PFAS Survey Data Analysis

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Survey Demographic Profile

Data Analysis

Weighting

Prior to analysis, individual survey responses were weighted so that marginal proportions of the survey (`##r run_reference("tabdemo")`) matched national level benchmarks from the 5-year 2021 American Community Survey (ACS) on sex/gender, age group, race/ethnicity, and education level (`##r run_reference("tabweights")`). Weights on gender were developed by re-coding "female" and "other" responses as "non-male" because the ACS only provides binary response options for sex. Using this approach, responses from both "female" and "other" respondents have the same marginal weight. Kennedy et al. (2022) provide substantial discussion on the treatment of sex and gender in survey adjustment. Due to small subpopulation sample sizes within the Race/Ethnicity variable, Race/Ethnicity were recoded as White or Caucasian and Non-white categories. Weights were developed by poststratification raking using the American National Election Study (ANES) weighting algorithm implemented in the *anesrake* R package (DeBell and Krosnick 2009; Pasek 2018).

Models

To explore factors associated with an individual's understanding of PFAS two different proportional odds models (Agresti 2002) were developed relating (1) self-described knowledge of PFAS (4 responses ranging from "I've never heard of it, and don't know what it is" to "I'm confident I know what it is"); and (2) awareness of potential sources of PFAS (5 responses ranging from "Not at all familiar" to "Extremely Familiar" to Sex/Gender, Age, Race/Ethnicity, Education, and awareness of community exposure to PFAS (Yes, No, Not Sure). To explore factors associated with intended behavior change, a proportional odds model was developed relating intention to change use of items associated with

Table 1: Demographic profile (unadjusted) of survey respondents.

Characteristic	**N = 1,100**
Sex/Gender	
Male	529 (48%)
Female	565 (51%)
Other	4 (0.4%)
No answer	2 (0.2%)
Age	
18:24	125 (11%)
25:34	192 (17%)
35:44	204 (19%)
45:54	198 (18%)
55:64	171 (16%)
65+	208 (19%)
No answer	2 (0.2%)
Race/Ethnicity	
American Indian/Native American or Alaska Native	15 (1.4%)
Asian	49 (4.5%)
Hispanic or Latino or Spanish Origin of any race	109 (9.9%)
Black or African American	119 (11%)
Native Hawaiian or Other Pacific Islander	3 (0.3%)
White or Caucasian	723 (66%)
Other	21 (1.9%)
Two or More	57 (5.2%)
No answer	4 (0.4%)
Educational	
Some high school	47 (4.3%)
High school graduate or GED	418 (38%)
Associate degree	178 (16%)
Bachelor's degree	246 (22%)
Master's degree	132 (12%)
Doctorate or terminal degree	28 (2.5%)
Other	40 (3.6%)
No answer	11 (1.0%)

[1] n (%)

PFAS (5 responses ranging from "will never change" to "have already changed") to the same dependent variables.

The probability that an individual was aware of PFAS impacting their drinking water was also explored. A logistic regression model was developed to relate awareness of PFAS contamination in drinking water (a binary yes or no response) to Sex/Gender, Age, Race/Ethnicity, Education, and awareness of

Table 2: Marginal survey and target population proportions and marginal weighted values.

Characteristic	Unweighted N	Unweighted %	Target %	Weighted N	Weighted %
Age					
18:24	125	11.4	11.9	130.6	11.9
25:34	192	17.5	17.7	195.1	17.7
35:44	204	18.5	16.6	183.1	16.6
45:54	198	18.0	16.3	179.2	16.3
55:64	171	15.5	16.8	184.4	16.8
65+	208	18.9	20.7	227.6	20.7
No answer	2	0.2	NA	NA	NA
Education					
Some high school	47	4.3	7.8	85.8	7.8
High school graduate or GED	418	38.0	49.4	543.7	49.4
Associate degree	178	16.2	8.3	91.3	8.3
Bachelor's degree	246	22.4	19.4	213.7	19.4
Master's degree	132	12.0	8.3	91.3	8.3
Doctorate or terminal degree	28	2.5	1.3	14.7	1.3
Other	40	3.6	5.4	59.5	5.4
No answer	11	1.0	NA	NA	NA
Race/Ethnicity					
White	723	65.7	62.4	686.3	62.4
Non-white	373	33.9	37.6	413.7	37.6
No answer	4	0.4	NA	NA	NA
Sex/Gender					
Male	529	48.1	49.0	539.1	49.0
Not Male	569	51.7	51.0	560.9	51.0
No answer	2	0.2	NA	NA	NA

community exposure to PFAS, and drinking water source (filtered tap water, unfiltered tap water, bottled water, other). The last model evaluated the factors associated with an individuals level of concern about PFAS in their drinking water specifically. A proportional odds model fit level of concern (5 responses ranging from "Not at all concerned" to "Extremely concerned") to Sex/Gender, Age, Race/Ethnicity, Education, drinking water source, and awareness of PFAS contamination in drinking water.

Model results are presented as odds-ratios (with approximate p-values calculated by comparing the t-value against the standard normal distribution). Marginal effects are also presented as population-level predicted probabilities for a given predictor estimated using observed values (Hanmer and Ozan Kalkan 2013). 95% confidence intervals were derived using a parametric bootstrap as implemented in the *svyEffects* R package (Santos 2023). All models were fit using the *survey* package in R version 4.2.1 (Lumley 2004; R Core Team 2022).

Results

Table 3: Summary of weighted survey responses to questions about PFAS knowledge and awareness of community exposure.

Question	Response	Percent Response, SE
What is your main source of drinking water?	Unfiltered tap water	27.9, 1.5
	Filtered tap water	37.6, 1.6
	Bottled/prepackaged water	34.2, 1.6
	Other	0.3, 0.1
To your knowledge, has your primary source of drinking water been impacted by PFAS?	No	97.4, 0.5
	Yes	2.6, 0.5
How concerned are you about PFAS in your drinking water?	Not as all concerned	23.1, 1.4
	Slightly concerned	17.8, 1.2
	Moderately concerned	24.3, 1.4
	Very concerned	19.1, 1.3
	Extremely concerned	15.7, 1.2
To your knowledge, has your community been exposed to PFAS?	Yes	11.5, 1
	No	41.1, 1.6
	Not sure	47.4, 1.6
How would you describe your knowledge about PFAS as an environmental contaminant?	I've never heard of it, and don't know what it is	45.1, 1.6
	I've heard of it or seen it somewhere, but don't know what it is	31.6, 1.5
	I think I know what it is	17.2, 1.2
	I'm confident I know what it is	6.2, 0.8

Table 4: Summary of weighted responses to questions about awareness of different potential sources of PFAS.

Question	Not at all familiar	Slightly familiar
Drinking Water	45.8% (1.6)	19.7% (1.3)
Public waterways near waste disposal sites	45.2% (1.6)	18.3% (1.3)
Soils near waste disposal sites	46.3% (1.6)	20.2% (1.3)
Dairy products	51.1% (1.6)	16.3% (1.2)
Fresh produce	50.3% (1.6)	14.5% (1.1)
Freshwater fish	48.7% (1.6)	16.4% (1.2)
Seafood	48.8% (1.6)	15.3% (1.2)
Food packaging	48.1% (1.6)	16.2% (1.2)
Non-stick cookware	47% (1.6)	16.9% (1.2)
Personal hygiene products	46.6% (1.6)	14.7% (1.1)
Household products (fabrics, cleaning products, paints and sealants)	45% (1.6)	16% (1.2)
Fire extinguising foam	50.7% (1.6)	14.7% (1.1)
Fertilizers from wastewater plants	45.9% (1.6)	17.1% (1.2)

Most respondents had no knowledge (41.1%) or were unsure (47.4%) if their community has been exposed to PFAS (`##r run_reference("tabq1819")`). Only 11.5% responded that they knew their community has been exposed to PFAS. When asked to describe knowledge level about PFAS, 45.1% responded that they have never heard of it and don't know what it is. An additional 31.6% responded they have heard of PFAS, but don't know what PFAS are.

On average, 27.9% (minimum of 45% and maximum of 51.5%) of respondents were "not at all familiar" with potential sources of PFAS included in the survey (`#r run_reference("tabq20")`). The probability of response decreased for increasing levels of familiarity across all potential PFAS sources. Only 97.4% (minimum of 5.9% and maximum of 8.3%) of respondents, on average across all sources, responded "extremely familiar."

General PFAS Awareness and Intent to Change Product Use

We did not find evidence for any association between Sex, Race/Ethnicity, and Education with self-described knowledge about PFAS (`#r run_reference("tabmodel1")`). We can't exclude potential Race/Ethnicity sub-populations effects because Race/Ethnicity was collapsed into "White" and "Non-white" categories. For example, all the respondents identifying as "Native Hawaiian or Other Pacific Islander" (unweighted n = 3) responded that they had never heard of or knew what PFAS were. Some sub-populations might be more likely to answer that they have less knowledge about PFAS. With the sample size used in the current study we were not able to incorporate the sub-populations and develop a model that would converge.

Table 5: Odds ratios and approximate p-values from proportional odds model explaining self-described knowledge of PFAS.

Characteristic	**OR**	**SE**	**95% CI**	**p-value**
Sex				
Male	—	—	—	
Female	0.99	0.133	0.76, 1.29	>0.9
Other	0.80	0.735	0.19, 3.38	0.8
Age				
18:24	—	—	—	
25:34	1.38	0.235	0.87, 2.18	0.2
35:44	1.63*	0.237	1.03, 2.59	0.039
45:54	1.03	0.244	0.64, 1.67	0.9
55:64	1.09	0.255	0.66, 1.80	0.7
65+	0.94	0.259	0.57, 1.57	0.8
Race/Ethnicity				
White	—	—	—	
Non-white	0.95	0.149	0.71, 1.27	0.7
Education				
Some high school	—	—	—	
High school graduate or GED	0.65	0.327	0.34, 1.23	0.2
Associate degree	0.89	0.344	0.46, 1.76	0.7
Bachelor's degree	0.98	0.341	0.50, 1.92	>0.9
Master's degree	1.04	0.363	0.51, 2.12	>0.9
Doctorate or terminal degree	1.38	0.448	0.57, 3.32	0.5
Other	1.56	0.474	0.61, 3.94	0.4
Community PFAS Exposure				
Yes	—	—	—	
No	0.28***	0.189	0.19, 0.41	<0.001
Not sure	0.23***	0.203	0.16, 0.35	<0.001

[1] *p<0.05;* ***p<0.01;*** p<0.001

[2] OR = Odds Ratio, SE = Standard Error, CI = Confidence Interval

There was not strong evidence for the influence of age on PFAS knowledge among most of the age brackets (`#r run_reference("tabmodel1")`). However, there is evidence to support that someone in the 35:44 age bracket will respond with a higher self assessed knowledge level (OR = 1.63, p = 0.039) than someone in the reference bracket (18:24). There is also strong evidence that people aware of PFAS exposure in their communities self-report higher levels of knowledge about PFAS. People aware of PFAS exposure in their communities are 3.57 times and 4.35 times more likely to respond with a higher self-assessed knowledge level than those responding "No" (OR = 0.28, p < 0.001) or "Not sure" (OR = 0.23, p < 0.001) to awareness of PFAS contamination in their communities.

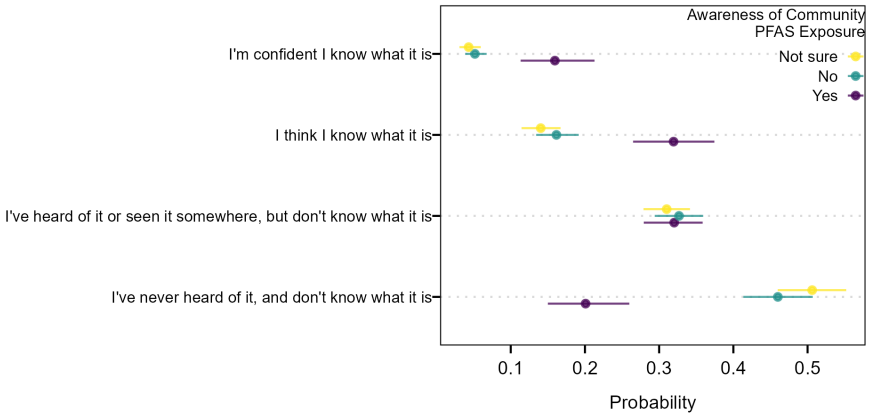

Figure 1: Average marginal predicted probabilities for self assessed knowledge of PFAS. Horizontal lines indicate the 95% confidence intervals of the marginal predicted probabilities.

Marginal predicted probabilities show that someone that is aware of community PFAS exposure is is much more likely to respond that they confidently know what PFAS (16%) are compared to those that said their community hasn't been exposed (5%) or don't know (4%; Figure Figure 1). Conversely, someone that is aware of community PFAS exposure was much less likely to respond that they had never heard of PFAS and didn't know what is was (20%) compared to those that said their community hasn't been exposed (46%) or don't know (51%). We infer that respondents that are aware of community PFAS exposure are most likely to respond that they have at least heard of PFAS, but they may or may not be aware of what PFAS's are. Respondents that are unaware or uncertain of community PFAS exposure are most likley to have never heard of it, and if they have they don't know what it is.

Awareness of community PFAS exposure also show strong associations with familiarity of potential PFAS sources and intentions to change use of items with potential for PFAS contamination (Figure 2, Figure 3). On average, 46% and 46.5% of those that were unaware of or not sure if their communties were

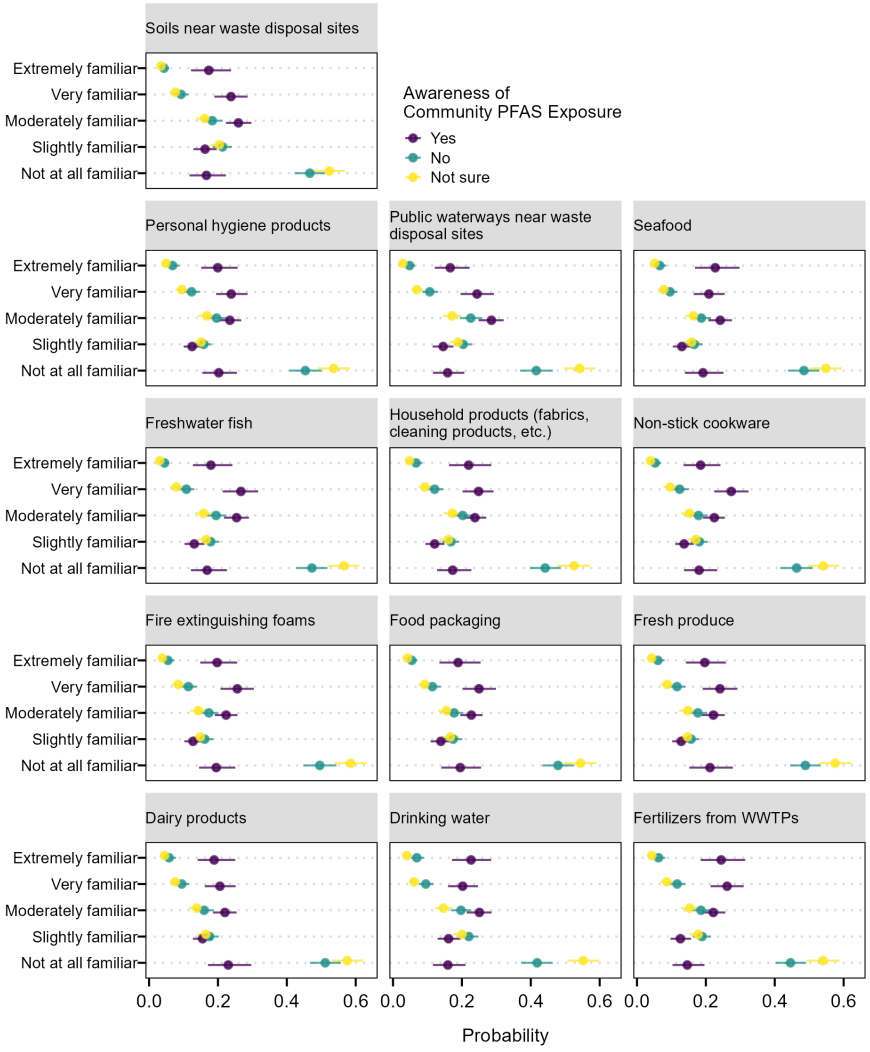

Figure 2: Average marginal predicted probabilities for an individual's familiarity with products that are associated with PFAS. Horizontal lines indicate the 95% confidence intervals of the marginal predicted probabilities.

contaminated by PFAS responded they were "not familiar at all" with specific sources of PFAS contamination. This decreased to averages of 6% and 4% for the "extremely familiar" response. On average, people that stated their communities were contaminated by PFAS had a lower probability (18%) of responding that they were "not familiar at all" and higher probability (20%) of being "extremely familiar" with PFAS sources compared to the other two groups.

People indicating no or unsure of PFAS community contamination were on average more likely to say they will never change their use of items (17% and 17%) compared to those aware of PFAS contamination in their community (8%; Figure 3). Those aware of community PFAS contamination were also more likely on average to have already changed use of items (22%) relative to the other two groups (11% for the "no" group and 10% for the "unsure" group).

PFAS and Drinking Water

There was not strong evidence that age, race, or education are predictive of an individual's awareness of PFAS contamination in their drinking water (`#r run_reference("tabmodel4")`). For individuals identifying as other, the odds of responding that they are aware their water is contaminated with PFAS was 100% lower (OR = 0, p < 0.001) than individuals identifying male. There was strong evidence for associations with both awareness of community PFAS exposure and drinking water sources. The odds that an individual aware of community PFAS exposure indicated their drinking water was contaminated with PFAS was 100 times greater than those that responded they were unaware of community PFAS exposure (OR = 0.01, p < 0.001) and 8.3 times lower than those that were uncertain of PFAS exposure (OR = 0.12, p = 0.003). These strong associations are indicative that awareness of community PFAS contamination may largely be attributed to contamination of drinking water supplies. Individuals with unfiltered tap water had 3.57 times the odds of being aware that their drinking water was contaminated than those with filtered tap water (OR = 0.28, p = 0.016).

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## notes

Add the following regression models:

Whats the probability of a response that drinking water has been impacted by PFAS (Q9.6) bas


What is the ordinal prob of response that a respondent is concerned about PFAS in *drinking
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References

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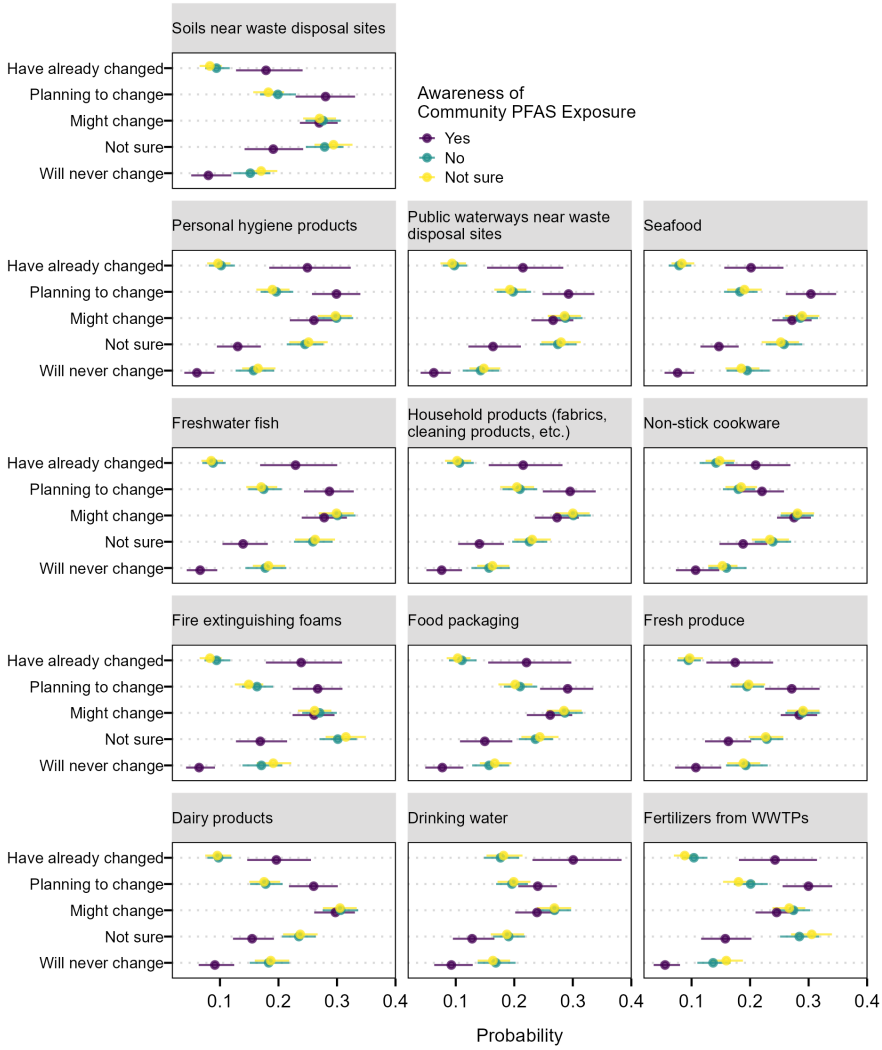

Figure 3: Average marginal predicted probabilities for an individual's intention to change use items associated with PFAS contamination. Horizontal lines indicate the 95% confidence intervals of the marginal predicted probabilities.'

Table 6: Odds ratios and approximate p-values from logistic regression model explaining awareness of PFAS contamination in drinking water.

Characteristic	**OR**	**SE**	**95% CI**	**p-value**
Sex				
Male	—	—	—	
Female	0.66	0.499	0.25, 1.75	0.4
Other	0.00***	1.22	0.00, 0.00	<0.001
Age				
18:24	—	—	—	
25:34	1.30	1.21	0.12, 14.0	0.8
35:44	0.72	1.19	0.07, 7.45	0.8
45:54	1.64	1.31	0.13, 21.2	0.7
55:64	4.47	1.40	0.29, 69.7	0.3
65+	0.80	1.29	0.06, 10.1	0.9
Race/Ethnicity				
White	—	—	—	
Non-white	0.58	0.557	0.19, 1.72	0.3
Education				
Some high school	—	—	—	
High school graduate or GED	0.74	1.36	0.05, 10.7	0.8
Associate degree	0.90	1.44	0.05, 15.0	>0.9
Bachelor's degree	1.46	1.25	0.13, 17.1	0.8
Master's degree	1.54	1.21	0.14, 16.5	0.7
Doctorate or terminal degree	1.61	1.56	0.08, 34.2	0.8
Other	2.20	1.35	0.15, 31.3	0.6
Community PFAS Exposure				
Yes	—	—	—	
No	0.01***	1.21	0.00, 0.09	<0.001
Not sure	0.12**	0.710	0.03, 0.49	0.003
Drinking Water Source				
Unfiltered tap water	—	—	—	
Filtered tap water	0.28*	0.523	0.10, 0.79	0.016
Bottled/prepackaged water	0.44	0.503	0.17, 1.19	0.11
Other	0.00***	1.09	0.00, 0.00	<0.001

[1] *p<0.05;* ***p<0.01;*** p<0.001

[2] OR = Odds Ratio, SE = Standard Error, CI = Confidence Interval

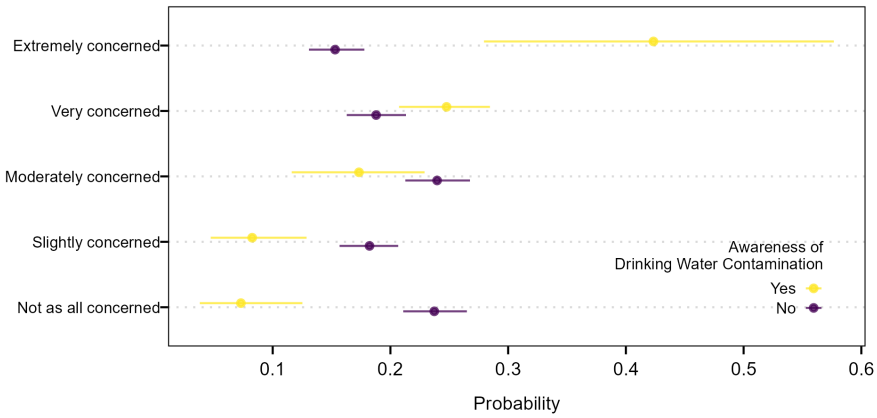

Figure 4: Average marginal predicted probabilities for concern about PFAS contamination in drinking water. Horizontal lines indicate the 95% confidence intervals of the marginal predicted probabilities.

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