

## **Characteristics of ‘Early Adopters’ of Water Treatment Capacity Needed to Remove PFAS and other Emerging Contaminants in the United States**

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### **Literature review search terms**

To understand the available literature on infrastructure and drinking water quality disparities, the following search terms were entered into PubMed and Web of Science for articles up to 5/2025:

((“water treatment”) AND (“disparit\*” OR “sociodemo\*” OR “environmental justice”))

((“water infra\*”) AND (“disparit\*” OR “sociodemo\*” OR “environmental justice”))

## **Section 1: Additional details on data processing**

### *Treatment process data*

As described in the manuscript, we obtained historical data (2004-2013) on PWS treatment infrastructure from a Freedom of Information Act request to the US EPA in June 2020. More recent PWS infrastructure data (2013-2022) were downloaded from the Safe Drinking Water Information System (SDWIS).<sup>1</sup> The full, initial water treatment infrastructure dataset spanning 2004-2022 included 102,078 PWS. Each PWS reported treatment processes and objectives on a quarterly basis for most years. We used the third quarter data for all years based on the data made available through our request to the US EPA.

Systems that became inactive based on SDWIS data (as described in the main manuscript) were treated as censored in the time-to-event modeling approaches. The modeling approaches can account for non-informative censoring (Kaplan-Meier analyses and adjusted regression models) or non-informative censoring conditional on the covariates (adjusted regression models only).<sup>2</sup>

### *Sociodemographic data*

As described, county-level sociodemographic data were obtained directly from the 5-year American Community Survey (ACS) by the US Census Bureau.<sup>3</sup> For 2004-2009, we used the first available ACS rolling data (2005-2009).<sup>4</sup> For all other years, census estimates were linked with the treatment records based on the last year of the rolling 5-year averages (e.g., 2005-2010 ACS data were linked with the 2010 treatment process records). CWS without reported county/counties served were excluded from all analyses to enable comparison between the analyses conducted with sociodemographic data at the county or service area boundary spatial scales. For a small percentage

of records (0.05%), sociodemographic estimates from the ACS were carried forward from the last available cycle due to missing data for a given cycle.

We conducted several analyses that stratified according to four US census regions (Midwest, Northeast, South, and West). We used census regions as opposed to census divisions for ease of interpretability (four compared to nine units) and because the event under study was relatively rare (5.1% of the study sample over the 2004-2022 period). However, these analyses all included fixed effects for census division. Puerto Rico was excluded from this analysis as an additional region because of low occurrence of the target event among the study sample over the analysis period.

#### *Dasymetric mapping approaches*

We used dasymetric mapping techniques to estimate the sociodemographic compositions of CWS included in the US EPA's Community Water System Service Area Boundaries dataset (version 1.2)<sup>5</sup> for each unique year of the study period in which 5-year American Community Survey (ACS) data were available.<sup>3</sup> To do so, we identified all spatial intersections between census tracts in the US with the CWS service area boundaries. We then used a 2019 high-resolution (30 meter by 30 meter) population density raster from Data for Good (Facebook Connectivity Lab and Center for International Earth Science Information Network)<sup>6</sup> to estimate the total population in each intersecting region and the total for each CWS's service area boundary. Each sociodemographic variable was then calculated per the following:

$$X_{it} = \frac{\sum X_{jt} P_j}{P_i}$$

where:

- $X_{it}$  is a given sociodemographic variable estimated for CWS service area boundary  $i$  based on ACS data for period  $t$

- $X_{jt}$  is a given sociodemographic variable estimated for intersecting region  $j$  based on ACS data for period  $t$
- $P_j$  is the total population estimated for intersecting region  $j$
- $P_i$  is the total population estimated for CWS service area boundary  $i$

## **Section 2: PFAS drinking water monitoring datasets used in this study**

A key difference between the statewide sampling data compilation and the nationwide UCMR cycles is that the statewide sampling data compilation primarily comprises systems serving fewer than 3,300 people (76% of total CWS, compared to approximately 89% nationwide), whereas both UCMR cycles have mandated sampling for all systems serving more than 10,000 people and representative subgroups of systems serving fewer than 3,300 people (7.4% of total CWS in UCMR 3 and 6.9% of total CWS in ongoing UCMR 5 testing). As of 2021, UCMR monitoring (including UCMR 5) mandates sampling for all systems serving between 3,301-10,000 people.<sup>7</sup> Additional details on the statewide sampling compilation can be found in a prior publication and data release.<sup>8,9</sup>

## **Section 3: Additional sensitivity analyses**

Additional sensitivity analyses were conducted with county-level sociodemographic composition. We examined the effect of replacing the median household income with each of the other six measures obtained from the ACS (percentage of residents making less than the federal poverty line, median value of owner-occupied housing units, percentage of income spent on rent, percentage of residents without a high school degree, percentage of homeowners, and the percentage of unemployed residents between ages 16-64)<sup>3</sup> and no adjustment. We modified the

primary model by excluding all racial/ethnic compositional variables. In addition, we used the primary model but replaced each of the time-varying sociodemographic values with the baseline values from the first year of reporting for each CWS. To examine the potential of selection bias related to the exclusion of systems that reported using advancements in treatment processes at baseline, we also included all systems (40,722 CWS) in a separate sensitivity analysis.

#### **Section 4: Supplemental results description**

##### *Additional comparison of results at the county and service area boundary scales and stratified by region*

We repeated the Kaplan-Meier analyses that compared survival curves between CWS of varying sizes stratified by census region to examine whether differences observed nationally were present across census regions. In these analyses, we similarly observed in all census regions that CWS serving >10,000 people adopted advancements in treatment processes at faster rates than CWS serving smaller populations (Figure S 20).

In analyses including service area sociodemographic composition, we observed that associations between the proportion of American Indian/Alaskan Native residents and adoption of advancements in treatment varied by system size. Inverse associations were observed among medium CWS (10-percentage-point increase in residents associated with a 52.5% [95% CI: -81.7%, -19.5%] reduction in the odds) and large and very large CWS (-60.9% [95% CI: -87.7%, -25.7%]), but a positive association was observed among small systems (16.4% [95% CI: 3.9%, 25.7%]) (Figure S 17 and Table S 6). Unlike analyses that incorporated county-level sociodemographic composition, the proportion of Hispanic/Latino residents within CWS service area boundaries was associated with significantly increased adjusted odds of adopting the treatment processes in the main model (4.5% [95% CI: 1.2%, 8.0%]), and among small and very

small CWS, urban CWS, and CWS with prior MCL violations. However, these associations were similar in magnitude to the associations from the models incorporating county-level sociodemographic composition, which had larger confidence intervals (Table 1 and Figure S 17).

We also observed that adjusted associations for the proportions of some racial/ethnic groups (excluding Black residents) were sensitive to the spatial scale in models stratified by census region (Table S 9). For example, in the Midwest region, a 10 percentage-point increase in the proportion of Asian, Native Hawaiian, and other Pacific Islander residents within service area boundaries was associated with a significant 54.6% decrease [95% CI: -77.0%, -21.3%] in the odds of adopting advancements in treatment processes among CWS. However, when instead considering the counties served by CWS in the Midwest, the association was similarly inverse, but overlapped with the null and had wider confidence intervals (-48.2% [95% CI: -86.8%, 98.0%]). In the West region, positive associations between the proportions of American Indian/Alaskan Native and Hispanic/Latino residents and advancements in treatment adoption that were observed at the service area boundary scale were not observed when considering the counties served by CWS (Table S 9).

Models that incorporated service area boundary sociodemographic composition had both slightly reduced and slightly greater median AUROC values (ranging from 0.63-0.88) compared to models with county-level sociodemographic composition (ranging from 0.61-0.88) (Figure S 21-Figure S 24). Importantly, CWS excluded from the analyses incorporating service area boundary estimates were overrepresented by small and very small CWS (95.1%), groundwater-sourced CWS (85.8%), and non-government CWS (75.3%) compared to CWS included in the model incorporating county-level sociodemographic composition (Table S 1 and Table S 13).

### *Additional results pertaining to median household income*

For the East South Central division (states of Alabama, Kentucky, Mississippi, and Tennessee), we again predicted the probabilities of adoption of reverse osmosis, ion exchange, or activated carbon processes for median household incomes ranging from \$10,000-90,000 USD. Among small CWS, this relationship generally plateaued near \$60,000-80,000 USD and decreased with incomes above this level (Figure S 19). Among medium CWS, significant increases in the probability of adopting reverse osmosis, ion exchange, or activated carbon processes were also observed with increased income and followed a concave upward association (Figure S 19 and Table S 10). Median household income was not significantly associated with adopting reverse osmosis, ion exchange, or activated carbon processes among large and very large CWS (Figure S 19 and Table S 10).

When we replaced median household income with alternate area-level socioeconomic status measures, we did not find significant adjusted associations with adoption of reverse osmosis, ion exchange, or activated carbon processes (Table S 12). Results from sensitivity analyses (e.g., including adjustments for additional MCL indicators) were similar to the primary results (Table S 8). We did not observe major differences in model fit between sensitivity analyses using alternate socioeconomic status measures when compared to the primary model. Median AUROC values ranged from 0.61-0.78 over the study window (Figure S 21-Figure S 23).

**Table S 1:** Descriptive statistics of CWS by system size in the primary analytic samples (county-level sociodemographic composition)

	All CWS ( <i>N</i> = 36,611)	Large or very large ( <i>n</i> = 3,090)	Medium ( <i>n</i> = 3,816)	Small or very small ( <i>n</i> = 29,705)	CWS with known PFAS detections <sup>a</sup> ( <i>n</i> = 3,025)
<b>Water system characteristics</b>					
Est. population served [millions]	203.1	162.8	22.4	17.9	85.9
Number of large or very large systems	3,090 (8.4%)	3,090 (100.0%)	0 (0.0%)	0 (0.0%)	1,261 (41.7%)
Number of medium systems	3,816 (10.4%)	0 (0.0%)	3,816 (100.0%)	0 (0.0%)	914 (30.2%)
Number of small or very small systems	29,705 (81.1%)	0 (0.0%)	0 (0.0%)	29,705 (100.0%)	850 (28.1%)
Number of systems with prior MCL violations	1,786 (4.9%)	266 (8.6%)	231 (6.1%)	1,289 (4.3%)	234 (7.7%)
Number of systems sourced by SW	6,548 (17.9%)	1,704 (55.1%)	1,373 (36.0%)	3,471 (11.7%)	1,305 (43.1%)
Government-owned	18,301 (50.0%)	2,716 (87.9%)	3,293 (86.3%)	12,292 (41.4%)	2,262 (74.8%)
Non-government-owned	18,310 (50.0%)	374 (12.1%)	523 (13.7%)	17,413 (58.6%)	763 (25.2%)
<b>Sociodemographic factors [mean; median (interquartile range)]</b>					
% Hispanic/Latino	11.8; 5.2 (2.1, 14.0)	15.6; 7.5 (2.9, 21.3)	12.6; 4.8 (2.0, 15.4)	11.3; 5.0 (2.1, 13.0)	13.7; 6.8 (2.8, 16.6)
% non-Hispanic Black	9.2; 3.9 (1.0, 13.2)	10.0; 5.9 (2.0, 13.3)	10.5; 4.9 (1.3, 15.8)	9.0; 3.5 (0.9, 12.3)	8.4; 5.3 (1.8, 11.0)
% non-Hispanic ANHOPI	2.1; 1.0 (0.5, 2.3)	3.6; 1.9 (0.8, 4.4)	2.3; 1.0 (0.4, 2.5)	1.9; 1.0 (0.5, 2.1)	3.3; 1.9 (0.8, 4.3)
% non-Hispanic AIAN	1.3; 0.3 (0.1, 0.6)	0.7; 0.2 (0.1, 0.5)	1.1; 0.2 (0.1, 0.5)	1.4; 0.3 (0.1, 0.6)	0.6; 0.2 (0.1, 0.4)
% non-Hispanic White	74.0; 78.8 (63.3, 90.4)	68.4; 74.0 (53.8, 86.3)	71.8; 77.5 (59.0, 89.7)	74.9; 79.6 (65.2, 90.9)	72.3; 78.1 (60.9, 88.1)
Median income [USD]	49,000; 46,000 (40,000, 56,000)	53,000; 52,000 (43,000, 62,000)	49,000; 46,000 (39,000, 56,000)	49,000; 46,000 (40,000, 56,000)	57,000; 55,000 (45,000, 68,000)
Population density [people/km <sup>2</sup> ]	334; 102 (40, 338)	791; 305 (103, 899)	420; 104 (44, 386)	276; 93 (36, 311)	705; 347 (104, 872)
<b>Ever adopted treatment processes (2004-2022)</b>	1,882 (5.1%)	497 (19.2%)	285 (7.5%)	1,100 (3.7%)	353 (11.6%)

CWS = Community water system

The descriptive statistics shown here refer to CWS included in analyses with county-level sociodemographic composition as described in the Methods. The sample differs slightly from the analyses using service area boundary sociodemographic composition (Table S 2) due to the available underlying data (Figure S 2).

<sup>a</sup>This sample refers to systems with known PFAS detections across three monitoring datasets (the Third Unregulated Contaminant Monitoring Rule,<sup>10</sup> a compilation of statewide PFAS sampling data of 28 states,<sup>9</sup> and the ongoing Fifth Unregulated Contaminant Monitoring Rule<sup>11</sup>).

Each observation corresponds to a CWS. Sociodemographic data shown here are at the county level. Table S 2 presents the same descriptive statistics based on the service area boundary estimates. Large or very large systems serve over 10,000 people; medium systems serve 3,301-10,000; and small or very small serve 25-3,300.

**Table S 2:** Descriptive statistics of CWS by system size in the primary analytic samples (service area boundary sociodemographic composition)

	<b>All CWS (N = 29,956)</b>	<b>Large or very large (N = 2,948)</b>	<b>Medium (N = 3,632)</b>	<b>Small or very small (N = 23,376)</b>	<b>CWS with known PFAS detections<sup>a</sup> (N = 2,878)</b>
<b>Water system characteristics</b>					
Est. population served [millions]	192.4	154.8	21.4	16.2	83.2
Number of large or very large systems	2,948 (9.8%)	2,948 (100.0%)	0 (0.0%)	0 (0.0%)	1,221 (42.4%)
Number of medium systems	3,632 (12.1%)	0 (0.0%)	3,632 (100.0%)	0 (0.0%)	896 (31.1%)
Number of small or very small systems	23,376 (78.0%)	0 (0.0%)	0 (0.0%)	23,376 (100.0%)	761 (26.4%)
Number of systems with prior MCL violations	1,615 (5.4%)	251 (8.5%)	221 (6.1%)	1,143 (4.9%)	213 (7.4%)
Number of systems sourced by SW	5,602 (18.7%)	1,618 (54.9%)	1,298 (35.7%)	2,686 (11.5%)	1,255 (43.6%)
Government-owned	16,659 (55.6%)	2,609 (88.5%)	3,153 (86.6%)	10,897 (46.6%)	2,192 (76.2%)
Non-government-owned	13,297 (44.4%)	339 (11.5%)	479 (13.2%)	12,479 (53.4%)	686 (23.8%)
<b>Sociodemographic factors [mean; median (interquartile range)]</b>					
% Hispanic/Latino	9.4; 3.5 (1.3, 10.3)	13.5; 6.2 (2.5, 16.3)	10.6; 3.7 (1.4, 12.1)	8.7; 3.2 (1.1, 9.5)	11.5; 4.7 (1.8, 13.4)
% non-Hispanic Black	7.2; 1.2 (0.2, 7.5)	9.4; 3.6 (1.2, 11.3)	9.4; 2.1 (0.4, 11.2)	6.6; 0.9 (0.1, 6.4)	7.2; 2.4 (0.6, 8.2)
% non-Hispanic ANHOPI	1.6; 0.5 (0.0, 1.6)	3.5; 1.7 (0.7, 3.6)	1.9; 0.6 (0.1, 1.7)	1.3; 0.4 (0.0, 1.3)	2.8; 1.3 (0.4, 3.2)
% non-Hispanic AIAN	0.9; 0.2 (0.0, 0.6)	0.6; 0.2 (0.1, 0.5)	0.8; 0.2 (0.0, 0.6)	1.0; 0.1 (0.0, 0.6)	0.6; 0.1 (0.0, 0.4)
% non-Hispanic White	79.2; 86.6 (70.3, 94.6)	71.0; 77.8 (59.5, 89.1)	75.5; 84.0 (63.9, 93.5)	80.8; 88.0 (72.9, 95.2)	76.2; 84.3 (66.0, 92.9)
Median income [USD]	54,000; 49,000 (40,000, 63,000)	58,000; 52,000 (41,000, 69,000)	53,000; 47,000 (37,000, 62,000)	54,000; 49,000 (40,000, 62,000)	63,000; 57,000 (44,000, 77,000)
Population density [people/km <sup>2</sup> ]	556; 329 (132, 670)	859; 647 (323, 1,089)	590; 390 (152, 709)	512; 295 (119, 599)	805; 556 (271, 974)
<b>Ever adopted treatment processes (2004-2022)</b>	1,916 (6.4%)	547 (18.6%)	329 (8.7%)	1,041 (4.4%)	394 (13.7%)

CWS = Community water system

The descriptive statistics shown here refer to CWS included in the service area boundary analyses as described in the Methods. Sociodemographic composition for CWS included in the US EPA's Community Water System Service Area Boundary dataset (version 1.2)<sup>5</sup> was estimated using dasymetric mapping techniques. The sample differs slightly from the analyses using county-level sociodemographic composition (Table S 1) due to the available underlying SAB data (Figure S 2).

<sup>a</sup>This sample refers to systems with known PFAS detections across three monitoring datasets (the Third Unregulated Contaminant Monitoring Rule,<sup>10</sup> a compilation of statewide PFAS sampling data of 28 states,<sup>9</sup> and the ongoing Fifth Unregulated Contaminant Monitoring Rule<sup>11</sup>).

Each observation corresponds to a CWS. Sociodemographic data shown here are at the service area boundary level. Table S 1 presents the same descriptive statistics based on the county-level estimates. Large or very large systems serve over 10,000 people; medium systems serve 3,301-10,000; and small or very small serve 25-3,300.

**Table S 3:** Kaplan-Meier survival and cumulative likelihood estimates [95% confidence intervals] for categorical CWS characteristics

<b>Categorical factor</b>	<b>Stratum</b>	<b>Years elapsed</b>	<b>Survival estimate</b>	<b>Cumulative likelihood estimate</b>
<b>PWS size</b>	Very small (serving 25-500)	3	0.989 [0.987, 0.990]	0.011 [0.011, 0.013]
	Very small (serving 25-500)	7	0.977 [0.975, 0.979]	0.023 [0.021, 0.026]
	Very small (serving 25-500)	11	0.970 [0.967, 0.972]	0.030 [0.028, 0.033]
	Very small (serving 25-500)	15	0.962 [0.959, 0.964]	0.039 [0.036, 0.042]
	Very small (serving 25-500)	18	0.956 [0.953, 0.960]	0.045 [0.041, 0.048]
	Small (serving 501-3,300)	3	0.989 [0.987, 0.991]	0.011 [0.009, 0.013]
	Small (serving 501-3,300)	7	0.978 [0.975, 0.981]	0.022 [0.020, 0.026]
	Small (serving 501-3,300)	11	0.969 [0.965, 0.972]	0.032 [0.028, 0.036]
	Small (serving 501-3,300)	15	0.961 [0.956, 0.964]	0.040 [0.036, 0.045]
	Small (serving 501-3,300)	18	0.954 [0.949, 0.958]	0.047 [0.043, 0.052]
	Medium (serving 3,301-10,000)	3	0.976 [0.970, 0.980]	0.024 [0.020, 0.030]
	Medium (serving 3,301-10,000)	7	0.958 [0.951, 0.964]	0.043 [0.037, 0.051]
	Medium (serving 3,301-10,000)	11	0.939 [0.931, 0.947]	0.063 [0.055, 0.072]
	Medium (serving 3,301-10,000)	15	0.927 [0.918, 0.935]	0.076 [0.067, 0.086]
	Medium (serving 3,301-10,000)	18	0.917 [0.907, 0.926]	0.087 [0.077, 0.097]
	Large (serving 10,001-100,000)	3	0.964 [0.956, 0.970]	0.037 [0.030, 0.045]
	Large (serving 10,001-100,000)	7	0.919 [0.908, 0.929]	0.085 [0.074, 0.097]
	Large (serving 10,001-100,000)	11	0.885 [0.872, 0.897]	0.122 [0.109, 0.137]
	Large (serving 10,001-100,000)	15	0.858 [0.844, 0.871]	0.153 [0.138, 0.169]
	Large (serving 10,001-100,000)	18	0.826 [0.811, 0.841]	0.191 [0.173, 0.210]
	Very large (serving >100,000)	3	0.878 [0.830, 0.913]	0.130 [0.091, 0.186]
	Very large (serving >100,000)	7	0.822 [0.767, 0.865]	0.196 [0.145, 0.265]
	Very large (serving >100,000)	11	0.765 [0.705, 0.814]	0.268 [0.206, 0.349]
	Very large (serving >100,000)	15	0.733 [0.671, 0.785]	0.310 [0.242, 0.398]
	Very large (serving >100,000)	18	0.715 [0.652, 0.768]	0.336 [0.264, 0.428]
<b>Source water type</b>	Groundwater source	3	0.988 [0.987, 0.989]	0.012 [0.011, 0.013]
	Groundwater source	7	0.975 [0.973, 0.977]	0.025 [0.023, 0.027]
	Groundwater source	11	0.967 [0.965, 0.969]	0.034 [0.032, 0.036]
	Groundwater source	15	0.958 [0.955, 0.960]	0.043 [0.040, 0.046]
	Groundwater source	18	0.951 [0.949, 0.954]	0.050 [0.047, 0.053]
	Surface water source	3	0.968 [0.963, 0.972]	0.033 [0.029, 0.038]
	Surface water source	7	0.942 [0.936, 0.948]	0.060 [0.054, 0.067]
	Surface water source	11	0.914 [0.906, 0.921]	0.090 [0.082, 0.099]
	Surface water source	15	0.894 [0.886, 0.903]	0.112 [0.103, 0.121]
	Surface water source	18	0.874 [0.864, 0.883]	0.135 [0.124, 0.146]

<b>Owner type</b>	Government-owned	3	0.982 [0.980, 0.984]	0.018 [0.016, 0.020]
	Government-owned	7	0.966 [0.963, 0.968]	0.035 [0.032, 0.038]
	Government-owned	11	0.951 [0.948, 0.954]	0.050 [0.047, 0.054]
	Government-owned	15	0.940 [0.936, 0.944]	0.062 [0.058, 0.066]
	Government-owned	18	0.930 [0.925, 0.933]	0.073 [0.069, 0.077]
	Non-government-owned	3	0.987 [0.985, 0.989]	0.013 [0.011, 0.015]
	Non-government-owned	7	0.973 [0.971, 0.976]	0.027 [0.025, 0.030]
	Non-government-owned	11	0.965 [0.962, 0.968]	0.035 [0.032, 0.038]
	Non-government-owned	15	0.956 [0.952, 0.959]	0.046 [0.042, 0.049]
	Non-government-owned	18	0.949 [0.945, 0.952]	0.053 [0.049, 0.057]

Results are shown for the 36,611 CWS included in the analyses that used county-level sociodemographic composition (see Table S 1 and Figure S 2).

**Table S 4:** Kaplan-Meier survival and cumulative likelihood estimates [95% confidence intervals] for categorical racial/ethnic and socioeconomic factors (analyses conducted with county-level sociodemographic composition)

Variable group	Sociodemographic factor	Year	Survival estimate (Q1)	Cumulative likelihood (Q1)	Survival estimate (Q4)	Cumulative likelihood (Q4)
Racial/ethnic composition	% Hispanic/Latino	3	0.981 [0.977, 0.984]	0.020 [0.016, 0.023]	0.986 [0.983, 0.989]	0.014 [0.011, 0.017]
	% Hispanic/Latino	7	0.965 [0.960, 0.970]	0.036 [0.031, 0.040]	0.972 [0.964, 0.978]	0.029 [0.022, 0.037]
	% Hispanic/Latino	11	0.954 [0.948, 0.959]	0.047 [0.042, 0.053]	0.959 [0.949, 0.969]	0.042 [0.032, 0.053]
	% Hispanic/Latino	15	0.945 [0.939, 0.951]	0.057 [0.050, 0.063]	0.951 [0.939, 0.962]	0.050 [0.038, 0.063]
	% Hispanic/Latino	18	0.934 [0.927, 0.942]	0.068 [0.060, 0.076]	0.941 [0.926, 0.954]	0.061 [0.047, 0.076]
	% Black	3	0.982 [0.978, 0.985]	0.018 [0.015, 0.022]	0.990 [0.988, 0.992]	0.010 [0.008, 0.013]
	% Black	7	0.965 [0.959, 0.971]	0.036 [0.030, 0.042]	0.979 [0.972, 0.985]	0.021 [0.015, 0.029]
	% Black	11	0.953 [0.946, 0.959]	0.048 [0.041, 0.055]	0.971 [0.963, 0.979]	0.029 [0.021, 0.038]
	% Black	15	0.944 [0.936, 0.950]	0.058 [0.051, 0.066]	0.963 [0.952, 0.972]	0.038 [0.028, 0.049]
	% Black	18	0.935 [0.927, 0.943]	0.067 [0.059, 0.076]	0.955 [0.944, 0.966]	0.046 [0.035, 0.058]
	% ANHOPI	3	0.986 [0.983, 0.988]	0.015 [0.012, 0.018]	0.982 [0.979, 0.986]	0.018 [0.014, 0.022]
	% ANHOPI	7	0.974 [0.969, 0.978]	0.027 [0.023, 0.031]	0.964 [0.956, 0.972]	0.036 [0.028, 0.045]
	% ANHOPI	11	0.963 [0.957, 0.968]	0.038 [0.033, 0.043]	0.951 [0.940, 0.962]	0.050 [0.039, 0.062]
	% ANHOPI	15	0.955 [0.949, 0.961]	0.046 [0.040, 0.052]	0.938 [0.925, 0.951]	0.064 [0.050, 0.078]
	% ANHOPI	18	0.945 [0.938, 0.951]	0.057 [0.050, 0.064]	0.927 [0.912, 0.942]	0.076 [0.060, 0.092]
	% AIAN	3	0.981 [0.977, 0.984]	0.020 [0.016, 0.023]	0.989 [0.986, 0.992]	0.011 [0.008, 0.014]
	% AIAN	7	0.963 [0.957, 0.969]	0.037 [0.031, 0.044]	0.974 [0.967, 0.980]	0.026 [0.020, 0.034]
	% AIAN	11	0.951 [0.944, 0.958]	0.050 [0.043, 0.058]	0.961 [0.953, 0.969]	0.039 [0.032, 0.048]
	% AIAN	15	0.939 [0.931, 0.947]	0.062 [0.054, 0.071]	0.952 [0.943, 0.960]	0.049 [0.041, 0.059]
	% AIAN	18	0.929 [0.920, 0.938]	0.073 [0.064, 0.083]	0.945 [0.936, 0.954]	0.056 [0.047, 0.067]
% White	3	0.989 [0.986, 0.992]	0.011 [0.008, 0.014]	0.979 [0.976, 0.982]	0.021 [0.018, 0.025]	
% White	7	0.977 [0.970, 0.983]	0.024 [0.018, 0.031]	0.961 [0.956, 0.965]	0.040 [0.035, 0.045]	
% White	11	0.965 [0.956, 0.974]	0.035 [0.027, 0.045]	0.947 [0.941, 0.953]	0.054 [0.048, 0.061]	
% White	15	0.957 [0.945, 0.967]	0.044 [0.034, 0.056]	0.936 [0.929, 0.942]	0.067 [0.060, 0.074]	
% White	18	0.947 [0.934, 0.959]	0.055 [0.042, 0.069]	0.926 [0.918, 0.933]	0.077 [0.069, 0.085]	

Socioeconomic status measures	% people of color	3	0.979 [0.976, 0.982]	0.021 [0.018, 0.024]	0.989 [0.986, 0.992]	0.011 [0.008, 0.014]
	% people of color	7	0.961 [0.956, 0.965]	0.040 [0.035, 0.045]	0.977 [0.970, 0.983]	0.023 [0.017, 0.030]
	% people of color	11	0.947 [0.941, 0.953]	0.054 [0.049, 0.061]	0.965 [0.956, 0.974]	0.035 [0.027, 0.045]
	% people of color	15	0.936 [0.929, 0.942]	0.067 [0.060, 0.074]	0.957 [0.946, 0.967]	0.044 [0.033, 0.056]
	% people of color	18	0.926 [0.919, 0.933]	0.077 [0.069, 0.085]	0.947 [0.934, 0.959]	0.055 [0.042, 0.069]
	Median income	3	0.986 [0.983, 0.989]	0.014 [0.012, 0.017]	0.985 [0.981, 0.988]	0.015 [0.012, 0.019]
	Median income	7	0.978 [0.975, 0.982]	0.022 [0.018, 0.026]	0.969 [0.961, 0.976]	0.032 [0.024, 0.040]
	Median income	11	0.967 [0.962, 0.972]	0.034 [0.029, 0.039]	0.957 [0.949, 0.966]	0.043 [0.035, 0.053]
	Median income	15	0.960 [0.955, 0.965]	0.041 [0.035, 0.046]	0.944 [0.933, 0.954]	0.058 [0.047, 0.069]
	Median income	18	0.951 [0.944, 0.957]	0.050 [0.044, 0.057]	0.935 [0.923, 0.947]	0.067 [0.055, 0.080]
	Median OOH value	3	0.984 [0.981, 0.987]	0.017 [0.014, 0.020]	0.980 [0.976, 0.984]	0.020 [0.016, 0.025]
	Median OOH value	7	0.974 [0.970, 0.978]	0.026 [0.022, 0.031]	0.956 [0.947, 0.964]	0.045 [0.036, 0.054]
	Median OOH value	11	0.963 [0.958, 0.968]	0.038 [0.033, 0.043]	0.942 [0.931, 0.952]	0.060 [0.049, 0.071]
	Median OOH value	15	0.956 [0.950, 0.961]	0.045 [0.040, 0.051]	0.925 [0.913, 0.937]	0.078 [0.065, 0.091]
	Median OOH value	18	0.948 [0.942, 0.954]	0.054 [0.047, 0.060]	0.913 [0.899, 0.926]	0.091 [0.076, 0.106]
	% residents under FPL	3	0.982 [0.979, 0.985]	0.018 [0.015, 0.021]	0.987 [0.984, 0.989]	0.014 [0.011, 0.016]
	% residents under FPL	7	0.962 [0.956, 0.968]	0.038 [0.032, 0.045]	0.978 [0.975, 0.982]	0.022 [0.018, 0.026]
	% residents under FPL	11	0.949 [0.942, 0.956]	0.052 [0.045, 0.060]	0.969 [0.964, 0.973]	0.032 [0.027, 0.037]
	% residents under FPL	15	0.936 [0.927, 0.944]	0.066 [0.057, 0.076]	0.961 [0.955, 0.967]	0.040 [0.034, 0.046]
	% residents under FPL	18	0.926 [0.916, 0.936]	0.077 [0.066, 0.087]	0.951 [0.944, 0.958]	0.050 [0.043, 0.058]
	% residents w/o HS diploma	3	0.985 [0.983, 0.988]	0.015 [0.012, 0.018]	0.986 [0.982, 0.989]	0.014 [0.011, 0.018]
	% residents w/o HS diploma	7	0.966 [0.959, 0.971]	0.035 [0.029, 0.042]	0.975 [0.968, 0.981]	0.025 [0.019, 0.032]
	% residents w/o HS diploma	11	0.954 [0.947, 0.961]	0.047 [0.040, 0.055]	0.964 [0.955, 0.972]	0.036 [0.028, 0.046]
	% residents w/o HS diploma	15	0.938 [0.929, 0.947]	0.064 [0.055, 0.073]	0.958 [0.948, 0.967]	0.043 [0.033, 0.054]
	% residents w/o HS diploma	18	0.930 [0.920, 0.940]	0.073 [0.062, 0.083]	0.948 [0.937, 0.959]	0.053 [0.042, 0.066]
	% homeowners	3	0.988 [0.985, 0.990]	0.012 [0.010, 0.015]	0.983 [0.980, 0.987]	0.017 [0.013, 0.02]
	% homeowners	7	0.973 [0.966, 0.979]	0.027 [0.021, 0.035]	0.969 [0.963, 0.975]	0.031 [0.026, 0.038]
	% homeowners	11	0.963 [0.954, 0.971]	0.038 [0.029, 0.047]	0.958 [0.950, 0.964]	0.043 [0.036, 0.051]
	% homeowners	15	0.951 [0.939, 0.962]	0.051 [0.039, 0.063]	0.948 [0.939, 0.956]	0.054 [0.045, 0.063]

% homeowners	18	0.942 [0.929, 0.955]	0.059 [0.046, 0.074]	0.939 [0.929, 0.948]	0.063 [0.054, 0.073]
% income spent on rent	3	0.986 [0.983, 0.989]	0.014 [0.012, 0.018]	0.984 [0.980, 0.987]	0.017 [0.013, 0.020]
% income spent on rent	7	0.972 [0.968, 0.976]	0.028 [0.024, 0.033]	0.968 [0.962, 0.973]	0.033 [0.027, 0.039]
% income spent on rent	11	0.958 [0.952, 0.963]	0.043 [0.038, 0.049]	0.955 [0.947, 0.963]	0.046 [0.038, 0.054]
% income spent on rent	15	0.947 [0.941, 0.953]	0.054 [0.048, 0.061]	0.948 [0.939, 0.956]	0.054 [0.045, 0.063]
% income spent on rent	18	0.937 [0.931, 0.944]	0.065 [0.058, 0.072]	0.938 [0.927, 0.948]	0.064 [0.054, 0.076]

Results are shown for the first and fourth quartiles of each sociodemographic factor. 95% confidence intervals were determined from county-level cluster bootstrapping.

**Table S 5:** Adjusted changes in odds of adoption of advancements in treatment processes between 2004-2022 associated with customer sociodemographic composition at the county level

	All systems <sup>a</sup>	Stratified: large/very large <sup>b</sup>	Stratified: medium <sup>b</sup>	Stratified: small/very small <sup>b</sup>	Stratified: rural systems <sup>c</sup>	Stratified: urban systems <sup>c</sup>	Systems with prior MCL violations	Systems with known PFAS detections <sup>d</sup>
<b>% Hispanic/Latino (10 percentage point change)</b>	4.6 [-1.4, 10.5]	6.2 [-2.3, 14.8]	-6.6 [-20.4, 6.1]	4.4 [-2.8, 11.8]	1.6 [-7.1, 9.2]	5.7 [-2.5, 14.7]	6.8 [-4.2, 19.0]	4.0 [-6.6, 14.3]
<b>% Black (10 percentage point change)</b>	-19.3 [-26.2, -12.1]	-18.5 [-28.6, -8.5]	-24.4 [-35.9, -12.8]	-13.8 [-23.7, -4.2]	-24.0 [-32.6, -16.1]	-12.1 [-23.6, 0.5]	-22.1 [-36.6, -8.8]	-23.9 [-34.9, -13.0]
<b>% ANHOPI (10 percentage point change)</b>	2.8 [-17.0, 22.0]	26.6 [-11.9, 65.1]	-24.9 [-64.3, 14.3]	3.3 [-19.2, 28.6]	8.4 [-28.6, 31.1]	-1.2 [-27.8, 26.1]	-24.5 [-80.7, 30.3]	-10.8 [-45.9, 35.7]
<b>% AIAN (10 percentage point change)</b>	-2.5 [-18.5, 8.4]	-19.4 [-61.8, 13.5]	-35.9 [-88.0, -1.4]	3.0 [-11.7, 13.6]	-0.5 [-18.6, 11.2]	-8.3 [-54.0, 71.5]	15.1 [-15.7, 40.8]	-19.2 [-69.7, 15.4]
<b>Median income (10,000 USD change)</b>	0.2 [-5.2, 5.6]	-10.3 [-18.0, -1.9]	-2.9 [-15.2, 8.6]	6.1 [-0.1, 12.1]	-1.3 [-13.3, 11.3]	-1.5 [-8.5, 5.6]	11.1 [-2.0, 27.1]	-1.6 [-11.0, 7.6]
<b>N (total CWS)</b>	521,176 (36,611)	43,439 (3,090)	57,581 (3,816)	420,156 (29,705)	237,167 (16,038)	283,023 (20,194)	25,448 (1,786)	44,523 (3,025)

Adjusted percent changes and [95% confidence intervals] determined from county-level cluster bootstrapping are shown for United States (US) community water systems (CWS). Results are from piecewise logistic regressions that adjusted for several county-level sociodemographic factors (% Hispanic/Latino, % Black, % Asian, Native Hawaiian and other Pacific Islander [ANHOPI], % American Indian / Alaskan Native [AIAN], and median household income), CWS size, source water type, owner type, an indicator for prior MCL violation, population density, fixed effects for census division, and fixed effects for the year on study. Associations for all racial/ethnic variables are shown in relation to a 10-percentage-point increase and the association for median income is shown in relation to a 10,000 USD increase.

<sup>a</sup>Model includes all CWS after applying the exclusion criteria (see Methods).

<sup>b</sup>Definitions of CWS size by customer base from US Environmental Protection Agency: very small: 25-500; small: 501-3,300; medium: 3,301-10,000; large: 10,001-100,000; and very large: >100,000.<sup>12</sup>

<sup>c</sup>Based on US Department of Agriculture Rural-Urban Continuum Codes (urban: CWS serving counties in metropolitan areas of <250,000 to ≥1 million, rural: CWS serving counties in non-metropolitan areas with smaller populations).

<sup>d</sup>Model includes only CWS with known PFAS detections above the minimum reporting levels or uniform detection limits across the Third Unregulated Contaminant Monitoring Rule monitoring (2013-2015),<sup>10</sup> a compilation of statewide PFAS sampling data from 28 states (2017-2024),<sup>9</sup> and the ongoing Fifth Unregulated Contaminant Monitoring Rule (2023-ongoing).<sup>13</sup>

**Table S 6:** Adjusted changes in odds of adoption of advancements in treatment processes between 2004-2022 associated with customer sociodemographic composition at the service area boundary level

	All systems <sup>a</sup>	Stratified: large/very large <sup>b</sup>	Stratified: medium <sup>b</sup>	Stratified: small/very small <sup>b</sup>	Stratified: rural systems <sup>c</sup>	Stratified: urban systems <sup>c</sup>	Systems with prior MCL violations	Systems with known PFAS detections <sup>d</sup>
<b>% Hispanic/Latino (10 percentage point change)</b>	4.5 [1.0, 8.0]	4.4 [-1.1, 10.0]	-3.6 [-13.8, 5.8]	6.0 [ 0.9, 11.0]	3.8 [-2.7, 10.0]	5.7 [1.5, 9.9]	6.9 [1.8, 11.9]	3.0 [-4.3, 10.6]
<b>% Black (10 percentage point change)</b>	-14.2 [-18.9, -9.7]	-12.9 [-20.5, -5.5]	-17.9 [-28.9, -7.9]	-9.2 [-16.9, -2.0]	-23.1 [-30.3, -16.5]	-5.2 [-11.6, 0.7]	-19.6 [-27.1, -12.7]	-9.9 [-19.2, -0.8]
<b>% ANHOPI (10 percentage point change)</b>	-1.8 [-15.9, 10.9]	12.6 [-7.8, 31.9]	-33.8 [-63.5, -8.6]	0.0 [-24.1, 20.6]	-1.8 [-15.9, 10.9]	1.5 [-14.4, 16.0]	-6.0 [-26.6, 12.7]	13.1 [-10.4, 35.2]
<b>% AIAN (10 percentage point change)</b>	8.9 [-5.9, 19.1]	-60.9 [-87.7, -25.7]	-52.5 [-81.7, -19.5]	16.4 [3.9, 25.7]	-4.6 [-31.8, 11.7]	23.4 [3.5, 36.0]	-5.1 [-32.0, 12.0]	-65.0 [-93.3, -21.2]
<b>Median income (10,000 USD change)</b>	-2.3 [-4.7, 0.0]	-6.5 [-10.7, -2.5]	-2.8 [-9.2, 3.5]	0.1 [-3.2, 3.4]	-3.0 [-9.8, 4.0]	-2.8 [-5.6, -0.1]	-2.6 [-6.5, 1.4]	-4.1 [-9.0, 0.7]
<b>N (total CWS)</b>	454,178 (29,956)	42,196 (2,948)	55,595 (3,632)	356,387 (23,376)	210,016 (13,566)	243,930 (16,385)	162,421 (10,812)	42,462 (2,878)

Adjusted percent changes and [95% confidence intervals] determined from system-level cluster bootstrapping are shown for United States (US) community water systems (CWS). Results are from piecewise logistic regressions that adjusted for several sociodemographic factors at the service area boundary level (% Hispanic/Latino, % Black, % Asian, Native Hawaiian and other Pacific Islander [ANHOPI], % American Indian / Alaskan Native [AIAN], and median household income), CWS size, source water type, owner type, an indicator for prior MCL violation, population density, fixed effects for census division, and fixed effects for the year on study. Associations for all racial/ethnic variables are shown in relation to a 10-percentage-point increase and the association for median income is shown in relation to a 10,000 USD increase.

<sup>a</sup>Model includes all CWS after applying the exclusion criteria (see Methods).

<sup>b</sup>Definitions of CWS size by customer base from US Environmental Protection Agency: very small: 25-500; small: 501-3,300; medium: 3,301-10,000; large: 10,001-100,000; and very large: >100,000.<sup>12</sup>

<sup>c</sup>Based on US Department of Agriculture Rural-Urban Continuum Codes (urban: CWS serving counties in metropolitan areas of <250,000 to ≥1 million, rural: CWS serving counties in non-metropolitan areas with smaller populations).

<sup>d</sup>Model includes only CWS with known PFAS detections above the minimum reporting levels or uniform detection limits across the Third Unregulated Contaminant Monitoring Rule monitoring (2013-2015),<sup>10</sup> a compilation of statewide PFAS sampling data from 28 states (2017-2024),<sup>9</sup> and the ongoing Fifth Unregulated Contaminant Monitoring Rule (2023-ongoing).<sup>13</sup>

**Table S 7:** Adjusted changes in odds of adoption of advancements in treatment processes between 2004-2022 associated with customer sociodemographic composition: stratified by source water type

	Service area boundary		County	
	Groundwater	Surface water	Groundwater	Surface water
<b>% Hispanic/Latino (10 percentage point change)</b>	9.0 [3.1, 14.9]	-6.0 [-13.9, 0.5]	4.9 [-2.3, 12.3]	0.5 [-7.9, 7.8]
<b>% Black (10 percentage point change)</b>	-4.4 [-14.7, 5.4]	-14.3 [-22.3, -6.1]	-4.3 [-15.5, 7.3]	-22.3 [-31.6, -13.0]
<b>% ANHOPI (10 percentage point change)</b>	-0.1 [-17.5, 15.3]	-20.4 [-69.4, 8.9]	2.0 [-13.1, 15.2]	-11.0 [-52.6, 6.2]
<b>% AIAN (10 percentage point change)</b>	17.0 [0.3, 28.2]	11.5 [-24.3, 35.1]	-7.0 [-29.0, 14.2]	29.3 [-10.8, 72.6]
<b>Median income (10,000 USD change)</b>	2.7 [-1.6, 6.6]	-11.9 [-16.7, -7.0]	5.1 [-1.7, 11.6]	-12.1 [-19.4, -4.1]
<b>N (total CWS)</b>	381,389 (24,354)	72,789 (5,602)	439,673 (30,063)	81,503 (6,548)

Adjusted percent changes and [95% confidence intervals] determined from county- or system-level cluster bootstrapping are shown for United States (US) community water systems (CWS). Results are from piecewise logistic regressions, stratified by source water type, that adjusted for several sociodemographic factors at the county and service area boundary level (% Hispanic/Latino, % Black, % Asian, Native Hawaiian and other Pacific Islander [ANHOPI], % American Indian / Alaskan Native [AIAN], and median household income), CWS size, owner type, an indicator for prior MCL violation, population density, fixed effects for census division, and fixed effects for the year on study. Associations for all racial/ethnic variables are shown in relation to a 10-percentage-point increase and the association for median income is shown in relation to a 10,000 USD increase. Census regions are inclusive of census subdivisions (Midwest, which includes West North Central and East North Central; Northeast: New England and Middle Atlantic; South: South Atlantic, East South Central, and West South Central; and West: Pacific and Mountain).

**Table S 8:** Sensitivity results for several unstratified models showing percent changes in the odds [95% confidence interval] for the association between sociodemographic factors and reporting adoption of advancements in treatment processes (2004-2022)

Independent variable	Baseline variables only <sup>a</sup>	Excl. WSP systems <sup>b</sup>	Incl. all systems <sup>c</sup>	Excl. racial/ethnic measures	Adjust for alternative MCL indicators <sup>d</sup>	Adjust for climatic regions <sup>e</sup>
% Hispanic/Latino	5.0 [-4.0, 13.3]	6.2 [-3.0, 14.8]	1.6 [-5.8, 8.4]	-	5.6 [-2.8, 14.0]	1.3 [-7.1, 9.6]
% Black	-18.9 [-28.5, -8.6]	-18.9 [-30.0, -7.8]	-18.5 [-26.9, -9.5]	-	-19.8 [-29.0, -9.9]	-13.3 [-23.6, -2.8]
% AIAN	-1.7 [-25.9, 13.1]	-1.1 [-27.7, 15.3]	3.3 [-11.3, 14.9]	-	-1.8 [-26.7, 13.8]	-2.0 [-25.6, 17.0]
% ANHOPI	-1.5 [-33.7, 27.0]	5.3 [-20.4, 31.4]	-6.0 [-30.5, 15.2]	-	3.7 [-23.4, 30.9]	-3.9 [-39.0, 48.4]
Median income	1.2 [-6.9, 9.9]	0.1 [-9.0, 9.0]	2.3 [-3.9, 8.8]	1.9 [-5.3, 9.6]	0.0 [-7.4, 7.4]	0.2 [-7.2, 8.0]
<b>N (total CWS)</b>	521,150 (36,611)	388,074 (28,055)	560,088 (40,722)	521,176 (36,611)	521,176 (36,611)	521,176 (36,611)

Results are from piecewise logistic regressions that adjusted for several county-level sociodemographic factors (% Hispanic/Latino, % Black, % Asian, Native Hawaiian and other Pacific Islander [ANHOPI], % American Indian and Alaskan Native [AIAN], and median household income), CWS size, source water type, owner type, an indicator for prior MCL violation, population density, fixed effects for census division, and fixed effects for the year on study. Associations for all racial/ethnic variables are shown in relation to a 10-percentage-point increase and the association for median income is shown in relation to a 10,000 USD increase. 95% confidence intervals were determined from bootstrapping.

<sup>a</sup>This model includes sociodemographic factors only from the first year on study for each CWS.

<sup>b</sup>This model excludes CWS that reported implementing water source protection according to individual state policy.<sup>1</sup>

<sup>c</sup>This model includes all additional CWS that reported advancements in treatment processes at the first year on study.

<sup>d</sup>This model adjusts for five separate MCL violation indicators (all prior to 2004), rather than one combined indicator that excludes violations of the total and the revised total coliform rules. In this model, there are separate indicators for violations of the total and revised total coliform rules, total trihalomethanes, total haloacetic acids, arsenic, and nitrate.

<sup>e</sup>This model alternatively adjusts for nine fixed effects representing the climatic regions from the National Oceanic and Atmospheric Administration, in addition to a fixed effect for Territories and Tribal systems

**Table S 9:** Adjusted changes in odds of adoption of advancements in treatment processes between 2004-2022 associated with customer sociodemographic composition: stratified by census region

	Service area boundary				County			
	Midwest	Northeast	South	West	Midwest	Northeast	South	West
<b>% Hispanic/Latino (10 percentage point change)</b>	5.5 [-9.3, 20.2]	-4.4 [-23.1, 11.5]	-0.7 [-7.0, 5.2]	6.2 [1.2, 11.1]	18.3 [-14.5, 46.5]	-20.0 [-50.5, 16.9]	-2.6 [-13.7, 6.0]	4.1 [-4.0, 11.6]
<b>% Black (10 percentage point change)</b>	-5.4 [-19.5, 7.2]	16.1 [-2.9, 38.1]	-18.6 [-23.8, -13.7]	7.7 [-20.0, 27.9]	-5.8 [-36.7, 24.2]	20.6 [-26.9, 95.5]	-21.6 [-28.8, -14.8]	58.4 [-22.7, 251.6]
<b>% ANHOPI (10 percentage point change)</b>	-54.6 [-77.0, -21.3]	-0.9 [-34.6, 38.8]	-19.5 [-56.0, 23.0]	12.4 [-1.8, 25.4]	-48.2 [-86.8, 98.0]	-5.5 [-64.6, 114.6]	29.6 [-41.7, 239.9]	3.4 [-21.3, 21.5]
<b>% AIAN (10 percentage point change)</b>	-21.9 [-79.1, 4.4]	-16.3 [-92.0, 80.5]	-56.2 [-79.1, -31.8]	23.9 [11.4, 34.2]	-22.1 [-74.2, 3.7]	-45.1 [-99.9, 626.4]	-60.6 [-87.1, -32.8]	4.7 [-10.8, 17.5]
<b>Median income (10,000 USD change)</b>	-8.1 [-14.5, -1.9]	2.4 [-1.7, 6.6]	-2.6 [-7.4, 2.2]	-2.1 [-7.3, 2.9]	-6.8 [-18.4, 4.9]	10.2 [-2.3, 23.1]	0.0 [-11.3, 9.2]	-3.9 [-13.0, 6.3]
<b>N (total CWS)</b>	96,502 (6,459)	74,638 (4,771)	200,194 (12,502)	82,844 (6,133)	105,836 (7,345)	85,934 (5,824)	233,498 (15,830)	95,170 (7,236)

Adjusted percent changes and [95% confidence intervals] determined from county- or system-level cluster bootstrapping are shown for United States (US) community water systems (CWS). Results are from piecewise logistic regressions, stratified by census region, that adjusted for several sociodemographic factors at the county and service area boundary level (% Hispanic/Latino, % Black, % Asian, Native Hawaiian and other Pacific Islander [ANHOPI], % American Indian / Alaskan Native [AIAN], and median household income), CWS size, source water type, owner type, an indicator for prior MCL violation, population density, fixed effects for census division, and fixed effects for the year on study. Associations for all racial/ethnic variables are shown in relation to a 10-percentage-point increase and the association for median income is shown in relation to a 10,000 USD increase. Census regions are inclusive of census subdivisions (Midwest, which includes West North Central and East North Central; Northeast: New England and Middle Atlantic; South: South Atlantic, East South Central, and West South Central; and West: Pacific and Mountain).

**Table S 10:** Sensitivity analysis results for models including quadratic terms for median income showing percent changes in the odds [95% confidence interval] for the association between sociodemographic factors and reporting adoption of advancements in treatment processes (2004-2022)

<b>Independent variable</b>	<b>Unstratified</b>	<b>Stratified: large/very large</b>	<b>Stratified: medium</b>	<b>Stratified: small/very small</b>
% Hispanic/Latino	7.0 [-1.5, 10.6]	6.9 [-2.6, 14.6]	-3.2 [-18.4, 5.9]	8.1 [-2.6, 12.2]
% Black	-19.9 [-26.2, -12.2]	-17.9 [-28.1, -8.5]	-26.1 [-35.9, -14.4]	-15.0 [-23.4, -2.8]
% AIAN	-2.0 [-17.9, 8.7]	-15.1 [-62.4, 12.2]	-36.3 [-87.8, -4.1]	3.7 [-11.2, 14.8]
% ANHOPI	4.9 [-17.2, 23.0]	24.2 [-14.6, 62.3]	-26.9 [-66.7, 10.4]	8.1 [-17.6, 33.5]
Median income	5.3 [-16.0, 35.6]	-18.7 [-38.6, 17.8]	-38.3 [-58.0, -12.0]	44.0 [7.6, 101.9]
Median income (squared)	-0.4 [-2.3, 1.3]	0.7 [-2.1, 2.8]	3.8 [0.8, 6.7]	-2.5 [-4.9, -0.3]
<b><i>N</i> (total CWS)</b>	<b>521,176 (36,611)</b>	<b>43,439 (3,090)</b>	<b>57,581 (3,816)</b>	<b>420,156 (29,705)</b>

Results are from piecewise logistic regressions that adjusted for several county-level sociodemographic factors (% Hispanic/Latino, % Black, % Asian, Native Hawaiian and other Pacific Islander [ANHOPI], % American Indian and Alaskan Native [AIAN], and median household income), CWS size, source water type, owner type, an indicator for prior MCL violation, population density, fixed effects for census division, and fixed effects for the year on study. Associations for all racial/ethnic variables are shown in relation to a 10-percentage-point increase and the association for median income is shown in relation to a 10,000 USD increase. 95% confidence intervals were determined from county-level cluster bootstrapping. CWS system sizes refer to very small: serving 25-500 people; small: 501-3,300 people; medium: 3,301-10,000 people; large: 10,001-100,000 people; and very large: >100,000 people.

**Table S 11:** Sensitivity analysis results for models including quadratic terms for median income showing percent changes in the odds [95% confidence interval] for the association between sociodemographic factors and reporting adoption of advancements in treatment processes (2004-2022)

<b>Independent variable</b>	<b>Unstratified</b>	<b>Stratified: large/very large</b>	<b>Stratified: medium</b>	<b>Stratified: small/very small</b>
% Hispanic/Latino	4.3 [0.9, 7.8]	4.2 [-1.4, 9.7]	-4.1 [-14.2, 5.4]	6.0 [0.7, 11.0]
% Black	-14.4 [-18.8, -10.0]	-13.1 [-20.7, -5.9]	-18.7 [-29.5, -9.2]	-9.3 [-16.6, -2.0]
% AIAN	8.5 [-6.1, 18.8]	-61.4 [-88.3, -27.4]	-53.7 [-82.2, -21.0]	6.3 [4.1, 25.9]
% ANHOPI	-2.1 [-16.2, 10.7]	12.4 [-7.4, 31.3]	-35.5 [-64.2, -9.2]	-0.1 [-24.7, 21.2]
Median income	-5.8 [-11.4, 0.8]	-10.3 [-19.7, 1.4]	-16.2 [-26.9, -1.7]	-0.9 [-8.9, 10.7]
Median income (squared)	0.2 [-0.2, 0.6]	0.3 [-0.4, 0.8]	1.0 [0.0, 1.6]	0.1 [-0.6, 0.5]
<b>N (total CWS)</b>	<b>454,178 (29,956)</b>	<b>42,196 (2,948)</b>	<b>55,595 (3,632)</b>	<b>356,387 (23,376)</b>

Results are from piecewise logistic regressions that adjusted for several sociodemographic factors at the service area boundary level (% Hispanic/Latino, % Black, % Asian, Native Hawaiian and other Pacific Islander [ANHOPI], % American Indian and Alaskan Native [AIAN], and median household income), CWS size, source water type, owner type, an indicator for prior MCL violation, population density, fixed effects for census division, and fixed effects for the year on study. Associations for all racial/ethnic variables are shown in relation to a 10-percentage-point increase and the association for median income is shown in relation to a 10,000 USD increase. 95% confidence intervals were determined from county-level cluster bootstrapping. CWS system sizes refer to very small: serving 25-500 people; small: 501-3,300 people; medium: 3,301-10,000 people; large: 10,001-100,000 people; and very large: >100,000 people.

**Table S 12:** Sensitivity analysis results for models including varying SES measures showing percent changes in the odds [95% confidence interval] for the association between sociodemographic factors and reporting adoption of advancements in treatment processes (2004-2022)

Independent variable	Primary model	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
% Hispanic/Latino	4.6 [-4.1, 12.8]	4.6 [-4.3, 12.6]	4.2 [-5.2, 12.8]	4.6 [-9.0, 19.0]	4.4 [-4.7, 13.6]	3.6 [-5.0, 11.7]	4.0 [-4.6, 12.0]	4.5 [-3.7, 12.5]
% Black	-19.3 [-28.9, -9.5]	-19.2 [-28.4, -9.4]	-19.9 [-29.3, -9.7]	-19.3 [-28.9, -9.4]	-19.4 [-29.02 -9.2]	-20.5 [-30.5, -10.3]	-19.9 [-29.4, -9.6]	-19.3 [-28.8, -9.5]
% AIAN	-2.5 [-27.1, 12.2]	-2.2 [-26.8, 12.4]	-2.8 [-26.7, 11.7]	-2.6 [-26.7, 12.0]	-2.8 [-28.8, 13.5]	-0.8 [-25.9, 14.5]	-4.1 [-27.5, 11.5]	-2.6 [-25.8, 11.9]
% ANHOPI	2.8 [-25.3, 29.7]	1.1 [-30.1, 33.0]	2.2 [-26.4, 29.3]	3.1 [-24.9, 30.4]	3.4 [-24.3, 30.7]	3.0 [-25.1, 32.3]	4.3 [-24.6, 33.4]	3.1 [-24.5 31.0]
Median income	0.2 [-7.0, 8.3]	-	-	-	-	-	-	-
Median value of owner-occupied housing units	-	0.2 [-0.98, 1.31]	-	-	-	-	-	-
% homeowners	-	-	-2.5 [-17.0, 13.9]	-	-	-	-	-
% w/o HS diploma	-	-	-	0.0 [-16.5, 18.5]	-	-	-	-
% under FPL	-	-	-	-	1.1 [-18.0, 25.5]	-	-	-
% income spent on rent	-	-	-	-	-	21.7 [-6.2, 59.0]	-	-
% unemployed (aged 16-64)	-	-	-	-	-	-	1.9 [-4.1, 8.1]	-
<i>N</i> (total CWS)	521,176 (36,611)	521,176 (36,611)	521,176 (36,611)	521,176 (36,611)	521,176 (36,611)	521,176 (36,611)	521,176 (36,611)	521,176 (36,611)

Results are from piecewise logistic regressions that adjusted for several county-level sociodemographic factors (% Hispanic/Latino, % Black, % Asian, Native Hawaiian and other Pacific Islander [ANHOPI], % American Indian and Alaskan Native [AIAN] and various area-level socioeconomic status measures), CWS size, source water type, owner type, an indicator for prior MCL violation, population density, fixed effects for census division, and fixed effects for the year on study. Associations for all proportional variables are shown in relation to a 10-percentage-point increase and the associations for median income and median value of owner-occupied housing units are shown in relation to 10,000 USD increases. 95% confidence intervals were determined from county-level cluster bootstrapping. We used a Bonferroni-corrected significance level (with a reduced  $\alpha = \frac{0.05}{8} = 0.00625$ ) to account for multiple hypothesis testing in assessing the results from this set of sensitivity analyses and the primary analysis.<sup>14</sup>

**Table S 13:** Descriptive statistics of CWS excluded from the service area boundary analyses

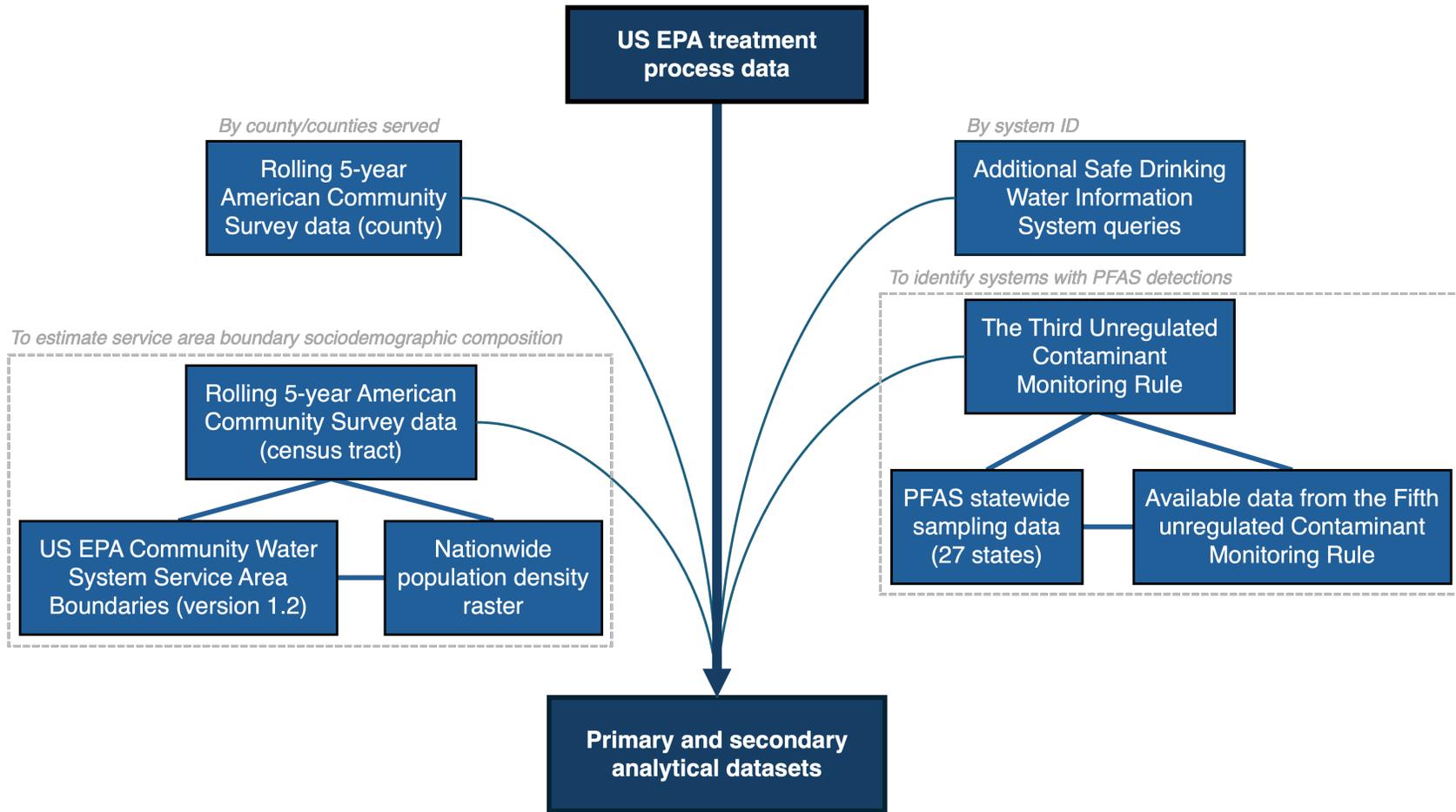
	<b>CWS excluded from service area analysis (N = 6,655)</b>	<b>CWS excluded from service area analysis (w/ known PFAS detections) (N = 147)</b>
<b>Water system characteristics</b>		
Est. population served [millions]	10.7	2.6
Number of large or very large systems	142 (2.1%)	40 (27.2%)
Number of medium systems	184 (2.8%)	18 (12.2%)
Number of small or very small systems	6,329 (95.1%)	89 (60.5%)
Number of systems with prior MCL violations	171 (2.6%)	21 (14.3%)
Number of systems sourced by SW	946 (14.2%)	50 (34.0%)
Government-owned	1,642 (24.7%)	70 (47.6%)
Non-government-owned	5,013 (75.3%)	77 (52.4%)
<b>Sociodemographic factors [mean; median (interquartile range)]</b>		
% Hispanic/Latino	15.0; 5.5 (2.3, 14.7)	30.9; 8.8 (3.1, 56.8)
% non-Hispanic Black	10.6; 5.9 (1.5, 15.5)	8.0; 5.6 (2.1, 9.2)
% non-Hispanic ANHOPI	2.0; 1.0 (0.5, 2.1)	2.3; 1.5 (0.2, 3.3)
% non-Hispanic AIAN	2.1; 0.2 (0.1, 0.5)	0.3; 0.1 (0.0, 0.2)
% non-Hispanic White	69.2; 76.0 (59.1, 88.1)	60.0; 76.7 (22.6, 87.3)
Median income [USD]	48,000; 46,000 (40,000, 56,000)	54,000; 56,000 (35,000, 68,000)
Population density [people/km <sup>2</sup> ]	364; 144 (54, 414)	689; 430 (131, 857)
<b>Ever adopted treatment processes (2004-2022)</b>	206 (3.1%)	4 (2.7%)

CWS = Community water system

<sup>a</sup>This refers to systems with known PFAS detections across three monitoring datasets (the Third Unregulated Contaminant Monitoring Rule,<sup>10</sup> a compilation of statewide PFAS sampling data of 28 states,<sup>9</sup> and the ongoing Fifth Unregulated Contaminant Monitoring Rule<sup>11</sup>).

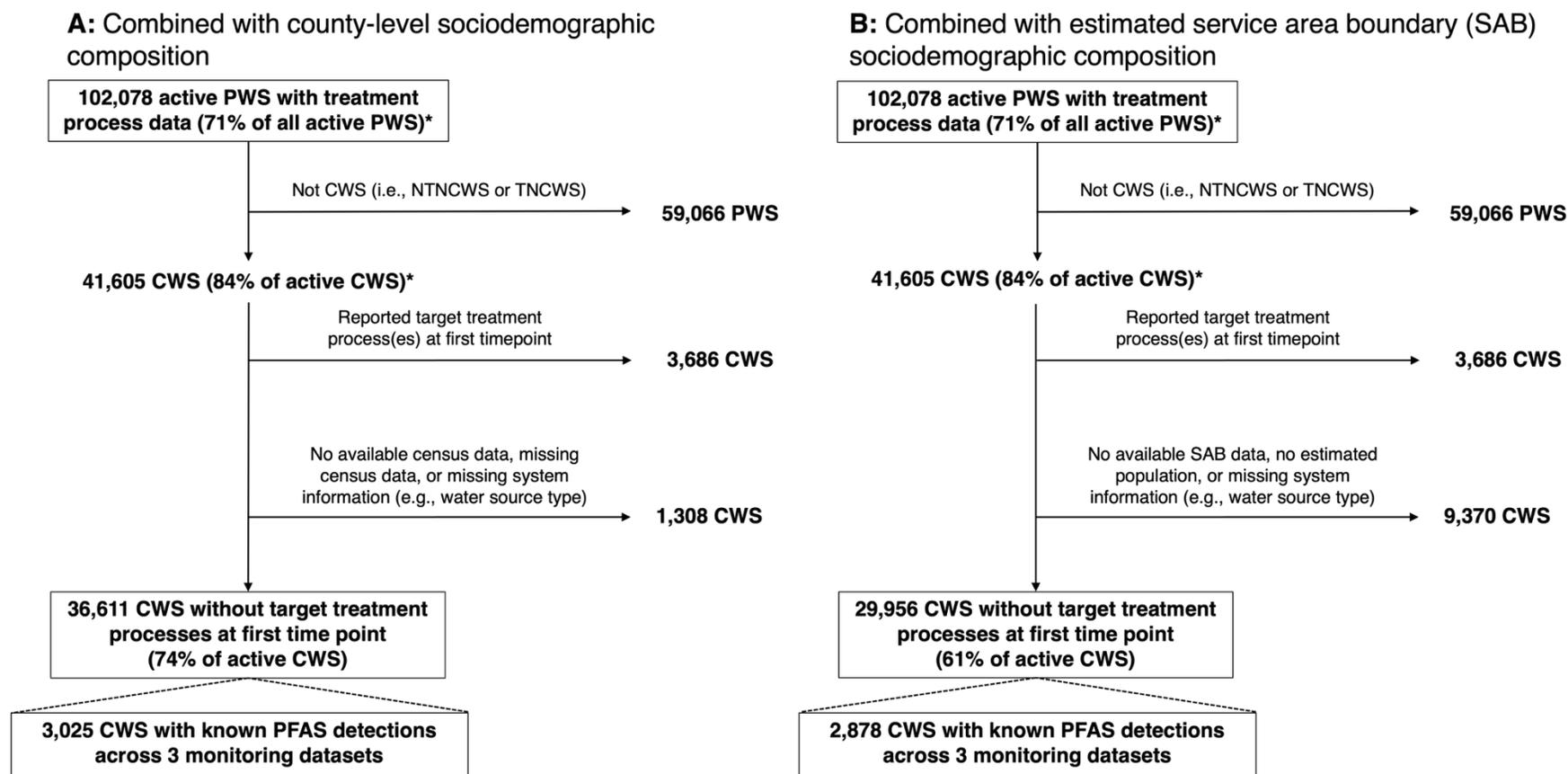
Each observation corresponds to a CWS. Sociodemographic data shown here are at the county-served level because these CWS do not have estimated sociodemographic composition available at the service area boundary level. Large or very large systems serve over 10,000 people; medium systems serve 3,301-10,000; and small or very small serve 25-3,300.

**Figure S 1:** Overview of data aggregation in this study



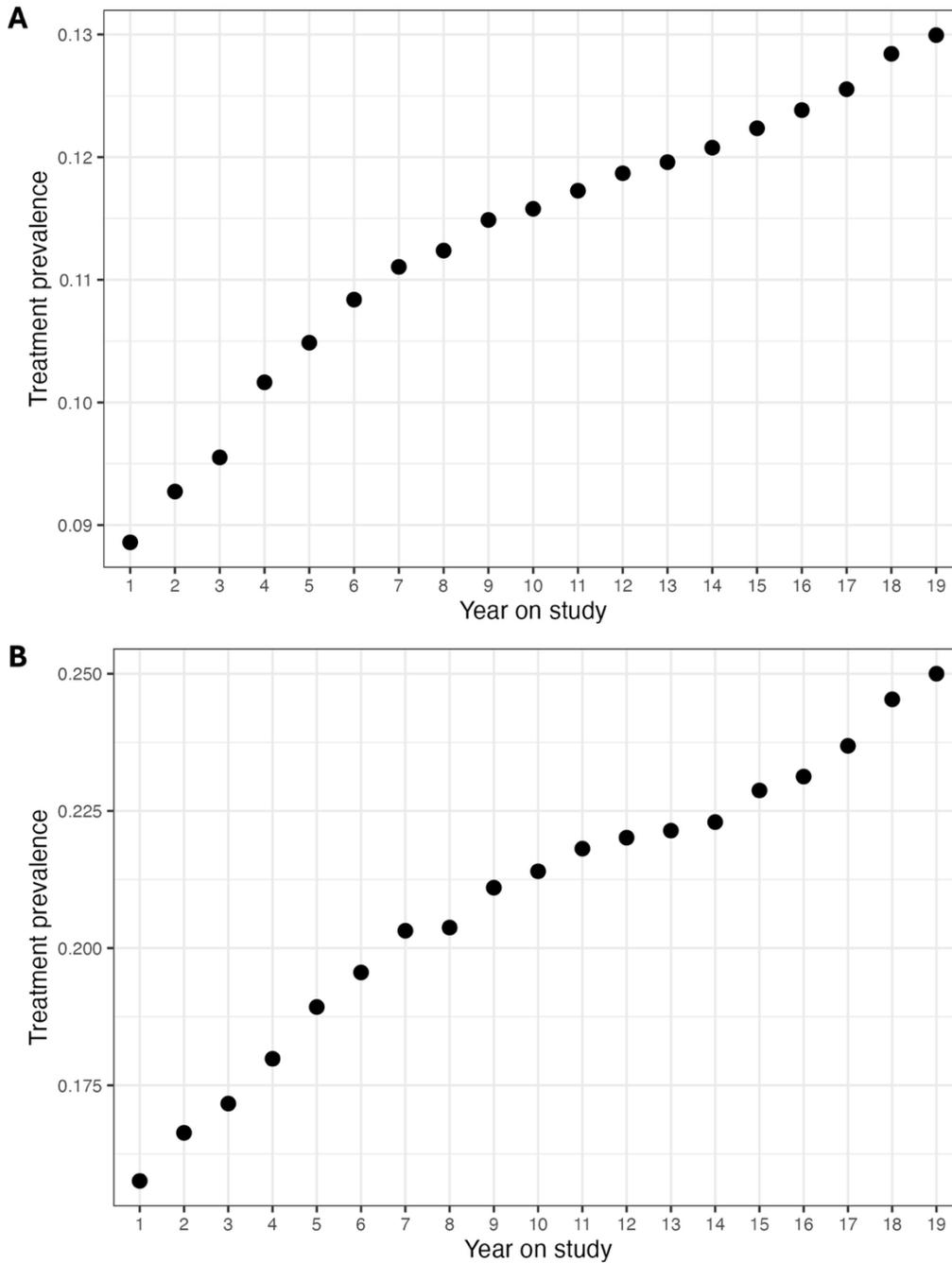
US EPA treatment records were obtained by Freedom of Information Act Requests and through the Safe Drinking Water Information System; American Community Survey (ACS) data (county- and tract-level) were obtained from the US Census Bureau;<sup>3</sup> service area boundary sociodemographic composition was estimated using ACS data, US EPA’s Community Water System Service Area Boundaries dataset (version 1.2)<sup>5</sup> and a nationwide population density raster;<sup>15</sup> and systems with known PFAS detections were identified across three monitoring datasets.<sup>9-11</sup> Flowcharts of the analytical datasets are provided in Figure S 2.

**Figure S 2:** Determination of primary analytic sample for CWS included in this study



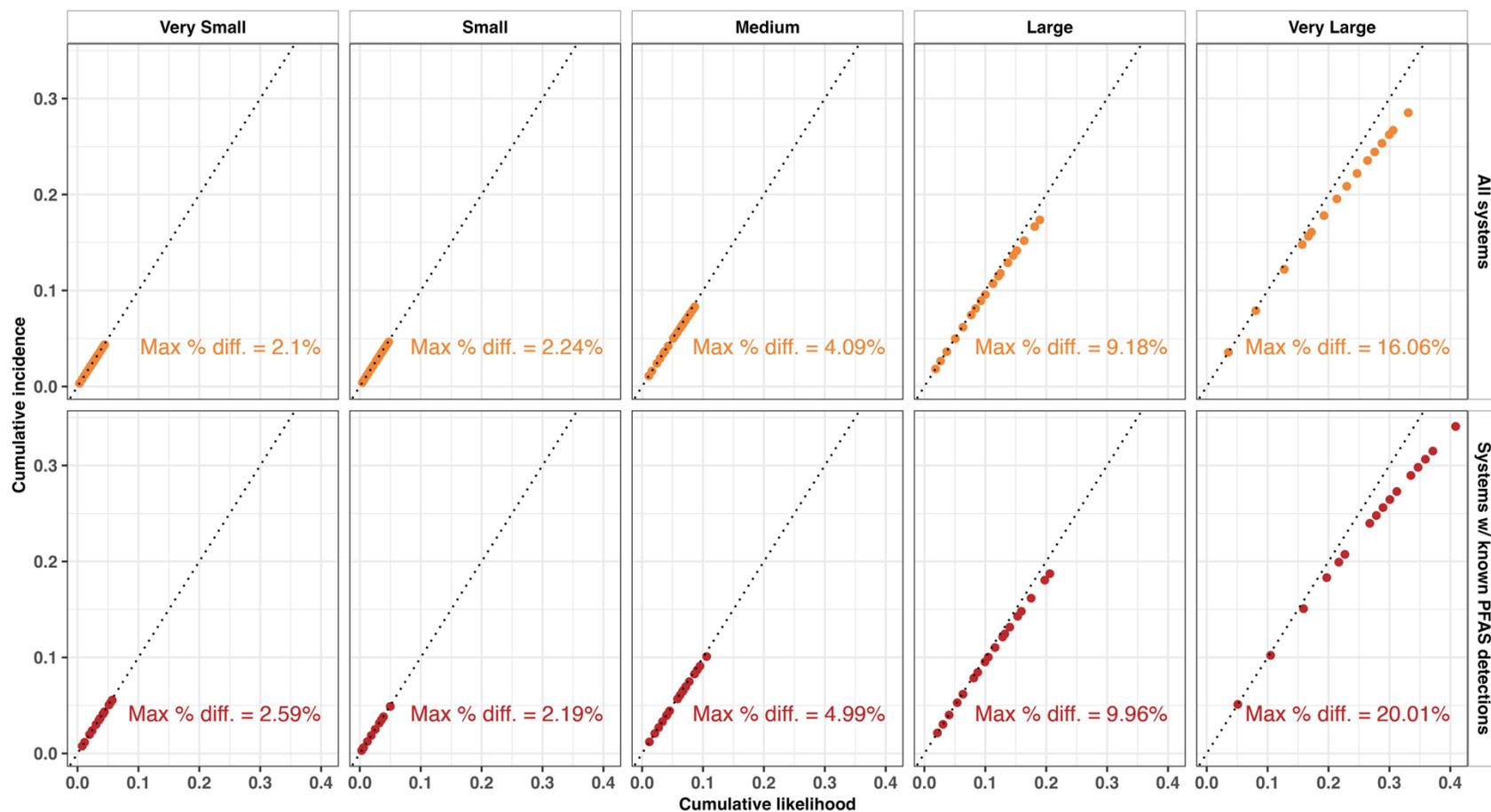
Systems with known PFAS detections were determined based on three monitoring datasets (the Third Unregulated Contaminant Monitoring Rule, a compilation of statewide PFAS sampling data of 28 states, and the ongoing Fifth Unregulated Contaminant Monitoring Rule). \*The total universe of active public water systems (PWS) and CWS were enumerated using 2022 (Q4) data from the Safe Drinking Water Information System.<sup>1</sup>

**Figure S 3:** Prevalence of the specified advancements in treatment processes over the study period (2004-2022)



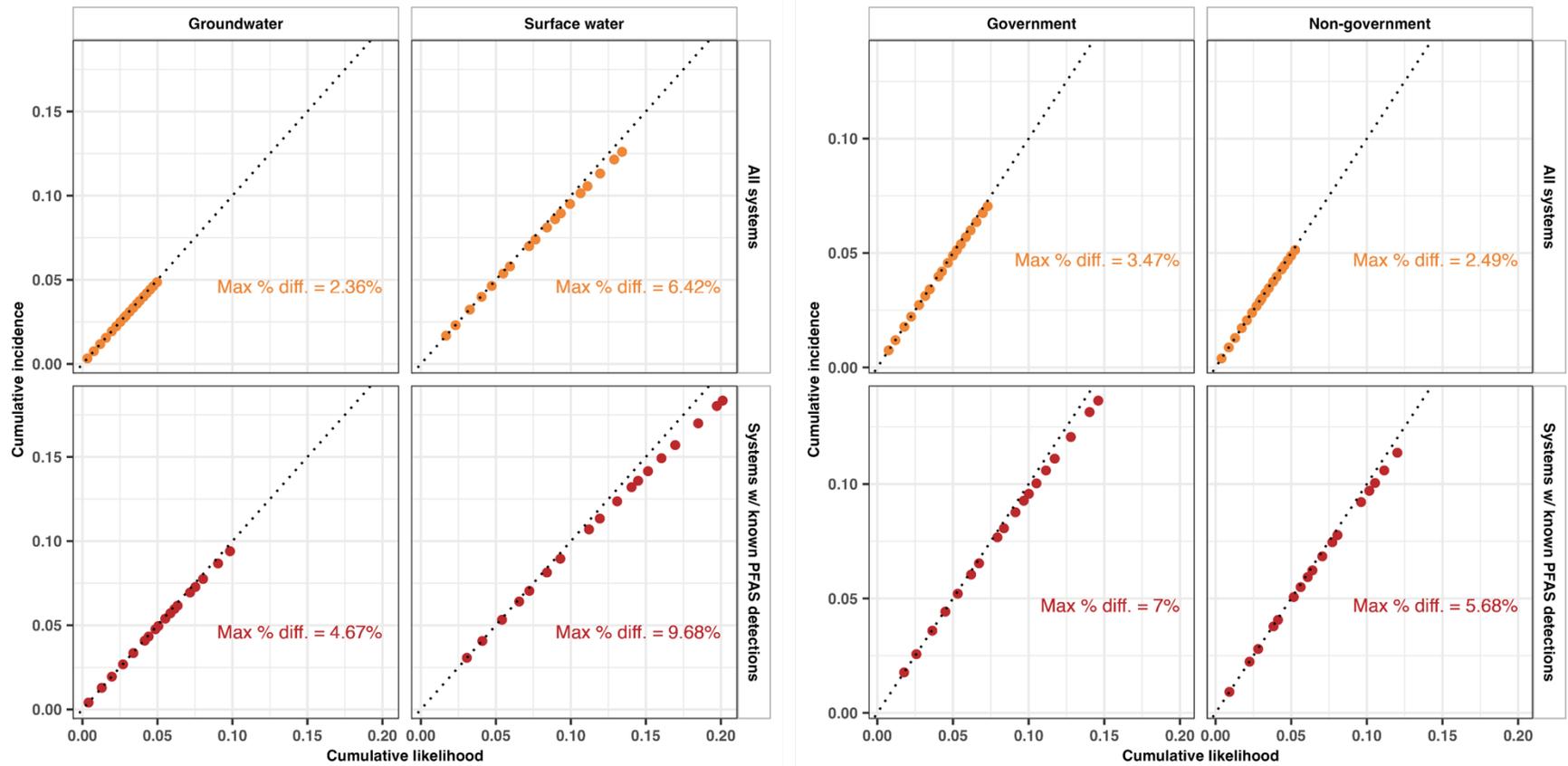
**A:** At baseline among all CWS, approximately 8.5% of CWS in the full treatment process database reported adoption of advancements in treatment processes. CWS that reported adoption of advancements in treatment processes in the first year of available are excluded from the primary analyses but included in this figure for clarity. **B:** The same is shown for systems with known PFAS detections.

**Figure S 4:** Comparing cumulative likelihoods and incidences for CWS sizes from Kaplan-Meier analyses



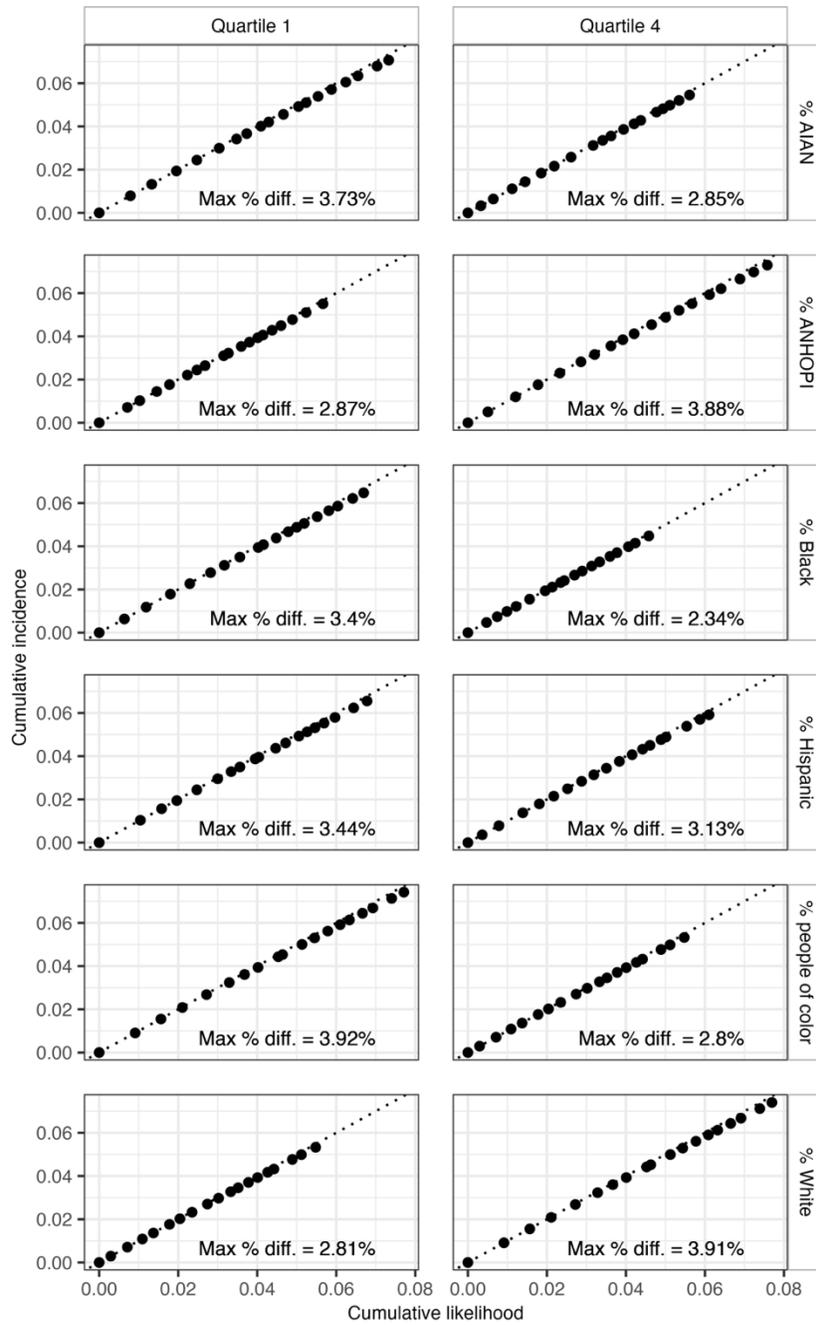
The dashed line depicts a line with an intercept at 0 and slope of 1.  $R^2$  based on simple linear regressions were all  $>0.99$ .

**Figure S 5:** Comparing cumulative likelihoods and incidences for CWS source water and ownership types from Kaplan-Meier analyses



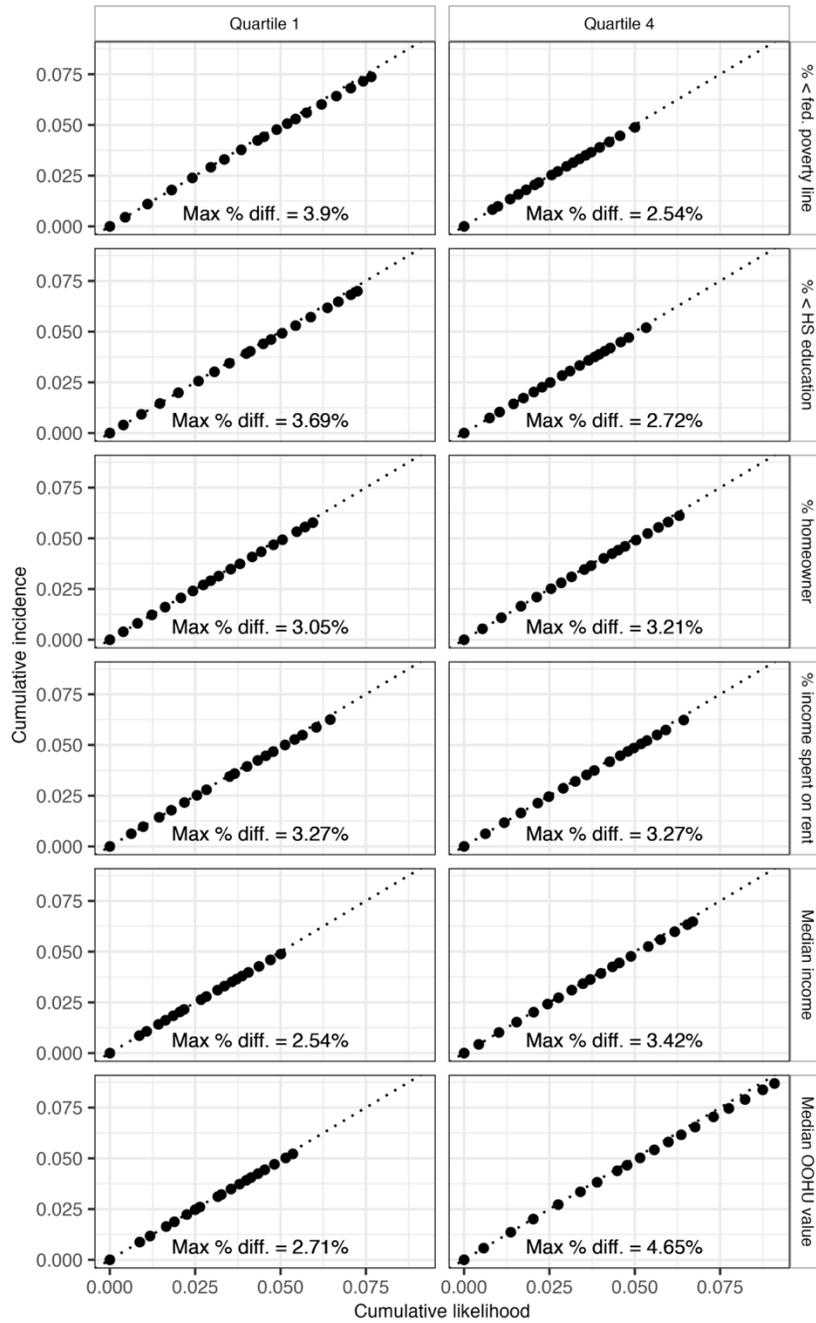
The dashed line depicts a line with an intercept at 0 and slope of 1.  $R^2$  based on simple linear regressions were all  $>0.99$ .

**Figure S 6:** Comparing cumulative likelihoods and incidences for racial/ethnic compositional measures from Kaplan-Meier analyses



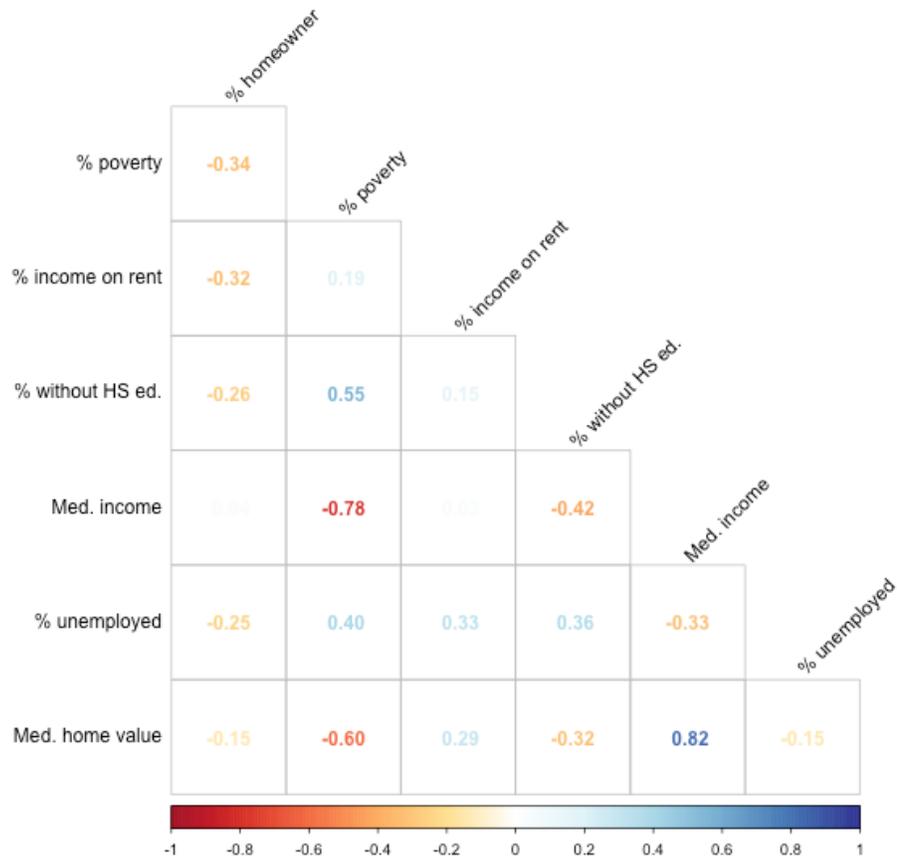
The dashed line depicts a line with an intercept at 0 and slope of 1.  $R^2$  based on simple linear regressions were all  $>0.99$ .

**Figure S 7:** Comparing cumulative likelihoods and incidences for socioeconomic status measures from Kaplan-Meier analyses

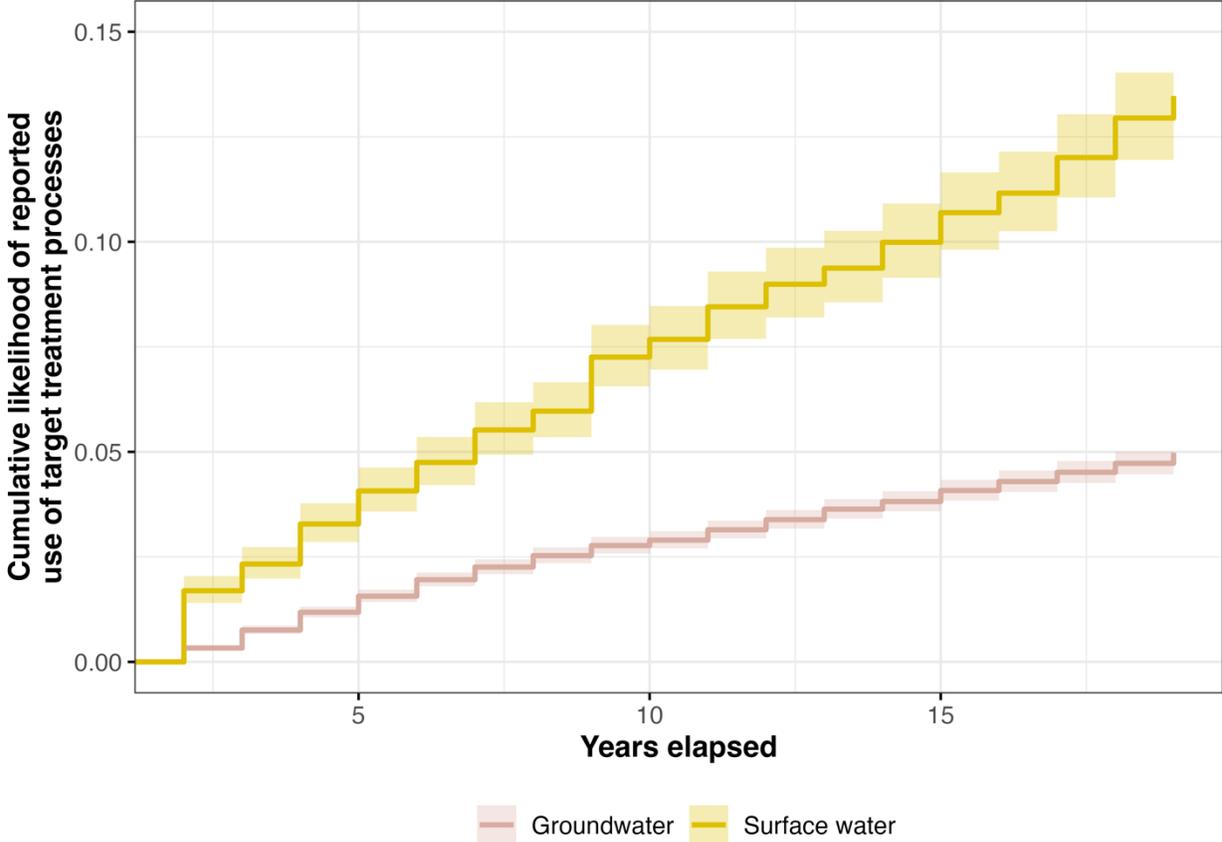


The dashed line depicts a line with an intercept at 0 and slope of 1.  $R^2$  based on simple linear regressions were all  $>0.99$ .

**Figure S 8:** Spearman's correlation coefficient matrix for area-level socioeconomic status indicators

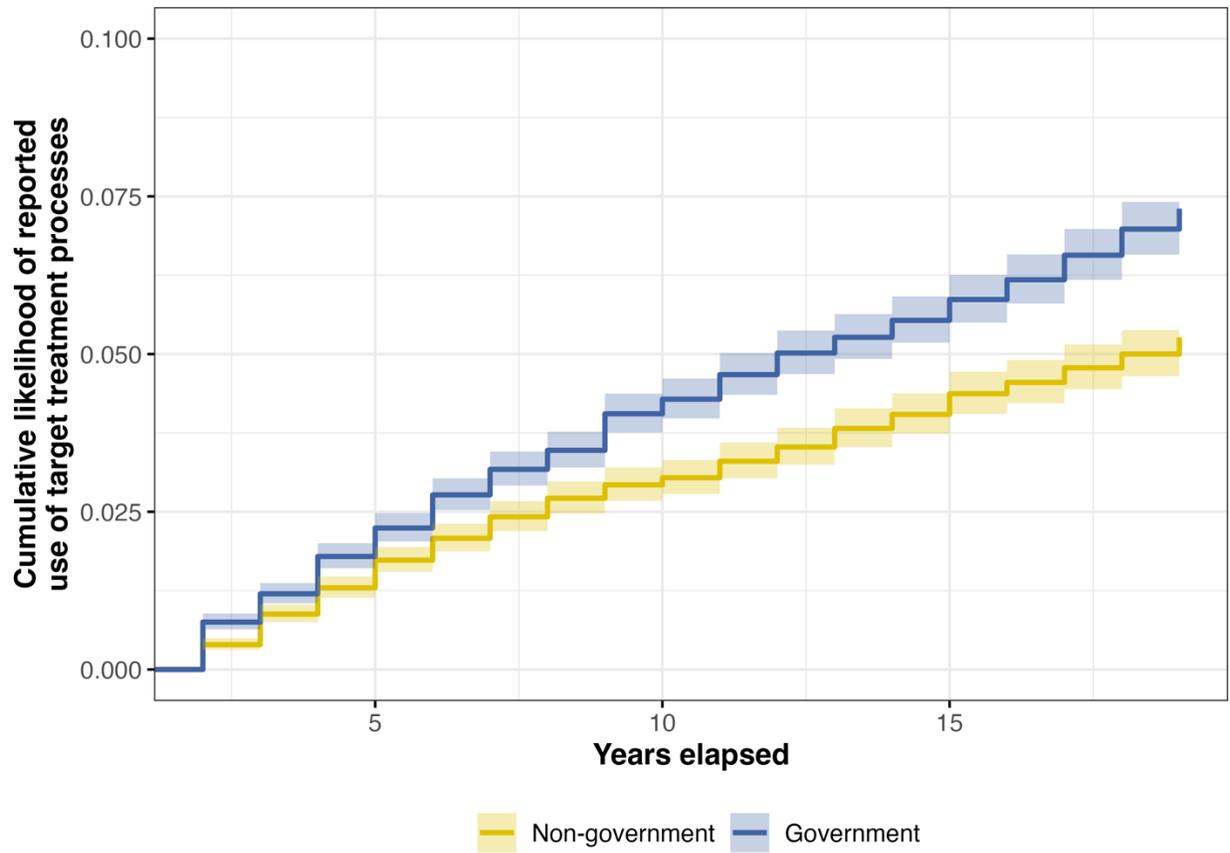


**Figure S 9:** Kaplan-Meier curves comparing reported adoption of advancements in treatment processes between groundwater and surface water CWS



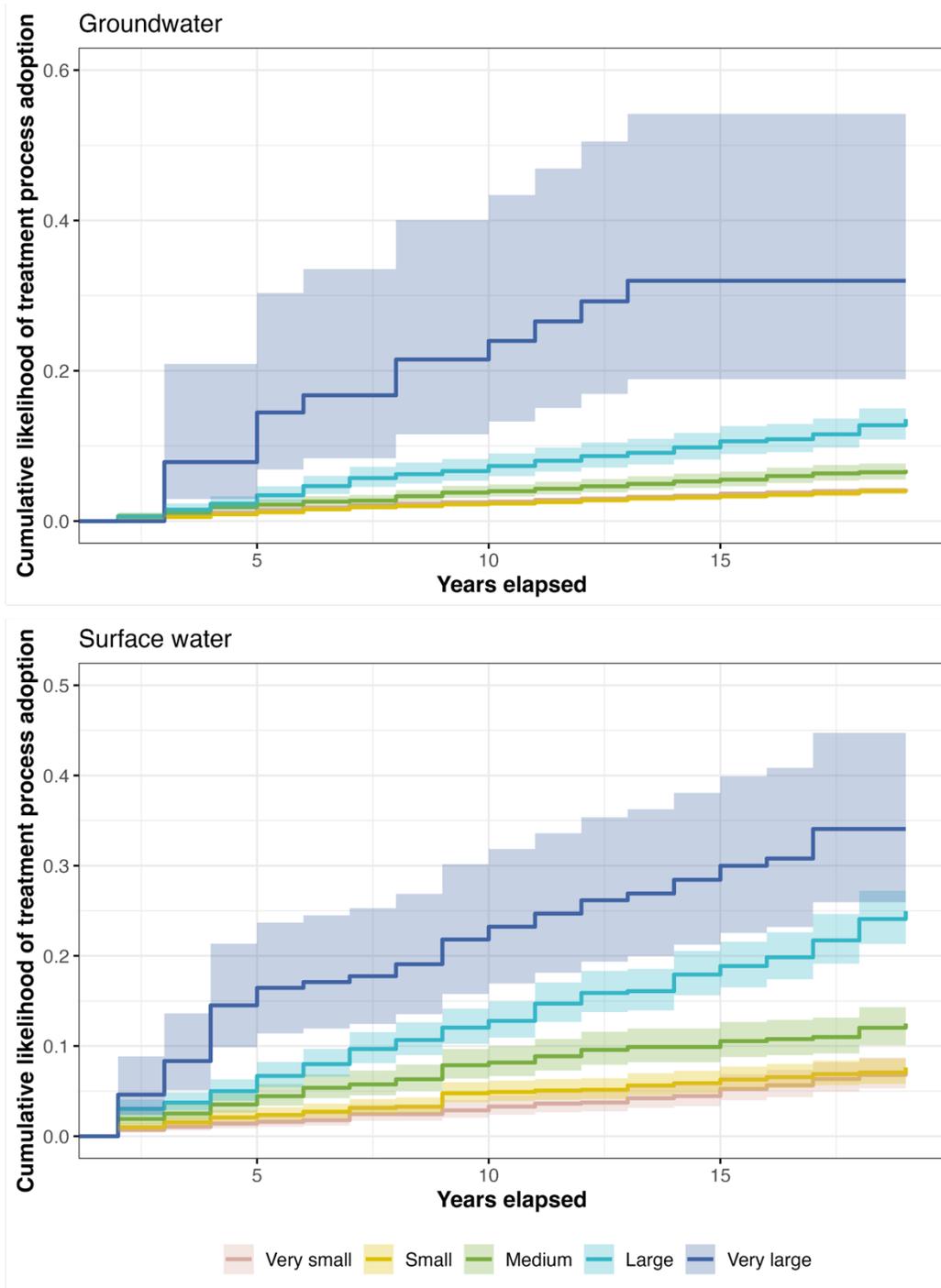
Cumulative likelihood curves are shown with 95% confidence intervals.

**Figure S 10:** Kaplan-Meier curves comparing reported adoption of advancements in treatment processes between CWS owner types



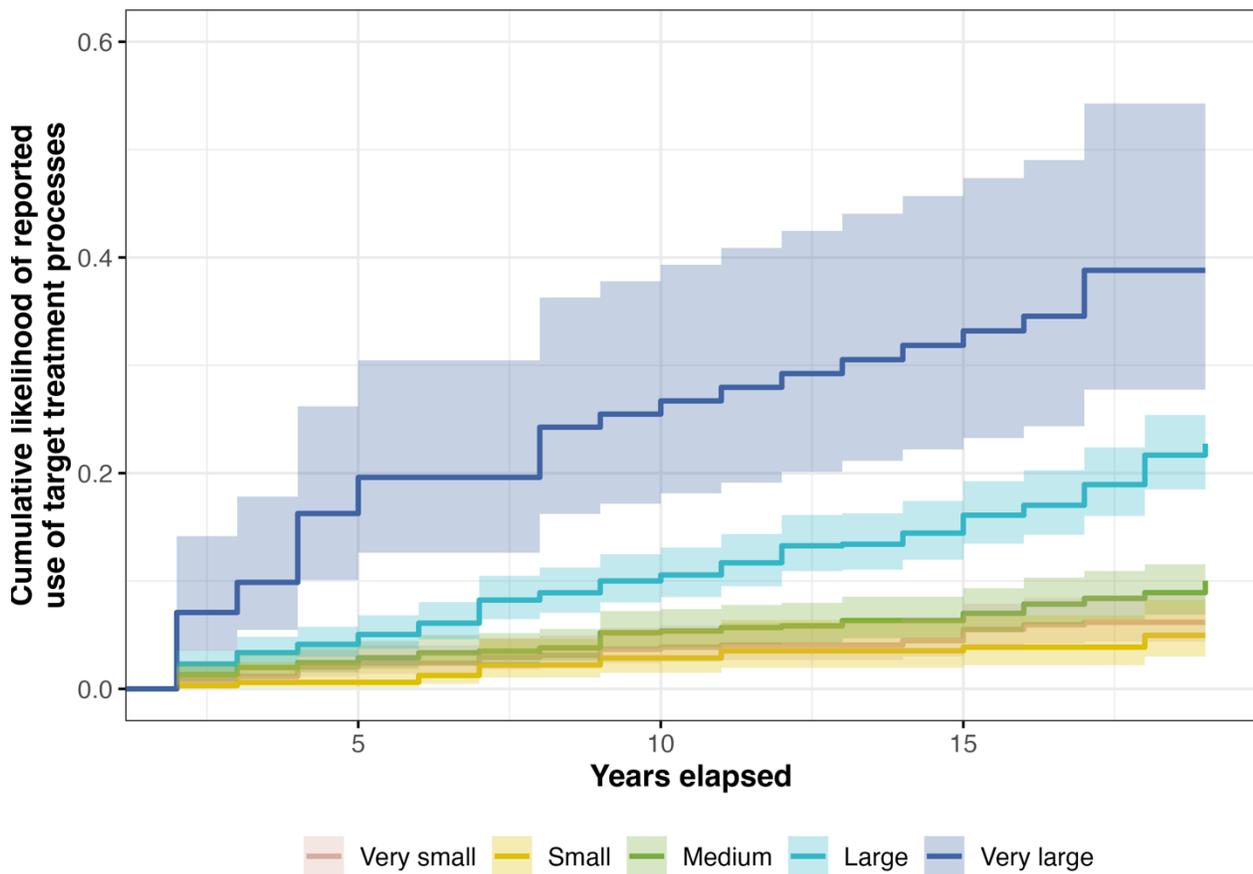
Using data from the Safe Drinking Water Information System,<sup>1</sup> private, public/private, and Native American/Tribal CWS were categorized as non-government-owned and federal-, state-, and locally owned systems were categorized as government-owned. Cumulative likelihood curves are shown with 95% confidence intervals.

**Figure S 11:** Kaplan-Meier curves comparing reported adoption of advancements in treatment processes stratified by source water type and system size groups



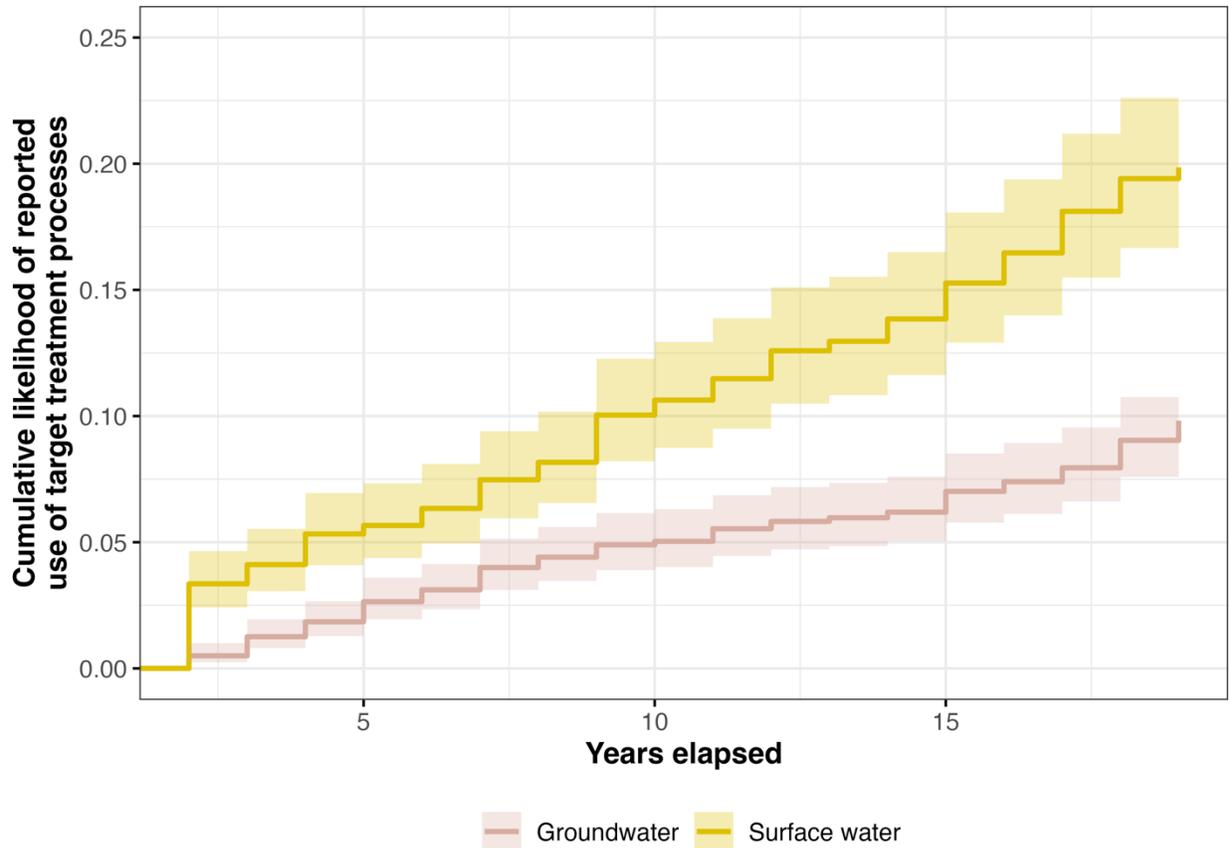
Cumulative likelihood curves are shown with 95% confidence intervals. These figures show results stratified by source water type (groundwater and surface water shown separately) and then by system size groups (very small, small, medium, large, and very large). We also analyzed cumulative likelihood curves among other combinations of the categorical variables (e.g., system size groups then source water type, and ownership type then system size groups) for comparison.

**Figure S 12:** Kaplan-Meier curves comparing reported adoption of advancements in treatment processes between system size groups among systems with known PFAS detections



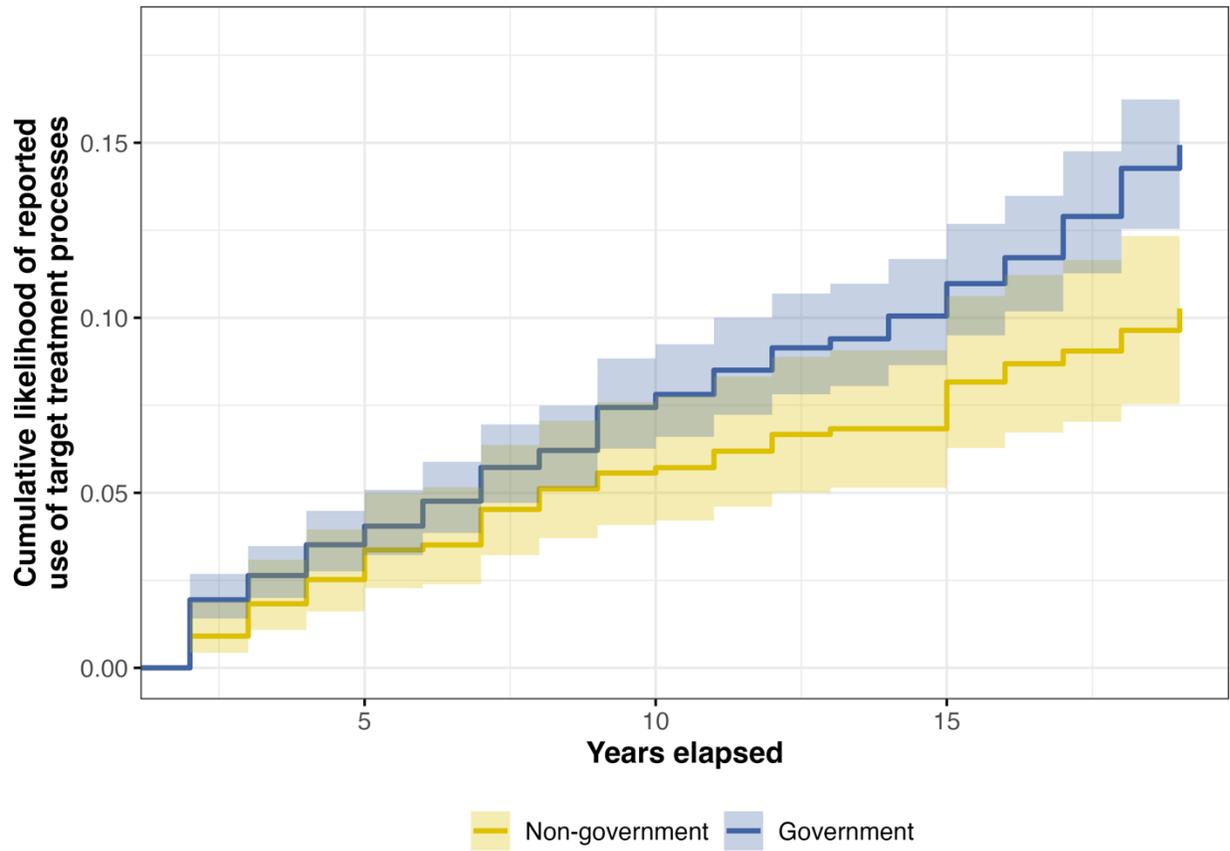
Systems with known PFAS detections were determined based on three monitoring datasets (the Third Unregulated Contaminant Monitoring Rule, a compilation of statewide PFAS sampling data of 28 states, and the ongoing Fifth Unregulated Contaminant Monitoring Rule). Cumulative likelihood curves are shown with 95% confidence intervals.

**Figure S 13:** Kaplan-Meier curves comparing reported adoption of advancements in treatment processes between groundwater and surface water CWS among systems with known PFAS detections



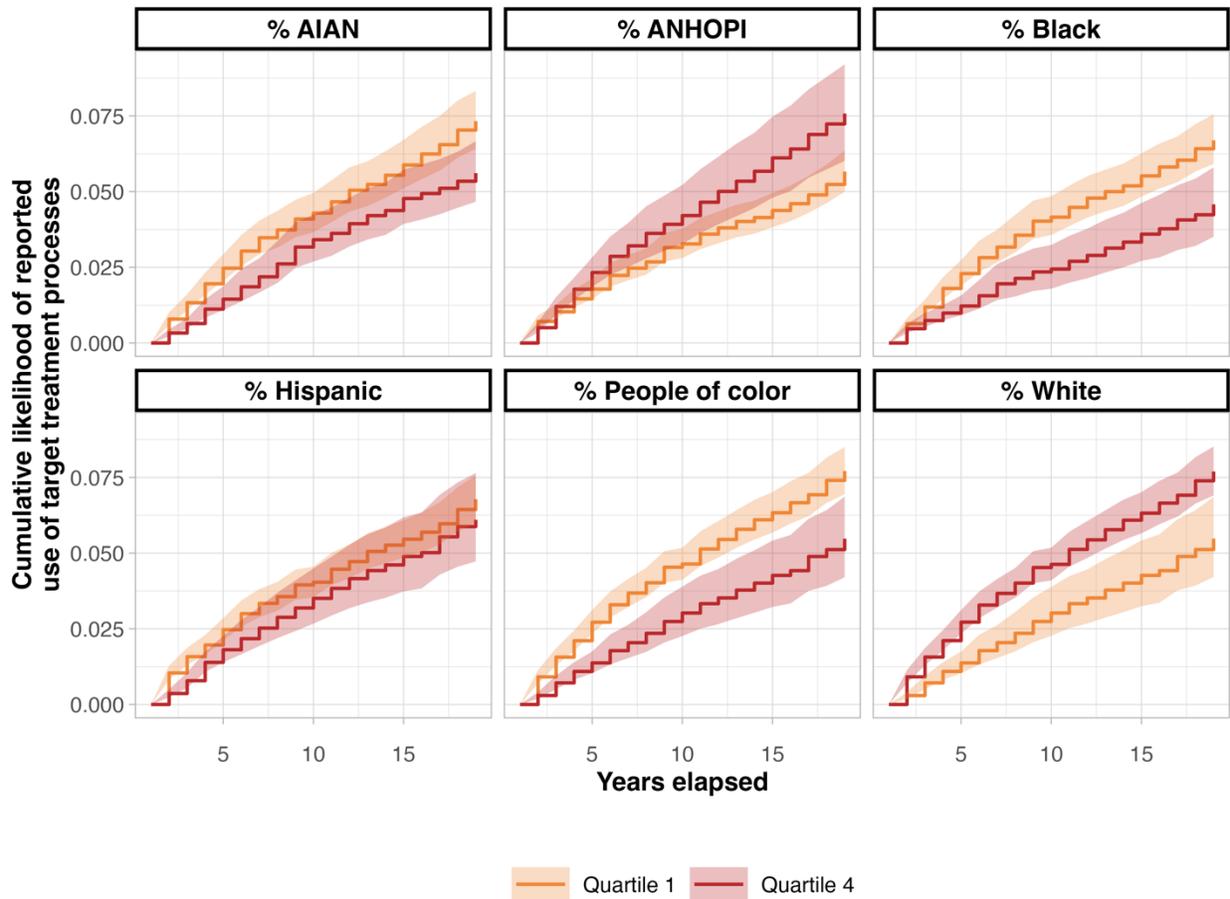
Systems with known PFAS detections were determined based on three monitoring datasets (the Third Unregulated Contaminant Monitoring Rule, a compilation of statewide PFAS sampling data of 28 states, and the ongoing Fifth Unregulated Contaminant Monitoring Rule). Cumulative likelihood curves are shown with 95% confidence intervals.

**Figure S 14:** Kaplan-Meier curves comparing reported adoption of advancements in treatment processes between CWS owner types among systems with known PFAS detections



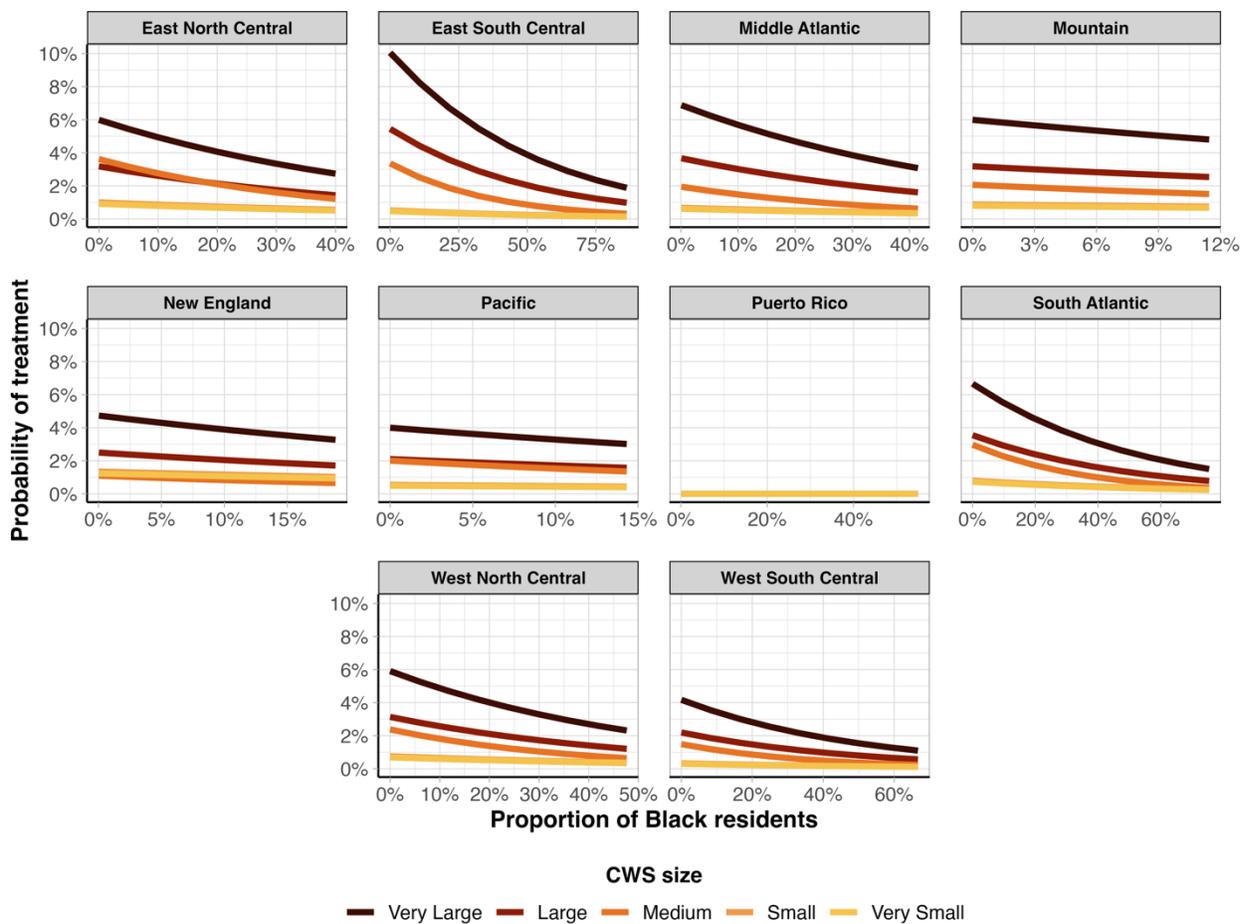
Systems with known PFAS detections were determined based on three monitoring datasets (the Third Unregulated Contaminant Monitoring Rule, a compilation of statewide PFAS sampling data of 28 states, and the ongoing Fifth Unregulated Contaminant Monitoring Rule). Cumulative likelihood curves are shown with 95% confidence intervals.

**Figure S 15:** Kaplan-Meier curves comparing reported adoption of advancements in treatment processes between quartiles of several racial/ethnic compositional factors (with sociodemographic composition at the county level)



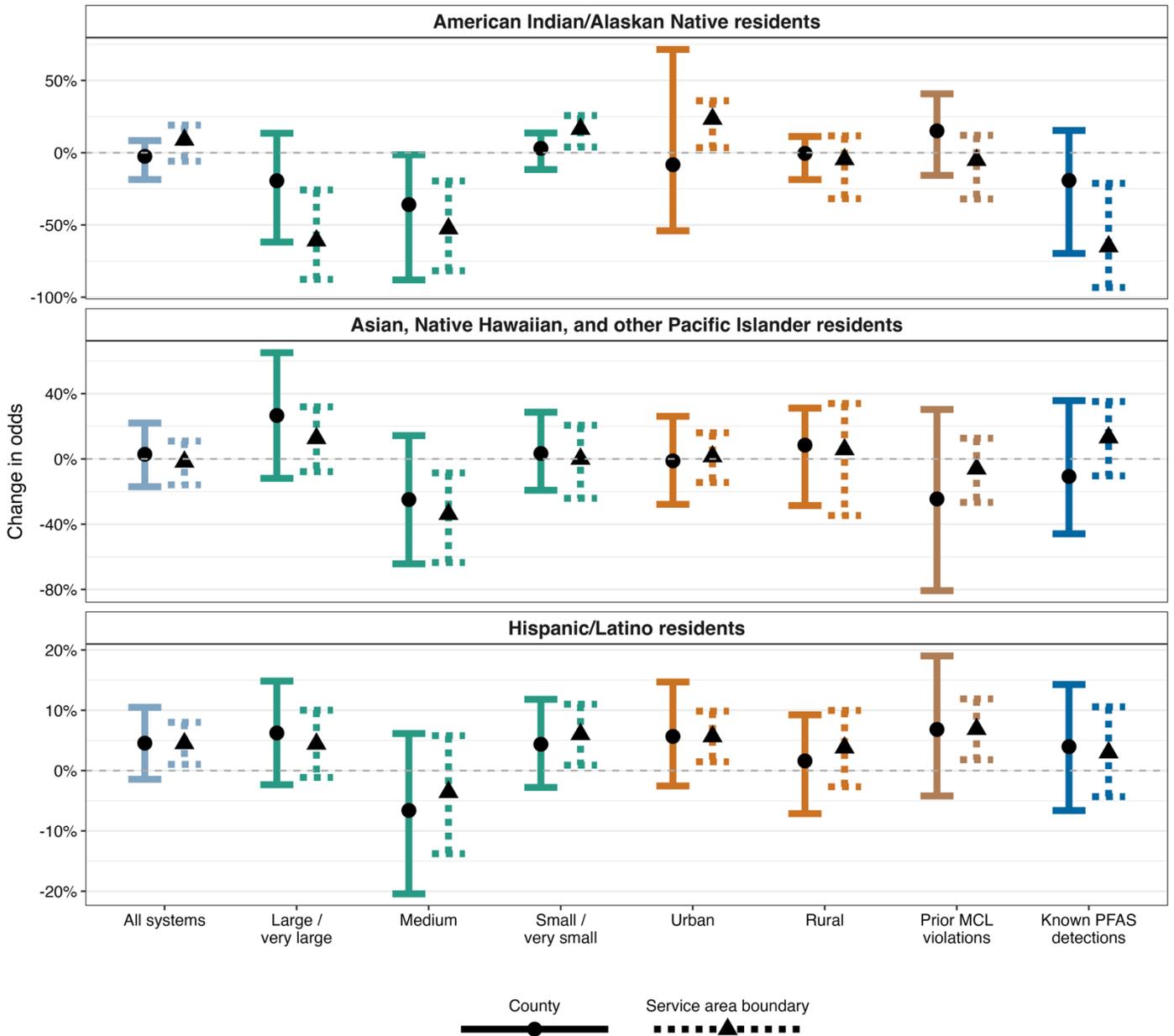
AIAN: non-Hispanic American Indian and Alaskan Native residents. ANHOPI: non-Hispanic Asian, Native Hawaiian and other Pacific Islander residents. Significant differences between survival curves were assessed based on 95% confidence intervals and log-rank tests.

**Figure S 16:** Example predicted probabilities of reported adoption of advancements in treatment processes from stratified regression models with varying CWS sizes and proportion of Black customers served



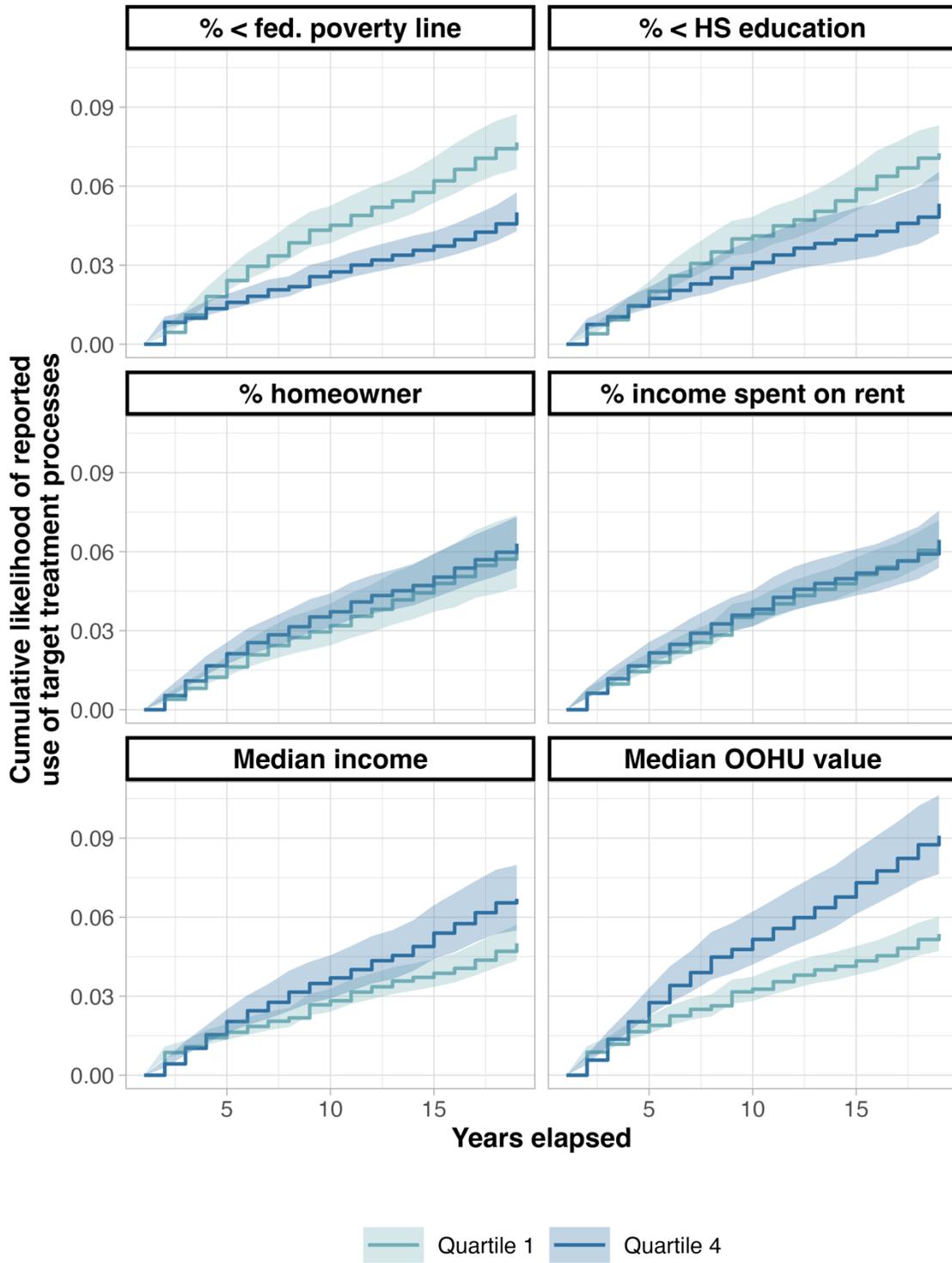
Predicted probabilities of adoption advancements in water treatment processes among US community water systems (CWS) with varying sizes and proportion of non-Hispanic Black residents (obtained from the models with county-level sociodemographic composition). Size categories are based on the number of customers served by CWS and include: very small: 25-500, small: 501-3,300, medium: 3,301-10,000, large: 10,001-100,000, and very large: >100,000. Predicted probabilities are shown from the division-specific, empirical minimum and maximum proportion of Black residents served for publicly owned, surface water CWS in each census division without a pre-period MCL violation (excl. total coliform) and with division-specific mean values for population density, median household income, and racial/ethnic composition within the 1st year of reporting. Puerto Rico is also shown, although no events occurred among the analytic sample over the study period.

**Figure S 17:** Comparison of results from adjusted models for additional racial/ethnic compositional factors based on county and service area sociodemographic composition



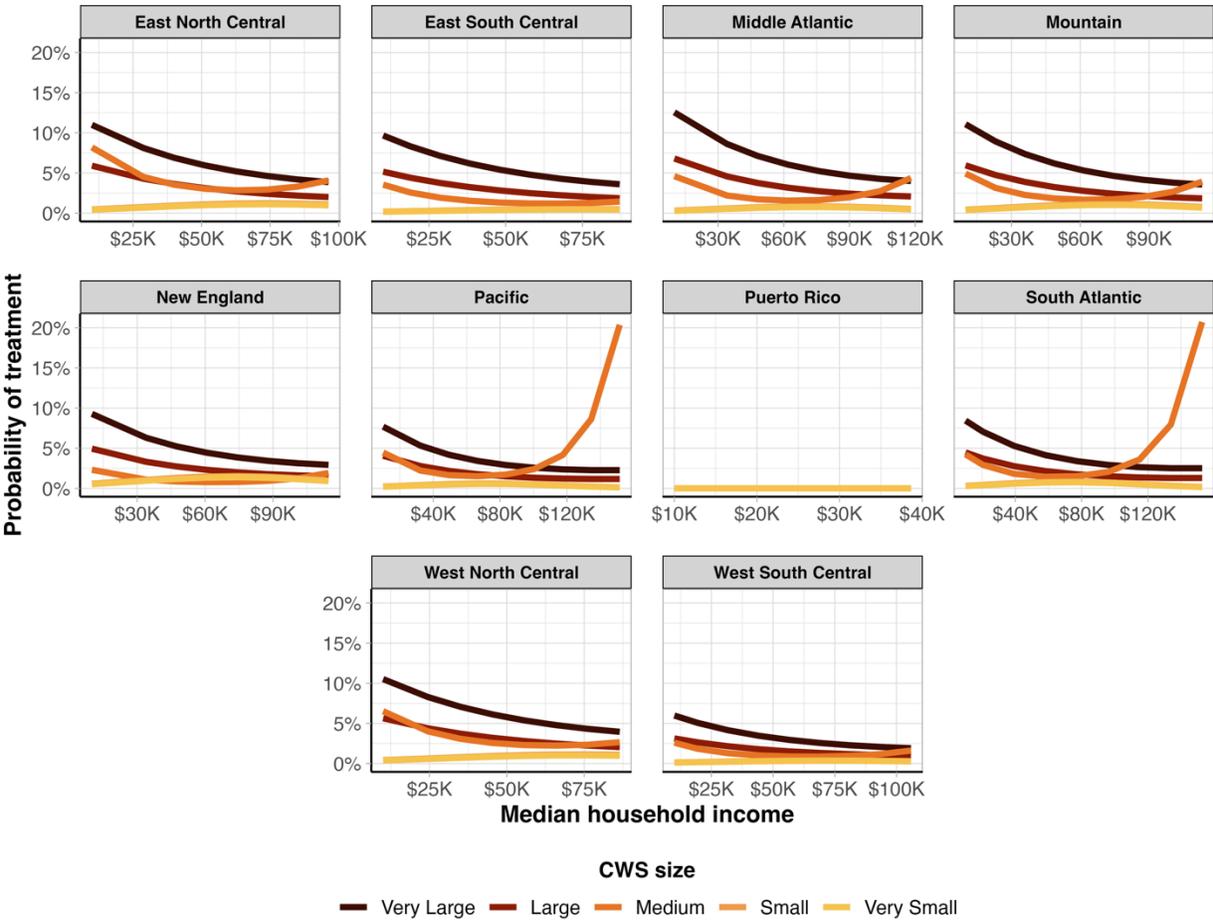
MCL = maximum contaminant level.

**Figure S 18:** Kaplan-Meier curves comparing reported adoption of advancements in treatment processes between quartiles of several area-level socioeconomic factors (with sociodemographic composition at the county level)



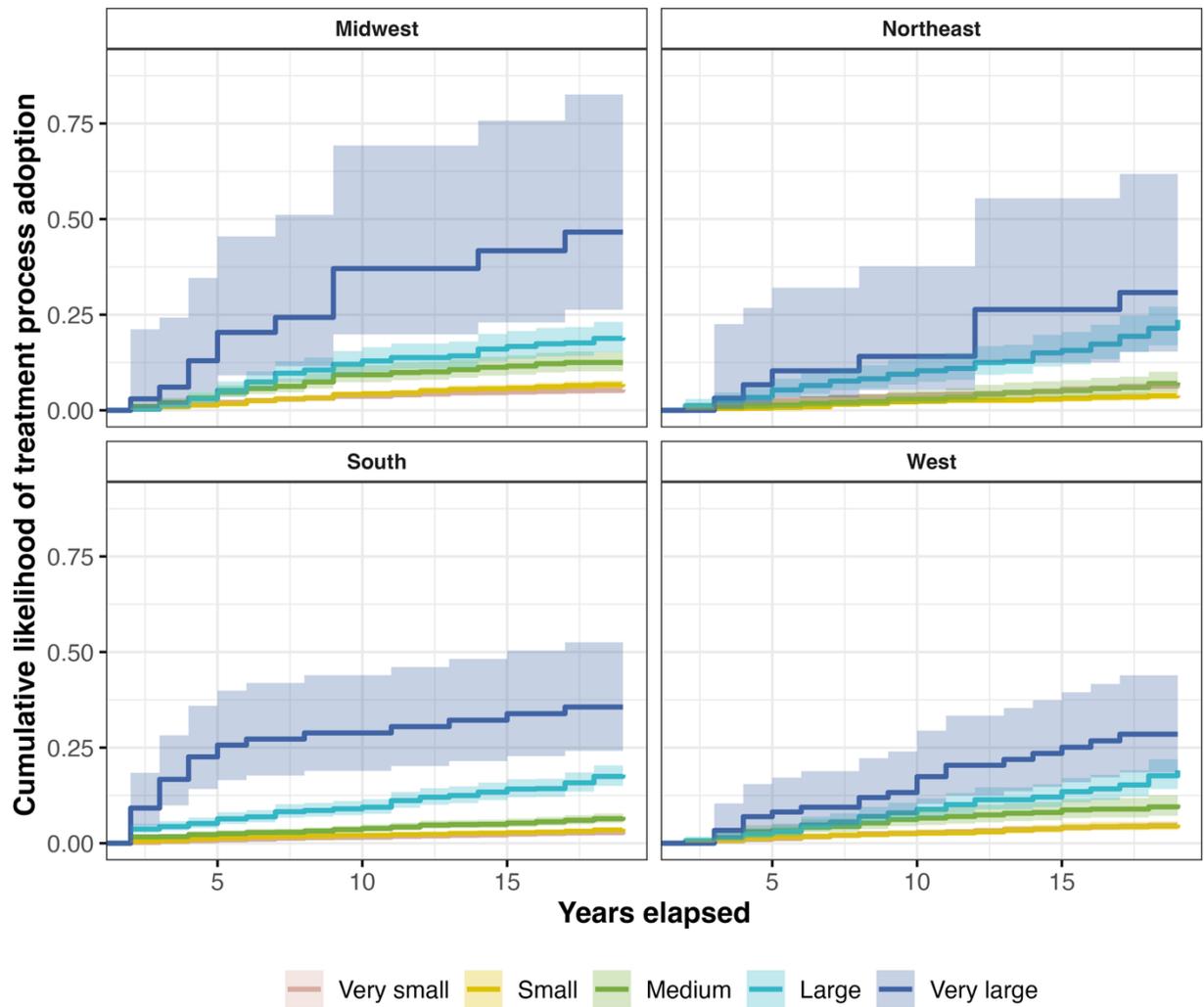
Median OOHU value: median value of owner-occupied housing units. Significant differences between survival curves were assessed based on 95% confidence intervals and log-rank tests.

**Figure S 19:** Example predicted probabilities of reported adoption of advancements in treatment processes from regression models allowing non-linearity for the associations between median income and adoption of advancements in treatment processes



Predicted probabilities of adoption advancements in water treatment processes among US community water systems (CWS) with varying sizes and median household income (obtained from the models with county-level sociodemographic composition). Size categories are based on the number of customers served by CWS and include: very small: 25-500, small: 501-3,300, medium: 3,301-10,000, large: 10,001-100,000, and very large: >100,000. Predicted probabilities are shown from the division-specific, empirical minimum and maximum median household income for publicly owned, surface water CWS in each census division without a pre-period MCL violation (excl. total coliform) and with division-specific mean values for population density and racial/ethnic composition within the 1st year of reporting. Puerto Rico is also shown, although no events occurred among the analytic sample over the study period. These models were restricted to allow for a quadratic association between median household income and adoption of advancements in treatment processes, as opposed to a more flexible functional form.

**Figure S 20:** Kaplan-Meier curves comparing reported adoption of advancements in treatment processes between system size groups: stratified by census region

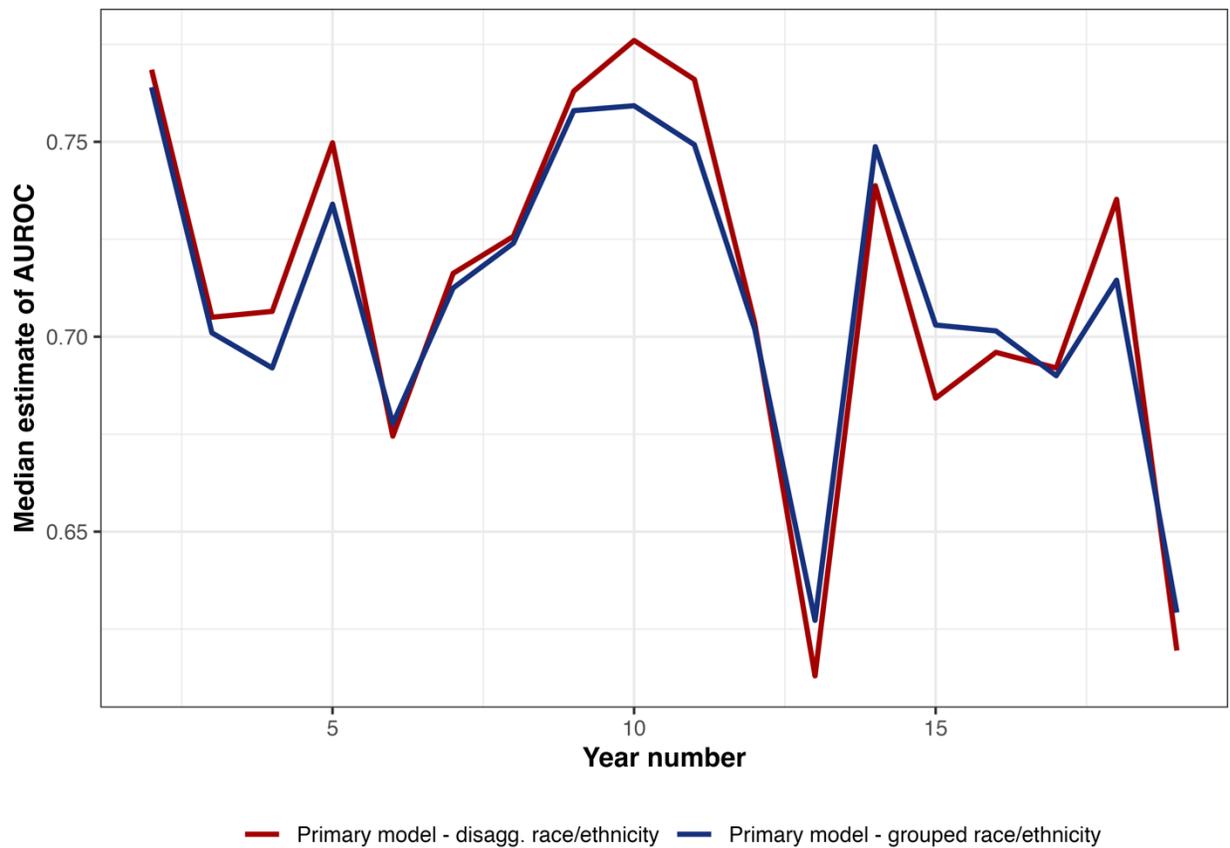


Cumulative likelihood curves are shown with 95% confidence intervals. Curves above are stratified according to four census regions (Midwest, Northeast, South, and West) and system size groups (very small, small, medium, large, and very large).s

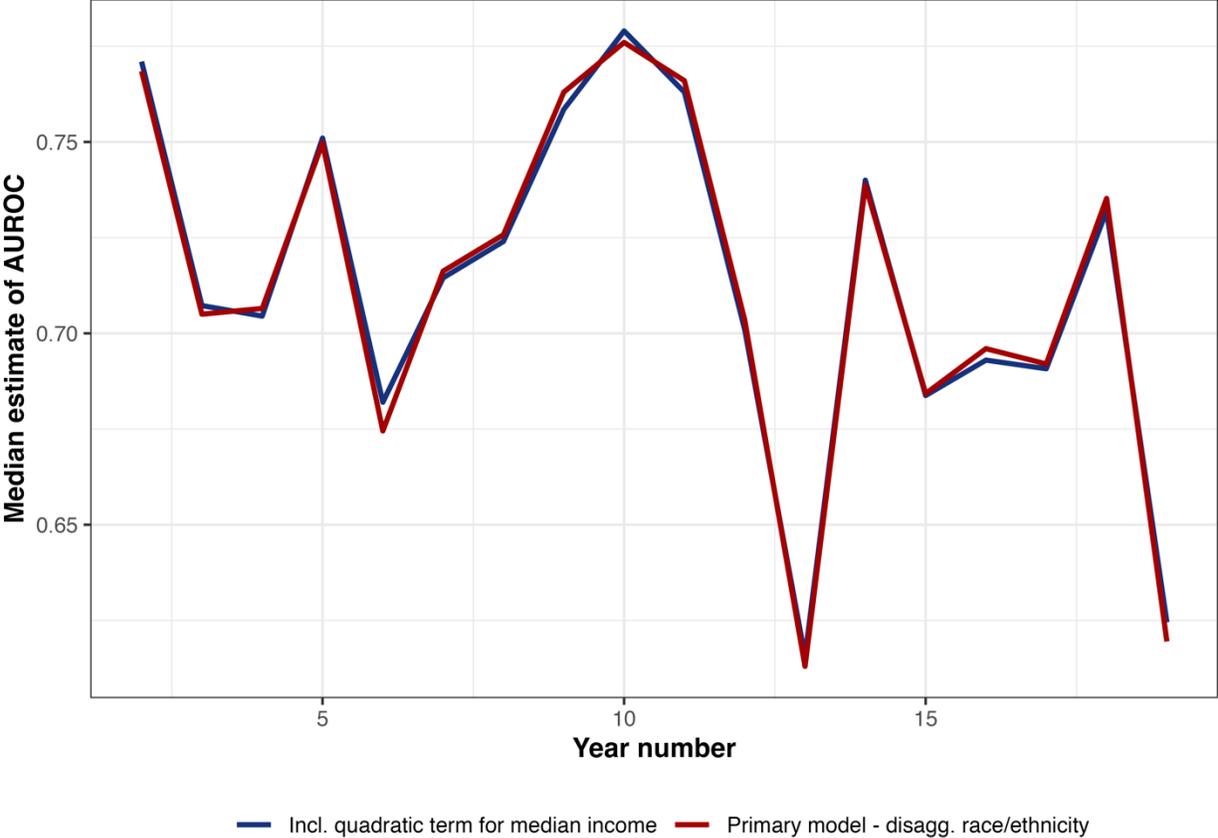
### Model fit assessment

For several sensitivity analyses, we assessed model fit by comparing time-dependent area under the receiver operating characteristic curves (AUROC). From each adjusted model, predicted probabilities of reporting advancements in treatment processes for each CWS were calculated, then 1000 random CWS were selected with and without the event under study for each year (with replacement), and the proportion of CWS with the event that had a greater predicted probability compared to the CWS without the event for each year was calculated. This was repeated 100 times. The median values of the AUROC are shown from several of these assessments in Figure S 21, Figure S 22, Figure S 23, and Figure S 24.

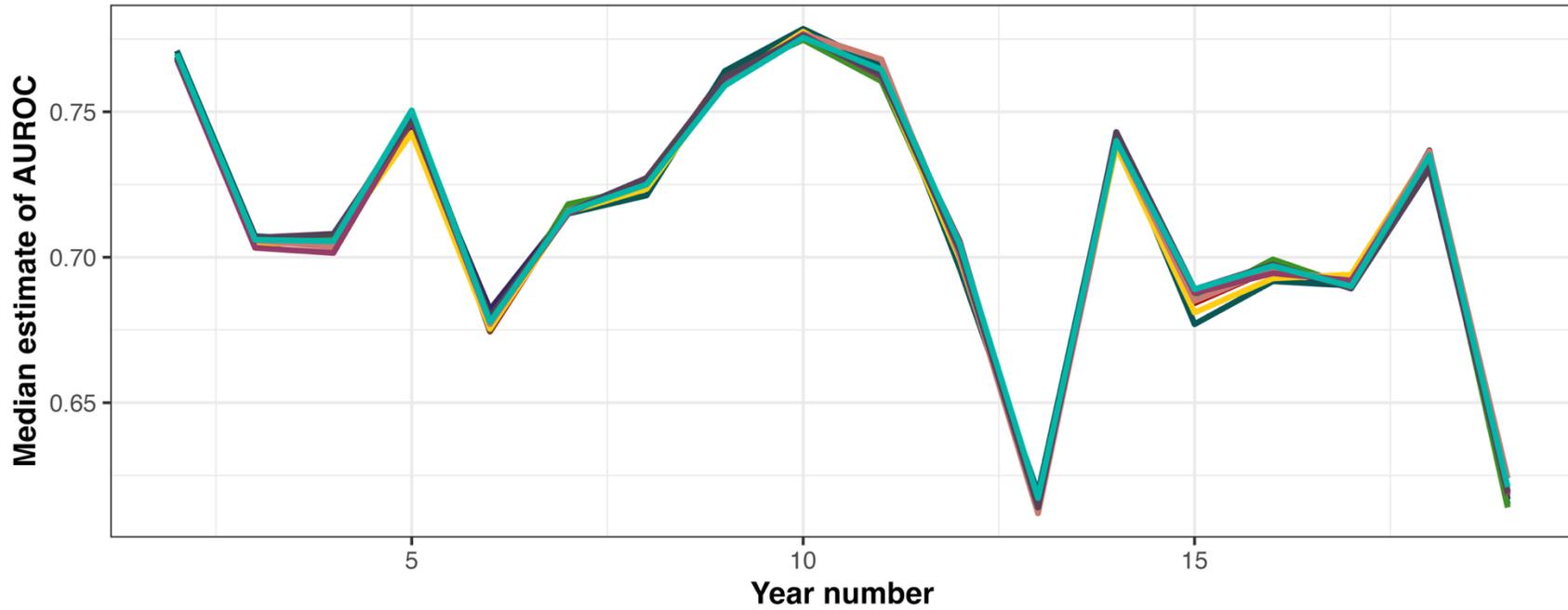
**Figure S 21:** Comparison of area under the receiver operating characteristic curves for the primary models



**Figure S 22:** Comparison of area under the receiver operating characteristic curves to the model including a quadratic term of median income



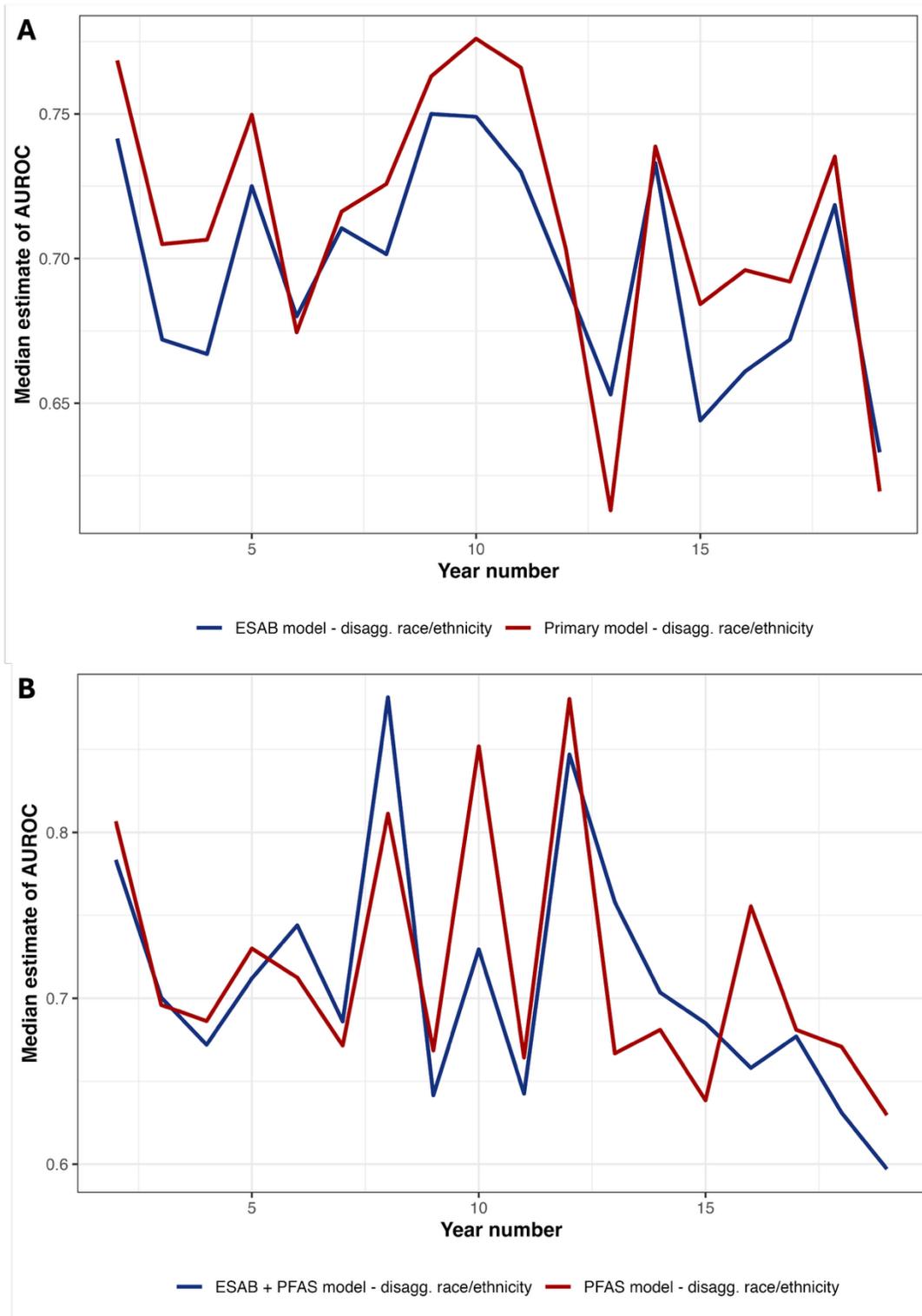
**Figure S 23:** Comparison of area under the receiver operating characteristic curves between models with various area-level socioeconomic status measures



- Primary model - disagg. race/ethnicity
- Unstratified (varying SES, time-varying): % homeowners
- Unstratified (varying SES, time-varying): % income spent on rent
- Unstratified (varying SES, time-varying): % under fed. poverty line
- Unstratified (varying SES, time-varying): % unemployed
- Unstratified (varying SES, time-varying): % w/o HS education
- Unstratified (varying SES, time-varying): Median income
- Unstratified (varying SES, time-varying): Median OOHU value
- Unstratified (varying SES, time-varying): no SES variable

Median OOHU value = median value of owner-occupied housing units.

**Figure S 24:** Comparison of area under the receiver operating characteristic curves to the models using sociodemographic composition estimates within CWS service area boundaries



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