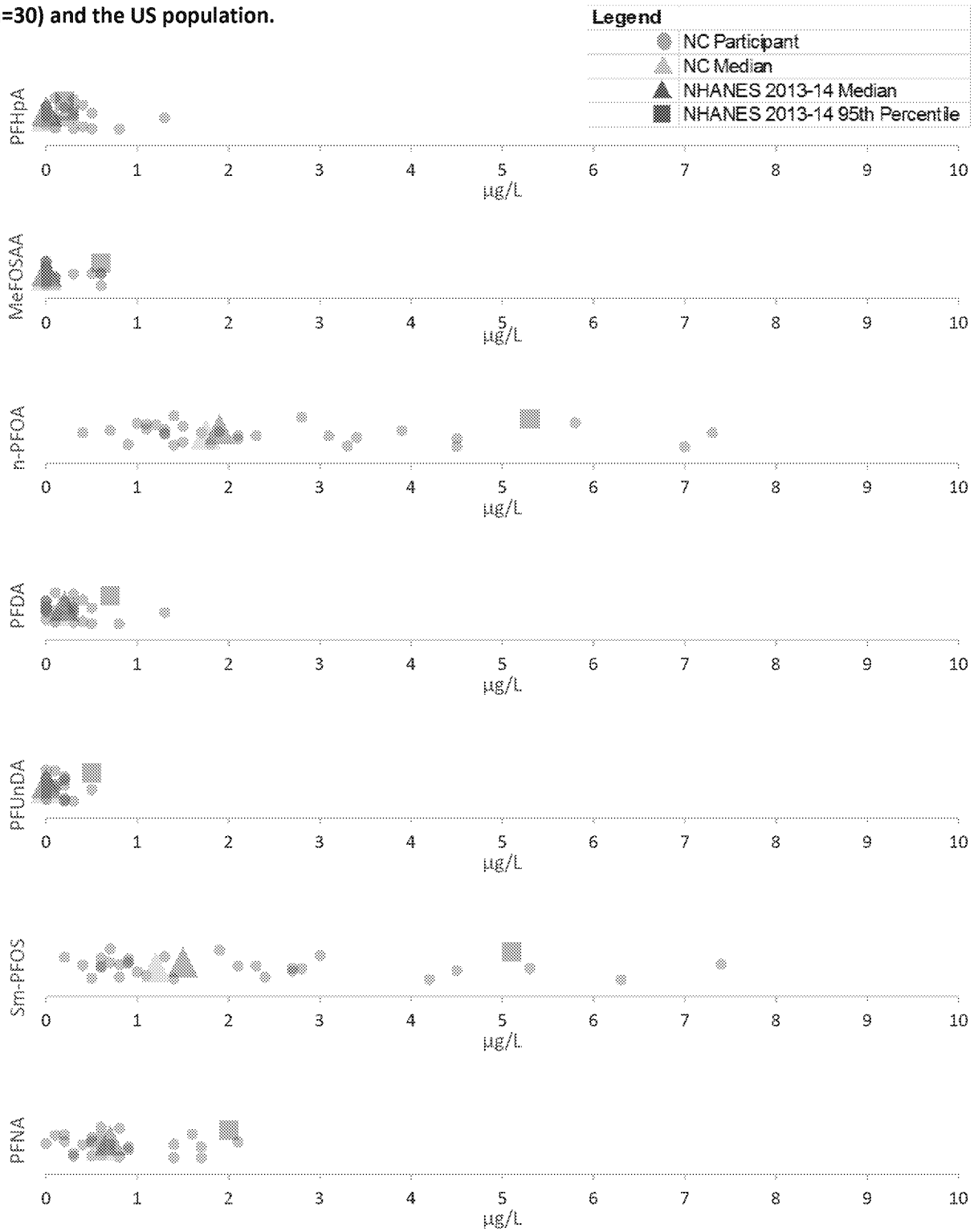
Figure 2. Distribution of PFAS levels found in blood of investigation participants in North Carolina (n=30) and the US population.