For Online Publication

Appendix for
Drinking Water Contaminant Concentrations and Birth Outcomes

A1 Data Construction Details

While the drinking water regulations are often complicated, in general the maximum contaminant level (MCL) can be seen as the maximum amount of contamination allowed in public drinking water before a regulatory intervention takes place. The intervention may be a violation, which generally includes public reporting requirements (e.g. in the case of coliform or nitrate); or it may be a requirement for a set of precautionary actions ("treatment techniques") to be taken to reduce the level of contamination in the water for end-users (e.g. in the case of lead and copper). On the other hand, the maximum contaminant level goals (MCLG) are levels below which there is no known or expected health risks (US Environmental Protection Agency, 2018). As shown in Table A1 for ten selected contaminants, in some instances the MCLG are lower than the MCL.

The main two reasons for MCL to exceed MCLG are that the EPA believes that it is excessively costly for community water systems (CWS) to reduce contamination to the MCLG, or that measurement technology is unable to accurately measure contamination closer to the MCLG (US Environmental Protection Agency (2016b)). Since for some contaminants, the reason MCL are not reduced toward MCLG is due to concerns over imprecise measurements for low levels of contamination, this may raise concerns over the quality of our water sample data. We take the position espoused in the EPA internal document (US Environmental Protection Agency (2006)), describing how measures below MCL still contain (albeit noisy) information: "[i]t is recommended that all values between the PQL and MDL be reported. They are real, the concentration is fuzzy, but their values can give indications or trends and should be reported." Note that in this quote, both the PQL and MDL are below the MCL: the PQL (practical quantitative limit) is the level at which the EPA believes the samples can be used for administrative purposes while the MDL (method detection level) is a lower level below which the sample reading cannot reliably be distinguished from zero. More detail on how MCL are limited by noise in the water quality measures is available in the EPA six-year review technical report (US Environmental Protection Agency (2016a)).

A1.1 Discussion of Our Main Index Measures

To illustrate our index measures, in Table A1, we display ten example contaminants in our data, the number of births with that contaminant measured in our analytic sample (column 1), and the across-birth correlation of that contaminant with our measure of overall contamination (column 2) and chemical-only contamination (column 3). Of course, the correlations reported are conditional on the set of births for which the contaminant is indeed measured, with counts reported in column 1. We find that the disinfectant byproducts trihalomethanes, haloacetic acids, and chlorite, are positively correlated with our measure of overall contamination, as is lead, total coliform (an important microbial measure) and turbidity (a general measure of the cloudiness of water). Note that chlorite is listed by the US EPA as potentially having negative impacts on reproductive health, but it is sampled relatively rarely in our data; yet, for the births for which it is sampled, our index appears to be strongly related to this measure. By contrast, however, nitrate and arsenic, two popular measures in the water policy literature (e.g. Grooms, 2016), are not highly correlated with our measures. Atrazine, a controversial herbicide (Rohr and McCoy, 2010) and as of 2001 one of the most common herbicides detected in streams and ground water (Gilliom and Hamilton, 2006), is only weakly positively correlated with our measures.

Table A1: Ten selected contaminants, correlation with our two contaminant groups, and regulatory and health standards.

| Name | (1)

# of Births | (2)
Cor w/ All | (3)
Cor w/ Chem | (4)
MCL | (5)
MCLG |
|---|---|---|---|---|---|
| TRIHALOMETHANES | 1,144,050 | 0.179 | 0.209 | 0.080 | – |
| HALOACETIC ACIDS (FIVE) | 1,130,519 | 0.134 | 0.150 | 0.060 | – |
| NITRATE | 1,041,320 | 0.040 | 0.094 | 10.000 | 10.000 |
| CHLORINE | 872,825 | 0.213 | – | 4.000 | 4.000 |
| ARSENIC (IOC) | 741,404 | -0.035 | 0.059 | 0.010 | 0.000 |
| TOTAL COLIFORM | 723,596 | 0.424 | – | 0.050 | 0.000 |
| ATRAZINE (SOC) | 590,628 | 0.120 | 0.140 | 0.003 | 0.003 |
| LEAD | 421,453 | 0.172 | 0.468 | 0.015 | 0.000 |
| TURBIDITY | 106,765 | 0.427 | – | 2.000 | – |
| CHLORITE | 23,247 | 0.394 | -0.037 | 1.000 | 0.800 |

Notes: Table displays the number of births in our analytic sample with a measure on each contaminant (column 1), and the correlation of that measure with the two groups we use in analysis: all in column (2), and chemical-only in column (3). Maximum contaminant limits (MCL) are in column (4) while health goals (MCLG) are in column (5). Dashes (−) indicate that the contaminant is not included in that group, or that there is no MCLG for that contaminant.

For a full list of the contaminants used in our analysis, refer to Table A2. This table lists all 94 contaminants studied in our analysis, and shows whether it is part of our All or Chem (chemical-only) index measures. It also provides the number of births for which we have non-missing contamination measures (at least one sample during the birth's gestation period for the CWS at birth) and the total number of drinking water samples for the contaminant in our input data.

Table A2: Contaminants by group

Row	ID	Name	All	Chem	Births	Samples
1	999	chlorine	✓	✓	938671	4816645
2	1030	lead	✓	✓	450922	93545
3	1022	copper	✓	✓	465965	93488
4	2950	trihalomethanes	✓	✓	1239417	82338
5	3100	total coliform	✓		785817	77823
6	1040	nitrate	✓	✓	1117361	76439
7	2456	haloacetic acids (five)	✓	✓	1224600	74626
8	1006	chloramine	✓	✓	234710	44909
9	100	turbidity	✓		111782	40059
10	2987	tetrachloroethylene	✓	✓	1039128	38903
11	2984	trichloroethylene	✓	✓	1039602	38891
12	2991	toluene	✓	✓	1039130	38751
13	2980	1,2-dichloroethane	✓	✓	1039073	38747
14	2981	1,1,1-trichloroethane	✓	✓	1039126	38743
15	2990	benzene	✓	✓	1038953	38736
16	2979	trans-1,2-dichloroethylene	✓	✓	1039541	38720
17	2992	ethylbenzene	✓	✓	1037610	38695
18	2378	1,2,4-trichlorobenze	✓	✓	1039042	38691
19	2380	cis-1,2-dichloroethylene	✓	✓	1039068	38674
20	2977	1,1-dichloroethylene	✓	✓	1039169	38673
21	2964	dichloromethane	✓	✓	1038983	38666
22	2982	carbon tetrachloride	✓	✓	1038126	38666
23	2985	1,1,2-trichloroethane	✓	✓	1038971	38662
24	2989	chlorobenzene	✓	✓	1038483	38661
25	2968	o-dichlorobenzene	✓	✓	1038524	38657
26	2969	para-dichlorobenzene	✓	✓	1038518	38650
27	2983	1,2-dichloropropane	✓	✓	1039005	38649
28	2955	xylenes (total)	✓	✓	1037830	38640
29	2996	styrene	✓	✓	1039347	38616
30	1041	nitrite	✓	✓	529308	32221
31	2976	vinyl chloride	✓	✓	643919	27665
32	2941	chloroform (thm)	✓	✓	311636	25217
33	2944	chlorodibromomethane (thm)	✓	✓	309861	25145
34	2943	bromodichloromethane (thm)	✓	✓	311525	25136
35	2942	bromoform (thm)	✓	✓	308017	24730
36	1005	arsenic (ioc)	✓	✓	787789	23956

37	2050	atrazine (soc)	✓	✓	635751	18226
38	2039	di (2-ethyl) phthalate (soc)	✓	✓	698366	17202
39	2037	simazine (soc)	✓	✓	639790	16551
40	2051	alachlor (soc)	✓	✓	592562	16424
41	1025	fluoride (ioc)	✓	✓	450789	16402
42	2042	hexachlorocyclopentadiene(soc)	✓	✓	647018	16276
43	2035	di (2-eth) adipate (soc)	✓	✓	654311	16184
44	2946	ethylene dibromide (edb) (soc)	✓	✓	596121	16124
45	2306	benzo(a)pyrene (soc)	✓	✓	619395	16090
46	2326	pentachlorophenol (soc)	✓	✓	623120	16069
47	2105	2,4 - d (soc)	✓	✓	391691	15890
48	2931	1,2-dribomo-3-chloroprop (soc)	✓	✓	582020	15752
49	2010	lindane (soc)	✓	✓	566031	15515
50	2015	methoxychlor (soc)	✓	✓	542303	15421
51	2959	chlordane (soc)	✓	✓	543058	15175
52	2040	piclorem (soc)	✓	✓	537392	15072
53	2046	carbofuran (soc)	✓	✓	530220	14833
54	2036	oxymal (vydate) (soc)	✓	✓	530677	14805
55	2033	endothall (soc)	✓	✓	527098	14608
56	1010	barium (ioc)	✓	✓	451330	13815
57	1015	cadmium (ioc)	✓	✓	452156	13624
58	1085	thallium (ioc)	✓	✓	451158	13595
59	1075	beryllium (ioc)	✓	✓	450796	13540
60	1074	antimony (ioc)	✓	✓	451315	13536
61	1035	mercury (ioc)	✓	✓	425068	13520
62	1020	chromium (ioc)	✓	✓	452054	13499
63	1045	selenium (ioc)	✓	✓	451787	13484
64	2034	glyphosate (soc)	✓	✓	264887	13452
65	2005	endrin (soc)	✓	✓	314336	13449
66	2274	hexachlorobenzene (soc)	✓	✓	314975	13440
67	2031	dalapon (soc)	✓	✓	338562	13421
68	2065	heptachlor (soc)	✓	✓	310391	13402
69	2020	toxaphene (soc)	✓	✓	297146	13396
70	1024	cyanide (free) (ioc)	✓	✓	438139	13388
71	2110	2,4,5 - tp silvex (soc)	✓	✓	309427	13358
72	2067	heptachlor epoxide (soc)	✓	✓	307172	13347
73	2041	dinoseb (soc)	✓	✓	306771	13267
74	3001	heterotrophic bacteria - enumeration	✓		169026	13123
75	2032	diquat (soc)	✓	✓	277141	13014
76	2383	pcbs (soc)	✓	✓	252770	12321
77	1008	chlorine dioxide	✓	✓	8177	12041

78	1009	chlorite	✓	✓	24122	11888
79	2063	2,3,7,8-tcdd (dioxin) (soc)	✓	✓	185862	10309
80	4030	radium-228	✓	✓	256112	8483
81	4020	radium-226	✓	✓	250946	7979
82	4006	combined uranium	✓	✓	216562	7073
83	4002	alpha/incl. radon & uranium	✓	✓	209737	5128
84	2451	dichloroacetic acid	✓	✓	20452	2783
85	2452	trichloroacetic acid	✓	✓	20452	2781
86	2454	dibromoacetic acid	✓	✓	20452	2779
87	2450	monochloroacetic acid	✓	✓	20410	2775
88	2453	monobromoacetic acid	✓	✓	20408	2774
89	4100	gross beta particle activity	✓	✓	123706	2447
90	1094	asbestos	✓	✓	62226	2157
91	1011	bromate	✓	✓	26251	1839
92	2044	aldicarb sulfone	✓	✓	89377	1568
93	2043	aldicarb sulfoxide	✓	✓	89274	1567
94	2047	aldicarb	✓	✓	81614	1511

All contaminants used in our analysis are included. The "Births" column reports the number of births for which we observe at least one sample of the given contaminant during its gestation.

A1.2 Mechanisms for effects of water contamination on health

In stark contrast to air pollution, where research generally focuses on a handful of key contaminants that impact health,[52] there are over 90 drinking water contaminants covered by the National Primary Drinking Water Regulations (NPDWRs), each contaminant may have different potential health effects (US Environmental Protection Agency (2018)), and the research literature appears to provide little guidance on which contaminants are likely to affect birth outcomes.

Bacterial contaminants are especially likely to have short-term effects such as gastrointenstinal illness. While most bacteria that occur in drinking water are harmless, some, such as those from human or animal wastes, may cause short-term, and potentially severe, illnesses. By contrast, US EPA expects most chemical (non-bacterial) contaminants to have health consequences only after long periods of exposure. These health effects may include cancer, liver and kidney damage, reproductive problems, and/or nervous system effects (US Environmental Protection Agency (2018)).

There is a sizeable epidemiological literature on the effects of water pollution on infant health. A detailed summary of the epidemiology literature up to the mid 2000s is provided in Wigle et al. (2008). Wigle et al. (2008) concludes that there is "limited" evidence that prenatal lead exposure leads to greater chance of preterm birth, while there is "inadequate" evidence that arsenic, cadmium, nitrate, and disinfectant byproducts (DBPs) lead to preterm birth. Moreover, they assess that there is "limited" evidence that lead, DBPs, and nitrate exposure will lead to greater chance of low birth

[52]For example, in Beatty and Shimshack (2014), only three air pollutants were studied: carbon monoxide, ozone, and particulate matter (PM10).

weight, while for arsenic and cadmium there is "inadequate" evidence. All contaminants listed here, and many more, are present in our water quality data.

More recently, epidemiologists have found that arsenic exposure in drinking water (Kile et al. (2016)) and, more generally, exposure to toxic metals (Sanders et al. (2014)) is associated with poorer birth outcomes; epidemiologists continue to debate whether nitrate contamination in drinking water affects birth outcomes or infant health (Manassaram et al. (2006)). While useful contributions to our understanding, these studies as a rule do not use rigorous econometric methods to isolate exogenous variation in water quality to identify causal effects; one plausible reason for this is small sample sizes. We describe other studies for the five contaminants we include in the reproductive-specific index in Section A1.3.

In summary, we do not have a randomized toxicological study for each covered contaminant on human health, so it is unclear whether some of the chemical contaminants may have short-run effects either alone or when combined with other chemical or bacterial contaminants. Indeed, multipollutant exposure analysis is an emerging subfield in epidemiology, especially in the context of air pollution (e.g. see Oakes et al. (2014), Snowden et al. (2015), and Davalos et al. (2017)). These issues motivate exposure analyses that study the effects of pollution sources (e.g. threats to drinking water, such as industrial facilities near source intakes), rather than pollutants *per se*. In this sense, the approach we take in this paper is traditional: we study the relationship between measured contaminants and health. We leave studies of the effects of drinking water intake exposures to potential point pollution sources as a direction for future research.

In addition, in spite of the NPDWRs regulating a broad range of contaminants, there are still more potentially harmful chemicals or bacteria that could be present in drinking water. Thus, the measures of contamination we observe may be correlated with other, unobserved measures of contamination, which themselves affect fetal health. For example, the EPA currently has over 100 unregulated water contaminants on their "contaminant candidate list," and in their six-year reviews, US EPA evaluates whether some of these should be added to currently regulated contaminants (US Environmental Protection Agency (2016a)).

For these reasons, in our main analysis we aggregate across contaminants, construct omnibus measures of water quality, and estimate the effects of these overall measures on birth outcomes.

A1.3 An alternative reproductive health index of five contaminants based on data availability and prior research

The National Primary Drinking Water Regulation provides a brief overview of the main health-based concerns for each contaminant regulated by SDWA. They identify two indicators that could be used to create an index that is specific to birth outcomes: reproductive difficulties, and health effects for infants. There are also studies within epidemiology and economics that have looked at birth outcomes (such as those studied in this paper, i.e., preterm birth, low birth weight) associated with exposure to contamination in drinking water. Table A3 summarizes the contaminants identified by the EPA and epidemiological/economic literature.

Our goal was to create a summary index of a smaller subset of contaminants that would be more specific to reproductive health and that would be frequently measured in the CWS in Pennsylvania (see Table A2 for number of births overlapping with contaminant samples). We identified 5 contaminants that had decent overlap between what the NPDWR identifies and the epidemiology

literature: arsenic, atrazine, Di(2-ethylhexyl) Phthalate (DEHP), nitrate, and tetrachloroethylene (PCE or PERC). For arsenic, the epidemiological literature is quite large, yet the EPA does not identify it as a contaminant of concern for pregnancy, reproduction, or infants. We choose to include it due to the large associational epi literature (Myers et al., 2010; Saha et al., 2012; Rahman et al., 2017; Bozack et al., 2018).[53] For atrazine, both the EPA and the epi literature showed concerns for birth outcomes (Rinsky et al., 2012; Migeot et al., 2013; Stayner et al., 2017; Almberg et al., 2018; Porpora et al., 2019).[54] DEHP is implicated in reproductive difficulties as well as associated with poor birth outcomes such as preterm birth in drinking water, soil, and food (Ferguson et al., 2014)[55]. Nitrate can be problematic for infants due to blue baby syndrome and has a growing set of studies both in epidemiology and economics suggesting it can be problematic for birth outcomes (Migeot et al., 2013; Stayner et al., 2017; Sherris et al., 2021; Coffman et al., 2022). [56] Finally, we include tetrachloroehtylene due to a growing epi literature suggesting an association with birth outcomes (Sonnenfeld et al., 2001; Aschengrau et al., 2018, 2020).[57]. Much of the literature supporting the NPDWR are over 20 years old, and so we decided to include contaminants that had recent support for a possible effect on birth outcomes (Porpora et al., 2019).

It is important to note that while the EPA and epidemiological literature (including economic literature) suggests strong impacts for lead exposure and infant health (Dave and Yang, 2022; Grossman and Slusky, 2019), lead is measured every 3 years per the regulation and so we decided not to include it in this index due to also wanting an index made up of contaminants that are frequently sampled. We chose not to include disinfectant byproducts in our sub-index due to a growing literature suggesting that early research that found associations between DBP and birth outcomes may not have been replicable with recent data (Savitz et al., 2006; Horton et al., 2011; Mashau et al., 2018). Lead and DBPs are in our omnibus index that is used in the main specification.

A1.4 Non-detection and Limits of Measurement

Recall that non-detect values are reported in the Pennsylvania sampling data we use as zeroes, and we treat them as zeroes throughout our analysis. One concern is that treating these as zeroes inflates the distance between the 10th and the 90th percentile, which we use to standardize our estimates. It is possible that the 10th percentile is a zero and the 90th percentile is very large, due to the nondetects being zeroes. However, while many states have non-detection

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[53]Some papers have found null associations or mixed results for the association between arsenic and birth outcomes (Saha et al., 2012; Bozack et al., 2018).

[54]Some papers have found null associations or mixed results for the association between atrazine and birth outcomes (Almberg et al., 2018).

[55]Some papers have found null associations or mixed results for the association between DEHP and birth outcomes (Ferguson et al., 2019)

[56]Some papers have found null associations or mixed results for the association between nitrate and birth outcomes (Albouy-Llaty et al., 2016; Ebdrup et al., 2022).

[57]Some papers have found null associations or mixed results for the association between tetrachloroethylene and birth outcomes (Forand et al., 2012). Sonnenfeld et al. (2001) found at most a weak association between tetrachloroethylene exposure and birth outcomes. However, they found an association between exposure and birth weight for infants of older mothers and mothers with a history of fetal loss. Aschengrau et al. (2020) found tetrachloroethylene-contaminated drinking water to be associated with delayed time-to-pregnancy, and increased risks of placental abruption, stillbirths stemming from placental dysfunction, and certain brith defects. No associations were observed with pregnancy loss, birth weight, and gestational duration.

Table A3: Drinking Water Contaminants Associated with Birth Outcomes and Reproductive Difficulties

| | NPDWR Indicated Health Risks | | Epi Lit |
Contaminant	Reproductive	Infant	Birth Outcomes
1,2-Dibromo-3- chloropropane (DBCP)	x		
Arsenic			x
Atrazine	x		x
Benzo(a)pyrene (PAHs)	x		
Carbofuran	x		
Chlorine dioxide		x	
Chlorite		x	
Di(2-ethylhexyl) adipate	x		
Di(2-ethylhexyl) phthalate (DEHP)	x		x
Dinoseb	x		
Dioxin (2,3,7,8-TCDD)	x		
Disenfectant Byproducts (DBP)			x
Ethylene dibromide	x		
Fecal coliform and E. coli		x	
Glyphosate	x		
Hexachlorobenzene	x		
Lead		x	x
Methoxychlor	x		
Nitrate		x	x
Nitrite		x	
Polychlorinated biphenyls (PCBs)	x		
Tetrachloroethylene			x
Trichloroethylene			x

Notes This table lists contaminants identified in the National Primary Drinking Water Regulation Table as having either an impact on reproduction or infants. We also identify some contaminants that have a large literature within epidemiology (or economics, i.e., lead) studying the association between exposure in drinking water and birth outcomes. Some of these contaminants have mixed results in this literature. We bold the 5 contaminants that we include in our 5-contaminant reproductive-specific water quality index.

levels for reporting that are relatively high, Pennsylvania Department of Environmental Protection's (PA DEP) policy is to have testing laboratories report their sample results as long as they are above the EPA's designated Method Detection Limit (MDL), which varies depending on contaminant and method of analysis. As a result, Pennsylvania provides an ideal case to study variation in water quality conditional on regulatory compliance, since less data is suppressed than in many other states. For supporting evidence we compare PA DEP's reporting thresholds with California's for a subset of contaminants for which we can do this, and find that PA DEP's reporting thresholds are much lower. See Tables A4 and A5. PA DEP's reporting thresholds can be found in documents posted online at http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=690145. California's detection limits for purposes of reporting can be found at https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/mclreview/mcls_dlrs_phgs.pdf.

Table A4: Comparing Non-Detect Levels in PA and CA

ID	Name	Method	PA DLR = EPA MDL	CA DLR	% Difference
All VOCs	All VOCs	All Methods	0.0005	0.0005	0
1074	Antimony	ASTM D3697	0.001	0.006	-83.33
1074	Antimony	SM 3113 B	0.003	0.006	-50.00
1074	Antimony	EPA 200.9	8e-04	0.006	-86.67
1074	Antimony	EPA 200.8	4e-04	0.006	-93.33
1005	Arsenic	SM 3114 B; ASTM D1972	0.001	0.002	-50.00
1005	Arsenic	SM 3113 B; ASTM D2972	0.001	0.002	-50.00
1005	Arsenic	EPA 200.9	5e-04	0.002	-75.00
1005	Arsenic	EPA 200.8	0.0014	0.002	-30.00
1010	Barium	SM 3111 D	0.1	0.1	0.00
1010	Barium	SM 3113 B	0.002	0.1	-98.00
1010	Barium	EPA 200.7; SM 3120 B	0.002	0.1	-98.00
1075	Beryllium	SM 3113 B; ASTM D3645	2e-04	0.001	-80.00
1075	Beryllium	EPA 200.9	2e-05	0.001	-98.00
1075	Beryllium	EPA 200.7; SM 3120 B	3e-04	0.001	-70.00
1075	Beryllium	EPA 200.8	3e-04	0.001	-70.00
1015	Cadmium	SM 3113 B	1e-04	0.001	-90.00
1015	Cadmium	EPA 200.7	0.001	0.001	0.00
1020	Chromium	SM 3113 B	0.001	0.01	-90.00
1020	Chromium	EPA 200.7; SM 3120 B	0.007	0.01	-30.00
1024	Cyanide, free	SM 4500-CN- C, E; ASTM D2036A	0.02	0.1	-80.00
1024	Cyanide, free	EPA 335.4	0.005	0.1	-95.00
1024	Cyanide, free	SM 4500-CN- C, F	0.05	0.1	-50.00
1024	Cyanide, free	SM 4500-CN- C, G; ASTM D2036B	0.02	0.1	-80.00
1024	Cyanide, free	Kelada-01	5e-04	0.1	-99.50
1024	Cyanide, free	QuikChem 10-204-00-1-X	6e-04	0.1	-99.40
1024	Cyanide, free	ASTM D6888; OIA-1677, DW (ALPKEM)	5e-04	0.1	-99.50
1035	Mercury	EPA 245.1; SM 3112 B; ASTM D3223	2e-04	0.001	-80.00
1035	Mercury	EPA 245.2	2e-04	0.001	-80.00
1036	Nickel	SM 3113 B	0.001	0.01	-90.00
1036	Nickel	EPA 200.9	6e-04	0.01	-94.00
1036	Nickel	EPA 200.7; SM 3120 B	0.005	0.01	-50.00
1036	Nickel	EPA 200.9	5e-04	0.01	-95.00
1045	Selenium	SM 3114 B; ASTM D3859	0.002	0.005	-60.00
1045	Selenium	SM 3113 B; ASTM D3859	0.002	0.005	-60.00
1085	Thallium	EPA 200.9	7e-04	0.001	-30.00
1085	Thallium	EPA 200.8	3e-04	0.001	-70.00
1094	Asbestos	EPA 100.1, 100.2	0.01	0.2	-95.00
1040	Nitrate	SM 4500-NO3- E; ASTM D3867	0.01	0.4	-97.50
1040	Nitrate	EPA 300.0, 300.1; SM 4110 B; ASTM D4327; B-1011 (Waters)	0.01	0.4	-97.50
1040	Nitrate	SM 4500-NO3- D; 601 (ATI Orion)	1	0.4	150.00
1040	Nitrate	EPA 353.2; SM 4500-NO3- F; ASTM D3867	0.05	0.4	-87.50
1040	Nitrate	ASTM D6508	0.076	0.4	-81.00
1041	Nitrite	SM 4500-NO3- E; ASTM D3867	0.01	0.4	-97.50
1041	Nitrite	EPA 300.0, 300.1; SM 4110 B; ASTM D4327; B-1011 (Waters)	0.004	0.4	-99.00
1041	Nitrite	EPA 353.2; SM 4500-NO3- F; ASTM D3867	0.05	0.4	-87.50
1041	Nitrite	SM 4500-NO2- B	0.01	0.4	-97.50
1041	Nitrite	ASTM D6508	0.103	0.4	-74.25

However, notwithstanding PA DEP's data advantages, it is still theoretically possible that the currently-used 10th to 90th percentile difference is inflated due to the "jump to zero" effect of detection limits. In order to investigate whether this concern is empirically relevant, we provide below our index measure when we use the zeroes provided in the data (which are below EPA MDL) versus when we replace cases below the MDLs with the corresponding EPA MDL (for the contaminant and method combination). We merged the contaminant method detection limits provided by PA with our data, obtaining data on 69 contaminants. To be specific, to construct the following table, for simplicity we (1) took the maximum MDL by contaminant (because contaminants have multiple possible methods of analysis, there are multiple MDLs for each contaminant), then (2) for every birth that is exposed to an average level of contamination (for a particular contaminant) below the MDL, we replace that birth's average level of contamination with the MDL (since their low level of contamination must be driven by having some nondetects, which are treated as zero). Furthermore, note that after we replace these birth-specific contamination measures in this way, our index measures will increase for every birth, since our index measures are averaged over contaminants including those with replaced-with-MDL values, and those without replaced-with-MDL values. As a result, not only does the 10th percentile rise, but also the 90th percentile will rise, as the entire distribution of contamination shifts to the right (based on how many nondetects each birth experiences during gestation).

Table A6 shows our findings from this exercise. For these 69 contaminants, the 10th-to-90th percentile difference (for these contaminants) was 0.03 (0.03 - 0) prior to the replace-with-MDL (Panels A1 and B1), but rises to 2.19 (2.25 - 0.06) after replace-with-MDL (because Coliform is not one of the contaminants on the list, there is no difference between the All and Chemical rows in this table). Our interpretation is that, were we to try to adjust our analysis by replacing non-detects with the detection limit, this would in fact increase the 10th-to-90th difference that we use, so our estimates are currently reported in a way that makes them look conservative.

A1.5 Community Water System Boundaries and Linking Births to Water Quality

Recall that we calculate the average exposure to contamination for each birth during gestation for the system where the mother resides on the birth certificate. Except for differences in gestation length, this means that the contamination measure is the same for two births born on the same date in the same water system.

This raises the concern that there could be within water system heterogeneity in water quality. The water samples we have are matched to water system, but not at any more granular level, and there are a few very large (population) water systems in Pennsylvania. Consider two of the larger systems: the Philadelphia Water Department and the Pittsburgh Water and Sewer Authority.

The Philadelphia Water Department is, roughly-speaking, two water distribution systems, one that intakes from the Delaware River (eastern side of city) and one that intakes from the Schuylkill River (western side of the city). See page 6 of https://water.phila.gov/pool/files/2019-pwd-water-quality-report.pdf for details; we reproduced the map from that page below.

While we analyze this water system as one system, there are indeed two systems involved here, and, actually, three treatment plants (two sourcing from the Schuylkill), although there are places of
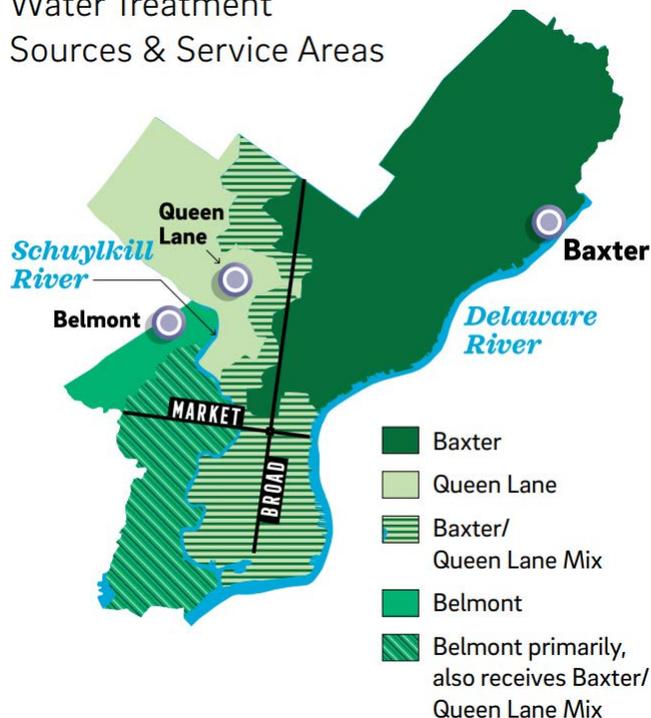
Table A5: Comparing Non-Detect Levels in PA and CA, Continued

ID	Name	Method	PA DLR = EPA MDL	CA DLR	% Difference
4002	Gross Alpha particle	All methods	3	3	0.00
4020	Radium-226	All methods	1	1	0.00
4030	Radium-228	All methods	1	1	0.00
4006	Uranium	All methods	1	1	0.00
4100	Gross beta	All methods	4	4	0.00
4174	Strontium-90	All methods	2	2	0.00
4102	Tritium	All methods	1000	1000	0.00
2051	Alachlor	All methods	0.00044	0.001	-56.00
2050	Atrazine	All methods	0.00022	5e-04	-56.00
2306	Benzo(a)pyrene	All methods	4.4e-05	1e-04	-56.00
2046	Carbofuran	All methods	0.000198	0.005	-96.04
2959	Chlordane	All methods	0.00044	1e-04	340.00
2105	2,4-D	All methods	0.00022	0.01	-97.80
2031	Dalapon	All methods	0.0022	0.01	-78.00
2931	Dibromochloropropane (DBCP)	All methods	4.4e-05	1e-05	340.00
2035	Di(2-ethylhexyl)adipate	All methods	0.00132	0.005	-73.60
2041	Dinoseb	All methods	0.00044	0.002	-78.00
2032	Diquat	All methods	0.00088	0.004	-78.00
2033	Endothall	All methods	0.0198	0.045	-56.00
2005	Endrin	All methods	2.2e-05	1e-04	-78.00
2946	Ethylene dibromide (EDB)	All methods	2.2e-05	2e-05	10.00
2034	Glyphosate	All methods	0.0132	0.025	-47.20
2065	Heptachlor	All methods	8.8e-05	1e-05	780.00
2067	Heptachlor epoxide	All methods	4.4e-05	1e-05	340.00
2274	Hexachlorobenzene	All methods	0.00022	5e-04	-56.00
2042	Hexachlorocyclopentadiene	All methods	0.00022	0.001	-78.00
2010	Lindane	All methods	4.4e-05	2e-04	-78.00
2015	Methoxychlor	All methods	0.00022	0.01	-97.80
2036	Oxymal (Vydate)	All methods	0.0044	0.02	-78.00
2326	Pentachlorophenol	All methods	8.8e-05	2e-04	-56.00
2040	Picloram	All methods	0.00022	0.001	-78.00
2037	Simazine	All methods	0.000154	0.001	-84.60
2063	2,3,7,8-TCDD (Dioxin)	All methods	1.1e-08	5e-09	120.00
2020	Toxaphene	All methods	0.0022	0.001	120.00
2110	2,4,5-TP (Silvex)	All methods	0.00044	0.001	-56.00
2383	PCBs	All methods	0.00022	5e-04	-56.00
1009	Chlorite	All methods	0.02	0.02	0.00

Table A6: Distribution of drinking water contamination experienced by Pennsylvanian births during gestation – 69 contaminants for which we observe thresholds for reporting by the PA DEP.

Contaminant	(1) Mean	(2) SD	(3) 10th	(4) 25th	(5) 50th	(6) 75th	(7) 90th	(8) Max	(9) Births
Panel A1: Trimmed sample - nondetects are zero (births used in analysis)									
All	0.01	0.03	0.00	0.00	0.01	0.02	0.03	0.28	1,148,370
Chemical	0.01	0.03	0.00	0.00	0.01	0.02	0.03	0.28	1,148,370
Panel B1: Raw sample - nondetects are zero (including births not used)									
All	0.02	0.32	0.00	0.00	0.01	0.02	0.03	230.00	1,160,108
Chemical	0.02	0.32	0.00	0.00	0.01	0.02	0.03	230.00	1,160,108
Panel A2: Trimmed sample - nondetects replaced with nondetect limit (births used in analysis)									
All	0.44	0.86	0.06	0.08	0.10	0.13	2.25	4.57	1,148,271
Chemical	0.44	0.86	0.06	0.08	0.10	0.13	2.25	4.57	1,148,271
Panel B2: Raw sample - nondetects replaced with nondetect limit									
All	0.52	2.14	0.06	0.08	0.10	0.13	2.28	230.00	1,160,108
Chemical	0.52	2.14	0.06	0.08	0.10	0.13	2.28	230.00	1,160,108

Water Treatment
Sources & Service Areas

Legend:
- Baxter
- Queen Lane
- Baxter/ Queen Lane Mix
- Belmont
- Belmont primarily, also receives Baxter/ Queen Lane Mix

overlap that would complicate analysis even if we had more granular data. Our sampling data, which we average over the samples reported by the system (at different and unknown to us distribution plants or, in some cases, different points in the distribution) thus represents only a proxy for the water quality experienced by each individual, and not a perfect measure.

Turning to a second example, the Pittsburgh Water and Sewer Authority sources its water entirely from the Allegheny River, and has one water treatment plant (https://www.pgh2o.com/your-water/water-quality-treatment). In this case the concern appears less warranted.

We thus recognize inherent measurement limitations in linking mother exposure to water quality using CWS of residence. To address this concern, we include a sensitivity analysis where we run our main analysis, dropping large systems. We include the results in Appendix Tables A23 and A24 (later in this Appendix). We did this by sorting births by system size (number of people served by the CWS) and then dropping the 50% of births in our sample in the largest systems (those in the bottom of the dataset). The largest system in this restricted sample serves 118,000 people (contrast with the largest system, Philadelphia Water Department, which serves 1,600,000 people), and thus this is a meaningful restriction. As the tables show, our main results are robust to this sample restriction.

A second concern about the births to CWS linkage we conduct is that the boundaries of water systems change over time. As mentioned in the main text, the vintage of the community water service map we use as the 2016, month 4, version of the data. We used this vintage since it was the latest available at the start of our research. However, PennState University's Pennsylvania Spatial Data Access (PASDA), the source of the data, has versions of this data from 2011 to 2022 (https://www.pasda.psu.edu/download/dep/historic/PublicWaterSupply/).

This suggests the possibility of using multiple versions of the boundary data to better measure spatial relationship between mothers and water providers. But since 2011 is near the end of our sample frame (2003-2014), the range of data that is available is of limited use for longitudinal analysis in our study. An additional concern we have about studying multiple years of these service boundaries is it is unclear to us whether the changes from year-to-year are corrections of service boundaries reported, or whether they are true additions or subtractions. With this in mind, the following two maps, in Figures A1 and A2, compare the 2011/04 vintage with 2016/04 (first map), and 2016/04 with 2022/10 (second map). Blue areas are CWS coverage gains, while orange areas are CWS losses.
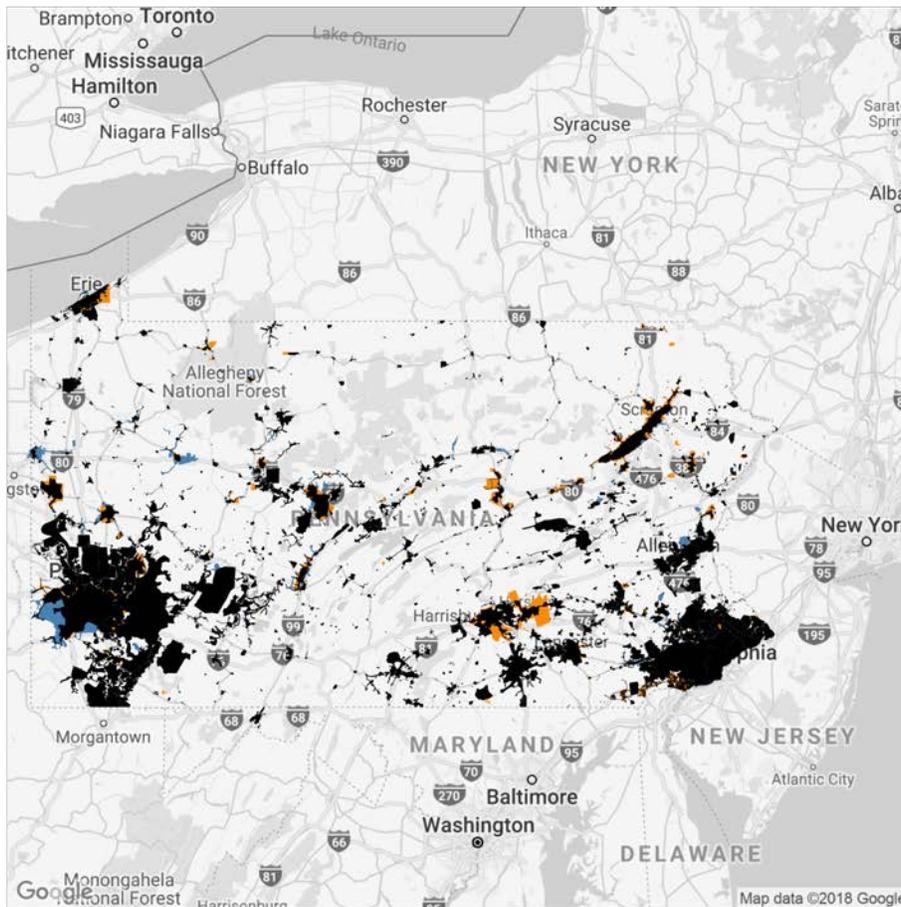
Blue areas are CWS coverage gains, while orange areas are CWS losses.

Figure A1: Changes in PWS Boundaries 2011 compared to 2016

Clearly there are some significant changes in these boundaries, but it is less clear whether these are true changes or measurement error (corrections of the maps, or mistakes in reporting).

To shed further light on these issues, we argue that concerns regarding boundary changes could take two forms: (1) if boundaries change randomly (measurement error for example), then that will add noise into our independent variable as births will not be being correctly matched to contamination. This classical measurement error would attenuate our effect estimates. (2)
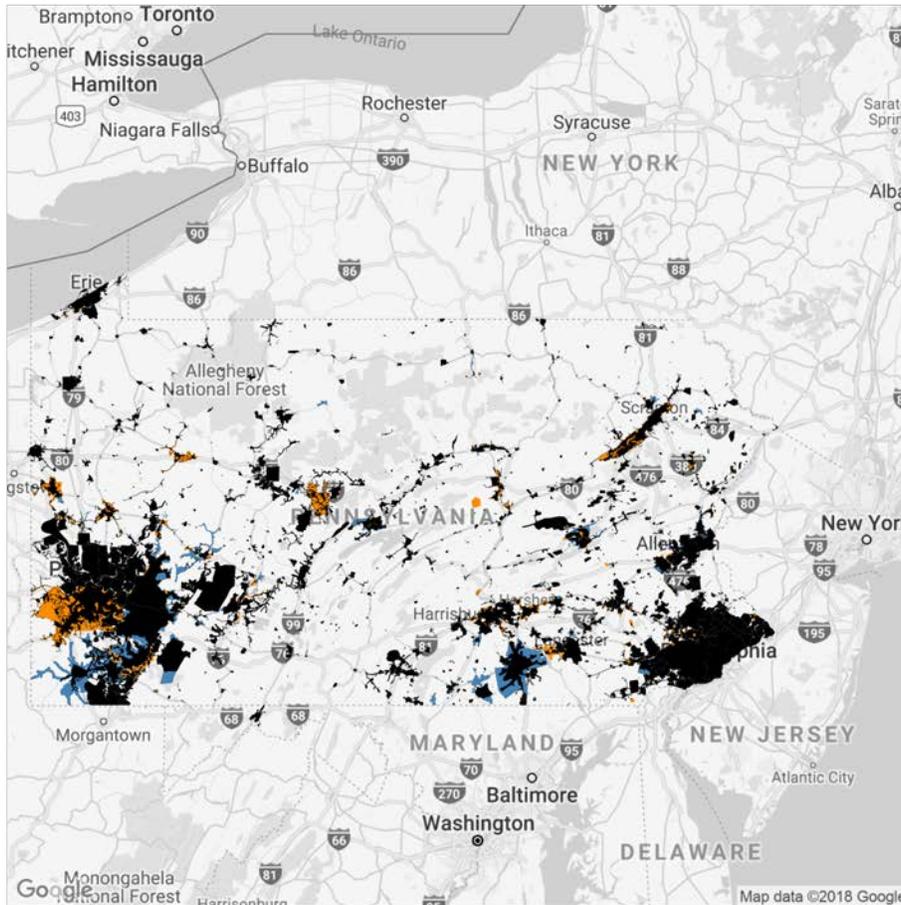
Figure A2: Changes in PWS Boundaries 2016 compared to 2022

Boundary changes could be an omitted variable (confounder), that is, they could be systematically correlated with contamination and outcomes, and could thus bias our estimates. The two maps we provided above suggest that boundary changes are likely to be correlated with the demographics of the system, as it is the suburban and rural areas that expand or contract, not the major cities. As a result, we admit the possibility that boundary changes may be correlated with outcomes (through socioeconomic status, for example). We instead focus on the question of whether boundary changes are correlated with levels of CWS contamination.

For this auxiliary analysis, we examined CWS level average contamination (taken over the last nine months) for our two omnibus measures, all and chemical-only RRMCL, averaged over the contaminants for which we have samples. We then regressed the change in CWS contamination from 2011/04 to 2015/12 (the first and last month available in our sampling data) on (a) whether the CWS had any meaningful net increase in area (i.e., above the very trivial threshold of 100 square meters) or decrease (i.e. below the threshold of 100 square meters lost) (columns (1) and (3) in the table below), with the excluded group of no meaningful change; and (b) the net change in square kilometers (columns (2) and (3) in the table below). The results of these four regressions we include in the table below. As the table shows, there is no statistically significant relationship between the change in CWS contamination over this period, and CWS boundary changes (though,

Table A7: Change in Contamination Correlated with Changes in CWS Boundaries

	(1) ΔAll	(2) ΔAll	(3) ΔChemical	(4) ΔChemical
Meaningful Increase	0.0353		0.00839	
	(0.0247)		(0.00755)	
Meaningful Decrease	0.00406		-0.00868	
	(0.0238)		(0.0120)	
Net Δ Square Km		0.000225		0.000436*
		(0.000610)		(0.000251)
Constant	-0.0108	-0.00688	0.00314	0.00349
	(0.00852)	(0.00763)	(0.00311)	(0.00278)
N	1546	1546	1546	1546

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

note that column 4 is statistically significant at the 10% level). This suggests that boundary changes are unlikely to be an omitted variable, since they are not strongly related to CWS contamination levels.

A2   Sensitivity analyses

This section repeats our main analysis using different sample restrictions and different indices of contamination. Regressions estimating the effects of water contamination on birth outcomes are repeated for each subsample or index definition.

Since much of our sensitivity analysis rests on sample restrictions, we begin by more fully comparing our analytic sample to the full population of births (including those not matched to water systems, plural, and exposed to MCL). To do so, we add an additional column to our summary statistics table (Table 2 in the main text) which includes all births. This is included as Table A8. (We dropped some columns from this version of the summary statistics table to conserve space.)

Note that in the main text, we exclude plural births. The first change in sample we explore is including plural births. Results are in Tables A9 and A10.

Concern over to what extent our results are driven by mother mobility motivates the second change in sample: we re-run our models, excluding all mothers (with multiple births) that ever switch a CWS across births. Results are shown in Table A11 and A12.

Interest in how our results would change if we keep births exposed to MCL violations, or remove births with high samples more rigorously, motivates our third and fourth sets of sensitivity analyses. We re-run the models including births exposed to MCL, and re-run the models excluding births linked to any samples exceeding the corresponding MCL. For this last sensitivity analyses, four contaminants present a challenge due to samples very often exceeding their MCLs, so we

further estimate models that drop these four contaminants from our index construction, and models that keep these four contaminants (with the concomitant substantial reduction in sample size). Our results are included in Tables A15 through A20.

Concern over our sample changing between the mom FE models and the CWS FE models motivates our next analysis, where we force these samples to be identical. We saw in the main text that estimates were sensitive to which fixed-effects structure we employed, in spite of mother and birth characteristics being similar across the two samples; it is interesting to see whether the effect estimates remain different after forcing the samples to be identical. Results are in Tables A21 and A22.

Finally, concern over mismeasurement of the link between water contamination and exposure, that may be especially acute in large CWS (with complicated distribution systems), motivates a sensitivity analysis estimating our models for smaller CWS only. Results are in Tables A23 and A24.

We present each of these sensitivity analyses in the following appendix subsections.

Table A8: Sample means and, when appropriate, standard deviations, for selected statistics and subsamples of births.

Characteristic	(1) All Births	(2) NP No MCL	(3) Analytic Sample	(4) Mom FE Sample
Sample Sizes				
No. of births	1,608,619	1,241,656	1,216,132	700,815
No. of moms	992,451	832,674	820,173	304,934
No. of CWSs	1,542	1,537	1,459	1,343
Outcomes				
Low birth weight	0.083	0.067	0.067	0.065
Preterm birth	0.099	0.082	0.082	0.081
Small for gestational age	0.099	0.095	0.096	0.091
Term birth weight (g)	3,398	3,396	3,396	3,402
	(475.2)	(468.9)	(468.8)	(467.2)
CWS births per 100k per month	117.7	113.4	112.7	112.1
	(110.8)	(107.4)	(103.3)	(98.59)
Other characteristics				
Mom age (years)	28.09	27.87	27.87	27.69
	(6.032)	(6.054)	(6.057)	(5.858)
Mom Black	0.177	0.210	0.213	0.220
Mom Hispanic	0.058	0.068	0.069	0.074
Mom white, not Hispanic	0.765	0.722	0.718	0.713
HS or less	0.403	0.401	0.401	0.406
Mom smokes	0.219	0.224	0.223	0.216
Mom married	0.606	0.569	0.568	0.578
WIC/Medicaid	0.442	0.477	0.478	0.482
Different CWS next birth	0.406	0.369	0.368	0.368
Mean RRCML, all contaminants	0.104	0.095	0.078	0.078
	(2.978)	(2.237)	(0.078)	(0.077)
Mean RRCML, chemical only	0.095	0.085	0.069	0.069
	(3.201)	(2.238)	(0.080)	(0.079)

Notes: Sample consists of all births. Means (for indicator variables, proportions) are displayed, with standard deviations in parentheses when appropriate; NP = non-plural birth. Column (1) provides statistics for for all births, including those not matched to water systems. Column (2) restricts to non-plural births without MCLs that are matched to water systems. Column (3) restricts to our analytic sample, keeping only births with an overall measure of contamination and for which that measure is below the 99th percentile. Column (4) describes births in our mother fixed-effects specifications.

A2.1 All births (including plural)

Table A9: Effects of contamination on low birth weight and preterm birth, all births (including plural)

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: low birth weight						
CWS FE						
10th to 90th RRMCL	0.01817***	0.01732***	0.01363***	0.01308***	0.01137***	0.01009***
	(0.00393)	(0.00165)	(0.00309)	(0.00122)	(0.00259)	(0.00137)
Observations	1,262,235	1,260,752	1,262,235	1,260,752	1,262,235	1,260,752
Adj R^2	0.0043	0.0047	0.1549	0.1551	0.2079	0.2080
Mom & CWS FE						
10th to 90th RRMCL	0.01242***	0.01214***	0.01010***	0.00983***	0.00884***	0.00764***
	(0.00308)	(0.00137)	(0.00266)	(0.00120)	(0.00230)	(0.00136)
Observations	754,689	753,372	754,689	753,372	754,689	753,372
Adj R^2	0.2738	0.2741	0.3455	0.3456	0.3752	0.3753
Panel B: preterm birth						
CWS FE						
10th to 90th RRMCL	0.02489***	0.02355***	0.02004***	0.01905***	0.01721***	0.01531***
	(0.00506)	(0.00208)	(0.00402)	(0.00160)	(0.00329)	(0.00170)
Observations	1,262,235	1,260,752	1,262,235	1,260,752	1,262,235	1,260,752
Adj R^2	0.0034	0.0039	0.1453	0.1457	0.2209	0.2212
Mom & CWS FE						
10th to 90th RRMCL	0.01808***	0.01774***	0.01553***	0.01524***	0.01407***	0.01255***
	(0.00415)	(0.00178)	(0.00365)	(0.00156)	(0.00297)	(0.00165)
Observations	754,689	753,372	754,689	753,372	754,689	753,372
Adj R^2	0.3016	0.3021	0.3681	0.3684	0.4125	0.4127

Notes: see notes to Table 3 in the main text.

Table A10: Effects of contamination on small for gestational age and term birth weight, all births (including plural)

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical

Panel A: small for gestational age

CWS FE

10th to 90th RRMCL	0.00444***	0.00380***	0.00236***	0.00170***	0.00209***	0.00137**
	(0.00080)	(0.00069)	(0.00075)	(0.00060)	(0.00078)	(0.00060)
Observations	1,259,696	1,258,220	1,259,696	1,258,220	1,259,696	1,258,220
Adj R^2	0.0050	0.0050	0.0569	0.0568	0.0575	0.0575

Mom & CWS FE

10th to 90th RRMCL	0.00388***	0.00294***	0.00306***	0.00195**	0.00319***	0.00205**
	(0.00101)	(0.00087)	(0.00095)	(0.00082)	(0.00097)	(0.00084)
Observations	751,908	750,588	751,908	750,588	751,908	750,588
Adj R^2	0.1627	0.1633	0.1886	0.1892	0.1887	0.1893

Panel B: term birth weight

CWS FE

10th to 90th RRMCL	-11.08***	-10.66605***	-9.66***	-9.36292***	-9.46***	-8.69350***
	(1.46)	(1.30313)	(1.51)	(1.20495)	(1.65)	(1.31206)
Observations	1,135,217	1,133,896	1,135,217	1,133,896	1,135,217	1,133,896
Adj R^2	0.0157	0.0157	0.1199	0.1200	0.1241	0.1242

Mom & CWS FE

10th to 90th RRMCL	-9.93***	-9.43433***	-9.15***	-8.56855***	-9.31***	-8.23830***
	(1.68)	(1.32991)	(1.80)	(1.34776)	(1.84)	(1.42809)
Observations	634,768	633,676	634,768	633,676	634,768	633,676
Adj R^2	0.3579	0.3580	0.4151	0.4152	0.4171	0.4171

Notes: see notes to Table 3 in the main text.

A2.2 Only non-plural births to non-moving moms

In this subsection, we repeat our main specifications providing evidence of the effects of contamination on birth outcomes, except we remove moms who switch CWS at any point across births. Of course, this sample restriction only applies to mothers with multiple births in our data. Our intent is to test whether our results are driven by movers.

Table A11: Effects of contamination on low birth weight and preterm birth, no movers.

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: low birth weight						
CWS FE						
10th to 90th RRMCL	0.01370***	0.01502***	0.01260***	0.01395***	0.01130***	0.01131***
	(0.00320)	(0.00137)	(0.00303)	(0.00126)	(0.00246)	(0.00145)
Observations	885,494	884,502	885,494	884,502	885,494	884,502
Adj R^2	0.0053	0.0056	0.0464	0.0466	0.1066	0.1067
Mom & CWS FE						
10th to 90th RRMCL	0.00882***	0.01034***	0.00841***	0.00963***	0.00835***	0.00808***
	(0.00307)	(0.00136)	(0.00288)	(0.00128)	(0.00228)	(0.00147)
Observations	374,367	373,867	374,367	373,867	374,367	373,867
Adj R^2	0.2021	0.2023	0.2240	0.2242	0.2577	0.2578
Panel B: preterm birth						
CWS FE						
10th to 90th RRMCL	0.01948***	0.02155***	0.01819***	0.02023***	0.01653***	0.01690***
	(0.00443)	(0.00192)	(0.00409)	(0.00176)	(0.00325)	(0.00193)
Observations	885,494	884,502	885,494	884,502	885,494	884,502
Adj R^2	0.0037	0.0042	0.0467	0.0472	0.1314	0.1317
Mom & CWS FE						
10th to 90th RRMCL	0.01321***	0.01616***	0.01254***	0.01518***	0.01260***	0.01324***
	(0.00463)	(0.00204)	(0.00444)	(0.00194)	(0.00341)	(0.00202)
Observations	374,367	373,867	374,367	373,867	374,367	373,867
Adj R^2	0.1917	0.1920	0.2178	0.2180	0.2658	0.2658

Notes: see notes to Table 3 in the main text.

Table A12: Effects of contamination on small for gestational age and term birth weight, no movers

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: small for gestational age						
CWS FE						
10th to 90th RRMCL	0.00432***	0.00330***	0.00364***	0.00278***	0.00344***	0.00247***
	(0.00090)	(0.00076)	(0.00085)	(0.00071)	(0.00091)	(0.00075)
Observations	884,128	883,138	884,128	883,138	884,128	883,138
Adj R^2	0.0059	0.0059	0.0386	0.0386	0.0396	0.0397
Mom & CWS FE						
10th to 90th RRMCL	0.00323***	0.00160	0.00325***	0.00149	0.00365***	0.00194*
	(0.00122)	(0.00103)	(0.00123)	(0.00104)	(0.00126)	(0.00105)
Observations	373,142	372,638	373,142	372,638	373,142	372,638
Adj R^2	0.1887	0.1890	0.1984	0.1988	0.1985	0.1989
Panel B: term birth weight						
CWS FE						
10th to 90th RRMCL	-11.41***	-10.70***	-10.34***	-10.09***	-10.38***	-9.56821***
	(1.56)	(1.37)	(1.66)	(1.30)	(1.82)	(1.46)
Observations	812,779	811,873	812,779	811,873	812,779	811,873
Adj R^2	0.0182	0.0182	0.0942	0.0944	0.0986	0.0988
Mom & CWS FE						
10th to 90th RRMCL	-8.53***	-8.78***	-8.67***	-8.72***	-9.27***	-8.86***
	(2.30)	(1.69)	(2.34)	(1.73)	(2.41)	(1.83)
Observations	327,108	326,672	327,108	326,672	327,108	326,672
Adj R^2	0.4672	0.4674	0.4941	0.4942	0.4955	0.4957

Notes: see notes to Table 3 in the main text.

A2.3 Including births exposed to MCL violations

In this subsection, we repeat our main specifications except we do not exclude births exposed to MCL violations.

Table A13: Effects of contamination on low birth weight and pre-term birth, including births exposed to MCL

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: Low birth weight						
CWS FE						
10th to 90th RRMCL	0.01306***	0.01449***	0.01200***	0.01342***	0.01016***	0.01064***
	(0.00277)	(0.00129)	(0.00263)	(0.00120)	(0.00217)	(0.00130)
Observations	1,257,166	1,255,522	1,257,166	1,255,522	1,257,166	1,255,522
Adj R^2	0.0050	0.0053	0.0452	0.0455	0.1050	0.1053
Mom & CWS FE						
10th to 90th RRMCL	0.00918***	0.01059***	0.00896***	0.01013***	0.00780***	0.00795***
	(0.00225)	(0.00114)	(0.00212)	(0.00111)	(0.00180)	(0.00126)
Observations	738,790	737,372	738,790	737,372	738,790	737,372
Adj R^2	0.1482	0.1487	0.1664	0.1668	0.2077	0.2080
Panel B: Preterm birth						
CWS FE						
10th to 90th RRMCL	0.01948***	0.02118***	0.01818***	0.01987***	0.01584***	0.01635***
	(0.00373)	(0.00170)	(0.00346)	(0.00158)	(0.00277)	(0.00162)
Observations	1,257,166	1,255,522	1,257,166	1,255,522	1,257,166	1,255,522
Adj R^2	0.0037	0.0042	0.0464	0.0469	0.1308	0.1311
Mom & CWS FE						
10th to 90th RRMCL	0.01515***	0.01688***	0.01482***	0.01631***	0.01347***	0.01362***
	(0.00333)	(0.00158)	(0.00316)	(0.00152)	(0.00252)	(0.00160)
Observations	738,790	737,372	738,790	737,372	738,790	737,372
Adj R^2	0.1465	0.1469	0.1641	0.1644	0.2227	0.2229

Notes: see notes to Table 3 in the main text.

Table A14: Effects of contamination on small for gestational age and term birth weight, including births exposed to MCL

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: small for gestational age						
CWS FE						
10th to 90th RRMCL	0.00326***	0.00291***	0.00266***	0.00237***	0.00242***	0.00206***
	(0.00073)	(0.00058)	(0.00071)	(0.00054)	(0.00075)	(0.00055)
Observations	1,255,208	1,253,568	1,255,208	1,253,568	1,255,208	1,253,568
Adj R^2	0.0054	0.0054	0.0378	0.0378	0.0388	0.0388
Mom & CWS FE						
10th to 90th RRMCL	0.00222**	0.00164**	0.00220**	0.00149*	0.00231**	0.00155*
	(0.00099)	(0.00081)	(0.00096)	(0.00079)	(0.00099)	(0.00081)
Observations	736,689	735,266	736,689	735,266	736,689	735,266
Adj R^2	0.1376	0.1382	0.1532	0.1538	0.1535	0.1541
Panel B: term birth weight						
CWS FE						
10th to 90th RRMCL	-10.19***	-10.05***	-9.30***	-9.38***	-9.04***	-8.78***
	(1.35)	(1.18)	(1.47)	(1.14)	(1.58)	(1.24)
Observations	1,154,988	1,153,455	1,154,988	1,153,455	1,154,988	1,153,455
Adj R^2	0.0168	0.0168	0.0941	0.0941	0.0985	0.0985
Mom & CWS FE						
10th to 90th RRMCL	-9.15***	-9.19***	-9.28***	-8.93***	-9.40***	-8.58***
	(1.69)	(1.29)	(1.79)	(1.35)	(1.83)	(1.43)
Observations	647,223	645,961	647,223	645,961	647,223	645,961
Adj R^2	0.3400	0.3400	0.3795	0.3795	0.3816	0.3816

Notes: see notes to Table 3 in the main text.

A2.4 Removing births with any samples exceeding MCL

In this subsection, we repeat our main specifications except not only do we exclude births exposed to reported MCL violations, we also exclude births exposed to any samples that were in excess of MCL. Independent audits of EPA's reported MCL violations around the year 2000 found that a large share of drinking water violations were not reported accurately (see the references and discussion in Bennear and Olmstead (2008), who note that for some contaminants around 85% of MCL violations were not accurately reported), so there is concern that the MCL violations data provided by the US EPA is imperfect. However, by 2011, the middle of our study period, close to 75% of health-based violations were accurately reported across states to EPA (Baker et al., 2023). To provide additional statistics for this question, we requested the MCL violations from Pennsylvania and compared them to the data on health-based violations we FOIA'd the EPA for. We combined the EPA and PA violations from 2000-2015 and found that 80% of them were in both files, 6% were in PA only and 14% were in EPA only. Our main specifications used the EPA violations as the gold standard, making up 94% of the total reported violations.

While our analysis and more recent literature suggests the EPA violations data is of reasonable quality, due to lingering concerns that violations might not be accurately reported or measured, we use the sampling data to identify individual sampling concentrations (results) that are above the MCL. The alternative regressions displayed in Tables A15 through A20 test whether our findings are sensitive to a stronger definition of "compliant drinking water" where we exclude births exposed to any samples in excess of the MCL.[58]

There are four contaminants where births very often have samples that exceed the MCL: Total Coliform, TTHM, HAA5, or lead. Note that none of these contaminants have MCL violations generated using single samples: the Total Coliform rule uses monthly aggregates, TTM and HAA5 use running annual averages, and lead uses 90th percentiles. It is therefore perfectly consistent that samples often exceed their corresponding MCL, but do not trigger regulatory violations, in these cases. Due to these contaminants, we estimate three versions of this sensitivity analysis. In our first version, included in Tables A15 and A16, we construct our water quality index measure the same way as we do in the text, including these four contaminants, but we do not use these four contaminants to drop births exposed to samples that exceed their MCL. This first version maximizes our sample size for this robustness check, while keeping our index consistent with what we calculate in the main text. In our second version, included in Tables A17 and A18, we simply do not include these contaminants in the analysis at all: not in the index, nor in the sample restriction. In our third version, included in Tables A19 and A20, we include these in the index and drop births exposed to exceedences for any and all contaminants (including hese four contaminants), which leads to a substantial reduction in sample size.

The results from these sensitivity analyses are displayed in the following tables. Our findings are, for the most part, robust to these changes.

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[58]It is important to note that this is not how the regulations are written or enforced. Many violations are determined using aggregated distributional cut-offs, as opposed to the stringent approach we are using here limiting by individual samples that exceed the MCL.

Table A15: Effects of contamination on low birth weight and preterm birth, removing births with any samples exceeding MCL, except for four contaminants with widespread exceedances (total coliform, TTHM, HAA5, and lead).

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: low birth weight						
CWS FE						
10th to 90th RRMCL	0.01461***	0.01456***	0.01345***	0.01345***	0.01652***	0.01035***
	(0.00280)	(0.00155)	(0.00262)	(0.00143)	(0.00175)	(0.00174)
Observations	1,004,287	1,002,929	1,004,287	1,002,929	1,004,287	1,002,929
Adj R^2	0.0052	0.0054	0.0460	0.0462	0.1065	0.1066
Mom & CWS FE						
10th to 90th RRMCL	0.01180***	0.01116***	0.01130***	0.01060***	0.01302***	0.00818***
	(0.00194)	(0.00133)	(0.00182)	(0.00125)	(0.00154)	(0.00152)
Observations	511,624	510,569	511,624	510,569	511,624	510,569
Adj R^2	0.1533	0.1532	0.1715	0.1714	0.2122	0.2119
Panel B: preterm birth						
CWS FE						
10th to 90th RRMCL	0.02186***	0.02154***	0.02045***	0.02016***	0.02476***	0.01617***
	(0.00382)	(0.00210)	(0.00351)	(0.00192)	(0.00235)	(0.00225)
Observations	1,004,287	1,002,929	1,004,287	1,002,929	1,004,287	1,002,929
Adj R^2	0.0040	0.0043	0.0472	0.0475	0.1314	0.1315
Mom & CWS FE						
10th to 90th RRMCL	0.01865***	0.01816***	0.01806***	0.01751***	0.02150***	0.01451***
	(0.00304)	(0.00191)	(0.00287)	(0.00180)	(0.00221)	(0.00207)
Observations	511,624	510,569	511,624	510,569	511,624	510,569
Adj R^2	0.1567	0.1568	0.1740	0.1740	0.2299	0.2296

Notes: see notes to Table 3 in the main text. In this analysis, we do not include births exposed to water quality samples exceeding their respective MCL for any contaminants except four with widespread exceedences (Total Coliform, TTHM, HAA5, and Lead).

Table A16: Effects of contamination on small for gestational age and term birth weight, removing births with any samples exceeding MCL, except for four contaminants with widespread exceedances (total coliform, TTHM, HAA5, and lead).

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: small for gestational age						
CWS FE						
10th to 90th RRMCL	0.00309***	0.00247***	0.00249***	0.00197***	0.00242***	0.00160***
	(0.00078)	(0.00063)	(0.00075)	(0.00059)	(0.00073)	(0.00058)
Observations	1,002,592	1,001,241	1,002,592	1,001,241	1,002,592	1,001,241
Adj R^2	0.0052	0.0052	0.0378	0.0379	0.0389	0.0389
Mom & CWS FE						
10th to 90th RRMCL	0.00219*	0.00101	0.00194*	0.00075	0.00092*	0.00077
	(0.00117)	(0.00107)	(0.00112)	(0.00103)	(0.00127)	(0.00103)
Observations	510,015	508,959	510,015	508,959	510,015	508,959
Adj R^2	0.1378	0.1382	0.1535	0.1538	0.1537	0.1541
Panel B: term birth weight						
CWS FE						
10th to 90th RRMCL	-10.49***	-9.18398***	-9.73***	-8.73***	-10.72***	-8.16***
	(1.34)	(1.19)	(1.39)	(1.16)	(1.43)	(1.37)
Observations	921,294	920,064	921,294	920,064	921,294	920,064
Adj R^2	0.0162	0.0162	0.0935	0.0937	0.0979	0.0981
Mom & CWS FE						
10th to 90th RRMCL	-9.67***	-8.01***	-9.33***	-7.57***	-9.30***	-7.27***
	(1.83)	(1.55)	(1.83)	(1.54)	(1.89)	(1.65)
Observations	445,586	444,713	445,586	444,713	445,586	444,713
Adj R^2	0.3422	0.3423	0.3812	0.3813	0.3833	0.3834

Notes: see notes to Table 3 in the main text, and Table A15 in the appendix.

Table A17: Effects of contamination on low birth weight and preterm birth, removing births with any samples exceeding MCL, excluding four contaminants (total coliform, TTHM, HAA5, and lead) from the analysis entirely.

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: low birth weight						
CWS FEs						
10th to 90th RRMCL	0.00983***	0.00904***	0.00903***	0.00832***	0.00723***	0.00663***
	(0.00108)	(0.00100)	(0.00100)	(0.00092)	(0.00080)	(0.00093)
Observations	980,718	979,158	980,718	979,158	980,718	979,158
Adj R^2	0.0052	0.0053	0.0461	0.0461	0.1067	0.1066
Mom & CWS FEs						
10th to 90th RRMCL	0.00793***	0.00735***	0.00738***	0.00681***	0.00591***	0.00545***
	(0.00089)	(0.00083)	(0.00084)	(0.00078)	(0.00068)	(0.00080)
Observations	491,834	490,505	491,834	490,505	491,834	490,505
Adj R^2	0.1523	0.1522	0.1702	0.1702	0.2112	0.2110
Panel B: preterm birth						
CWS FEs						
10th to 90th RRMCL	0.01442***	0.01322***	0.01341***	0.01230***	0.01068***	0.01019***
	(0.00139)	(0.00128)	(0.00129)	(0.00118)	(0.00102)	(0.00113)
Observations	980,718	979,158	980,718	979,158	980,718	979,158
Adj R^2	0.0041	0.0041	0.0472	0.0473	0.1316	0.1316
Mom & CWS FEs						
10th to 90th RRMCL	0.01244***	0.01156***	0.01177***	0.01091***	0.00947***	0.00924***
	(0.00117)	(0.00109)	(0.00111)	(0.00103)	(0.00089)	(0.00099)
Observations	491,834	490,505	491,834	490,505	491,834	490,505
Adj R^2	0.1556	0.1556	0.1725	0.1725	0.2288	0.2287

Notes: see notes to Table 3 in the main text. In these specifications we include all births except those exposed to any samples that exceed their respective MCL. We discard the four contaminants with widespread exceedences (total coliform, TTHM, HAA5, and lead) from the analysis entirely. Since the indices used in this table do not have the same contaminants as the all or chemical indices used elsewhere (due to the exclusion of the four aforementioned contaminants), the distribution for the indices in this table is different. We do not provide detailed statistics for these distributions, but to aid comparison: the distance between the 10th to 90th RRMCL (a one-unit change in the independent variable) is 0.0611 for the All contaminant index used in this table, and it is 0.0551 for the Chemical index used in this table.

Table A18: Effects of contamination on small for gestational age and term birth weight, removing births with any samples exceeding MCL, excluding four contaminants (total coliform, TTHM, HAA5, and lead) from the analysis entirely.

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: small for gestational age						
CWS FEs						
10th to 90th RRMCL	0.00139***	0.00120***	0.00108**	0.00092**	0.00080*	0.00070
	(0.00050)	(0.00044)	(0.00049)	(0.00043)	(0.00037)	(0.00043)
Observations	979,100	977,545	979,100	977,545	979,100	977,545
Adj R^2	0.0052	0.0052	0.0378	0.0378	0.0388	0.0388
Mom & CWS FEs						
10th to 90th RRMCL	0.00045	0.00041	0.00033	0.00026	0.00023	0.00025
	(0.00072)	(0.00065)	(0.00071)	(0.00064)	(0.00056)	(0.00064)
Observations	490,311	488,990	490,311	488,990	490,311	488,990
Adj R^2	0.1368	0.1366	0.1525	0.1524	0.1528	0.1527
Panel B: term birth weight						
CWS FEs						
10th to 90th RRMCL	-5.35***	-4.99***	-5.08***	-4.79***	-4.15***	-4.59***
	(0.79)	(0.70)	(0.79)	(0.71)	(0.61)	(0.82)
Observations	899,901	898,475	899,901	898,475	899,901	898,475
Adj R^2	0.0161	0.0161	0.0936	0.0936	0.0980	0.0980
Mom & CWS FEs						
10th to 90th RRMCL	-5.28***	-4.90***	-5.21***	-4.71***	-4.09***	-4.65***
	(1.06)	(0.97)	(1.05)	(0.95)	(0.82)	(0.97)
Observations	428,339	427,191	428,339	427,191	428,339	427,191
Adj R^2	0.3396	0.3396	0.3788	0.3788	0.3810	0.3809

Notes: see notes to Table 3 in the main text, and Table A17 in the appendix.

Table A19: Effects of contamination on low birth weight and preterm birth, removing births with any samples exceeding MCL, including the four contaminants with widespread exceedances (total coliform, TTHM, HAA5, and lead).

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: low birth weight						
CWS FEs						
10th to 90th RRMCL	0.01971***	0.01698***	0.01840***	0.01586***	0.01989***	0.01232***
	(0.00236)	(0.00201)	(0.00223)	(0.00190)	(0.00239)	(0.00191)
Observations	344,101	343,470	344,101	343,470	344,101	343,470
Adj R^2	0.0077	0.0077	0.0477	0.0476	0.1176	0.1174
Mom & CWS FEs						
10th to 90th RRMCL	0.01311***	0.01190***	0.01277***	0.01148***	0.01440***	0.00933***
	(0.00270)	(0.00227)	(0.00256)	(0.00216)	(0.00271)	(0.00211)
Observations	106,463	106,100	106,463	106,100	106,463	106,100
Adj R^2	0.1798	0.1790	0.2007	0.2000	0.2419	0.2411
Panel B: preterm birth						
CWS FEs						
10th to 90th RRMCL	0.02857***	0.02466***	0.02677***	0.02315***	0.02904***	0.01855***
	(0.00294)	(0.00248)	(0.00279)	(0.00235)	(0.00295)	(0.00236)
Observations	344,101	343,470	344,101	343,470	344,101	343,470
Adj R^2	0.0081	0.0081	0.0512	0.0513	0.1419	0.1419
Mom & CWS FEs						
10th to 90th RRMCL	0.02241***	0.02082***	0.02161***	0.02000***	0.02509***	0.01720***
	(0.00334)	(0.00281)	(0.00311)	(0.00263)	(0.00329)	(0.00231)
Observations	106,463	106,100	106,463	106,100	106,463	106,100
Adj R^2	0.1807	0.1802	0.2019	0.2013	0.2557	0.2548

Notes: see notes to Table 3 in the main text. In this analysis, we do not include births exposed to any water quality sample with a result that exceeds the respective MCL. We include the four contaminants with widespread exceedances in this analysis. This leads to a substantial reduction in sample sizes, as observed in the table.

Table A20: Effects of contamination on small for gestational age and term birth weight, removing births with any samples exceeding MCL, including the four contaminants with widespread exceedances (total coliform, TTHM, HAA5, and lead).

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: small for gestational age						
CWS FEs						
10th to 90th RRMCL	0.00292**	0.00241**	0.00262**	0.00215**	0.00270*	0.00183*
	(0.00115)	(0.00100)	(0.00113)	(0.00097)	(0.00122)	(0.00098)
Observations	343,395	342,771	343,395	342,771	343,395	342,771
Adj R^2	0.0040	0.0040	0.0364	0.0364	0.0377	0.0377
Mom & CWS FEs						
10th to 90th RRMCL	-0.00092	-0.00115	-0.00050	-0.00080	-0.00100	-0.00083
	(0.00242)	(0.00206)	(0.00242)	(0.00206)	(0.00258)	(0.00206)
Observations	106,009	105,647	106,009	105,647	106,009	105,647
Adj R^2	0.1702	0.1698	0.1824	0.1821	0.1826	0.1823
Panel B: term birth weight						
CWS FEs						
10th to 90th RRMCL	-10.16***	-8.66***	-10.47***	-8.97***	-11.26***	-8.76***
	(2.04)	(1.70)	(1.97)	(1.66)	(2.09)	(1.79)
Observations	314,836	314,283	314,836	314,283	314,836	314,283
Adj R^2	0.0130	0.0130	0.0883	0.0884	0.0929	0.0929
Mom & CWS FEs						
10th to 90th RRMCL	-5.71	-5.38	-7.59**	-7.09**	-8.89*	-7.03**
	(3.97)	(3.44)	(3.79)	(3.27)	(4.10)	(3.38)
Observations	92,157	91,851	92,157	91,851	92,157	91,851
Adj R^2	0.4015	0.4010	0.4357	0.4352	0.4380	0.4375

Notes: see notes to Table 3 in the main text, and Table A19 in the appendix.

A2.5 Using the mom FE sample in the CWS FE regressions also

In the main specifications, using mother fixed-effects rather than CWS fixed-effects often appreciably and significantly changes the effect estimates. In fact, this is the main way in which our results are sensitive. In this subsection, we present results subsetting throughout to the sample used in the mother fixed-effects specifications. Note that sample sizes are slightly larger in this subsection than in the main text because, in order to maintain exact balance across CWS fixed-effects and mother fixed-effects regressions, we do not iteratively remove singletons (Correia (2015)); this also means that standard errors in this subsection are slightly understated.

Table A21: Effects of contamination on low birth weight and preterm birth, using the mother fixed-effects sample throughout

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: low birth weight						
CWS FE						
10th to 90th RRMCL	0.01291***	0.01414***	0.01180***	0.01298***	0.00997***	0.01002***
	(0.00289)	(0.00140)	(0.00274)	(0.00131)	(0.00232)	(0.00146)
Observations	701,006	699,750	701,006	699,750	701,006	699,750
Adj R^2	0.0056	0.0058	0.0481	0.0483	0.1092	0.1094
Mom & CWS FE						
10th to 90th RRMCL	0.00957***	0.01049***	0.00932***	0.01003***	0.00819***	0.00775***
	(0.00245)	(0.00120)	(0.00232)	(0.00115)	(0.00198)	(0.00133)
Observations	701,006	699,750	701,006	699,750	701,006	699,750
Adj R^2	0.1505	0.1507	0.1689	0.1690	0.2102	0.2103
Panel B: preterm birth						
CWS FE						
10th to 90th RRMCL	0.01990***	0.02139***	0.01854***	0.01998***	0.01632***	0.01630***
	(0.00412)	(0.00184)	(0.00384)	(0.00170)	(0.00307)	(0.00176)
Observations	701,006	699,750	701,006	699,750	701,006	699,750
Adj R^2	0.0042	0.0046	0.0502	0.0506	0.1355	0.1357
Mom & CWS FE						
10th to 90th RRMCL	0.01571***	0.01715***	0.01533***	0.01658***	0.01405***	0.01377***
	(0.00363)	(0.00166)	(0.00345)	(0.00160)	(0.00276)	(0.00170)
Observations	701,006	699,750	701,006	699,750	701,006	699,750
Adj R^2	0.1486	0.1489	0.1663	0.1665	0.2252	0.2252

Notes: standard errors in parentheses; $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Standard errors are twoway clustered on public water system and mother. Each cell is a separate regression. Observations (number of births) and adjusted R^2s (for the full model, i.e. including the fixed-effects) are reported. In each regression, the sample is restricted to births in our analytic sample for whom we observe at least one water quality sample of the given contaminant group during gestation in the public water system of residence at the time of birth. Control variables used vary over super-columns; independent variable, i.e. the contaminant group studied, vary across columns; the outcomes varies over panels; the specification used (either public water system fixed-effects or mom fixed-effects) varies over sub-panels; temp & TRI ctrls = weather and toxics release inventory (air pollution) controls.

Table A22: Effects of contamination on small for gestational age and term birth weight, using the mother fixed-effects sample throughout

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: small for gestational age						
CWS FE						
10th to 90th RRMCL	0.00294**	0.00225***	0.00228**	0.00164**	0.00212*	0.00141*
	(0.00116)	(0.00087)	(0.00109)	(0.00083)	(0.00114)	(0.00085)
Observations	699,702	698,443	699,702	698,443	699,702	698,443
Adj R^2	0.0062	0.0062	0.0386	0.0387	0.0394	0.0394
Mom & CWS FE						
10th to 90th RRMCL	0.00279***	0.00180**	0.00276***	0.00166**	0.00290***	0.00174**
	(0.00100)	(0.00084)	(0.00096)	(0.00081)	(0.00099)	(0.00083)
Observations	699,702	698,443	699,702	698,443	699,702	698,443
Adj R^2	0.1391	0.1397	0.1546	0.1552	0.1548	0.1554
Panel B: term birth weight						
CWS FE						
10th to 90th RRMCL	-9.46***	-9.03***	-8.40***	-8.22***	-8.25***	-7.60***
	(1.55)	(1.45)	(1.69)	(1.41)	(1.85)	(1.53)
Observations	644,014	642,882	644,014	642,882	644,014	642,882
Adj R^2	0.0194	0.0194	0.0997	0.0998	0.1037	0.1039
Mom & CWS FE						
10th to 90th RRMCL	-9.05***	-8.81***	-9.15***	-8.57***	-9.33***	-8.24***
	(1.73)	(1.33)	(1.84)	(1.37)	(1.87)	(1.45)
Observations	644,014	642,882	644,014	642,882	644,014	642,882
Adj R^2	0.3488	0.3488	0.3875	0.3876	0.3896	0.3896

Notes: see notes to Table A21

A2.6   Estimating on Smaller CWS Only

Concern over mismeasurement of the link between water contamination and exposure, that may be especially acute in large CWS (with complicated distribution systems), motivates a sensitivity analysis estimating our models for smaller CWS only. To conduct this analysis, we sorted births by CWS size (number of people served by the CWS) and then dropped the 50% of births in our sample in the largest systems (those in the bottom of the dataset). The largest system in this restricted sample serves 118,000 people (contrast with the largest system, Philadelphia Water Department, which serves 1,600,000 people), and thus this is a meaningful restriction. The results of estimating on this subsample are included below.

Table A23: Effects of drinking water contamination on low birth weight and preterm birth, small systems only.

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: low birth weight						
CWS FEs						
10th to 90th RRMCL	0.01280***	0.01161***	0.01185***	0.01080***	0.01259***	0.00789***
	(0.00124)	(0.00108)	(0.00119)	(0.00104)	(0.00121)	(0.00094)
Observations	597,900	596,418	597,900	596,418	597,900	596,418
Adj R^2	0.0040	0.0042	0.0376	0.0378	0.0911	0.0914
Mom & CWS FEs						
10th to 90th RRMCL	0.00863***	0.00801***	0.00844***	0.00783***	0.00913***	0.00555***
	(0.00129)	(0.00113)	(0.00124)	(0.00110)	(0.00128)	(0.00107)
Observations	282,179	281,162	282,179	281,162	282,179	281,162
Adj R^2	0.1584	0.1585	0.1755	0.1756	0.2094	0.2097
Panel B: pre-term birth						
CWS FEs						
10th to 90th RRMCL	0.01907***	0.01732***	0.01782***	0.01621***	0.01890***	0.01240***
	(0.00166)	(0.00143)	(0.00159)	(0.00136)	(0.00159)	(0.00124)
Observations	597,900	596,418	597,900	596,418	597,900	596,418
Adj R^2	0.0035	0.0037	0.0400	0.0403	0.1167	0.1171
Mom & CWS FEs						
10th to 90th RRMCL	0.01543***	0.01454***	0.01519***	0.01430***	0.01666***	0.01138***
	(0.00166)	(0.00141)	(0.00159)	(0.00135)	(0.00157)	(0.00126)
Observations	282,179	281,162	282,179	281,162	282,179	281,162
Adj R^2	0.1659	0.1661	0.1842	0.1844	0.2328	0.2330

Notes: see notes to Table 3 in the main text.

Table A24: Effects of drinking water contamination on small for gestational age and term birth weight, small systems only.

	(1)	(2)	(3)	(4)	(5)	(6)
	No controls		Adding mother ctrls		Adding temp & TRI ctrls	
	All	Chemical	All	Chemical	All	Chemical
Panel A: small for gestational age						
CWS FEs						
10th to 90th RRMCL	0.00133*	0.00139**	0.00088	0.00105*	0.00122	0.00069
	(0.00069)	(0.00057)	(0.00066)	(0.00055)	(0.00064)	(0.00055)
Observations	597,188	595,707	597,188	595,707	597,188	595,707
Adj R^2	0.0043	0.0043	0.0357	0.0357	0.0366	0.0366
Mom & CWS FEs						
10th to 90th RRMCL	0.00026	0.00052	0.00016	0.00046	0.00054	0.00029
	(0.00128)	(0.00107)	(0.00126)	(0.00105)	(0.00123)	(0.00104)
Observations	281,525	280,500	281,525	280,500	281,525	280,500
Adj R^2	0.1568	0.1576	0.1697	0.1705	0.1700	0.1708
Panel B: term birth weight						
CWS FEs						
10th to 90th RRMCL	-8.18***	-6.83***	-7.66***	-6.49***	-7.57***	-5.74***
	(1.23)	(1.07)	(1.19)	(1.02)	(1.19)	(1.06)
Observations	552,670	551,295	552,670	551,295	552,670	551,295
Adj R^2	0.0148	0.0148	0.0894	0.0894	0.0935	0.0936
Mom & CWS FEs						
10th to 90th RRMCL	-7.90***	-6.53***	-7.82***	-6.47***	-7.54***	-6.08***
	(1.98)	(1.72)	(1.89)	(1.64)	(1.91)	(1.65)
Observations	249,414	248,510	249,414	248,510	249,414	248,510
Adj R^2	0.3879	0.3877	0.4231	0.4230	0.4248	0.4247

Notes: see notes to Table 3 in the main text.

A3   Effects of MCL violations on birth outcomes

In this section, we closely follow Currie et al. (2013) using our data. We believe this comparison is important since our data represents a more recent time period and a different state. Overall, we find similar results, although ours are less precise. In general, the estimated effect of a reported health-based MCL violation on birth outcomes is less robust than the effects of our continuous measures of water contamination that we use in the main text. On the one hand, this may be surprising since violations indicate contamination in exceedence of regulatory thresholds; on the

other hand, the very fact that there was a violation raises the possibility of significant avoidance behavior, such as through bottled water purchases (Zivin et al. (2011)).

As in the main text, we obtained Safe Drinking Water Information System (SDWIS) data on CWS drinking water violations from the US Environmental Protection Agency (US EPA). This SDWIS data records the compliance period, contaminant, and CWS for each drinking water violation received by each CWS in the United States over our sample period. We focus on "MCL violations", which are cases where the CWS is observed to have exceeded a "maximum contaminant level," a threshold over which contamination cannot cross without regulatory repercussions. Note that a drinking water compliance period is a period of time that varies based on contaminant and CWS, but is typically measured in quarters (3 months).

We begin by presenting summary statistics in Table A25, similar to those in Currie et al. (2013). Note that, following Currie et al. (2013), in Table A25 we restrict to mothers with multiple births, and we do not remove plural births. There are more mothers in this sample than in the mom fixed-effects sample in the main text since in the main text we removed plural births, all births exposed to an MCL violation, and births that had no samples during their gestation period (note that even births with no water quality samples during gestation can be flagged as being exposed or not exposed to an MCL violation).

Studying these statistics, in particular, comparing column (1) with column (2) in Table A25, we find that only about 3% of births in our sample are exposed to any MCL violations; contrast this with Currie et al. (2013)'s finding of about 8% of births exposed in New Jersey from 1997 to 2007. As a result, while our sample of births is about 50% larger than theirs, as would be expected given that we have an additional year and Pennsylvania is a larger state, the number of births exposed to an MCL violation is actually over 40% smaller in our sample. For chemical contamination, these differences are even larger; we have about 75% fewer births exposed to chemical contamination than Currie et al. (2013). We should keep this in mind when interpreting our results, especially for chemical MCL, as we have much less variation in the independent variables as Currie et al. (2013).

Moreover, we find that births that are exposed to an MCL violation are more likely to be from mothers that are *advantaged* on multiple measures. For example, mothers tend to be older for births exposed to MCL violations, and mothers exposed to MCL violations are less likely to be racial minorities, are more likely to have bachelors degrees or higher education, and are much more likely to be married. These are all opposite of the findings of Currie et al. (2013), who find that mothers exposed to MCL violations tend to be much more disadvantaged on average. For example, focusing on teen birth, they found that, overall, 3.3% of births were to mothers below the age of 19, while among births exposed to any MCL violation, this rate was about 4.6%; by contrast, in our sample these statistics are practically the reverse, at 5% and 2.6%, respectively.

We use the exact model from their paper (Currie et al., 2013), which is the same regression model as our mom fixed-effects specifications in the main text, except for three differences. First, we use the same controls as used in Currie et al. (2013). Second, the independent variable is an indicator for at least one day of overlap between the gestation period and an MCL violation.[59] Third, we include plural births (Currie et al. (2013) makes no mention of excluding plural births). For comparison, we also present additional results (a) adding additional controls (for plurality, WIC, and payment type) like in our water sample models in the main text, and (b) removing plural births.

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[59]It is unclear in Currie et al. (2013) how much overlap between an MCL violation and the gestation period is required for their definition of contamination; we use at least one day of overlap.

Following Currie et al. (2013), we run the model for all MCL violations and then separately for just chemical violations. Chemical violations include all MCL violations except Total Coliform Rule violations. Note that Total Coliform violations are by far the most common MCL violation in our data (at over 70% of MCL violations).

To account for the fact that in the MCL-violation-based specifications, births with longer gestation periods are more likely to have an intersection with an MCL violation (and these birth tend to have better outcomes on average), in our specifications that have MCL exposure as the independent variable, we instrument for contamination using the same "full term gestation" instrument that was used in Currie et al. (2013). To construct this full term gestation instrument, we fix the date of conception and pretend that birth lasted exactly 39 weeks.[60] We then construct "full gestation contamination" using this pretend gestation period, and use this constructed variable as an instrument for actual MCL violation exposure. Note that for our water sample regressions in the main text, this instrumental variables approach was unnecessary because there is no mechanical correlation between average water quality and gestational length.

Tables A26, A27, and A28 report the estimated impacts of MCL violations on low birth weight and prematurity. First, consider Table A26, which reports our attempt at estimating the exact model of Currie et al. (2013) on our sample. We find in this case that the estimated effects are similar to those in Currie et al. (2013), although they are less precisely estimated. In the preferred IV and FE specification (column 4), we find that exposure to an MCL violation for any contaminant increases the probability of low birth weight by about 0.38pp; the analogous result in Currie et al. (2013) was 0.34pp. It is interesting to note that our OLS estimates in column (1) are negative and over four times larger in magnitude than the comparable estimates in Currie et al. (2013), suggesting that the mechanical correlation in our data is more severe than in Currie et al. (2013). While our estimated effects of exposure to a chemical MCL violation on low birth weight has a point estimate of around 0.25pp, compared to Currie et al. (2013) estimate of 0.37pp, it is statistically insignificant. This may have been expected, given the very few births that can be connected to chemical contamination in this data (see Table A25). Table A26 also contains our estimated impacts of MCL violations on pre-term birth, using the same model as Currie et al. (2013). Effects on pre-term birth of "any" MCL violation is about a 0.56pp increase, about twice as large as the estimate in Currie et al. (2013), which was about a 0.25pp increase.

In Table A27, we add several additional control variables to the Currie et al. (2013) specification, including WIC and Medicaid indicators, Toxics Release Inventory facility measures (as used in the main text), and plurality indicators. From our explorations (not shown), we found that the inclusion of plurality indicators changes our inference the most. While the point estimates for chemical MCL violations are stable (although the standard errors increase), the estimates for "any" violations are cut in half with the inclusion of these controls, and are insignificant in the new specification.

Finally, Table A28 report results from specifications that include the additional controls and remove plural births from the sample. This is the sample and specification that we use in all tables in this paper, except for tables A26 and A27 which we have just discussed. With this sample selection, the estimated effect of "any" MCL violations on pre-term birth rises back to roughly where it was earlier, and while the effects of "any" MCL violations on low birth weight rise, they remain statistically insignificant.

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[60]A full gestation length is considered to be 39 weeks. This is not to be confused with the minimum gestation length for the birth to not be classified as pre-term, which is 37 weeks.

Table A25: Sample means for all mothers and those exposed to MCL violations during gestation

Characteristic	(1) All	(2) With MCL Any	(3) With MCL Chem	(4) Switchers Any	(5) Switchers Chem
No. of observations	826218	26144	8243	56284	17138
Low birth weight ($\leq 2500g$)	0.096	0.082	0.080	0.074	0.071
Preterm (≤ 36 weeks)	0.112	0.096	0.097	0.087	0.086
Mom's age					
< 19	0.049	0.024	0.033	0.038	0.045
19 – 24	0.259	0.193	0.246	0.233	0.275
25 – 34	0.554	0.596	0.594	0.582	0.567
35+	0.139	0.186	0.127	0.148	0.113
Mom's race					
African-American	0.212	0.127	0.092	0.155	0.128
Hispanic	0.070	0.034	0.034	0.048	0.042
White, not hispanic	0.723	0.821	0.878	0.792	0.839
Mom's education					
Less than highschool	0.140	0.081	0.102	0.109	0.130
Highschool only	0.255	0.210	0.270	0.227	0.265
Some college	0.178	0.177	0.191	0.176	0.186
College or more	0.420	0.527	0.432	0.482	0.415
Mother smokes	0.215	0.191	0.249	0.203	0.246
Mother is married	0.589	0.700	0.671	0.655	0.633
Mother on WIC/Medicaid	0.471	0.350	0.418	0.401	0.451
Mother moved	0.467	0.570	0.495	0.633	0.584

Notes: Observations are births. Only mothers with multiple births are included. Switcher means births among the set of mothers with at least one birth experiencing and at least one not experiencing an MCL violation. "With MCL" contains births exposed to an MCL violation (i.e., at least one day overlap between the gestation period and an MCL violation in the water system at the time of birth).

Table A26: Effects of MCL violations during gestation on birth outcomes − Replication of Currie et al. (2013)

	(1) OLS	(2) IV	(3) FE	(4) IV and FE
Panel A: Any MCL, Low Birth Weight				
Any MCL	-0.0025	0.0051***	-0.0020	0.0035
	(-1.3436)	(2.6142)	(-0.9393)	(1.6122)
Panel B: Any MCL, Pre-term Birth				
Any MCL	-0.0044**	0.0058***	-0.0029	0.0047**
	(-2.1996)	(2.6891)	(-1.2721)	(1.9725)
Panel C: Chem MCL, Low birth weight				
Chem MCL	-0.0061*	-0.0018	-0.0009	0.0020
	(-1.9233)	(-0.5492)	(-0.2562)	(0.5456)
Panel D: Chem MCL, Pre-term Birth				
Chem MCL	-0.0081**	-0.0014	-0.0007	0.0042
	(-2.3066)	(-0.3957)	(-0.1734)	(1.0172)
No. observations	826218	826218	826218	826218
Full-gestation IV		✓		✓
Mom FE			✓	✓

Notes: t-statistics in parentheses; $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each cell is a separate regression. Sample consists of mothers with multiple births. The independent variables "Any MCL" and "Chem MCL" are indicators for whether an MCL of the specified type occurred during the gestation period. Standard errors are clustered at the mother. "Full-gestation IV" instruments for actual exposure to an MCL violation with predicted exposure given a gestation period of exactly 39 weeks. All regressions include the control variables used in Currie et al. (2013).

Table A27: Effects of MCL violations during gestation on birth outcomes − Adding additional controls (incl. plurality) to the Currie et al. (2013) model

	(1)	(2)	(3)	(4)
	OLS	IV	FE	IV and FE
Panel A: Any MCL, Low Birth Weight				
Any MCL	-0.0005	0.0054***	-0.0014	0.0033
	(-0.3015)	(3.1734)	(-0.6822)	(1.6257)
Panel B: Any MCL, Pre-term Birth				
Any MCL	-0.0022	0.0063***	-0.0020	0.0048**
	(-1.2310)	(3.2887)	(-0.9140)	(2.1166)
Panel C: Chem MCL, Low birth weight				
Chem MCL	-0.0023	0.0012	0.0002	0.0030
	(-0.8163)	(0.4195)	(0.0586)	(0.8464)
Panel D: Chem MCL, Pre-term Birth				
Chem MCL	-0.0042	0.0016	0.0005	0.0053
	(-1.3469)	(0.4866)	(0.1364)	(1.3343)
No. observations	826218	826218	826218	826218
Full-gestation IV		✓		✓
Mom FE			✓	✓

See notes to Table A26.

Table A28: Effects of MCL violations during gestation on birth outcomes − Removing all plural births

	(1)	(2)	(3)	(4)
	OLS	IV	FE	IV and FE
Panel A: Any MCL, Low Birth Weight				
Any MCL	0.0000	0.0048***	-0.0006	0.0039**
	(0.0220)	(3.2193)	(-0.3058)	(1.9761)
Panel B: Any MCL, Pre-term Birth				
Any MCL	-0.0009	0.0063***	0.0000	0.0063***
	(-0.5614)	(3.7555)	(0.0164)	(2.8921)
Panel C: Chem MCL, Low birth weight				
Chem MCL	-0.0022	0.0009	0.0003	0.0033
	(-0.8821)	(0.3669)	(0.0835)	(0.9750)
Panel D: Chem MCL, Pre-term Birth				
Chem MCL	-0.0040	0.0015	0.0007	0.0055
	(-1.4103)	(0.5061)	(0.2001)	(1.4425)
No. observations	768228	768228	768228	768228
Full-gestation IV		✓		✓
Mom FE			✓	✓

See notes to table A26.