

TITLE PAGE

Complete Title

- Did a nocebo effect contribute to the rise in special education enrollment following the Flint, Michigan Water Crisis?

Short Title

- Nocebo effect and special education in Flint

Authors

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MAE and SR worked with Flint residents to expose the Flint Water Crisis, and their data, testimony and emails have been subpoenaed in several lawsuits. They are not party to any of these lawsuits. MAE has been subpoenaed as a fact witness in many of the lawsuits, but he has refused all financial compensation for time spent on those activities. SR is serving as a scientific consultant in a Flint lawsuit for VNA starting December 21 2022 on biosolids research, a topic unrelated to this manuscript, and is expected to be financially compensated for that work. All other authors declare they have no competing interests.

Author contributions:

S.R., K.J.P, and M.A.E. designed research; S.R., M.A.E. and G.D.G. performed research; S.R. and G.D.G. analyzed data; and S.R., K.J.P, G.D.G., and M.A.E. wrote the paper.

Data and materials availability:

All education data are publicly available on Michigan Department of Education's website www.mischooldata.org. Blood lead data were obtained from Michigan Department of Health and Human Services under a Data User Agreement (DUA #202103-144) following IRB approval (IRB #202103-04-NR). The data can be made available from MDHHS upon completion of a data use agreement with the agency. The authors assume full responsibility for the analysis and interpretation of the data. All poverty and food assistance data are publicly available from the US Census. All media coverage and Facebook interactions data downloaded from CrowdTangle are available in the supplementary materials.

One-Sentence Teaser

Psychological harm from negative labeling of Flint children as brain damaged likely contributed to increasing special education enrollment.

ABSTRACT PAGE

Structured Abstract:

Background: Exposure to waterborne lead during the Flint Water Crisis during April 2014-October 2015 is believed to have caused increased special education enrollment in Flint children.

Method: This retrospective population-based cohort study utilized de-identified data for children under six years of age who had their blood lead tested during 2011 to 2019, and special education outcomes data for children enrolled in public schools for corresponding academic years (2011-12 to 2019-20) in Flint, Detroit (control city) and the State of Michigan. Trends in the following crisis-related covariates were also evaluated: waterborne contaminants, poverty, nutrition, city governance, school district policies, negative community expectations, media coverage and social media interactions.

Results: Between 2011 and 2019, including the 2014-15 crisis period, the incidence of elevated blood lead in Flint children ($\geq 5\mu\text{g/dL}$) was always at least 47% lower than in the control city of Detroit ($P<0.0001$) and was also never significantly higher than that for all children tested in Michigan ($P=0.33$). Nonetheless, special education enrollment in Flint spiked relative to Detroit and Michigan ($P<0.0001$). There is actually an inverse relationship between childhood blood lead and special education enrollment in Flint.

Conclusion: This study failed to confirm any positive association between actual childhood blood lead levels and special education enrollment in Flint. Negative psychological effects associated with media predictions of brain damage could have created a self-fulfilling prophecy via a nocebo effect. The findings demonstrate a need for improved media coverage of complex events like the Flint Water Crisis.

Keywords:

blood lead; lead exposure; flint water crisis; nocebo effect; special education.

Key Messages:

- Waterborne lead exposure during the Flint crisis did not correlate with special education enrollment.
- Flint children were repeatedly labeled as lead poisoned and brain damaged in the crisis' aftermath.
- A nocebo effect could have contributed to negative educational outcomes in Flint.
- Erroneous, negative media labels can be internalized and lead to psychological harm in children.

MAIN TEXT

Introduction

In April 2014, the city of Flint, Michigan stopped purchasing treated Lake Huron water from Detroit and switched to corrosive Flint River water as a cost savings measure. The city also interrupted the addition of corrosion control chemicals to the treated water, which were required under federal regulations to reduce the leaching of the neurotoxin lead from lead pipes and home plumbing. This increased lead levels in tap water and children's blood mainly in the months of June-August 2014 (Roy et al., 2019). In response to residents' concerns, two of the authors assisted with sampling 269 Flint homes in 2015, proving the 90th percentile water lead level (27 µg/L) was almost twice the US Environmental Protection Agency (EPA) action level of 15 µg/L (Pieper et al., 2018). It was later revealed that the proportion of children < 6 years of age with elevated blood lead, i.e., ≥ 5 µg/dL US Centers for Disease Control and Prevention (CDC) reference level, increased following the water switch (Hanna-Attisha et al., 2016), primarily in June-August 2014 (Roy et al., 2019). Michigan officials later announced a Legionnaire's Disease outbreak that killed at least 13 people (Rhoads et al., 2017). These events became known in the media as the Flint Water Crisis (FWC). After the water problems were exposed, Flint reconnected to Detroit water in October 2015, a federal emergency was declared in January 2016, and over US\$1.2 billion in relief funds have been appropriated for residents including free bottled water (through April 2018), free lead faucet filters, health interventions, settlement money for lead-exposed children, special education services, and replacement of around 12,000 lead pipes to be completed in 2023 (Bosman, 2020; City of Flint, 2022; Roy & Edwards, 2019a; Roy & Edwards, 2020). Flint water has met all federal standards since late 2016 and many residents still consume only bottled

water due to lost trust (Flint Cares, 2018; Fonger et al., 2019; Reuben et al., 2022; Roy, 2017; Roy & Edwards, 2019b; Sobeck et al., 2020).

Recent media reports (Supplementary Materials [SM] Table S1) attribute increasing rates of special education enrollment and diagnoses of learning disabilities in Flint children to lead exposure and “lead poisoning” from the FWC (Alfonsi, 2020; Green, 2019) but none of these conclusions are based on peer reviewed data. Blood lead levels have been steadily dropping in the United States and in Flint for the past 50 years following the banning of lead from gasoline, paint and pipes (Dignam et al., 2019; Gomez et al., 2018). The peak childhood blood lead levels during the FWC (2014-15) were well below those recorded in Flint during 2011 (Gomez et al., 2018; Roy et al., 2019).

In this study, we investigate the hypothesis that increased negative educational outcomes were caused by lead exposure from the FWC as has been stated by the media and experts (ACLU, 2016; Alfonsi, 2020; Green, 2019; Redlener, 2018; Riley, 2018; Strauss, 2019). Trends in blood lead levels of Flint children were compared to the control city of Detroit, which has comparable socioeconomic and racial make-up (Table 1) and also used the same drinking water for over 50 years except for the 18 months of the FWC. We also compare Flint to state-wide trends from Michigan, and evaluate relevant extraneous factors that may have affected educational outcomes in Flint children.

After demonstrating that covariates unlikely played a primary role (Text S1), we probe the possibility of a nocebo effect (Barsky et al., 2002; Petrie & Rief, 2019) or a self-fulfilling prophecy, associated with repeated predictions of brain damage to Flint children via the intense publicity associated with the FWC. Research has shown that parents’ and teachers’

negative expectations of children can have adverse effects on educational outcomes. Past studies also suggest that these effects are cumulative and have a greater impact on disadvantaged populations (Jussim et al., 2009; Madon et al., 1997; Madon et al., 2011; Rosenthal & Jacobson, 1968). To examine the interaction between media stories and community perceptions, we evaluated a) representative national and local media stories and associated social media interactions, b) public statements of government, medical and school leaders, and c) resident feedback in media's news stories, highlighting the purported effects of lead and "lead poisoning" during the FWC period on children and their educational outcomes in Flint and the control city of Detroit.

Table 1. Key demographic factors of comparison for Flint and Detroit (control city).

Measure	Flint	Detroit (Control)
Water source	1950s-Apr 2014	
	Lake Huron	Lake Huron
	Apr 2014-Oct 2015	
	Flint River	Lake Huron
	Oct 2015 – present	
	Lake Huron	Lake Huron
Approximate # of lead service line connections (% of total water connections)	80,000 (40%)	Pre-2016: 12,000 (40%) Current: <1,400 (4.7%)
Drinking water source in public schools	Bottled water (Sep 2015-Feb 2022) Filtered water (Feb 2022-present)	Bottled water (Aug 2018-Aug 2019) Filtered water (Aug 2019-present)
Net change in population (2011 to 2019), %* #	-8.4% (105,391 to 96,559)	-8.6% (738,223 to 674,841)
Population < 5 years old (range during 2011-19), %*	7.5-8.3%	7.0-7.3%
Persons per household, 2014-18	2.36	2.55
Net change in unemployment rate (2011 to 2019), %†	-52.1% (19% to 9.1%)	-58.1% (20.5% to 8.6%)
Net change in median household income (2011 to 2019), %*	+8.3% (\$26,621 to \$28,834)	+10.9% (\$27,862 to \$30,894)
Health outcomes (range during 2011-2019), overall rank in Michigan	77-82 of 83 (Genesee Co.)	81-83 of 83 (Wayne Co.)
Percent below poverty level (range during 2011-19), %*	38.8-41.9%	35-40.9%
Worst American city to live in, rank (based on 2015 data)	#1	#3
% decline in total students attending public schools in 10 years (2009-10 till 2018-19)	43.1%	68.4%

% of total resident students attending charter schools, 2018-19 (national rank in charter school enrollment)	45.6% (#3)	37.9% (#2)
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* Data from American Community Survey 5-Year Estimates Data Profiles via US Census (US Census, 2022).

US Census language: Estimates are not comparable to other geographic levels of health estimates (due to methodology differences that may exist between different data sources).

† Data from Michigan Bureau of Labor Market (Michigan Department of Technology Management and Budget, 2022).

Other data references: City of Flint, 2022; David et al., 2017; Goetz, 2022; Mack, 2019; Sauter et al., 2017; University of Wisconsin Population Health Initiative, 2022

Materials and Methods

Elevated blood lead

Childhood blood lead testing is required under Medicaid, where all children receive a screening blood lead test at ages 1 and 2 years, and up to 5 years (Cantor et al., 2019, US Preventive Services Task Force et al., 2019), but not all children receive such tests in practice. The State of Michigan sampling methodology and reporting guidelines have not changed markedly since 1998 (Michigan Department of Health and Human Services, 2020). The percentage of children under six years of age with blood lead above the 2012-21 CDC reference level of 5 µg/dL, and the pre-2012 CDC “level of concern” of 10 µg/dL, were calculated for Flint, Detroit, and Michigan for the years 2011-19 using a dataset with 1,445,808 blood lead levels of all Michigan children tested, obtained from the Michigan Department of Health and Human Services (MDHHS) through a Data User Agreement (#202103-144) following IRB approval (IRB #202103-04-NR). Separately, de-duplicated data were also provided to us after MDHHS epidemiologists extracted the highest blood lead values per child per year using the following standard criteria (in order of preference):

- The highest venous blood lead test result available during the calendar year
- If there is no venous test result available, the highest capillary blood lead test result available during the calendar year
- If there is no test result with blood type available, the highest test result available during the calendar year

Educational outcomes

The data on all special education outcomes and general education 3rd grade reading proficiency for students enrolled in Flint Community Schools, Detroit Public Schools

Community District, and all public schools in Michigan for the academic years 2011-12 until 2019-20 (or, latest available) were downloaded from the Michigan Department of Education's website www.mischooldata.org. The special education enrollment data during 2006-07 to 2010-11 was obtained through Freedom of Information Act requests to the Michigan Department of Education.

Poverty and Nutrition

The rates of poverty and households with children aged 0-18 years receiving food assistance (i.e., on Supplemental Nutrition Assistance Program) for Flint, Detroit and Michigan for 2011-19 were obtained from the US Census Bureau (US Census, 2022).

Media coverage and social media interactions

A representative list of national and local media stories on lead exposure and educational outcomes of Flint children and Detroit children during October 2015-January 2021 (Table S1) was gathered using Google searches with keywords “lead”, “children”, “education”, “Flint” with and without the term “-Detroit” (i.e., removes all search results with “Detroit”), and “Detroit” with and without “-Flint”. The CrowdTangle extension v3.0.29 in Google's Chrome Browser was utilized to gather total “interactions” (reactions, comments, and shares) of all Facebook users and total follower counts of public pages (e.g., celebrities, news organizations, and politicians) and public groups who shared the media stories on Facebook® from publishing date until the time of conducting research (August 2020-September 2021). The representative negative expectations commentary of community leaders, teachers, parents and schoolchildren about lead exposure during the FWC period and educational difficulties for Flint and Detroit (Table S2) were gathered through manual screening of articles, posts and videos published during October 2015-

January 2021, which were in turn obtained through open-ended Google searches using multiple keywords, including “Flint” (Flint only), “Detroit” (Detroit only), “Flint Water Crisis” (Flint only), “lead”, “poisoning”, “education”, and “children”. Separately, the total count and number of interactions data for all posts and web links shared on official Facebook® pages of Michigan local media (Data S1) with the keywords “lead poisoned” during January 2016-November 2020 were downloaded from CrowdTangle (www.crowdtangle.org) and network maps were plotted in Gephi v0.9.2 (CrowdTangle, 2020).

Statistical Analyses

All analyses were conducted in Excel® 2016 (Microsoft), SAS® 9.4 (SAS Institute, Cary NC), or GraphPad PRISM 8.4.3 (GraphPad Software). General linear mixed-effects modeling was used to model changes in binary effects over time, between Flint and Detroit (both nested within Michigan). Data are presented as mean with 95% confidence intervals. Pairwise planned comparisons sliced through each year were made and $P < 0.05$ was considered significant after false discovery rate adjustment within each outcome. All tests were two tailed. No further adjustment for multiple comparisons was performed. Ordinary least squares regression lines were fitted between log of percentage students enrolled in special education and log %EBL in the same years and the slopes compared within GraphPad PRISM.

Results

This retrospective population-based cohort study utilized longitudinal datasets (de-identified aggregated yearly data) for Flint, the control city Detroit, and the entire State of Michigan to examine the hypothesized link between lead exposure and educational outcomes.

Elevated blood lead

The proportion of children < 6 years with elevated blood lead (%EBL) at or above the 5 µg/dL CDC reference level decreased significantly from 2011 to 2019 ($P_{(time)} < 0.0001$) in Flint, Detroit and Michigan overall. The %EBL in Flint steadily decreased by 65.8% between 2011-19 from 5.42% to 1.85% (Risk Ratio= 0.43, 95% CI 0.33, 0.56, $P < 0.0001$), notwithstanding the FWC increase that occurred in the months of June-August 2014 immediately following the water switch (1,17). The corresponding %EBL in Detroit and Michigan also saw large decrements of 41.3% (Risk Ratio=0.69, 95% CI 0.65, 0.74, $P < 0.0001$) and 55.3% (Risk Ratio=0.58, 95% CI 0.56, 0.61) from 2011-2019, respectively (Figure 1a).

There were also substantial differences in %EBL between Flint, Detroit and all of Michigan (Figure 1a) ($P_{(time*center)} < 0.0001$). Specifically, %EBL in Flint was 47-77% lower than for Detroit during 2011-19. Even in the worst FWC year of 2014, children in Detroit had more than double the %EBL than Flint. The %EBL in Flint (which comprised 2.2% to 2.4% of the State population) was also 13-35% lower than for the State of Michigan between 2012-19, with the exception of 2014 when Flint exceeded the %EBL in Michigan by 0.20 percentage points (i.e., 3.72% in Flint vs. 3.52% in Michigan). In other

words, the net effect of the FWC, was to temporarily raise the blood lead of Flint children, up to the average for all data reported by the State of Michigan.

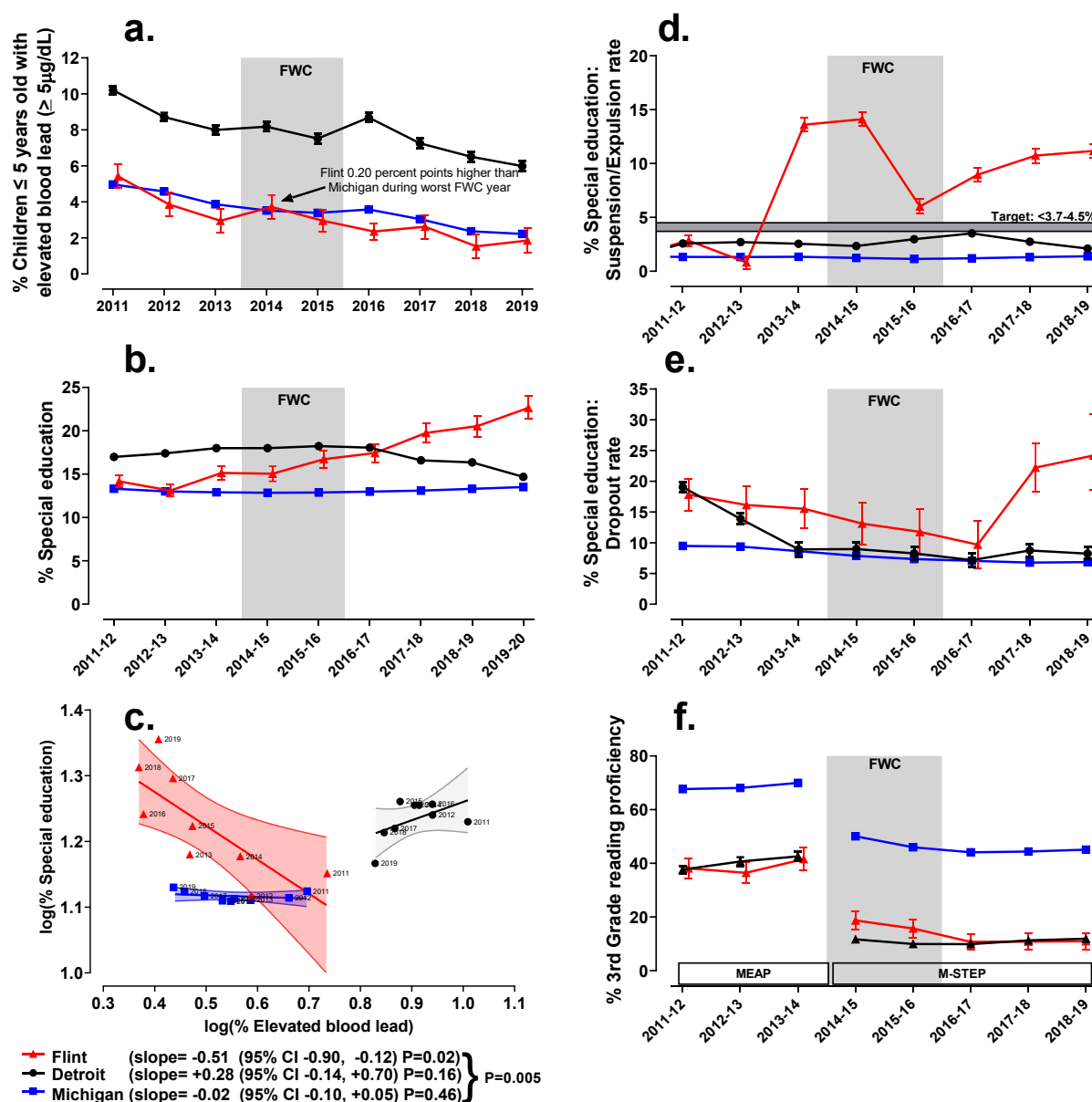
The relative trends between Flint, Detroit, and Michigan at the pre-2012 CDC 10 µg/dL “level of concern” blood lead threshold (%EBL10) were somewhat similar (Figure S1) to those seen at the 5 µg/dL level (%EBL). The %EBL10 for Flint was statistically indistinguishable from Michigan during 2011-19 even during the 2014 and 2015 FWC years. Finally, the %EBL10 for Flint was 65-77% lower than Detroit ($p < 0.00001$) for the entire 2011-19 time period.

Analysis at the individual child-level was conducted to consider isolated cases of anomalously high blood lead from acute exposure during the FWC that were possibly masked by yearly aggregated trends (i.e., Figure 1a). Plotting blood lead measurements of every tested child in Flint and Detroit with blood lead ≥ 5 µg/dL (Figure 2a-2b) and comparing the count and percentage of children in Flint, Detroit, and Michigan with blood lead ≥ 5 , 10, 20, 25 and 40 µg/dL (Figure 3) during the FWC period of 539 days (April 25 2014-October 16 2015) revealed:

- a) The mean blood lead of all children with blood lead ≥ 5 µg/dL in Detroit was 12.4% higher than in Flint (unpaired two-tailed t-test; $p < 0.05$).
- b) The count of Detroit children was higher than Flint children in every blood lead category (≥ 5 -40 µg/dL).
- c) Detroit children had statistically higher blood lead than Flint children at and above the 5 and 10 µg/dL blood lead thresholds.
- d) Data for Flint children were statistically indistinguishable from that reported for all State of Michigan children in every blood lead category (≥ 5 -40 µg/dL).

- e) There were 28 children who tested at or above 40 µg/dL in Michigan during the FWC period, of which half (14) were in Detroit and none (0) in Flint.
- f) There were four Flint children with blood lead at or above 25 µg/dL, both during the FWC and in the same time duration pre-FWC (November 1 2012 – April 24 2014).

Fig. 1. Childhood blood lead and educational outcomes. Trends in (A) percentage of children < 6 years of age with elevated blood lead $\geq 5 \mu\text{g/dL}$ (%EBL), (B) enrollment of public school students in special education programs, (D) special education suspension/expulsion rates, (E) special education dropout rates, and (F) general education 3rd grade reading proficiency*, for Flint, Detroit, and Michigan, 2011-19 (and corresponding school years of 2011-12 to 2019-20). Error bars are \pm 95% confidence intervals and maybe contained within symbols. (C) Scatter plot between %EBL vs. special education enrollment rate for Flint, Detroit, and Michigan by year. 95% confidence bands for the ordinary least squares fits are shown. P value shown is for comparison of slopes.



* The State of Michigan followed the Michigan Educational Assessment Program (MEAP) testing standards until 2013-14 and then switched to Michigan Student Test of Educational Progress (M-STEP) starting 2014-15.

Fig. 2. Individual child-level blood lead measurements $\geq 5 \mu\text{g/dL}$ during the FWC period (April 25 2014–October 16 2015). (A) Detroit and (B) Flint. The data is de-duplicated; i.e., only highest blood lead value per child is shown.

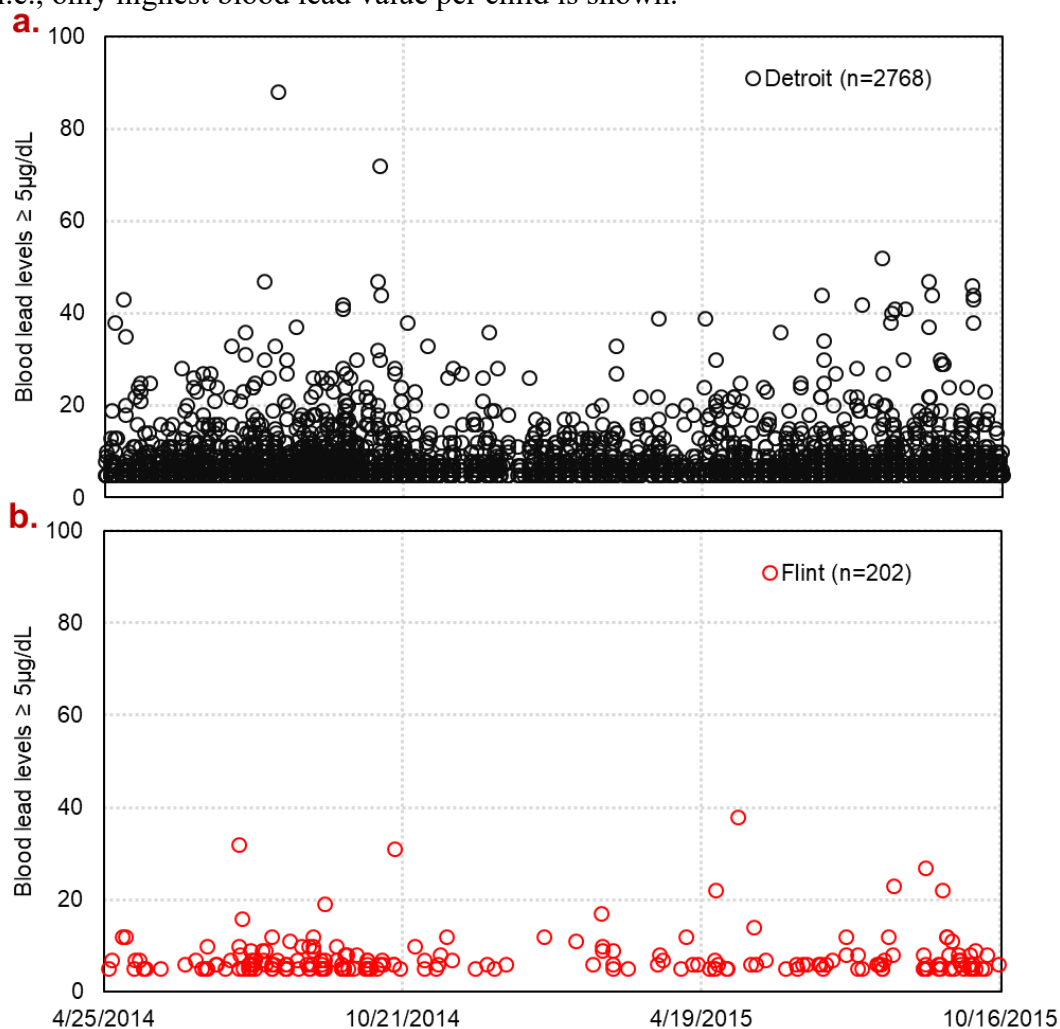
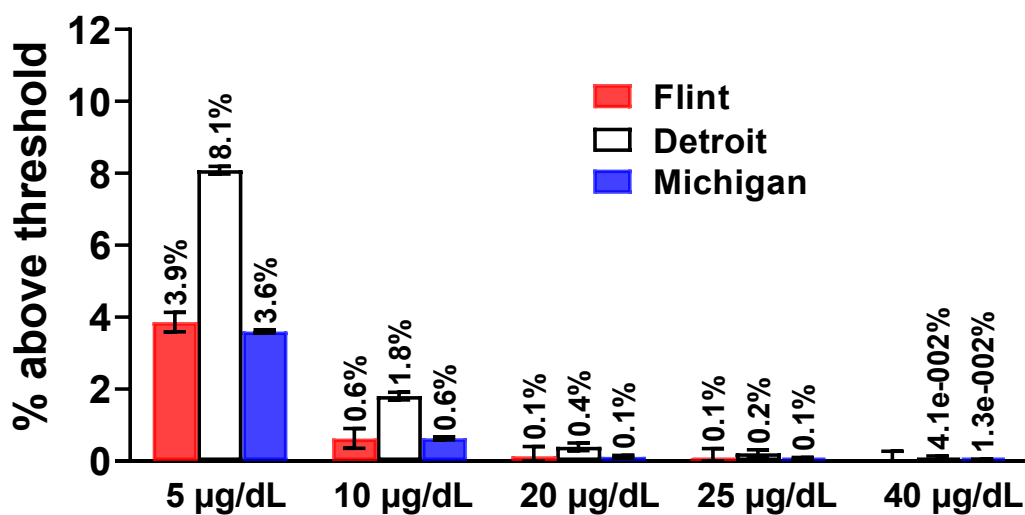


Fig. 3. Percentage of children < 6 years of age with blood lead $\geq 5 - 40 \mu\text{g/dL}$ in Flint, Detroit, and Michigan during April 25, 2014 – October 16, 2015. The CDC threshold for elevated blood lead was $40 \mu\text{g/dL}$ between 1973-75, $25 \mu\text{g/dL}$ between 1985-90, $10 \mu\text{g/dL}$ until 2012 and $5 \mu\text{g/dL}$ until 2021.



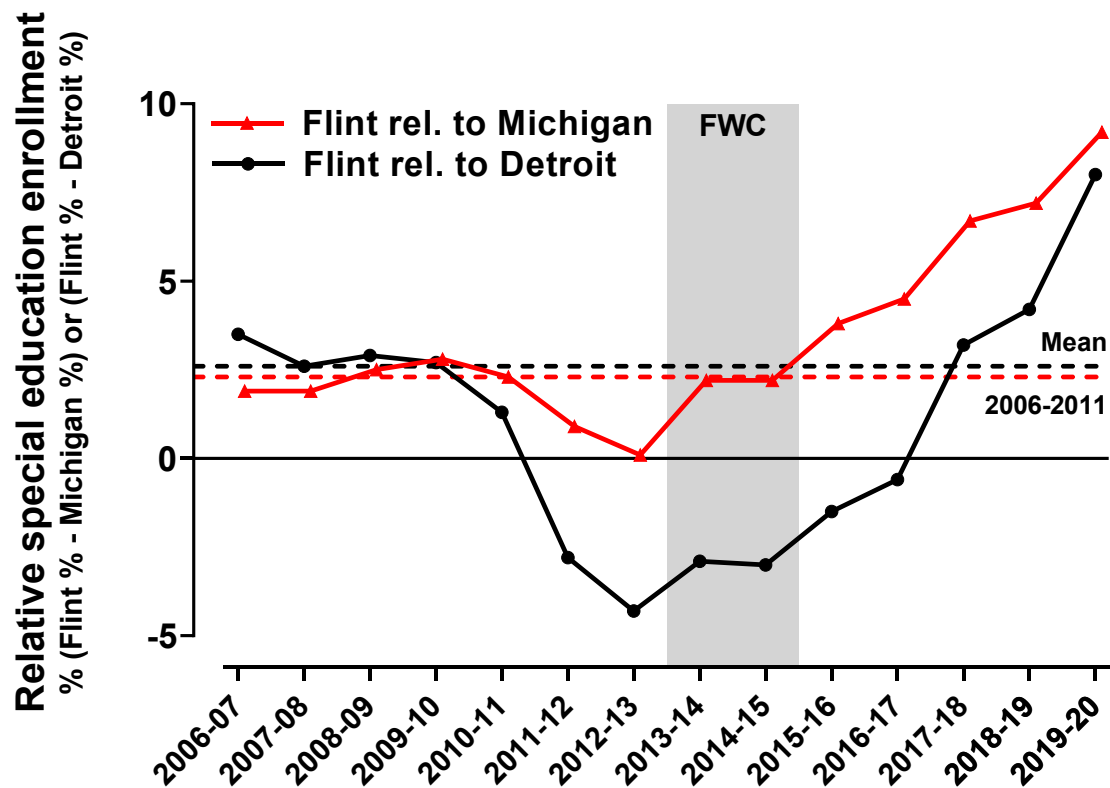
Overall educational outcomes

Of 23 special education outcomes monitored each academic year, nine worsened, nine improved and five did not change ($\leq \pm 1\%$ change) in Flint after the crisis vis-à-vis before the water crisis (Text S2). In a simple comparison relative to Detroit, only three outcomes worsened and another three improved in Flint.

Despite these overall neutral trends, four worsening outcomes in Flint were nonetheless emphasized and attributed to lead exposure from the FWC by the national media and experts (ACLU, 2016; Alfonsi, 2020; Green, 2019; Redlener, 2018; Riley, 2018; Strauss, 2019) including: a) special education enrollment; b) suspension or expulsion for children in special education; c) dropout for children in special education, and d) worsening reading proficiency of 3rd grade students in general education.

Each of these attributions is examined in greater detail for Flint Community Schools, Detroit Public Schools Community District, and all public schools in Michigan using data for the academic years 2011-12 until 2019-20. Special education enrollment was also examined from 2006-07 onwards to identify a baseline (Figure 4), and 3rd grade reading proficiency was not analyzed in 2019-2020 since tests were cancelled due to the COVID-19 pandemic.

Fig. 4. Special education enrollment in Flint relative to Detroit and Michigan, 2006-20



Special education enrollment

Special education enrollment trends are routinely gathered under federal and state laws (Individuals with Disabilities Act, 2004; Michigan Department of Education, 2020; Weiss et al., 2010), and the data are significantly different for Michigan, Detroit and Flint ($P < 0.0001$, Figure 1b). Overall, in the State of Michigan, the proportion of children in special education remained stable between 2011-12 and 2019-20 at 12.9-13.5%. The special education enrollment rate in Detroit slightly increased from 2011-12 to 2016-17 followed by a downtrend during 2017-18 to 2019-20 (Figure 1b). The special education enrollment rate in Flint started lower than Detroit ($P < 0.0001$) in 2011-12 as would be expected due to lower blood lead levels alone, but began rising in 2015-16 (relative to the previous three academic years) after the federal emergency and aggressive national and international reporting on the FWC (Green, 2019; Jackson, 2017; Pew Research Center, 2017). Flint special education enrollment even surpassed that in Detroit in 2017-18 ($P < 0.0001$). Notably, the spike in Flint special education enrollment rate only occurred in the 6-21 year age group, whereas the age group that would be considered most vulnerable to water lead exposure (i.e. those in the womb or up to age 1 during the FWC) saw no significant increase (Figure S2).

The special education enrollment rate in Flint relative to Michigan during 2013-15, including the first FWC year, was comparable to the 2006-11 baseline, but began to spike in the second FWC year (2015-16), when media coverage on the crisis increased markedly (see Figure 4, “Flint relative to Michigan”). This was associated with a strong diverging trend between the special education rates for Flint and Detroit starting in 2016-17 (Figure 1b). Similarly, Flint special education enrollment was much lower relative to Detroit between 2011-16 (see Figure 4, “Flint relative to Detroit”), became comparable in 2016-

17, and increased dramatically from 2017-20. There is actually a strong inverse relationship (Figure 1c) between %EBL and special education enrollment rate in Flint ($r = -0.79$ (95% CI $-0.96, -0.18$) $P = 0.021$), but there is no such relationship for the same time period in Detroit ($r = 0.20$ (95% CI $-0.59, 0.79$) $P = 0.63$) or Michigan ($r = 0.09$ (95% CI $-0.66, 0.75$) $P = 0.83$).

Special education suspension/expulsion rates

The special education suspension/expulsion rates in Flint increased 7.4 times in 2013-14 (13.6%) before the FWC began (Figure 1d) compared to the previous two school years, and peaked in the first FWC year 2014-15 (14.1%), before dropping more than half in the second FWC year 2015-16 (6%). Rates progressively rose during 2016-19 (9% to 11.2%) after the FWC came to light.

Special education dropout rates

The special education dropout rates in Flint roughly doubled in the 2017-20 school years (22.1%) versus 2014-17 (11.5%), after a steady decline during 2011-17 analogous to that occurring in Detroit and Michigan (Figure 1e).

General education reading proficiency

After the State of Michigan adopted the stricter Michigan Student Test of Educational Progress (M-STEP) standard in the 2014-15 school year, both Flint (22.3 percentage points) and Michigan (19.9 percentage points) witnessed identical drops (around 20 percentage points) in 3rd grade reading proficiency between 2013-14 and 2014-15, but Detroit fell even more precipitously (31 percentage points) (Figure 1f). During the FWC (2014-16 school year) and until the 2018-2019 school year, 3rd grade reading proficiency

stayed roughly the same in Detroit, however Flint continued to decrease until reaching the same level as Detroit.

Potential FWC covariates that could explain rising special education enrollment

Analyses of trends in covariates including waterborne contaminants besides lead, poverty, poor nutrition, City of Flint’s administration and emergency management decisions, and Flint Community Schools’ policies and funding do not appear to be primarily associated with the post-FWC rise in special education enrollment in Flint (Text S1).

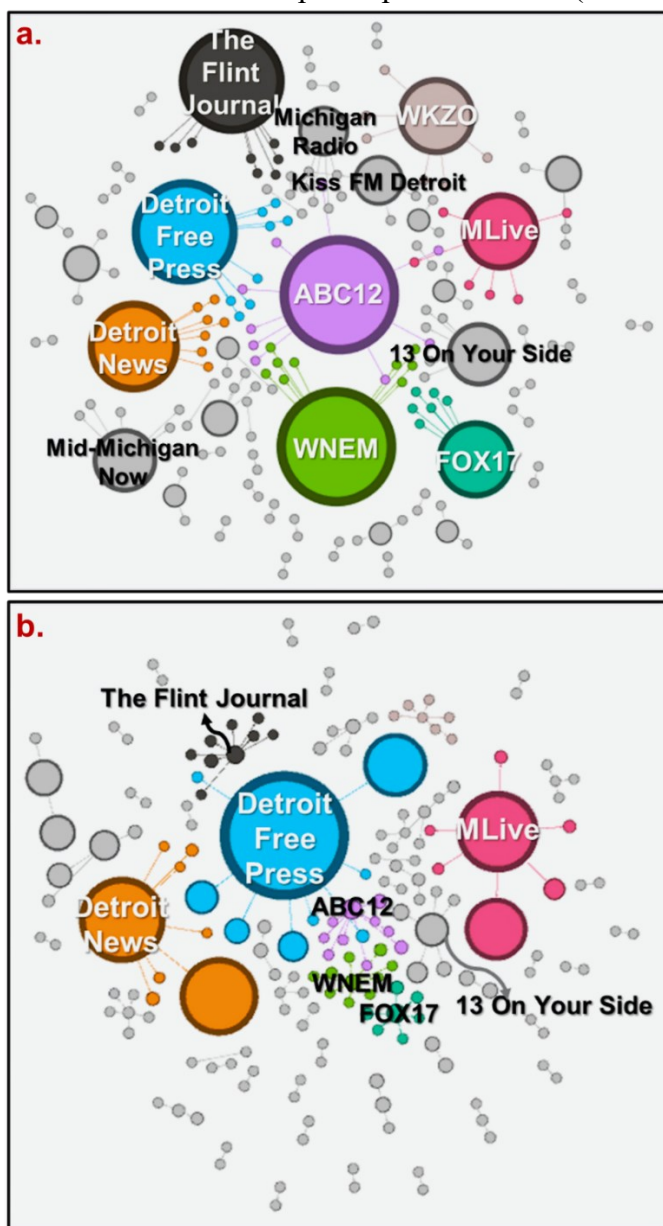
Negative community expectations and media coverage

The aggregated data from Facebook®, the dominant social media platform in the United States (Perrin & Anderson, 2019), obtained using the CrowdTangle (www.crowdtangle.com) public insights tool owned and operated by Facebook®, indicate news around lead “poisoning” of Flint children and worsening educational outcomes was interacted with hundreds of thousands of times and potentially reached tens of millions of users on Facebook® alone between 2015-21 (Table S1). In contrast, there were just two articles about Detroit children that saw just over 22,000 interactions. On average, 12.2% web traffic to news websites originate from social media, and, therefore, these reported values are gross underestimates of the total “reach” of news, which would include all newspaper and magazine hard copies read, news channel broadcasts watched, and radio programs and podcasts heard (Alexa, 2020). To illustrate, the *60 Minutes* Flint special education episode (Alfonsi, 2020) alone was interacted with over 27,000 times and potentially reached ~10 million users on Facebook, and its television broadcast was also watched by over 10 million viewers on the *CBS* channel (Table S1). Negative

pronouncements about lead exposure during the FWC period and educational difficulties in the media disproportionately originated from Flint community leaders describing Flint children, but similar claims were not made publicly by Detroit community leaders (Table S2) despite the much higher blood lead for Detroit children (Figures 1a, 2a, 2b, 3 and S1).

A search for all posts and weblinks shared on official Facebook® pages of Michigan local media (Data S1) with the keywords “lead poisoned” and no mention of “Flint” or “Detroit” during January 2016-November 2020 time period using CrowdTangle revealed over 80% articles (Data S2) discussed the FWC. Network mapping of these posts (Figure 5) revealed the media outlets who shared the most articles and links to be from Flint (*WNEM TV5*, *ABC12*, and *The Flint Journal/MLive*; collective n=32) followed by prominent state-level newspapers *Detroit Free Press* and *The Detroit News*. Moreover, the postings from Michigan’s Top three dailies by circulation (i.e., *Detroit Free Press*, *The Flint Journal/MLive*, and *Detroit News*) (Agility PR, 2020) saw the most interactions (~35,000) in the form of reactions, shares, and comments.

Fig. 5. Network Mapping of all posts and weblinks shared on official Facebook® pages of Michigan local media with the keywords “lead poisoned,” Jan 2016-Nov 2020. (A) Media outlets arranged by total number of posts/links shared. **(B)** Media outlets arranged by total interactions (reactions, shares, and comments) on posts/links shared. Raw values for all media bubbles in the maps are provided in SI (Table S4).



Notes: (i) The size of the media bubbles is relative; i.e., higher the metric of interest, larger the bubble. The numerous links emerging from each bubble indicate resharing of the posts/links to other Facebook® pages and the representative bubbles are also relatively sized according to the metric of interest. (ii) The Flint Journal belongs to the parent media company MLive and both have separate Facebook® pages. Therefore, while the pages appear separately in the left network map as they do in Facebook®, their interaction metrics are aggregated in text.

Discussion

This investigation confirms that the proportion of young children with elevated blood lead in Flint, Detroit and Michigan as a whole has been declining over the past 10 years. The %EBL trend in Flint is very similar to that observed across Michigan and has always been much lower than Detroit. In fact, the %EBL in Flint has now dropped below data for the United States (US CDC, 2020).

For additional perspective, the geometric mean blood lead even during the worst FWC year as reported in previous research (Gómez et al., 2018), was lower than that reported in the European nations of France and Poland (Table S3). Paradoxically, since the FWC was revealed in 2015 and residents were further protected from exposure to waterborne lead, Flint saw a dramatic spike in special education enrollment, while such enrollment remained steady across Michigan and even declined after 2015-16 in the control city of Detroit.

While lead is a neurotoxin with known potential for worsening educational outcomes (Jusko et al., 2008; Mendelsohn et al., 1998; Surkan et al., 2007; Watt et al., 1996), analysis of the data in Flint relative to Detroit is inconsistent with the attribution of rising special education enrollment in Flint to lead exposure. The worst lead exposure from the FWC was of relatively short duration (about one-sixth of the entire time on Flint River water), and is set against a historic decline in blood lead in Flint as well as Detroit, Michigan and nationally (Dignam et al., 2019; Gomez et al., 2018). The elevation in Flint childhood blood lead was above the relatively new 5 µg/dL CDC reference threshold but not the 10 µg/dL threshold “level of concern” exceeded in Washington DC children during its 2001-04 lead in drinking water crisis (Roy et al., 2019). The number of individual

children testing ≥ 25 $\mu\text{g/dL}$, a threshold above which it is reported that 20% of children require an average of nine years of special education (Swinburn, 2016), was 18 times higher in Detroit (0.21% of all children tested; $n=73$) than in Flint (0.08% of all children tested; $n=4$) during the FWC.

As early as January 2016, it was acknowledged that the worst-case incidence of elevated blood lead during the FWC was always less than half of the incidence in other Michigan cities of Detroit, Grand Rapids, and Muskegon, and 3,800 other communities across the United States (Frazier, 2018; Lanphear, 2017a; Mack, 2016; Pell & Schneyer, 2016; Wilkinson, 2016). Moreover, since %EBL in Detroit was always at least twice that in Flint before, during and after the FWC, worse outcomes, whether concurrent or lagged, would always be expected for Detroit children, but such an impact is not observed in the time period of interest. Instead, there is an incongruous inverse relationship between childhood blood lead and special education enrollment in Flint, while no such relationship exists for Detroit and Michigan.

Despite an equal number of overall special education outcomes worsening and improving (Text S2), only those that superficially appeared to be worsening were publicized in the media. Our detailed analysis shows these outcomes are insignificant or inconsistent with the actual lead exposure that occurred. Specifically, the seven-fold jump in suspension/expulsion rates of special education students had occurred in 2013-14 before the onset of the crisis, and the comparison with Detroit further discounts an association with lead exposure. Indiscriminate enforcement of suspension/expulsion policies before the FWC (*D.R. v. Michigan Department of Education*, 2016) may have contributed to this spike. The special education dropout rates in Flint only started to rise in 2017-18 post-

FWC after expectations of such an outcome was widely publicized in the media starting late 2016. Finally, the reduction in Flint general education 3rd grade reading proficiency after adoption of a new academic standard in 2014-15 was also observed in the Detroit control group, and could be attributed to the changed tests.

The rise in special education enrollment in Flint following the FWC was not associated with confounders of waterborne contaminants besides lead during the FWC, poverty, poor nutrition, and emergency management. The Flint schools' failure to properly enforce special education policies and a severe budget deficit since the early 2010s may have contributed to less Flint students being enrolled in special education programs pre-FWC, but the enrollment rate had returned to historical norms during the FWC.

A nocebo effect is consistent with the trend of rising special education enrollment after the FWC was exposed (Colloca & Barsky, 2020; Petrie & Rief, 2019). As a top news story of 2016, the crisis engendered negative psychological effects described by residents as “Flint fatigue,” and the surrounding international media coverage has continued for over five years with negative headlines (Adams, 2016; Associated Press, 2020; Cuthbertson et al., 2016; Goodnough & Atkinson, 2016; Heard-Garris et al., 2017; May, 2016). The news reports and their popularity on social media (Table S1, Figure 5) and negative perceptions of Flint community leaders and parents (Table S2) could have heightened negative expectations about the effects on children, who readily accept and act on information from those they trust (Harris & Corriveau, 2011; Jaswal et al., 2010; Landrum et al., 2013). Contaminated water creates high public anxiety compared to other environmental concerns (Petrie et al., 2001). For example, the psychological impact of the FWC caused increased tap water avoidance amongst US children nationwide after the FWC came to

light (Rosinger & Young, 2020). The early speculation and worst case predictions of impacts on Flint children were also made in a vacuum of trust, uncertainties in the timing and magnitude of the water lead exposure due to manipulation of official test results, and an acknowledged “failure of government at all levels” that caused the FWC (Roy & Edwards, 2019a).

From 2016-18 arguments over the possible negative consequences of labeling Flint children “poisoned” versus “exposed” played out in the media (Clark & Filardo, 2018; Gomez & Dietrich, 2018; Drum, 2017; Mays, 2018; Schneider et al., 2016; Shell, 2016). The worst negative expectations for special education enrollments in years following the FWC appear to have been realized, even though comprehensive blood and water lead analyses eventually published in 2018-20 (Gomez et al., 2018; Gomez et al., 2019; Roy et al., 2019; Roy & Edwards, 2020) contradict the popular belief that Flint children experienced an unprecedented environmental lead exposure (Figure 1a). Moreover, in many cases, the national media (e.g., *The New York Times* (Green, 2019) and *CBS 60 Minutes* (Alfonsi, 2020)) have provided even worse prognoses, labeling Flint children as brain damaged or lead poisoned (Table S1). No comparable media labeling was applied to children in Detroit (Table S1, Figure 5) or the other Michigan cities with much higher %EBL incidence. A significant percentage of Flint households experience water crisis-related stress and other negative psychological effects, are meeting criteria for psychological trauma, report behavioral problems in their children, and believe that “the crisis would never be fixed” (Bosman & Greeson, 2020; Brooks & Patel, 2021; Ezell & Chase, 2021; Jones et al., 2022; Reuben et al., 2022; Sneed et al., 2020; Trejo et al., 2022).

A perception that Flint's water is still unsafe and a source of ongoing community concern is supported by continued high rates of bottled water use five years after the switchback to Detroit water. Bottled water use has persisted despite distribution of free lead filters, replacement of over 90% of lead pipes, and independent tests showing current Flint water lead levels to be lower than observed in other Michigan cities with old pipes (Alfonsi, 2020; City of Flint, 2022; Flint Cares, 2018; Reuben et al., 2022; Roy & Edwards, 2019a; Roy & Edwards, 2020). In fact, it is reported that some of Flint's youngest children have only bathed in and consumed bottled water their entire lives (Alfonsi, 2020; Fonger et al., 2019; Herndon, 2018).

Exposure to feared contaminants such as lead is known to create nocebo responses (Blettner et al., 2009; Crichton et al., 2014; Gruber et al., 2018; Petrie et al., 2005; Withöft & Rubin, 2013; Small & Borus, 1987). Other suspected water contamination incidents have caused health complaints that were difficult to explain by the level of toxicological exposure (David & Wessely, 1995a; Page et al., 2006). In the Camelford water contamination incident in Cornwall, England, health complaints were intensified by media interest, concerns about a conspiracy and litigation (David & Wessely, 1995b). However, in contrast to the FWC, those studies did not have direct data from continuous monitoring of the contaminant of concern in the blood of the affected population, or suitable control groups for comparison as in the research results presented herein.

It has also been argued that the actual (and small) magnitude of elevation in children's blood lead from the FWC does not matter in terms of the resulting health harm (e.g., Hanna-Attisha et al., 2018; Kuehn, 2016; Oleske et al., 2016; Schmidt, 2018; Schneider et al., 2016; Stateside Staff, 2018). However, the epidemiological study by Lanphear and

colleagues noted an inverse, supralinear dose-response relationship: a net decrease of 6.9 IQ points (95%CI 4.2-9.4) for blood lead increment of 2.4 to 30 $\mu\text{g/dL}$, with the steepest drop of 3.9 IQ points (95%CI 2.4-5.3) occurring for the lowest blood lead range of 2.4 to 10 $\mu\text{g/dL}$ (Lanphear et al., 2005). While the underlying (biological) mechanism has not been elucidated (Lanphear, 2017b), the supralinear curve confirms the scientific principle that “the dose makes the poison” for lead.

These data suggest that the rising enrollment in special education attributed to the FWC, may be associated with widespread negative expectations and not an elevation in blood lead. This possible nocebo effect in Flint represents an unfortunate natural large-scale experiment, in which a population has been repeatedly informed by trusted national and international media sources that an unprecedented lead exposure event had occurred with severe long-term adverse repercussions to children, even when the data indicate that the actual lead exposure was normal for the State and less than nearby communities.

Two of this paper’s authors (MAE/SR) personally witnessed such expectations during a science outreach program for over 1,000 K-12 Flint students in March 2017 (Edwards, 2017; Jacques, 2018), where several teachers openly expressed their belief that Flint children had been brain damaged, were incapable of learning, and that there was little point in trying to teach them (Bouffard, 2018; Edwards, 2017; Jacques, 2018; Roy & Edwards, 2019c). Trust of teachers in students and parents is a significant predictor of student achievement (Goddard et al., 2001). These and similar expectations have been broadcast in the media for over five years (e.g., Tables S1 and S2, Figure 5) and can strongly influence children’s school performance and behavior, such as those previously

documented in younger and stigmatized children from African-American and lower socioeconomic backgrounds (Jussim et al., 1996).

Students who require and receive special education services do benefit from them (Ballis and Heath, 2021) and higher special education enrollments are not necessarily indicative of permanent brain damage or health harm from the water lead exposure. In fact, part of the rise might be viewed as part of a proactive effort to compensate for the failures of government at all levels that caused the FWC (Wagner and Kennedy, 2017). In any event, the media have never publicized this possible positive interpretation.

Importantly, the media messaging has not changed, in spite of ample evidence that the actual lead exposures in Flint were not abnormally high relative to all of Michigan and were much lower than neighboring Detroit. It is possible that the harm from such messaging is continuing. For instance, the special education enrollment rate in Flint for 2019-20 (22.7%) is now over 1.5-1.7 times the rates in Detroit (14.7%), and is higher than Michigan (13.5%) and the United States overall (14.1%) (US Department of Education, 2020), despite the fact that Detroit children have always had more than double the incidence of %EBL than Flint (Figure 1a). This trend may even be accelerating due to universal special neuropsychological screening now being conducted for Flint children, which has recently indicated an 80% diagnosis rate for “language, learning or intellectual disorders” that are attributed to lead exposure from the FWC (Alfonsi, 2020; Chambers, 2019).

Our study has limitations. This study is limited by reliance on existing blood lead datasets collected under standard screening practices, covering about 23% of young children in

Michigan, 40% in Detroit and 39% of Genesee Co. in 2016 (Michigan Department of Health and Human Services, 2018). Since this is a population-based study, we did not have educational outcomes data at the individual level to adjust for potential confounders or to identify if multiple adverse outcomes were occurring for the same children. Our study is also limited by the lack of charter school data. And finally, our central analyses were correlational, and should be interpreted with caution. In contrast, the strength of this population-based study is the utilization of over 1.44 million individual childhood blood lead measurements and annual monitoring of outcomes in general and special education occurring under uniform Michigan educational policies in two cities with comparable demographics, using the same source of treated drinking water from Lake Huron except for the 18 months Flint was served by the Flint River and suffered the manmade public health crisis. The educational outcomes data are representative as they are weighted by city-level population instead of individual schools. The novel contribution of this study is uncovering of possible nocebo effect in the aftermath of a public health emergency involving a known neurotoxin, via an unfortunate natural experiment that could never have been studied intentionally.

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References

- ACLU. (2016). All Children Can Learn. D.R. v. Michigan Department of Education: A Civil Rights Lawsuit for the Children of Flint. *ACLU*.
https://www.aclumich.org/sites/default/files/field_documents/flint_lawsuit_fact_sheet.pdf Published October 2016. Accessed September 21, 2021
- Adams, C. (2016). 16 stories that defined 2016. *CBS News*. <https://www.cbsnews.com/news/16-stories-that-defined-2016/> Published December 2016. Accessed September 27, 2020
- Agility PR. (2020). Top 10 Michigan Daily Newspapers by Circulation. *Agility PR*. Available at: <https://www.agilitypr.com/resources/top-media-outlets/top-10-michigan-daily-newspapers-by-circulation/> Published 2020. Accessed July 04, 2021.
- Alexa. (2020). How Do The Top Websites Drive Traffic? *Alexa*. <https://try.alexa.com/resources/website-traffic-sources> Published 2020. Accessed September 27, 2020
- Alfonsi, S. (2020). Early results from 174 Flint children exposed to lead during water crisis shows 80% of them will require special education services. *CBS News 60 Minutes*.
<https://www.cbsnews.com/news/flint-water-crisis-effect-on-children-60-minutes-2020-03-15/> Published March 2020. Accessed June 21, 2020
- Associated Press. (2020). Flint mom: \$600 million settlement not enough. *Associated Press*.
<https://news.yahoo.com/flint-mom-600-million-settlement-203659157.html?guccounter=1> Published August 2020. Accessed September 27, 2020
- Ballis, B. & Heath, K. (2021). Special education: Beneficial to many, harmful to others. *Brookings Institute*. Available at: <https://www.brookings.edu/blog/brown-center-chalkboard/2021/05/26/special-education-beneficial-to-some-harmful-to-others/> (last accessed 12/5/22)
- Barsky, A.J., Saintfort, R., Rogers, M.P., & Borus, J.F. (2002). Nonspecific medication side effects and the nocebo phenomenon. *Jama*. 2002 Feb 6;287(5):622-7. doi: 10.1001/jama.287.5.622.
- Blettner, M., Schlehofer, B., Breckenkamp, J., Kowall, B., Schmiedel, S., Reis, U., Potthoff, P., Schüz, J., Berg-Beckhoff, G. (2009). Mobile phone base stations and adverse health effects: phase 1 of a population-based, cross-sectional study in Germany. *Occup Environ Med*. 2009 Feb;66(2):118-23. doi: 10.1136/oem.2007.037721. Epub 2008 Nov 18. PMID: 19017702.
- Bosman, J. (2020). Michigan to Pay \$600 Million to Victims of Flint Water Crisis. *The New York Times*.
<https://www.nytimes.com/2020/08/19/us/flint-water-crisis-settlement.html> Published August 2020. Accessed September 27, 2020
- Bosman, J., & Greeson, B. (2020). ‘Double Challenge Mode’ in Flint, Where Virus Follows Water Crisis. *The New York Times*. <https://www.nytimes.com/interactive/2020/08/18/us/flint-coronavirus.html> Published August 2020. Accessed September 27, 2020
- Bouffard, K. (2018). War of words, science still rages over lead contamination in Flint. *The Detroit News*.
<https://www.detroitnews.com/story/news/michigan/flint-water-crisis/2018/08/13/words-science-flint-water-lead-contamination/934390002/> Published March 2018. Accessed June 21, 2020
- Brooks, S.K., & Patel, S.S. (2021). Psychological Consequences of the Flint Water Crisis: A Scoping Review. *Disaster Medicine and Public Health Preparedness*. Cambridge University Press; 2021;;1–11.
- Cantor, A., Hendrickson, R., Blazina, I., Griffin, J., Grusing, S., McDonagh, M. (2019). *Screening for Elevated Blood Lead Levels in Children: A Systematic Review for the U.S. Preventive Services Task Force: Evidence Synthesis No. 174*. Rockville, MD: Agency for Healthcare Research and Quality; 2019. AHRQ publication 18-05245-EF-1.
- Chambers, J. (2019). ‘Intense assessments’ check if kids are all right in Flint. *Detroit News*.
<https://www.detroitnews.com/story/news/education/2019/03/12/flint-kids-exposed-lead-get-intense-assessments/2527556002/> Published March 2019. Accessed February 05, 2023.

- City of Flint. (2022). Service Line Replacement Program. *City of Flint*.
<https://www.cityofflint.com/progress-report-on-flint-water/> Published September 2022. Accessed December 04, 2022
- Clark, A., & Filardo, T.W. (2018). The Flint Children Were Indeed ‘Poisoned’ *The New York Times*.
<https://www.nytimes.com/2018/07/27/opinion/letters/flint-children-lead.html> Published July 2018.
 Accessed June 21, 2020
- Colloca, L., & Barsky, A.J. (2020). Placebo and nocebo effects. *New England Journal of Medicine*. 2020 Feb 6;382(6):554-61.
- Crichton, F., Dodd, G., Schmid, G., Gamble, G., Cundy, T., & Petrie, K.J. (2014). The power of positive and negative expectations to influence reported symptoms and mood during exposure to wind farm sound. *Health Psychol*. 2014;33(12):1588-1592. doi:10.1037/hea0000037
- CrowdTangle (2020). Network Mapping with Gephi and CrowdTangle. *CrowdTangle*.
<https://help.crowdtangle.com/en/articles/4495952-network-mapping-with-gephi-and-crowdtangle>
 Published 2020. Accessed September 21, 2021
- Cuthbertson, C.A., Newkirk, C., Ilardo, J., Loveridge, S., & Skidmore, M. (2016). Angry, Scared, and Unsure: Mental Health Consequences of Contaminated Water in Flint, Michigan. *J Urban Health*. 2016;93(6):899-908. doi:10.1007/s11524-016-0089-y
- David, A.S., & Wessely, S.C. (1995a). The legend of Camelford: medical consequences of a water pollution accident. *J Psychosom Res*. 1995;39(1):1-9. doi:10.1016/0022-3999(94)00085-j
- David, A.S., & Wessely, S.C. (1995b). The legend of Camelford: medical consequences of a water pollution accident. *Journal of psychosomatic research*. 1995 Jan;39(1):1.
- David, R., Hesla, K., & Pendergrass, S.A. (2017). A GROWING MOVEMENT: America’s Largest Public Charter School Communities. *National Alliance for Public Charter Schools*.
https://www.publiccharters.org/sites/default/files/documents/2017-10/Enrollment_Share_Report_Web_0.pdf Published October 2017. Accessed June 21, 2020
- Dignam, T., Kaufmann, R.B., LeSturgeon, L., & Brown, M.J. (2019). Control of lead sources in the United States, 1970-2017: public health progress and current challenges to eliminating lead exposure. *J Public Health Manag Pract*. 2019 Jan;25(Suppl 1 LEAD POISONING PREVENTION):S13. doi: 10.1097/PHH.0000000000000889
- DR v. MICHIGAN DEPARTMENT OF EDUCATION, No. 2: 16-cv-13694 (E.D. Mich. Oct. 8, 2016). Available at: https://www.aclumich.org/sites/default/files/Flint_Schools_Final_Complaint.pdf Filed October 2016. Accessed July 04, 2021.
- Drum, K. (2017). In Flint, We Are Laying Tragedy on Top of Tragedy on Top of Tragedy. *Mother Jones*.
<https://www.motherjones.com/kevin-drum/2017/01/flint-we-are-laying-tragedy-top-tragedy-top-tragedy/>
 Published January 2017. Accessed June 21, 2020
- Edwards, M.A. (2017). University of Michigan and Virginia Tech Students Spend Spring Break in Flint, MI Classrooms: Discuss Science of Flint Water Crisis. *Flint Water Study*.
<http://flintwaterstudy.org/2017/04/university-of-michigan-and-virginia-tech-students-spend-spring-break-in-flint-mi-classrooms-discuss-science-of-flint-water-crisis/> Published April 2017. Accessed June 21, 2020
- Ezell, J.M., & Chase, E.C. (2021). A population-based assessment of physical symptoms and mental health outcomes among adults following the Flint water crisis. *Journal of Urban Health*. 2021 Mar 31:1-2.
- Flint Cares. (2018). From Crisis to Recovery: Household Resources. *Flint Cares*. http://flintcares.com/wp-content/uploads/2018/05/Crisis-to-Recovery-Booklet_Rev.pdf Published May 2018. Accessed June 21, 2020
- Fonger, R. (2020). Kildee asks for \$110 million for Flint schools, registry, water reconnections. *Mlive*.
<https://www.mlive.com/news/flint/2020/04/kildee-asks-for-110-million-for-flint-schools-registry-water-reconnections.html> Published April 2020. Accessed June 21, 2020

- Fonger, R., Acosta, R., & Ahmad, Z. (2019). It's been 5 years. Flint still doesn't trust the water. *MLive*. <https://www.mlive.com/news/2019/04/its-been-5-years-flint-still-doesnt-trust-the-water.html> Published April 2019. Accessed June 21, 2020
- Frazier, A. (2018). Childhood Lead Exposure in Michigan: It's Not Just Flint. *Michigan State University*. <https://ippsr.msu.edu/public-policy/michigan-wonk-blog/childhood-lead-exposure-michigan-it%E2%80%99s-not-just-flint> Published February 2018. Accessed June 21, 2020
- Goddard, R.D., Tschannen-Moran, M., & Hoy, W.K. (2001). A multilevel examination of the distribution and effects of teacher trust in students and parents in urban elementary schools. *The elementary school journal*. 2001 Sep 1;102(1):3-17.
- Goetz, D. (2022). Flint schools unveil Elon Musk-funded water fountains. *MLive*. <https://www.mlive.com/news/flint/2022/02/flint-schools-unveil-elon-musk-funded-water-fountains.html> Published February 2022. Accessed December 03, 2022.
- Gómez, H., & Dietrich, K. (2018). The Children of Flint Were Not 'Poisoned' *The New York Times*. <https://www.nytimes.com/2018/07/22/opinion/flint-lead-poisoning-water.html> Published July 2018. Accessed June 21, 2020
- Gómez, H.F., Borgialli, D.A., Sharman, M., et al. (2018). Blood lead levels of children in Flint, Michigan: 2006-2016. *J Pediatr*. 2018 Jun 1;197:158-64. doi: 10.1016/j.jpeds.2017.12.063.
- Gómez, H.F., Borgialli, D.A., Sharman, M., et al. (2019). Analysis of blood lead levels of young children in Flint, Michigan before and during the 18-month switch to Flint River water. *Clin Toxicol (Phila)*. 2019;57(9):790-797. doi:10.1080/15563650.2018.1552003
- Goodnough, A., & Atkinson, S. (2016). A Potent Side Effect of the Flint Water Crisis: Mental Health Problems. *The New York Times*. <https://www.nytimes.com/2016/05/01/us/flint-michigan-water-crisis-mental-health.html> Published May 2016. Accessed June 21, 2020
- Green, E.L. (2019). Flint's Children Suffer in Class After Years of Drinking the Lead-Poisoned Water. *The New York Times*. <https://www.nytimes.com/2019/11/06/us/politics/flint-michigan-schools.html> Published November 2019. Accessed June 21, 2020
- Gruber, M.J., Palmquist, E., & Nordin, S. (2018). Characteristics of perceived electromagnetic hypersensitivity in the general population. *Scand J Psychol*. 2018 Aug;59(4):422-427. doi: 10.1111/sjop.12449. Epub 2018 May 9. PMID: 29741795.
- Hanna-Attisha, M., LaChance, J., Sadler, R.C., Champney Schnepf, A. (2016). Elevated blood lead levels in children associated with the Flint drinking water crisis: a spatial analysis of risk and public health response. *Am J Public Health*. 2016 Feb;106(2):283-90. doi: 10.2105/AJPH.2015.303003.
- Hanna-Attisha, M., Lanphear, B., & Landrigan, P. (2018). Lead Poisoning in the 21st Century: The Silent Epidemic Continues. *American Journal of Public Health*. 2018 Nov 1;108(11):1430-.
- Harris, P.L., & Corriveau, K.H. (2011). Young children's selective trust in informants. *Philosophical Transactions of the Royal Society B: Biological Sciences*. 2011 Apr 12;366(1567):1179-87.
- Heard-Garris, N.J., Roche, J., Carter, P., et al. (2017). Voices from Flint: Community Perceptions of the Flint Water Crisis. *J Urban Health*. 2017;94(6):776-779. doi:10.1007/s11524-017-0152-3
- Herndon, A.W. (2018). Michigan Governor's Race Tests Flint's Jaded Residents. *The New York Times*. <https://www.nytimes.com/2018/10/11/us/politics/flint-michigan-election-water.html> Published October 2018. Accessed September 27, 2020
- Individuals With Disabilities Education Act, 20 U.S.C. § 1400 (2004).
- Jackson, D.Z. (2017). Environmental Justice? Unjust Coverage of the Flint Water Crisis. *Harvard Kennedy School Shorenstein Center*. <https://shorensteincenter.org/environmental-justice-unjust-coverage-of-the-flint-water-crisis/> Published July 2017. Accessed June 21, 2020
- Jacques, E. (2018). The Adversity Antidote: how heroism education is being employed to navigate hardship and achieve wellbeing in Flint, Michigan. In: Efthimiou O, Allison ST, Franco ZE, eds.

- Heroism and wellbeing in the 21st Century: Applied and emerging perspectives. New York, New York: Routledge; 2018 Feb 13: Chapter 13.
- Jaswal, V.K., Croft, A.C., Setia, A.R., & Cole, C.A. (2010). Young children have a specific, highly robust bias to trust testimony. *Psychological Science*. 2010 Oct;21(10):1541-7.
- Jones, N., Dannis, J., O'Connell, L., LaChance, J., LeWinn, K. and Hanna-Attisha, M., 2022. Parent report of child behaviour: Findings from the Flint Registry cohort. *Paediatric and Perinatal Epidemiology*, 36(5), pp.750-758.
- Jusko, T.A., Henderson, Jr., C.R., Lanphear, B.P., Cory-Slechta, D.A., Parsons, P.J., & Canfield, R.L. (2008). Blood lead concentrations < 10 µg/dL and child intelligence at 6 years of age. *Environmental health perspectives*. 2008 Feb;116(2):243-8.
- Jussim, L., Eccles, J., & Madon, S. (1996). Social perception, social stereotypes, and teacher expectations: Accuracy and the quest for the powerful self-fulfilling prophecy. In Zanna MP, ed. *Advances in experimental social psychology*, 28: 281–388. Cambridge MA: Academic Press. doi: 10.1016/S0065-2601(08)60240-3
- Jussim, L., Robustelli, S.L., & Cain, T.R. (2009). Teacher expectations and self-fulfilling prophecies. In: Wentzel KR, Wigfield A, ed. *Handbook of motivation at school*. New York, New York: Routledge; 2009: Chapter 17.
- Kuehn, B.M. (2016). Pediatrician sees long road ahead for Flint after lead poisoning crisis. *Jama*. 2016 Mar 8;315(10):967-9. doi: 10.1001/jama.2016.1034.
- Landrum, A.R., Mills, C.M., & Johnston, A.M. (2013). When do children trust the expert? Benevolence information influences children's trust more than expertise. *Developmental Science*. 2013 Jul;16(4):622-38.
- Lanphear, B.P., Hornung, R., Khoury, J., Yolton, K., Baghurst, P., Bellinger, D.C., Canfield, R.L., Dietrich, K.N., Bornschein, R., Greene, T. and Rothenberg, S.J., 2005. Low-level environmental lead exposure and children's intellectual function: an international pooled analysis. *Environmental health perspectives*, 113(7), pp.894-899.
- Lanphear, B.P., 2017. Still treating lead poisoning after all these years. *Pediatrics*, 140(2).
- Lanphear, B.P., 2017. Low-level toxicity of chemicals: No acceptable levels?. *PLoS biology*, 15(12), p.e2003066.
- Mack, J. (2016). Lead levels elevated for thousands of Michigan children outside of Flint. *MLive*. https://www.mlive.com/news/2016/02/thousands_of_michigan_children.html Published February 2016. Accessed June 21, 2020
- Mack, J. (2019). Everything you need to know about Michigan's charter schools. *MLive*. <https://www.mlive.com/news/2019/11/everything-you-need-to-know-about-michigans-charter-schools.html> Published November 2019. Accessed June 21, 2020
- Madon, S., Jussim, L., & Eccles, J. (1997). In search of the powerful self-fulfilling prophecy. *J Pers Soc Psychol*. 1997 Apr;72(4):791. doi: 10.1037//0022-3514.72.4.791
- Madon, S., Willard, J., Guyll, M., & Scherr, K.C. (2011). Self-fulfilling prophecies: Mechanisms, power, and links to social problems. *Social and Personality Psychology Compass*. 2011 Aug;5(8):578-90. doi: 10.1111/j.1751-9004.2011.00375.x.
- Masten, S.J., Davies, S.H., & McElmurry, S.P. (2016). Flint water crisis: what happened and why?. *Journal-American Water Works Association*. 2016 Dec;108(12):22-34.
- May, J. (2016). Still standing: 100 Flint residents dealing with the daily pain of a poisoned water system. *MLive*. https://www.mlive.com/news/flint/2016/05/still_standing_100_flint_resid.html#2 Published May 2016. Accessed June 21, 2020
- Mays, M. (2018). Melissa Mays @FlintGate. *Twitter*. <https://twitter.com/FlintGate/status/962386580806782976> Published February 2018. Accessed June 21, 2020

- Mendelsohn, A.L., Dreyer, B.P., Fierman, A.H., Rosen, C.M., Legano, L.A., Kruger, H.A., Lim, S.W., & Courtlandt, C.D. (1998). Low-level lead exposure and behavior in early childhood. *Pediatrics*. 1998 Mar 1;101(3):e10-.
- Michigan Department of Education. (2020). Michigan Administrative Rules for Special Education (MARSE) With Related IDEA Federal Regulations. *Michigan Department of Education*. https://www.michigan.gov/documents/mde/MARSE_Supplemented_with_IDEA_Regs_379598_7.pdf Published May 2020. Accessed June 21, 2020
- Michigan Department of Health and Human Services. (2018). 2016 Data Report on Childhood Lead Testing and Elevated Levels: Michigan. *Michigan Department of Health and Human Services*. https://www.michigan.gov/documents/lead/2016_CLPPP_Annual_Report_5-1-18_621989_7.pdf Published November 2018. Accessed June 21, 2020
- Michigan Department of Health and Human Services. (2020). 2018 Provisional Annual Report on Childhood Lead Testing and Elevated Levels. *Michigan Department of Health and Human Services*. https://www.michigan.gov/documents/lead/2020.02.24_CLPPP_2018_Provisional_Report_Published_6_81911_7.pdf Published February 2020. Accessed June 21, 2020
- Michigan Department of Technology, Management and Budget (2022). City Dashboard. *Michigan Bureau of Labor Market Information and Strategic Initiatives*. <https://milmi.org/Regional-Dashboard/City-Dashboard> Published 2022. Accessed December 04, 2022
- Oleske, J.M., Bogden, J.D., Hanna-Attisha, M., LaChance, J. (2016). Lessons for flint's officials and parents from our 1970s newark lead program/hanna-attisha and lachance respond. *American journal of public health*. 2016 Jun 1;106(6):E1.
- Page, L.A., Petrie, K.J., & Wessely, S.C. (2006). Psychosocial responses to environmental incidents: a review and a proposed typology. *J Psychosom Res*. 2006 Apr 1;60(4):413-22.
- Pell, M.B., & Schneyer, J. (2016). The thousands of U.S. locales where lead poisoning is worse than in Flint. *Reuters*. <https://www.reuters.com/investigates/special-report/usa-lead-testing/#interactive-lead> Published December 2016. Accessed June 21, 2020
- Perrin, A., & Anderson, M. (2019). Share of U.S. adults using social media, including Facebook, is mostly unchanged since 2018. Pew Research Center. <https://www.pewresearch.org/fact-tank/2019/04/10/share-of-u-s-adults-using-social-media-including-facebook-is-mostly-unchanged-since-2018/> Published April 2019. Accessed September 27, 2020
- Petrie, K.J., Sivertsen, B., Hysing, M., et al. (2001). Thoroughly modern worries: the relationship of worries about modernity to reported symptoms, health and medical care utilization. *J Psychosom Res*. 2001;51(1):395-401. doi:10.1016/s0022-3999(01)00219-7
- Petrie, K.J., Broadbent, E.A., Kley, N., Moss-Morris, R., Horne, R., & Rief, W. (2005). Worries about modernity predict symptom complaints after environmental pesticide spraying. *Psychosom Med*. 2005;67(5):778-782. doi:10.1097/01.psy.0000181277.48575.a4
- Petrie, K.J., & Rief, W. (2019). Psychobiological mechanisms of placebo and nocebo effects: pathways to improve treatments and reduce side effects. *Annu Rev Psychol*. 2019 Jan 4;70:599-625. doi: 10.1146/annurev-psych-010418-102907.
- Pew Research Center. (2017). Searching for News: The Flint Water Crisis. *Pew Research Center*. <https://www.journalism.org/essay/searching-for-news/> Published April 2017. Accessed June 21, 2020
- Pieper, K.J., Martin, R., Tang, M., et al. (2018). Evaluating water lead levels during the Flint water crisis. *Environ Sci Technol*. 2018 Aug 7;52(15):8124-32. doi: 10.1021/acs.est.8b00791.
- Redlener, I. (2018). We still haven't made things right in Flint. *The Washington Post*. https://www.washingtonpost.com/opinions/we-still-havent-made-things-right-in-flint/2018/03/07/5c700692-2211-11e8-badd-7c9f29a55815_story.html Published March 2018. Accessed September 27, 2020

- Reuben, A., Moreland, A., Abdalla, S.M., Cohen, G.H., Friedman, M.J., Galea, S., Rothbaum, A.O., Schmidt, M.G., Vena, J.E. and Kilpatrick, D.G. (2022). Prevalence of Depression and Posttraumatic Stress Disorder in Flint, Michigan, 5 Years After the Onset of the Water Crisis. *JAMA network open*, 5(9), pp.e2232556-e2232556.
- Rhoads, W.J., Garner, E., Ji, P., et al. (2017). Distribution system operational deficiencies coincide with reported Legionnaires' disease clusters in Flint, Michigan. *Environ Sci Technol*. 2017;51(20):11986-95. doi: 10.1021/acs.est.7b01589.
- Riley, R. (2018). Sh-h-h. Snyder state update left out 75% drop in reading proficiency in Flint. *Detroit Free Press*. <https://www.freep.com/story/news/columnists/rochelle-riley/2018/02/06/sh-h-h-snyder-state-update-left-out-75-drop-reading-proficiency-flint/1074057001/> Published February 2018. Accessed June 21, 2020
- Rosenthal, R., & Jacobson, L.F. (1968). Teacher expectations for the disadvantaged. *Scientific American*. 1968 Apr 1;218(4):19-23. <https://www.jstor.org/stable/24926197>
- Rosinger, A.Y., & Young, S.L. (2020). In-home tap water consumption trends changed among US children, but not adults, between 2007 and 2016. *Water Resources Research*. 2020 Jul;56(7):e2020WR027657.
- Roy, S. (2017). The Hand-in-Hand Spread of Mistrust and Misinformation in Flint. *American Scientist*. 2017;105(1):22. doi: 10.1511/2017.124.22.
- Roy, S., & Edwards, M.A. (2019a). Preventing another lead (Pb) in drinking water crisis: Lessons from the Washington DC and Flint MI contamination events. *Current Opinion in Environmental Science & Health*. 2019 Feb 1;7:34-44. doi: 10.1016/j.coesh.2018.10.002
- Roy, S., & Edwards, M.A. (2019b). Citizen Science During the Flint, Michigan Federal Water Emergency: Ethical Dilemmas and Lessons Learned. *Citizen Science: Theory and Practice*. 2019 Mar 8;4(1). doi: 10.5334/cstp.154.
- Roy, S., & Edwards, M.A. (2019c). Flint water crisis shows the danger of a scientific dark age. *CNN*. <https://edition.cnn.com/2019/03/14/opinions/flint-water-myths-scientific-dark-age-roy-edwards/index.html> Published March 2019. Accessed June 21, 2020
- Roy, S., & Edwards, M.A. (2020). Efficacy of corrosion control and pipe replacement in reducing citywide lead exposure during the Flint, MI water system recovery. *Environmental Science: Water Research & Technology*. 2020. Doi: 10.1039/D0EW00583E
- Roy, S., Tang, M., & Edwards, M.A. (2019). Lead release to potable water during the Flint, Michigan water crisis as revealed by routine biosolids monitoring data. *Water res*. 2019 Sep 1;160:475-83. doi: 10.1016/j.watres.2019.05.091.
- Sauter, M.B., Stebbins, M., & Comen, E. (2017). 50 Worst American Cities to Live In. 24x7WallSt. <https://247wallst.com/special-report/2017/06/16/50-worst-cities-to-live-in/11/> Published June 2017. Accessed June 21, 2020
- Schmidt, C. (2018). America's Misguided War on Childhood Lead Exposures. *Undark*. <https://undark.org/2018/03/21/lead-testing-child-blood-levels/> Published March 2018. Accessed June 21, 2020
- Schneider, J.S., Lanphear, B.P., Lidsky, T.I., & Vernon, T.M. (2016). Expression of Concern to Scientific American Editors. *Scientific American*. <https://www.scientificamerican.com/article/flint-s-lead-tainted-water-may-not-cause-permanent-brain-damage/#comment-1-F4ED7E7E-28E4-4DD5-BAB17D9B3777606F> Published April 2016. Accessed June 21, 2020
- Shell, E.R. (2016). Flint's Lead-Tainted Water May Not Cause Permanent Brain Damage. *Scientific American*. <https://www.scientificamerican.com/article/flint-s-lead-tainted-water-may-not-cause-permanent-brain-damage/> Published March 2016. Accessed June 21, 2020
- Small, G.W., & Borus, J.F. (1987). The influence of newspaper reports on outbreaks of mass hysteria. *Psychiatric Quarterly*. 1987 Dec 1;58(4):269-78.

- Sneed, R.S., Dotson, K., Brewer, A., Pugh, P., & Johnson-Lawrence, V. (2020). Behavioral Health Concerns During the Flint Water Crisis, 2016-2018. *Community Ment Health J.* 2020;56(5):793-803. doi:10.1007/s10597-019-00520-7
- Sobeck, J., Smith-Darden, J., Hicks, M. et al. (2020). Stress, Coping, Resilience and Trust during the Flint Water Crisis. *Behavioral Medicine.* 2020 Oct 1;46(3-4):202-16. Doi: 10.1080/08964289.2020.1729085
- Stateside Staff. (2018). Pediatrician says “poisoned” is an accurate description of what happened to Flint children. *Michigan Radio.* <https://www.michiganradio.org/post/pediatrician-says-poisoned-accurate-description-what-happened-flint-children> Published August 2018. Accessed June 21, 2020
- Strauss, V. (2019). How the Flint water crisis set back thousands of students. *The Washington Post.* <https://www.washingtonpost.com/education/2019/07/03/how-flint-water-crisis-set-back-thousands-students/> Published July 2019. Accessed June 21, 2020
- Surkan, P.J., Zhang, A., Trachtenberg, F., Daniel, D.B., McKinlay, S., & Bellinger, D.C. (2007). Neuropsychological function in children with blood lead levels < 10 µg/dL. *Neurotoxicology.* 2007 Nov 1;28(6):1170-7.
- Swinburn, T. (2016). Costs of Lead Exposure and Remediation: Update. *Ecology Center and the Michigan Center for Children’s Environmental Health.* Available at: https://www.ecocenter.org/sites/default/files/Lead.Report.Designed.Final__0.pdf Published October 2016. Accessed July 04, 2021
- Trejo, S., Yeomans-Maldonado, G., Jacob, B., and Owusu, S. (2022). *Understanding the Psychosocial Effects of the Flint Water Crisis on School-Age Children in Michigan.* UM Education Policy Initiative. Available at: <https://edpolicy.umich.edu/research/epi-policy-briefs/understanding-psychosocial-effects-flint-water-crisis-school-age> (last accessed 12/5/22)
- University of Wisconsin Population Health Institute. (2022). County Health Rankings & Roadmaps. *University of Wisconsin Population Health Institute.* www.countyhealthrankings.org Published 2022. Accessed December 04, 2022
- US Census Bureau. (2022). Census Bureau Data. *US Census.* <https://www.data.census.gov/> Published 2022. Accessed December 04, 2022
- US Centers for Disease Control and Prevention. (2020). Blood Lead Levels in Children. *CDC.* <https://www.cdc.gov/nceh/lead/prevention/blood-lead-levels.htm> Published May 2020. Accessed September 27, 2020
- US Department of Education. (2020). Children 3 to 21 years old served under Individuals with Disabilities Education Act (IDEA), Part B. *National Center for Education Statistics.* https://nces.ed.gov/programs/digest/d19/tables/dt19_204.50.asp Published February 2020. Accessed September 27, 2020
- US Preventive Services Task Force, Curry, S.J., Krist, A.H., et al. (2019). Screening for Elevated Blood Lead Levels in Children and Pregnant Women: US Preventive Services Task Force Recommendation Statement. *JAMA.* 2019;321(15):1502-1509. doi:10.1001/jama.2019.3326
- Wagner, L. and Kennedy, M. (2017). Michigan Gov. Rick Snyder: 'We All Failed The Families Of Flint'. *NPR.* Available at: <https://www.npr.org/sections/thetwo-way/2016/03/17/470792212/watch-michigan-gov-rick-snyder-testifies-on-the-flint-water-crisis> (last accessed 12/6/22)
- Watt, G.C., Britton, A., Gilmour, W.H., Moore, M.R., Murray, G.D., Robertson, S.J., & Womersley, J. (1996). Is lead in tap water still a public health problem? An observational study in Glasgow. *BMJ.* 1996 Oct 19;313(7063):979-81.
- Weiss, C.L.A., & Mettrick, J.E. (2010). Individuals with Disabilities Education Act (IDEA). In: Clauss-Ehlers CS, eds. *Encyclopedia of Cross-Cultural School Psychology.* Boston, MA: Springer; 2010.
- Wilkinson, M. (2016). Kids' lead levels high in many Michigan cities. *Detroit News.* <https://www.detroitnews.com/story/news/michigan/flint-water-crisis/2016/01/27/many-michigan-cities-higher-lead-levels-flint/79438144/> Published January 2016. Accessed June 21, 2020

Witthöft, M., & Rubin, G.J. (2013). Are media warnings about the adverse health effects of modern life self-fulfilling? An experimental study on idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF). *J Psychosom Res.* 2013;74(3):206-212.
doi:10.1016/j.jpsychores.2012.12.002

Supplementary Materials for

Did a placebo effect contribute to the rise in special education enrollment following the Flint, Michigan Water Crisis?

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This file includes:

Figs. S1 to S2

Tables S1 to S4

Texts S1 (including Fig. S3) to S2 (including Figs. S4 to S22 and Table S5)

References

Other Supplementary Materials for this manuscript include the following:

Data S1 to S2

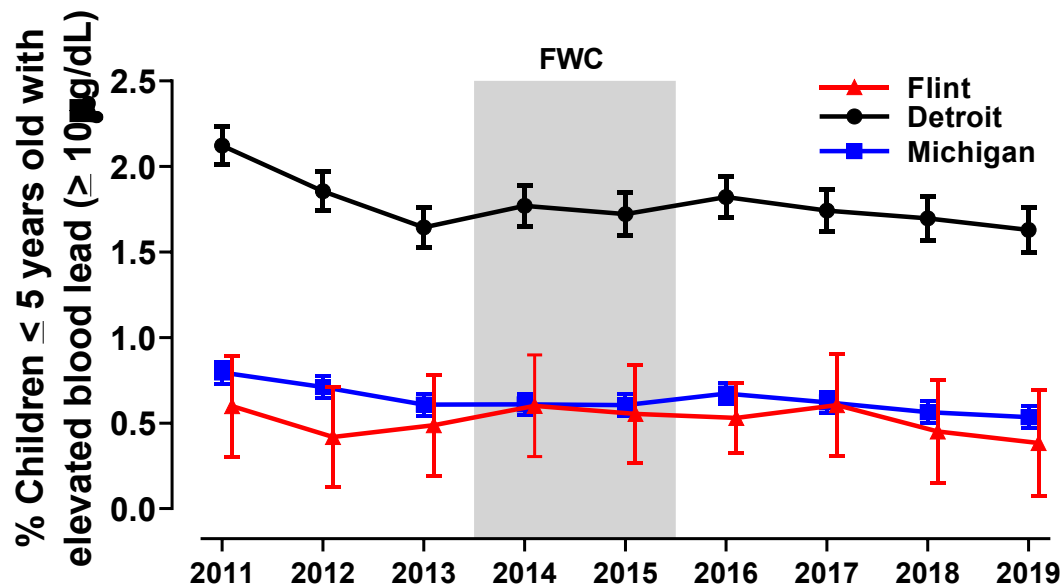


Fig. S1. Percentage of children ≤ 5 years of age with blood lead $\geq 10 \mu\text{g/dL}$ in Flint, Detroit, and Michigan, 2011-19. Error bars indicate 95% confidence intervals and maybe contained within symbols.

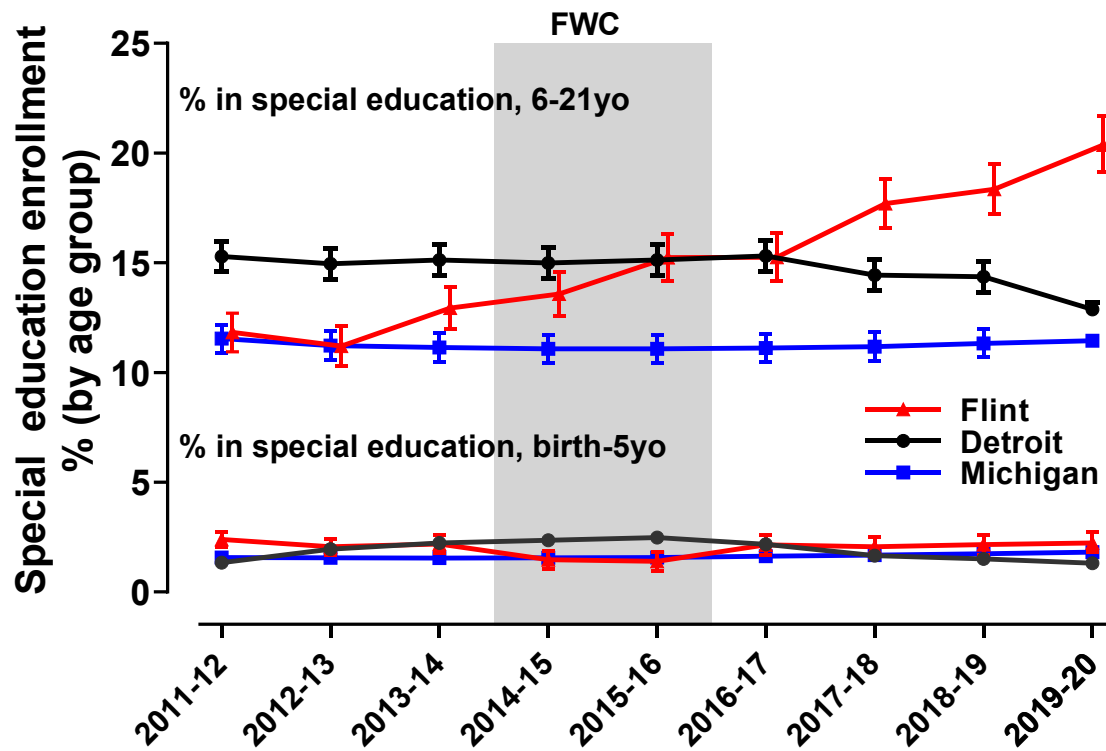


Fig. S2. Special education enrollment rate (by age groups) in Flint, Detroit, and Michigan, 2011-12 till 2019-20. Error bars indicate 95% confidence intervals and maybe contained within symbols.

Table S1. Representative national and local news headlines reporting lead poisoning in children or linking lead exposure to educational outcomes in Flint vs. Detroit, 2015-20.

Total resulting interactions and total followers receiving these headlines from public figures and groups on Facebook and sourced from CrowdTangle are also listed.

Month Year	Media outlet: Headline (Reference)	Total interactions	Total followers
FLINT			
Oct-15	The Guardian: 'We were paying to poison our kids': lead in Michigan city's water hits children (Felton, 2015)	5,450	236,093
Jan-16	TIME Magazine: (cover) "The Poisoning of an American City" (Sanburn, 2016)	31,034	11,531,720
Jan-16	Detroit Free Press: "Should Flint residents pay for lead-poisoned water?" (Egan, 2016)	4,246	345,045
Jan-16	The New York Times: "Flint Weighs Scope of Harm to Children Caused by Lead in Water" (Goodnough, 2016)	15,487	14,534,305
Jan-16	Al Jazeera: "Lead-Contaminated Water In Flint Probably Poisoned Thousands Of Children" (Al Jazeera, 2016)	216	0
Mar-16	Scientific American: "Flint's Lead-Tainted Water May Not Cause Permanent Brain Damage" (Shell, 2016a)	408	2,514,445
Jul-16	Scientific American: "The Brains of Flint's Children, Imperiled by Lead, Could Still Escape Damage" (Shell, 2016b)	181	2,607,589
Oct-16	Think Progress: "Families in Flint say there's a special education crisis that's about to get worse" Covert, 2016)	340	4,061
Feb-18	Detroit Free Press: "Sh-h-h. Snyder state update left out 75% drop in reading proficiency in Flint" (Riley, 2018)	3,168	208,228
Feb-18	The New Republic: "Did Flint's Water Crisis Damage Kids' Brains?" (Atkin, 2018)	1,221	510,702
Jul-18	The New York Times: "The Children of Flint Were Not 'Poisoned'" (Gomez and Dietrich, 2018)	7,861	2,915,046
Jul-18	The New York Times: "The Flint Children Were Indeed 'Poisoned'" (Clark and Filardo, 2018)	298	647,621
Aug-18	Michigan Radio: "Pediatrician says "poisoned" is an accurate description of what happened to Flint children" (Stateside Staff, 2018)	72	50,151
Jun-19	The Conversation: How the Flint water crisis set students back (Wood 2019)	550	69,786
Jul-19	The Washington Post: "The Flint water crisis set back thousands of students" (Strauss, 2019)	340	48,838

Aug-19	Detroit Metro Times: The number of Flint's students with special needs has increased by 56% since the water crisis, according to report (DeVito, 2019)	180,541	3,959,099
Aug-19	NBC Flint: "Learning disabilities, developmental problems increase amid Flint Water Crisis" (Spence, 2019)	201	23,180
Oct-19	Insider: 5 years into Flint's water crisis, a record number of local kids are struggling with learning disabilities — here are their stories (Ignaczak, 2019)	1,622	46,607,993
Nov-19	The New York Times: (front-page) "A Legacy of Poisoned Water: 'Damaged Kids' Fill Flint's Schools" and (online) "Flint's Children Suffer in Class After Years of Drinking the Lead-Poisoned Water" (Green, 2019)	92,095	26,274,554
Nov-19	The Detroit News: Flint weighs school closures as it grapples with special ed costs (Chambers, 2019)	669	248,684
Dec-19	Michigan Radio: "Exposed to lead in infancy, now Flint's youngest students face challenges in school" (Wells, 2019)	4,814	247,796
Dec-19	Detroit Free Press: Flint boy was suspended, sent home from school 50+ times. His mom blames water crisis. (Riley, 2019)	1,815	561,910
Dec-19	Michigan Radio: After 3 years, lawsuit over Flint schools' special needs crisis moving to trial (Wells, 2019)	702	63,736
Feb-20	WBUR: After Flint Water Crisis, Number Of Students With Special Education Needs Spikes (Mosley, 2020)	40,688	8,488,371
Mar-20	CBS 60 Minutes: "Early results from 174 Flint children exposed to lead during water crisis shows 80% of them will require special education services" (Alfonsi, 2020; TV Series Finale, 2020)	27,119; TV broadcast audience: 10,443,000	9,959,623
Mar-20	MLive: 80% of Flint kids tested need special services (Fonger, 2020)	8,899	806,234
Oct-20	MLive: Flint children exposed to lead suffer from dental problems, learning disabilities, other issues (Simpson-Mersha, 2020)	2,390	846,764
DETROIT			
Nov-17	Detroit News: Detroit kids' lead poisoning rates higher than Flint (MacDonald, 2017)	15,726	217,517
Nov-20	Detroit Metro Times: Lead poisoning endangers generations of Detroit children, with no end in sight (Neavling, 2020)	6,521	475,711

Table S2. Representative negative expectation commentaries of community leaders, teachers, parents and schoolchildren about lead exposure during the Flint Water Crisis period and educational difficulties for Flint and Detroit (arranged chronologically), 2015-21.

No.	Negative Expectation Commentary (Reference)
FLINT COMMUNITY LEADERS ON FLINT SCHOOLCHILDREN	
1	The FWC would “result in learning disabilities and the need for special education and mental health services and an increase in the juvenile justice system” – Flint Mayor (Office of Flint Mayor, 2015)
2	“In five years, these kids are going to have problems with special education. They're going to have cognition problems. Seven to 10 years, they're going to have behavioral problems” – Flint pediatrician (Monahan et al., 2016)
3	"There's real danger that the injury is going to be permanent and lifelong in them" [...] "Even low levels of lead -- especially if exposure to low levels continues over many months -- is going to cause some degree of brain damage to at least some of the children who have been exposed -- that's a big deal." – World-leading pediatrician and lead expert (Lapook, 2016)
4	“If you were going to put something in a population to keep them down for generations to come, it would be lead” – Flint pediatrician (Goodnough, 2016)
5	An “evolving, educational emergency,” [...] “Threat of significant disability” to “Flint's youngest students -- those not yet in school or the unborn” – Flint’s former public schools superintendent (House Democrats, 2016)
7	“When we see all over the TV about our toxic water in our hometown, it does something to you. It makes you fearful. What are they going to do to us next?” – Flint resident (The New Yorker, 2016)
8	“You know how hard it was to retrain own children, that they can’t turn on a faucet?” – Flint resident (The New Yorker, 2016)
6	“We know that this lead in our system, the amount of effects it’s going to have, is generational” – Director of local university’s early childhood development center (Felton, 2016)
9	“The crisis is also mentally damaging [...] The poisoned water supply is causing anxiety for residents who can't do basic, everyday water-related tasks without feeling paranoid.” – Flint resident (Counts, 2016)
10	“Water, has become the most lethal thing that they could...besides a bullet, these kids, and families, and seniors [could be] subjected to” – Flint resident (Flint Rising, 2016)

11	Flint [is] as a city “poisoned by lead” and recounted visiting a pastor who had hand wipes for congregants because they feared using their showers – Michigan’s then Attorney General (Livengood and Oosting, 2016)
12	Flint children, following their “prolonged exposure to lead” during the FWC, are “at risk of developing a disability, or already have a disability” and “face an unprecedented educational and civil rights disaster” – Class action lawsuit initial filing (D.R. v. Michigan Department of Education, 2016)
13	“There’s a special education crisis that’s about to get worse [due to the Flint Water Crisis]” – Complaint filed on behalf of Flint families (Covert, 2016)
14	“Many [individuals, especially children and youth] are interpreting the increased [national and worldwide] attention as an indicator that something much worse is unfolding that they have no power over” – Flint resident (Cuthbertson et al., 2016)
15	“They’ve already poisoned two generations of our family. What more can they take from us?” – Flint mother (Described and Captioned Media Program, 2017)
16	“The full effects of lead poisoning aren’t seen for five years. I’m waiting to see with my kids.” – Flint mother (Described and Captioned Media Program, 2017)
17	“What I see is hopelessness. [I am worried] that local kids would give up when lead’s symptoms surfaced, or even before” – Flint activist and former Mayoral candidate (Stillman, 2017)
18	“These kids are internalizing the messages about how the lead is affecting them” – Flint resident and director at a local university (Stillman, 2017)
19	“People are getting poisoned because you are not treating the water right” – Flint water researcher and first author of this article in documentary “Poisoned Water” (PBS NOVA, 2017)
20	“Lead poisoning = learning disabilities. It’s happening. A GENERATION is screwed because of incompetence.” – Flint resident and comic (Diener, 2018)
21	“They are killing us ... they killed us. We are an invisible people ... and we don’t matter.” – Senior Flint resident (Taylor, 2018)
22	“[Flint’s youngest children] are psychologically and emotionally built and equipped now to only drink bottled water” – Flint activist and former Mayoral candidate (Fonger et al., 2019)
23	“[My young nephews have] been taught to fear the water their whole lives” – Flint resident (Fonger et al., 2019)

24	“We don’t have quantitative data with respect to that yet, but we do know there will likely be some adverse effects based upon the water crisis on the educational outcomes of our youngsters” – Flint’s then school superintendent (Fonger et al., 2019)
25	“We have a school district where all that’s left are damaged kids who are being exposed to other damaged kids, and it’s causing more damage” - Flint school teacher for over 23 years (Green, 2019)
26	“The behavior issues, they’re way up. We never dealt with these behaviors.... [Previously] you might have one, two explosive kids in a couple years span. Now it’s widespread.” – Flint school teacher for over 20 years (Wells, 2019)
27	“We have just altered the life course trajectory of an entire generation of Flint children.” – Flint pediatrician (Smith, 2020)
28	“One out of five children in Flint schools require special education services, largely as a result of the crisis. ... The kids were very young when the water crisis occurred and who will carry with them for a lifetime some of the impact” – US Congressman, Flint (Fonger, 2020)
29	“We see a lot of anger in the younger ones” – Flint parent (Bosman and Greeson, 2020)
30	“It’s kind of to the point where I feel like my family is traumatized. We’re so screwed up in the head” – Flint parent (Bosman and Greeson, 2020)
31	“It’s been an upheaval in all aspects of life for me; and then, most people are like me ... Their houses are destroyed, their bodies are destroyed, their emotions, their mental health, their ability to learn, remember, retain.” – Flint resident and lead plaintiff on water lead lawsuits (Pierret, 2020)
32	“The emotional and mental toll from the crisis is something money can’t fix ... It’s almost like we got PTSD with the water because we don’t really drink it comfortably. Like, you know what I’m saying. When people actually lost their lives to it” – Flint resident (Sochocki and Owczarzak, 2020)
33	“The exposure to elevated lead is a tragic crisis that poses lifelong challenges and learning disadvantages for Flint families” – Flint pediatrician (Wisely, 2020)
34	“There needs to be something flagged, so say if my 9-year-old drank the water growing up has behavior issues...the cops have to remember the kids had behavior issues because of lead ... it’s really unfair” – Flint resident and director at a local university (Diaz, 2020)
35	“[A new \$20 million] juvenile detention center is going to make money off the fact that they poisoned these kids ... It’s gonna be bad.” – Flint activist (Diaz, 2020)
36	“[Special education] statistics have changed the way [our university’s] instructors train rising educators ... they must be prepared for classrooms where high numbers of

	students have special learning needs arising from lead exposure” – Chair of education department chair at local university that trains Flint school teachers (House, 2021)
37	“Because what Flint was, by and large, was this population-level trauma.” – Flint pediatrician (NPR, 2021)
38	“There may be no amount of money that would fully recognize the harm the residents of Flint have experienced, including their anxiety, fear, distrust, and anger over the events of last seven years.” - US federal judge approving \$641 million settlement in 2021 (Travis, 2021)
FLINT SCHOOLCHILDREN	
1	“Am I going to die?” - Flint 6th grader (Garcia, 2016)
2	The principal said, don’t wash your hand if you have a cut. – Flint child (The New Yorker, 2017)
3	“It’s depressing. I don’t think [the lead in Flint water situation] is ever going to change” – Flint 15 year old (May, 2016)
4	“Well, they said I’m not going to be smart anyway” – Flint boy “acting out” in school (Stillman, 2017)
5	“I think [official statements on the causes of the crisis are] all a lie. I think it’s genocide.” – Flint 11 th grader (Muhammad et al., 2018)
DETROIT COMMUNITY LEADERS ON DETROIT SCHOOL CHILDREN	
<i>Note: We could only find commentary on lead exposure in Detroit schoolchildren primarily during 2018-19, three years after the FWC was exposed, when Detroit tested their schools for lead and copper, found high levels, and switched to bottled water for one year until water filtration systems were installed.</i>	
1	“Although we have no evidence that there are elevated levels of copper or lead in our other schools where we are awaiting test results, out of an abundance of caution and concern for the safety of our students and employees, I am turning off all drinking water in our schools until a deeper and broader analysis can be conducted to determine the long-term solutions for all schools” – Detroit schools’ superintendent in August 2018 (Perkins, 2018)
2	“We have no reason to believe that any children have been harmed” – Detroit schools’ spokesperson in August 2018 (Reuters Staff, 2018)
3	“We completed our community meeting, and we’ve taken down recommendations [to switch to bottled water until water filtration systems are installed] and suggestions to make certain our kids are safe” – Detroit schools’ board member in September 2018 (Chambers, 2018)

4	“We are a baby Flint — or a Flint coming” – Detroit artist and parent in November 2018 (Nir, 2018)
5	“Up in Flint, Mich., the water is really poison. I hope it doesn’t get to that point in Detroit” – Detroit grandparent in November 2018 (Nir, 2018)
6	“The drinking water will be cold, it’ll be refreshing, [the students] can fill up a bottle and move it with them throughout the day” – Detroit schools’ superintendent in August 2019 after \$3 million in donations were used to install 500 filtration stations in all schools (Higgins, 2019)
DETROIT SCHOOLCHILDREN	
	No examples found.

Table S3. Geometric Mean (and 95% Confidence Interval, when available) of Blood Lead Levels in Flint, US, Canada, France, and Poland.

Location	Geometric Mean	Year and age group	Reference
Flint	1.87	2011; ≤ 5 years old	Gómez et al., 2018
Flint	1.19	2014 (worst FWC year); ≤ 5 years old	Gómez et al., 2018
US	0.81 (95% C.I.: 0.77-0.86)	2011-14; 1-5 years old	Tsoi et al., 2016
Canada	0.8	2012-13; 3-5 years old	Statistics Canada, 2015
France	1.49 (95% C.I.: 1.45-1.54)	2008-09; 1-6 years old	Rudnai, 2019
Poland	2.47 \pm 1.75	2013; 3-6 years old	Rudnai, 2019

Table S4. Raw values downloaded from CrowdTangle and used to plot network maps in Figure 5. (A) Total number of posts/weblinks shared on public Facebook pages of Michigan media with the keywords “lead poisoning”. (B) Total interactions (reactions, comments, and shares) on all such posts/weblinks for every media.

(A)	
News Media	Total number of posts/links shared
ABC12 (Flint)	9
WNEM (Flint)	9
The Flint Journal	8
Detroit Free Press	8
The Detroit News	7
Mlive	6
FOX17	6
WKZO	6
(B)	
News Media	Total Facebook interactions
Detroit Free Press	15,064
The Detroit news	9,677
MLive	9,069
ABC12 (Flint)	1,283
FOX17	1,090
The Flint Journal	1,011
WNEM (Flint)	691

Text S1

Potential FWC covariates that could explain rising special education enrollment

Waterborne contaminants besides lead

Besides lead, *Escherichia coli* bacteria, *Legionella pneumophila* bacteria, total trihalomethane chemicals, and iron were elevated at different time periods during the FWC causing boil water advisories (*E. coli*), discolored and smelly water (iron and possibly organic matter), and a Legionnaire's Disease outbreak (*Legionella pneumophila*) (Masten et al., 2016; Rhoads et al., 2017; Roy & Edwards, 2019a; Roy & Edwards, 2019b). However, none of these chemicals are associated with learning difficulties in the literature. No other regulated contaminants that are routinely monitored were at or above Safe Drinking Water Act regulations in our suite of inorganic and organic contaminant analytes collected citywide in August-September 2015 (Roy & Edwards, 2019b).

Poverty and nutrition

Poverty and poor nutrition were suggested as possible contributors to learning disabilities in Flint children affected by the FWC (Simpson-Mersha, 2020). Poverty rates (Figure S3a) were stable and similar in Flint and Detroit during the FWC years (range = 39.8-41.6%) before declining in both cities. The rate of households with children ages 0-18 years on food assistance (i.e., on US Supplemental Nutrition Assistance Program) in Flint, Detroit and Michigan decreased overall during 2011-19 (Figure 3b) and overlapped during the FWC years (range = 46.2-48.6%). The food assistance rates dropped thereafter for Detroit and Michigan, but increased slightly in Flint during 2016-18, likely due to the expanded state and federal assistance as part of the FWC emergency response (Golzynski, 2017; USDA, 2016).

City administration and emergency management decisions

Flint had four state-appointed emergency managers in 2011-15 (Goodin-Smith, 2018) when the decision was made to switch its water source. However, we cannot find any evidence that the managers made any financial or policy decisions affecting special education in Flint schools.

Flint public schools' policies and funding

The special education policies, procedures and programs in Flint Community Schools (FCS) have not changed for at least a decade, but the school district has operated at a severe budget deficit (e.g., \$67 million in 2011) since the Great Recession (Zinnes et al., 2020), and has "closed schools, fired teachers, outsourced employees and sold buildings" to erase the deficit (Adams, 2015). A 2016 class lawsuit alleged FCS schools, Genesee Intermediate School District, and Michigan Department of Education "committed ongoing and systemic violations" of federal and state special education laws and "failed to provide required special education [...] services to qualifying students" pre-FWC, which the agencies denied before settling for \$626.25 million (Brown, 2020; D.R. v. Michigan Department of Education, 2016; LeBlanc, 2020). FCS is currently offsetting its funding shortfall with, among other sources, \$9 million for special education from the class action settlement (LeBlanc, 2020), doubling of routine special education

funding to \$114 million by successfully arguing the special education funding calculation formula was unfair to Flint and highlighting their rising special education enrollment (East Village Magazine, 2020; Flint Community Schools, 2020), and \$114 million from a COVID-19 relief bill (Keefer, 2021).

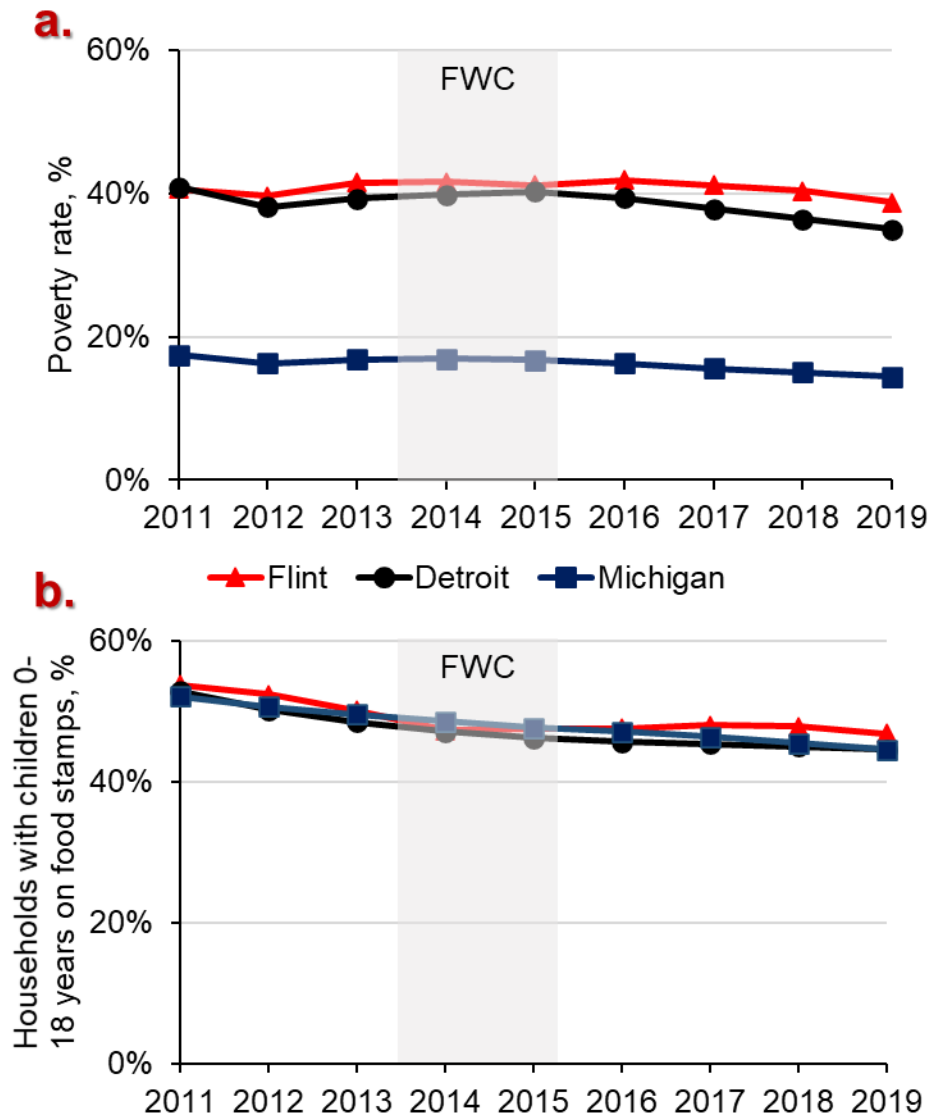


Fig. S3. (A) Poverty Rate and (B) Households with children ages 0-18 years receiving food assistance (Supplemental Nutritional Assistance Program) in Flint, Detroit and Michigan, 2011-19 (or latest available). Data from American Community Survey 5-Year Estimates Data Profiles (US Census, 2022).

Text S2

Analysis of special education outcomes covered under the Individuals with Disabilities Educational Improvement Act (IDEA) in Flint, Detroit, and Michigan

Of 29 special education indicators (30 indicators, including special education enrollment) measured annually under the Individuals with Disabilities Educational Improvement Act (Part B) in the 2011-2020 time period of study, there are 23 indicators with data available for Flint, Detroit, and Michigan at www.mischooldata.org (Table S5). The definitions for each educational outcome are available elsewhere (Michigan Department of Education, 2016; Michigan Department of Education, 2021).

Herein we defined “worsened” as a change in a manner that might superficially suggest brain damage to children from water lead exposure pre-FWC versus post-FWC, whereas “improved” is a change in the opposing direction. Visual examination of all 23 indicators (see Figures S4-S22) in Flint before versus after the Flint Water Crisis indicates that 9 improved, 5 stayed roughly the same ($\pm 1\%$ change), and another 9 worsened.

After considering simple control comparisons between trends in Flint versus the control City of Detroit, 3 of the 9 parameters related to student performance were worse post-FWC versus pre-FWC. Those 3 included special education enrollment rate, dropout rate, and suspension/expulsion rate. Likewise, 3 of 23 indicators (graduation rate, percentage of 3-5 year preschoolers receiving majority of services in a regular early childhood program, and percentage of 3-5 year preschoolers receiving majority of services in separate facilities) improved in Flint after the crisis relative to Detroit.

Thus, overall, an equal number of special education outcomes improved or worsened post-FWC versus pre-FWC, when considering trends in Flint alone, and Flint relative to the control city of Detroit.

The three parameters that we identified as worsening in Flint relative to the control City of Detroit are the same three parameters emphasized in the ACLU lawsuit (D.R. v. Michigan Department of Education, 2016). Media coverage has emphasized those same three parameters, plus the change in 3rd grade reading proficiency which did worsen in Flint but also worsened in the control city of Detroit. We can find no mention of any educational parameters that did not worsen in Flint in either the lawsuit or in media coverage.

Our paper more closely examines the 4 educational outcome changes that have been emphasized as worsening in Flint by the media, to imply evidence of brain damage that arose from water lead exposure.

Table S5. Crude comparison of special education outcomes before and after the FWC (roughly, 2014-15 to 2015-16 academic year). Indicators in Flint that were worse post-FWC than pre-FWC and worse than Detroit are underlined; conversely, indicators that improved on both criteria are italicized.

No.	Serial*	Special Education Outcome	Flint Post-FWC vis-à-vis Pre-FWC	Flint vis-à-vis Detroit Post-FWC	Figure/Notes
1	N/A	<u>Special Education Enrollment</u>	<u>Worsened</u>	<u>Worsened</u>	In manuscript: Figure 1a
2	1	<i>Graduation Rate</i>	<i>Improved</i>	<i>Improved</i>	Figure S4
3	2	<u>Dropout Rate</u>	<u>Worsened</u>	<u>Worsened</u>	Figure S4 (in manuscript: Figure 1f)
4	3B	Participation Rate for Math	No change	Improved	Figure S5
5	3B	Participation Rate for English Language Arts	No change	Improved	Figure S5
6	3C	Proficiency Rate of Math	Worsened ^{&}	Improved	Figure S6
7	3C	Proficiency Rate for English Language Arts	Worsened ^{&}	Improved	Figure S6
8	4A	<u>Suspension/Expulsion</u>	<u>Worsened</u>	<u>Worsened</u>	In manuscript: Figure 1e
9	4B	Suspension/Expulsion by Ethnicity	Not enough data [#]	Not enough data [#]	--
10	5A	Educational Environment: In regular class 80% or more of the day	Worsened	Improved	Figure S7
11	5B	Educational Environment: In regular class 40% or less of the day	Improved	No change	Figure S8
12	5C	Educational Environment: Served in separate facilities	Worsened (but within compliance)	Improved	Figure S9
13	6A	<i>Preschool Educational Environment: % age 3-5 receiving majority of services in a regular early childhood program</i>	<i>Improved</i>	<i>Improved</i>	Figure S10
14	6B	<i>Preschool Educational Environment: % age 3-5 with an IEP in a separate special</i>	<i>Improved</i>	<i>Improved</i>	Figure S11

		<i>education class, separate school or residential facility</i>			
15	7A1	Preschool Positive Social-Emotional Skills: Of those who entered or exited below age expectations, % who substantially increased rate of growth by age 6 or exit	Improved	No change	Figure S12
16	7A2	Preschool Positive Social-Emotional Skills: % functioning within age expectations by age 6 or exit	Improved	Worsened (but in compliance)	Figure S13
17	7B1	Preschool Acquisition and Use of Knowledge and Skills: Of those who entered or exited below age expectations, % who substantially increased rate of growth by age 6 or exit	Improved	No change	Figure S14
18	7B2	Preschool Acquisition and Use of Knowledge and Skills: % functioning within age expectations by age 6 or exit	No change	Worsened	Figure S15
19	7C1	Preschool Use of Appropriate Behaviors to Meet Their Needs: Of those who entered or exited below age expectations, % who substantially increased rate of growth by age 6 or exit	Improved	No change	Figure S16
20	7C2	Preschool Use of Appropriate Behaviors to Meet Their Needs: % functioning within age expectations by age 6 or exit	Improved	Worsened (but in compliance)	Figure S17
21	8	<u>Facilitated Parent Involvement (ages 3-5) (unrelated to student performance)</u>	<u>Worsened</u>	<u>Worsened</u>	Figure S18
22	8	Facilitated Parent Involvement (ages 6-21)	Not enough data [#]	Not enough data [#]	Figure S19
23	9	Disproportionate Representation – Child with a Disability	Not enough data [#]	Not enough data [#]	--
24	10	Disproportionate Representation – Eligibility Categories	Not enough data [#]	Not enough data [#]	--
25	11	Child Find	No change	No change	Figure S20
26	12	Early Childhood Transition	Worsened	Improved	Figure S21

27	13	Secondary Transition	No change	Improved	Figure S22
28-30	14A-14C	Postsecondary Outcomes	Not enough data [#]	Not enough data [#]	--

* Official indicator number as categorized under Individuals with Disabilities Educational Improvement Act & Introduction of a new policy that caps the proportion of children counted as proficient at 1% (Michigan Department of Education, 2016).

[#] on the web portal <https://mischooldata.org/selected-indicator-reports/>

Note: The Post-FWC vs. Pre-FWC comparison is made between the last and first academic years for which data is available. Similarly, the Flint vs. Detroit comparison post-FWC is made for the latest academic year for which data is available for both cities.

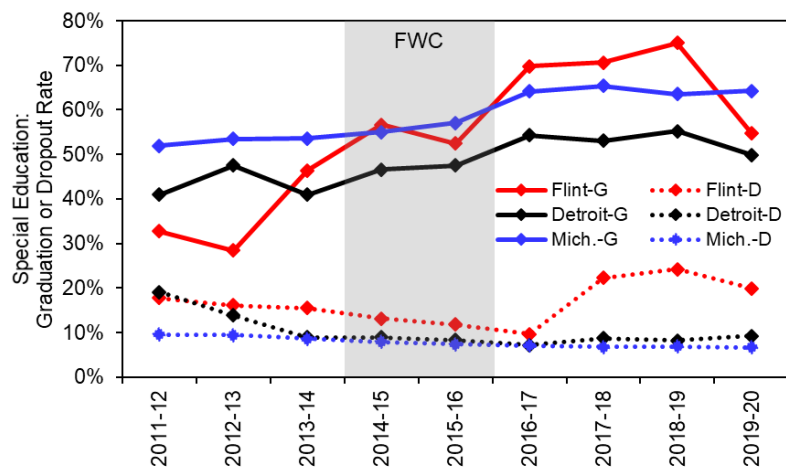


Fig. S4. Graduation and Dropout Rate. State targets: Graduation $\geq 80\%$; Dropout $\leq 8.0-9.5\%$.

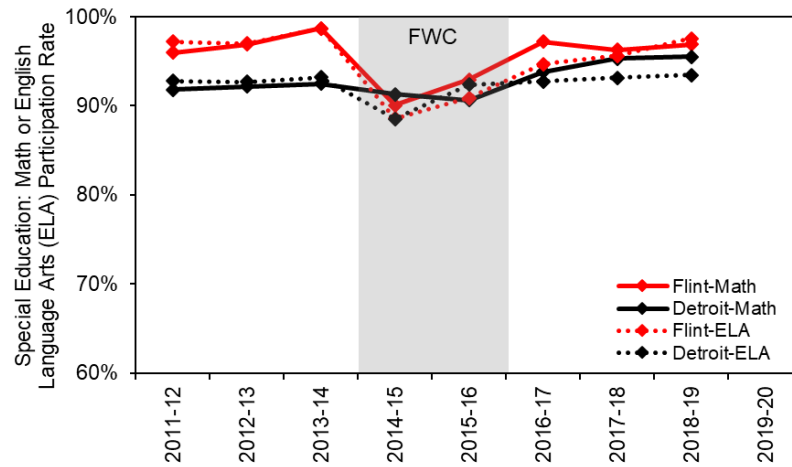


Fig. S5. Participation Rate for Math and English Language Arts. State target: $\geq 95\%$.

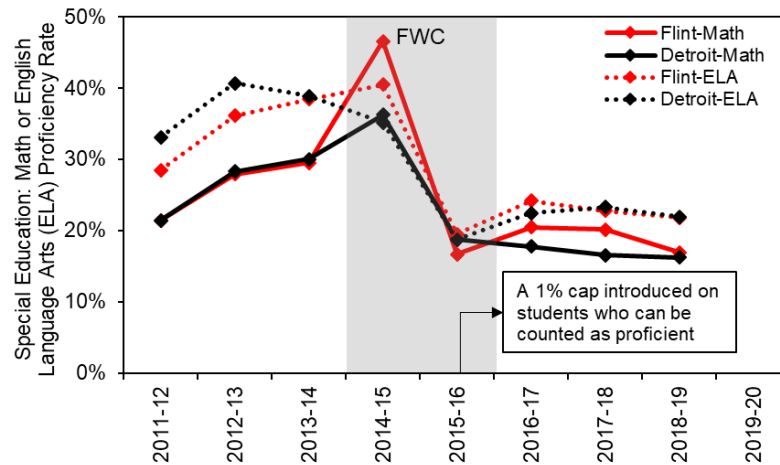


Fig. S6. Proficiency Rate for Math and English Language Arts. State assessments were suspended after Michigan public schools closed in March 2020 due to Covid-19. Thus, assessment data are not available for 2019-20.

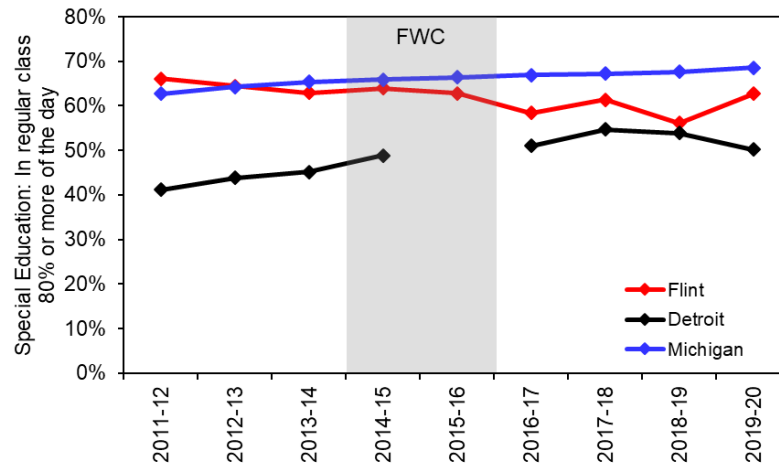


Fig. S7. Special education students spending time in general education classes 80% or more each day. State target: ≥ 63 -64.25%.

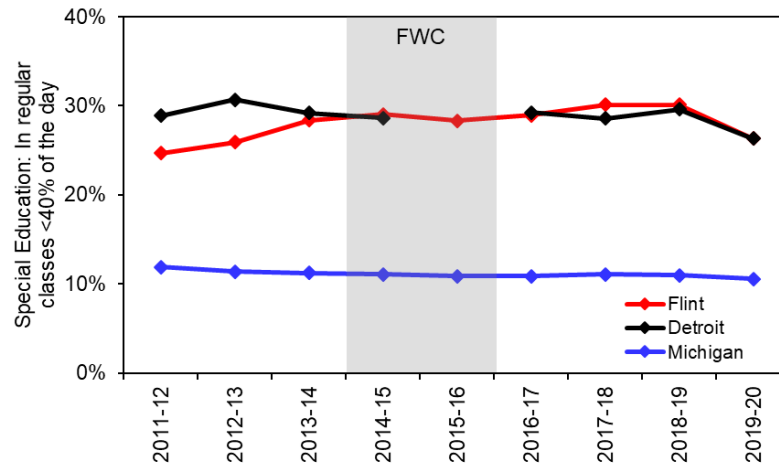


Fig. S8. Special education students spending time in general education classes less than 40% of the day. State target: ≤ 11.4 -11.9%.

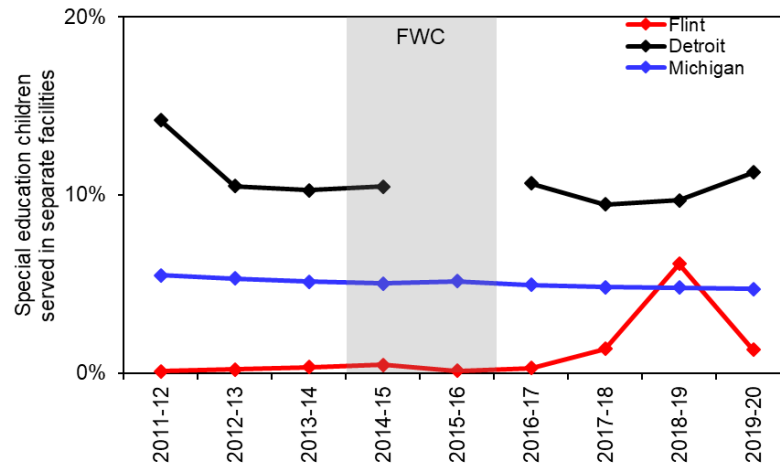


Fig. S9. Special education students being served in separate facilities. State target: ≤ 4.8 -5.5%. Flint met this target for all years except 2018-19.

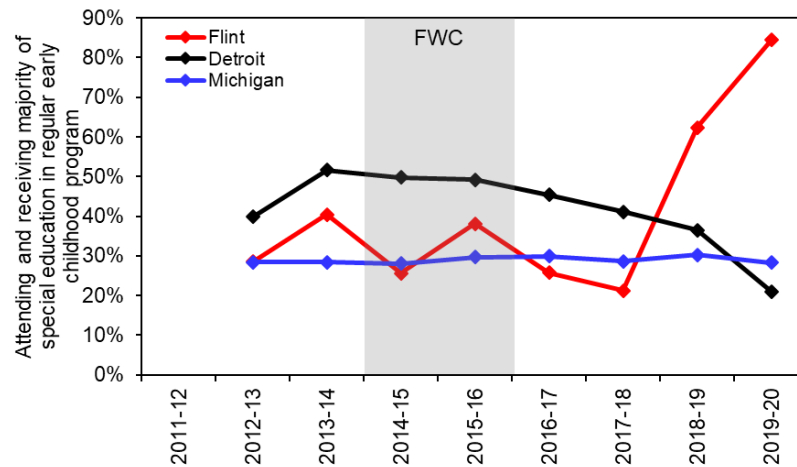


Fig. S10. Preschool Educational Environment: % age 3-5 receiving majority of services in a regular early childhood program. State target: ≥ 28.2 -28.8%.

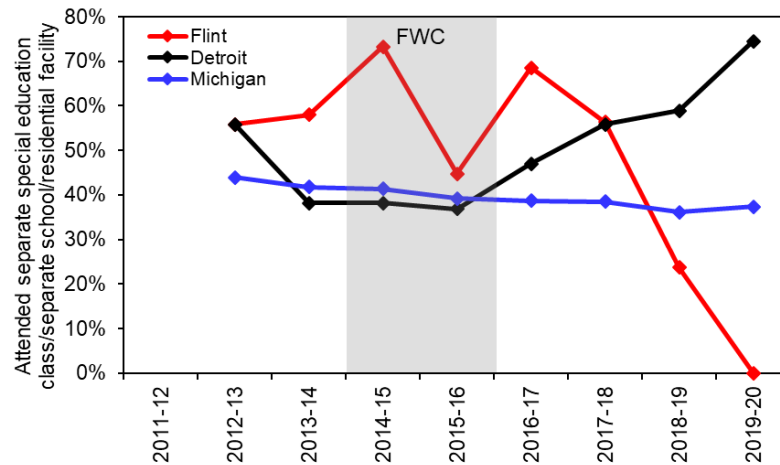


Fig. S11. Preschool Educational Environment: % age 3-5 with an IEP in a separate special education class, separate school or residential facility. State target: <=41-43.2%.

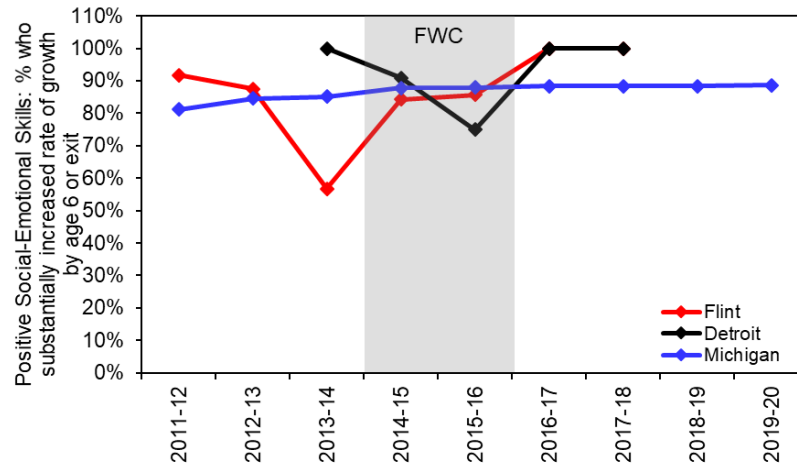


Fig. S12. Positive Social-Emotional Skills (incl. social relationships): Of those who entered or exited below age expectations, % who substantially increased rate of growth by age 6 or exit. State target $\geq 86-88\%$.

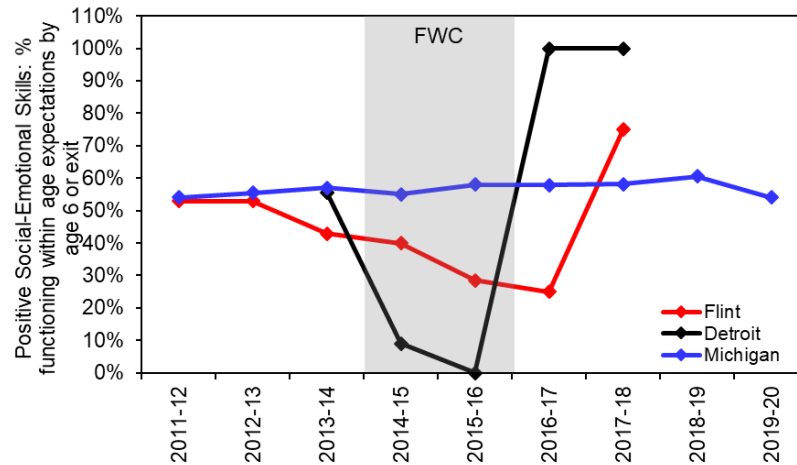


Fig. S13. Positive Social-Emotional Skills (including social relationships): % functioning within age expectations by age 6 or exit. State target: ≥ 54.9 -61%.

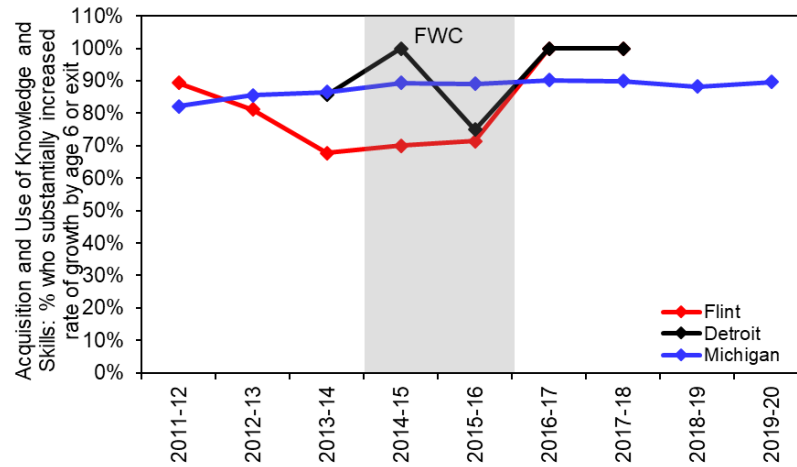


Fig. S14. Acquisition and Use of Knowledge and Skills: % who substantially increased rate of growth by age 6 or exit. State target: >87-89%.

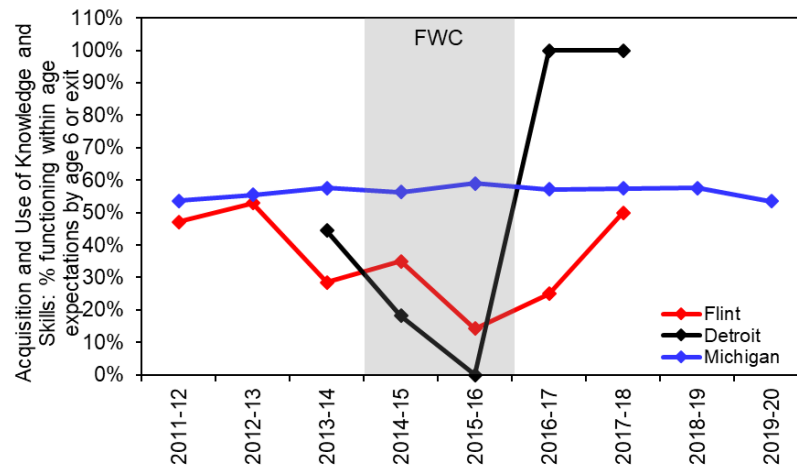


Fig. S15. Acquisition and Use of Knowledge and Skills: % functioning within age expectations by age 6 or exit. State target: $\geq 56-59\%$.

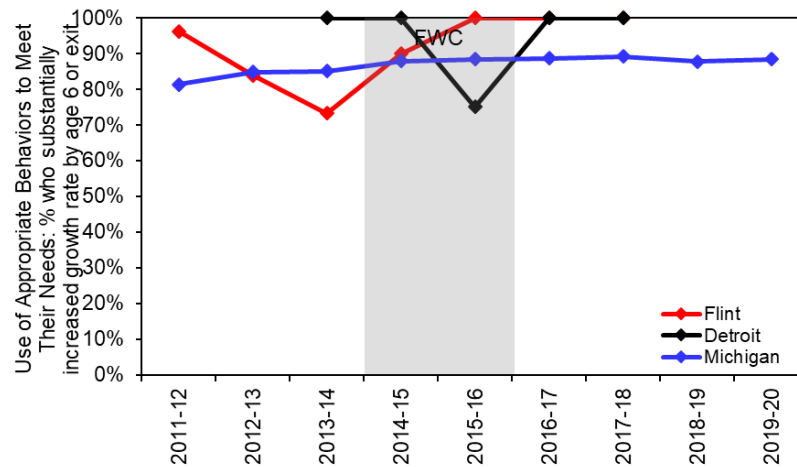


Fig. S16. Use of Appropriate Behaviors to Meet Their Needs: % who substantially increased rate of growth by age 6 or exit. State target: $\geq 86-89\%$.

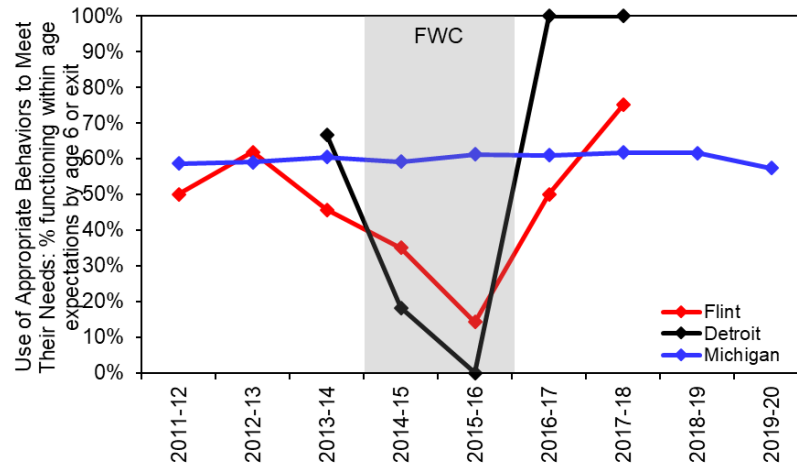


Fig. S17. Use of Appropriate Behaviors to Meet Their Needs: % functioning within age expectations by age 6 or exit. State target: >59.1-73%.

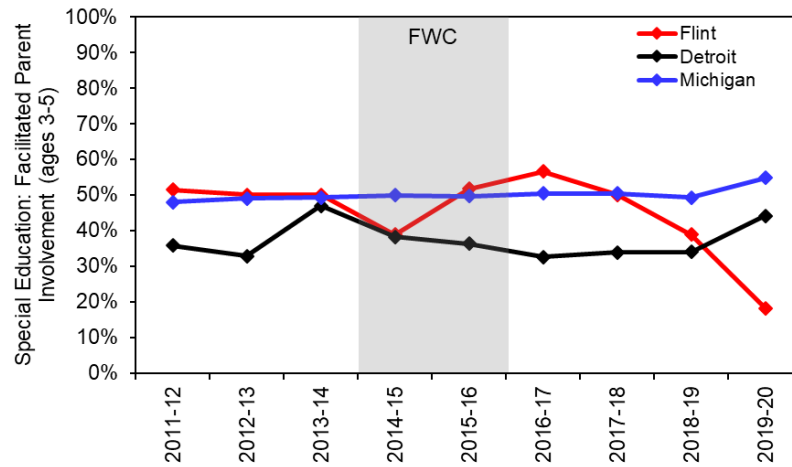


Fig. S18. Facilitated Parent Involvement for ages 3-5. State target: ≥ 35.5 -47.5%.

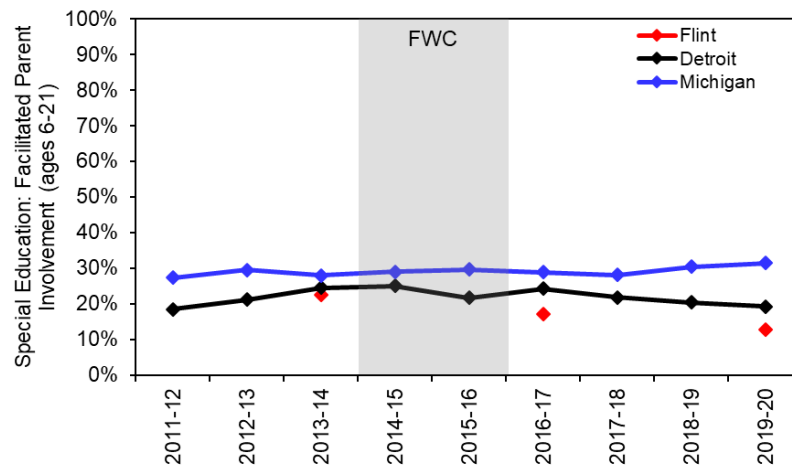


Fig. S19. Facilitated Parent Involvement for ages 6-21. State target: $\geq 22-26.8\%$.

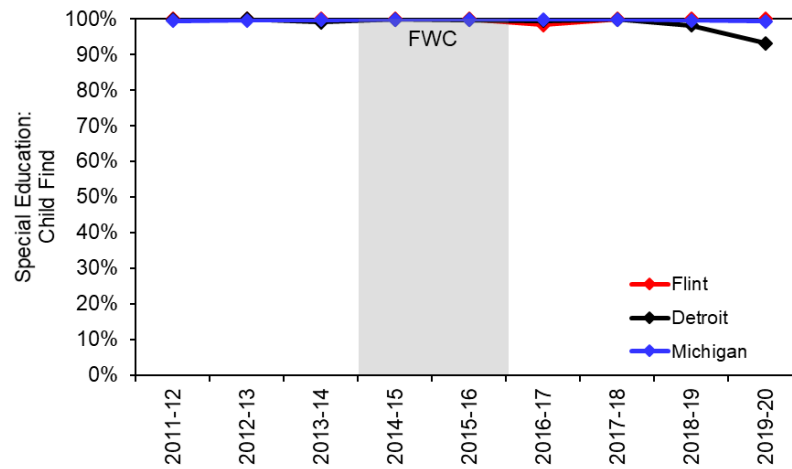


Fig. S20. Child Find. State target: 100%.

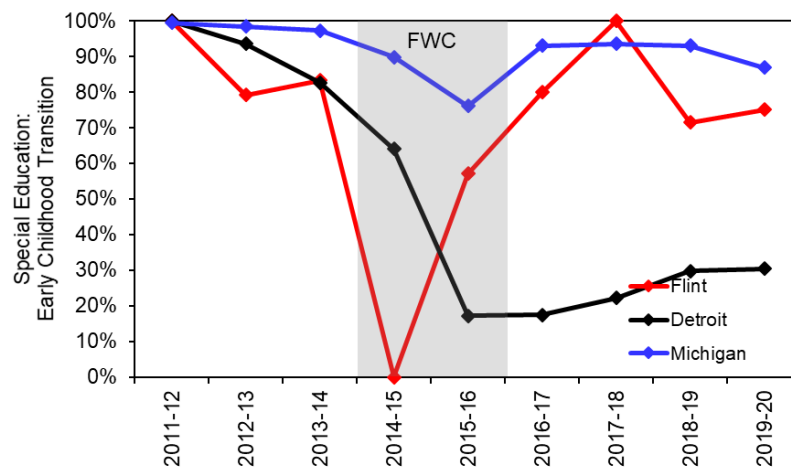


Fig. S21. Early Childhood Transition. State target: 100%.

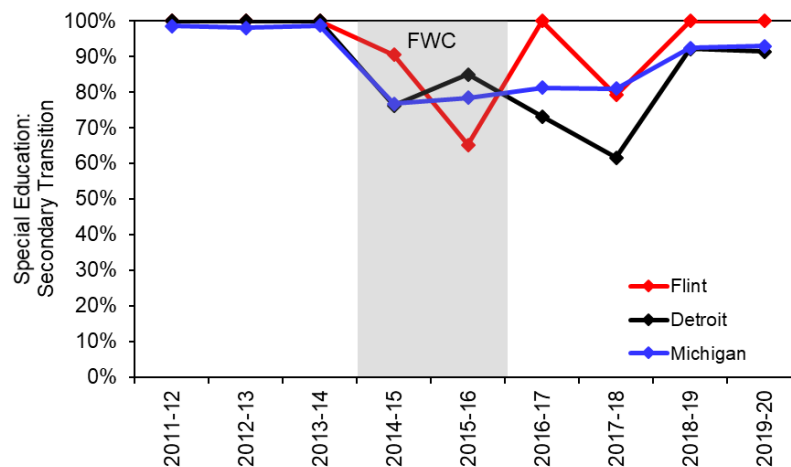


Fig. S22. Secondary Transition. State target: 100%.

References:

- Adams, D. (2015). Michigan special education group sues Flint School District for public records. *MLive*. Available at: https://www.mlive.com/news/flint/2015/03/statewide_special_ed_advocacy.html Published March 2015. Accessed July 04, 2021.
- Al Jazeera. Lead-Contaminated Water In Flint Probably Poisoned Thousands Of Children. YouTube. <https://www.youtube.com/watch?v=80z1v8oGjME> Published January 2016. Accessed June 21, 2020
- Alfonsi S. Early results from 174 Flint children exposed to lead during water crisis shows 80% of them will require special education services. CBS News 60 Minutes. <https://www.cbsnews.com/news/flint-water-crisis-effect-on-children-60-minutes-2020-03-15/> Published March 2020. Accessed June 21, 2020
- Atkin E. Did Flint's Water Crisis Damage Kids' Brains? The New Republic. <https://newrepublic.com/article/147066/flints-water-crisis-damage-kids-brains> Published February 2018. Accessed June 21, 2020
- Bosman J, Greeson B. 'Double Challenge Mode' in Flint, Where Virus Follows Water Crisis. The New York Times. <https://www.nytimes.com/interactive/2020/08/18/us/flint-coronavirus.html> Published August 2020. Accessed September 27, 2020
- Brown, J. (2020). It took a lawsuit to get my special needs son the help he requires. *Detroit Free Press*. Available at: <https://www.freep.com/story/opinion/contributors/2020/09/10/flint-lawsuit-settlement-special-needs/5751595002/> Published September 2020. Accessed September 21, 2021.
- Chambers J. More than half of Detroit's schools have tainted water from lead, copper. Detroit News. <https://www.detroitnews.com/story/news/education/2018/09/19/detroit-schools-have-tainted-water-lead-copper/1358767002/> Published September 2018. Accessed September 22, 2021
- Chambers J. Flint weighs school closures as it grapples with special ed costs. The Detroit News. <https://www.detroitnews.com/story/news/education/2019/11/19/flint-weighs-school-closures-grapples-special-ed-costs/3921929002/> Published November 2019. Accessed September 27, 2020
- Clark A, Filardo TW. 2018. The Flint Children Were Indeed 'Poisoned' The New York Times. <https://www.nytimes.com/2018/07/27/opinion/letters/flint-children-lead.html> Published July 2018. Accessed June 21, 2020
- Counts J. Faces of Flint: Carlos Young. Mlive. https://www.mlive.com/news/page/faces_of_flint_carlos_young.html Published May 2016. Accessed September 22, 2021
- Covert B. Families in Flint say there's a special education crisis that's about to get worse. Think Progress. <https://thinkprogress.org/flint-lawsuit-education-33a133bdc1a0/> Published October 2016. Accessed June 21, 2020
- Cuthbertson CA, Newkirk C, Ilardo J, Loveridge S, Skidmore M. Angry, Scared, and Unsure: Mental Health Consequences of Contaminated Water in Flint, Michigan. *J Urban Health*. 2016;93(6):899-908. doi:10.1007/s11524-016-0089-y
- Described and Captioned Media Program. From Flint: Voices of a Poisoned City. <https://dcmp.org/media/11330-from-flint-voices-of-a-poisoned-city> Published 2017. Accessed June 21, 2020
- DeVito L. The number of Flint's students with special needs has increased by 56% since the water crisis, according to report. Detroit Metro Times. <https://www.metrotimes.com/news-hits/archives/2019/08/28/the-number-of-flints-special-needs-students-has-increased-by-56-since-the-water-crisis-according-to-report> Published August 2019. Accessed September 27, 2020
- Diaz A. What should justice look like for Flint after the water crisis? Residents weigh in. Great Lakes Now. <https://www.greatlakesnow.org/2020/12/what-should-justice-look-like-for-flint-after-the-water-crisis-residents-weigh-in/> Published December 2020. Accessed September 22, 2021
- Diener J. I've lived near or in Flint most of my life. Twitter. <https://twitter.com/jonodiener/status/962070201272422405> Published February 2018. Accessed June 21, 2020

DR v. MICHIGAN DEPARTMENT OF EDUCATION. No. 2: 16-cv-13694. Available at: https://www.aclumich.org/sites/default/files/Flint_Schools_Final_Complaint.pdf Published October 2016. Accessed July 4, 2021.

East Village Magazine. (2020). Flint Community Schools move toward pursuit of special education funding. *East Village Magazine*. Available at: <https://www.eastvillagemagazine.org/2020/12/03/flint-community-of-schools-move-toward-pursuit-of-special-education-funding/> Published December 2020. Accessed September 21, 2021.

Egan P. Should Flint residents pay for lead-poisoned water? Detroit Free Press. <https://www.freep.com/story/news/local/michigan/2016/01/11/should-flint-residents-pay-lead-poisoned-water/78643368/> Published January 2016. Accessed September 19, 2021

Felton R. 'It's affected everybody': Flint children on the frontline of the water crisis. The Guardian. <https://www.theguardian.com/us-news/2016/mar/24/flint-children-water-crisis-lack-of-data-lead> Published March 2016. Accessed June 21, 2020

Felton R. 'We were paying to poison our kids': lead in Michigan city's water hits children. The Guardian. <https://www.theguardian.com/us-news/2015/oct/04/flint-michigan-lead-water-children-health> Published October 2015. Accessed September 19, 2021

Flint Community Schools. (2020). Statement of Plan Objections Re: GISD – Special Education Mandatory Plan. Objection to the Blended Student Count Formula. *Flint Community Schools*. Available at: <https://www.scribd.com/document/446802526/GISD-SpEd-Mandatory-Plan-Objection-Department-of-Education> Published February 2020. Accessed July 04, 2021.

Flint Rising. Cindy Cromwell. YouTube. <https://www.youtube.com/watch?v=JGs8GjF4gkg&t=14s> Published May 2016. Accessed September 22, 2021

Fonger R, Acosta R, Ahmad Z. It's been 5 years. Flint still doesn't trust the water. MLive. <https://www.mlive.com/news/2019/04/its-been-5-years-flint-still-doesnt-trust-the-water.html> Published April 2019. Accessed June 21, 2020

Fonger R. 80% of Flint kids tested need special services. Mlive. <https://www.mlive.com/news/flint/2020/03/dr-mona-tells-60-minutes-80-of-flint-kids-tested-need-special-services.html> Published March 2020. Accessed September 27, 2020

Fonger R. Kildee asks for \$110 million for Flint schools, registry, water reconnections. Mlive. <https://www.mlive.com/news/flint/2020/04/kildee-asks-for-110-million-for-flint-schools-registry-water-reconnections.html> Published April 2020. Accessed June 21, 2020

Garcia LE. When a Student Asks: Am I Going to Die? Lily's Blackboard. <http://lilysblackboard.org/2016/02/when-a-student-asks-am-i-going-to-die/> Published February 2016. Accessed June 21, 2020

Golzynski, D. (2017). Nutrition and the Flint Water Crisis. *ASPHN*. <https://asphn.org/wp-content/uploads/2017/09/Nutrition-and-the-Flint-Water-Crisis.pdf> Published September 2017. Accessed July 04, 2021.

Gomez H, Dietrich K. The Children of Flint Were Not 'Poisoned' The New York Times. <https://www.nytimes.com/2018/07/22/opinion/flint-lead-poisoning-water.html> Published July 2018. Accessed June 21, 2020

Gómez HF, Borgialli DA, Sharman M, Shah KK, Scolpino AJ, Oleske JM, Bogden JD. Blood lead levels of children in Flint, Michigan: 2006-2016. *The Journal of pediatrics*. 2018 Jun 1;197:158-64.

Goodin-Smith, O. (2018). Flint's history of emergency management and how it got to financial freedom. *MLive*. Available at https://www.mlive.com/news/flint/2018/01/city_of_the_state_flints_histo.html Published January 2018. Accessed July 04, 2021.

Goodnough A. Flint Weighs Scope of Harm to Children Caused by Lead in Water. The New York Times. <https://www.nytimes.com/2016/01/30/us/flint-weighs-scope-of-harm-to-children-caused-by-lead-in-water.html> Published January 2016. Accessed June 21, 2020

Green EL. Flint's Children Suffer in Class After Years of Drinking the Lead-Poisoned Water. The New York Times. <https://www.nytimes.com/2019/11/06/us/politics/flint-michigan-schools.html> Published November 2019. Accessed June 21, 2020

Higgins L. After a year, drinking water is flowing again in Detroit district schools. Detroit Chalkbeat. <https://detroit.chalkbeat.org/2019/8/28/21108789/after-a-year-drinking-water-is-flowing-again-in-detroit-district-schools> Published August 2019. Accessed September 22, 2021

House Democrats. House Democrats Hold Hearing: 'The Flint Water Crisis: Lessons for Protecting America's Children.' YouTube. https://www.youtube.com/watch?v=1fGFC_IwSm8 Published February 2016. Accessed June 21, 2020

House K. Flint residents unimpressed by Snyder charges linked to lead exposure. Michigan Radio. <https://www.michiganradio.org/environment-science/2021-01-14/flint-residents-unimpressed-by-snyder-charges-linked-to-lead-exposure> Published January 2021. Accessed September 22, 2021

Ignaczak NM. 5 years into Flint's water crisis, a record number of local kids are struggling with learning disabilities — here are their stories. Insider. <https://www.insider.com/flint-children-struggle-with-learning-disabilities-following-water-crisis-2019-10> Published October 2019. Accessed September 27, 2020

Keefer, W. (2021). Flint schools will receive \$114M – or \$36,000 per student – from COVID-19 relief bill. *MLive*. Available at: <https://www.mlive.com/news/flint/2021/03/flint-schools-will-receive-114m-or-36000-per-student-from-covid-19-relief-bill.html> Published March 2021. Accessed July 04, 2021.

Lapook J. Doctors explain the long-term health effects of Flint water crisis. CBS News. <https://www.cbsnews.com/news/doctors-explain-the-long-term-health-effects-of-flint-water-crisis/> Published January 2016. Accessed September 22, 2022

LeBlanc, B. (2020). Whitmer OKs creation of \$641M fund for Flint water crisis settlement. *Detroit News*. Available at: <https://www.detroitnews.com/story/news/local/michigan/2020/12/30/whitmer-oks-creation-641-m-fund-flint-water-crisis-settlement/4090843001/> Published December 2020. Accessed July 04, 2021.

Livengood C, Oosting J. Schuette vows justice for Flint at convention. The Detroit News. <https://www.detroitnews.com/story/news/politics/2016/07/18/schuette-flint-bailiffs-justice/87258486/> Published July 2016. Accessed September 22, 2021.

MacDonald C. Detroit kids' lead poisoning rates higher than Flint. Detroit News. <https://www.detroitnews.com/story/news/local/detroit-city/2017/11/14/lead-poisoning-children-detroit/107683688/> Published November 2017. Accessed September 20, 2021

Masten, S.J., Davies, S.H., & McElmurry, S.P. (2016). Flint water crisis: what happened and why?. *Journal-American Water Works Association*. 2016 Dec;108(12):22-34.

May J. Still standing: 100 Flint residents dealing with the daily pain of a poisoned water system. *MLive*. https://www.mlive.com/news/flint/2016/05/still_standing_100_flint_resid.html#2 Published May 2016. Accessed June 21, 2020

Michigan Department of Education. 1% MI-Access Proficiency Cap & Exceptions. Available at: https://www.michigan.gov/documents/mde/MI-Access_Cap_Exception_Information_459065_7_516453_7.pdf Published 2016. Accessed July 4, 2021.

Michigan Department of Education. Michigan's FFY 2019 Annual Performance Report At-a-Glance. Available at: https://www.michigan.gov/documents/mde/APR_Glance_571653_7.pdf Published April 2021. Accessed July 4, 2021.

Monahan K, Rappleye H, Gosk S, Sandler T. Internal Email: Michigan 'Blowing Off' Flint Over Lead in Water. NBC News. <https://www.nbcnews.com/storyline/flint-water-crisis/internal-email-michigan-blowing-flint-over-lead-water-n491481> Published January 2016. Accessed June 21, 2020

Mosley T. After Flint Water Crisis, Number Of Students With Special Education Needs Spikes. WBUR. <https://www.wbur.org/hereandnow/2020/02/05/flint-water-students-special-needs> Published February 2020. Accessed September 27, 2020

Muhammad M, De Loney EH, Brooks CL, Assari S, Robinson D, Caldwell CH. "I think that's all a lie...I think It's genocide": Applying a Critical Race Praxis to Youth Perceptions of Flint Water Contamination. *Ethn Dis*. 2018;28(Suppl 1):241-246. doi:10.18865/ed.28.S1.241

Neavling S. Lead poisoning endangers generations of Detroit children, with no end in sight. Metro Times. <https://www.metrotimes.com/detroit/lead-poisoning-endangers-generations-of-detroit-children-with-no-end-in-sight/Content?oid=25809555> Published November 2020. Accessed September 20, 2021

Nir SM. Not Far From Flint, Contamination Has Left Detroit School Taps Dry. The New York Times. <https://www.nytimes.com/2018/11/15/us/detroit-schools-water-lead-contamination.html> Published November 2018. Accessed September 22, 2021

NPR. Pediatrician Who Spotlit Lead In Flint Water Weighs In On Crisis. NPR. <https://www.npr.org/2021/01/14/956705090/pediatrician-who-spotlighted-lead-in-flint-water-weighs-in-on-crisis> Published January 2021. Accessed September 22, 2021

Office of Flint Mayor. Declaration of State of Emergency. Office of Flint Mayor. http://media.mlive.com/newsnow_impact/other/Read%20of%20Emergency%20declaration.pdf Published December 2015. Accessed June 21, 2020

PBS NOVA. Poisoned Water. PBS NOVA. https://www.youtube.com/watch?v=r_S8eNqBnaA Published May 2017. Accessed October 5, 2021

Perkins T. Detroit public schools shut off water after discovering elevated lead and copper levels. Detroit Metro Times. <https://www.metrotimes.com/news-hits/archives/2018/08/29/detroit-public-schools-shut-off-water-after-discovering-elevated-lead-and-copper-levels> Published August 2018. Accessed September 22, 2021

Pierret A. Flint water activist Melissa Mays holding out for more court settlements. ABC12. <https://www.abc12.com/2020/08/21/flint-water-activist-melissa-mays-holding-out-for-more-court-settlements/> Published August 2020. Accessed September 27, 2020

Reuters Staff. Detroit to shut off drinking water in schools after lead found. Reuters. <https://www.reuters.com/article/us-michigan-water-education/detroit-to-shut-off-drinking-water-in-schools-after-lead-found-idUSKCN1LE2G0> Published August 2018. Accessed September 22, 2021

Rhoads, W.J., Garner, E., Ji, P., et al. (2017). Distribution system operational deficiencies coincide with reported Legionnaires' disease clusters in Flint, Michigan. *Environ Sci Technol.* 2017;51(20):11986-95. doi: 10.1021/acs.est.7b01589.

Riley R. 2018. Sh-h-h. Snyder state update left out 75% drop in reading proficiency in Flint. Detroit Free Press. <https://www.freep.com/story/news/columnists/rochelle-riley/2018/02/06/sh-h-h-snyder-state-update-left-out-75-drop-reading-proficiency-flint/1074057001/> Published February 2018. Accessed June 21, 2020

Riley R. Flint boy was suspended, sent home from school 50+ times. His mom blames water crisis. Detroit Free Press. <https://www.freep.com/in-depth/news/columnists/rochelle-riley/2019/12/13/flint-water-crisis-children-school/3739525002/> Published December 2019. Accessed September 27, 2020

Roy, S., & Edwards, M.A. (2019a). Preventing another lead (Pb) in drinking water crisis: Lessons from the Washington DC and Flint MI contamination events. *Current Opinion in Environmental Science & Health.* 2019 Feb 1;7:34-44. doi: 10.1016/j.coesh.2018.10.002

Roy, S., & Edwards, M.A. (2019b). Citizen Science During the Flint, Michigan Federal Water Emergency: Ethical Dilemmas and Lessons Learned. *Citizen Science: Theory and Practice.* 2019 Mar 8;4(1). doi: 10.5334/cstp.154.

Rudnai P. SCOPING DOCUMENT. Prioritized substance group: Lead. HBM4EU. 2019. https://www.hbm4eu.eu/wp-content/uploads/2019/03/HBM4EU_Scoping-Documents_Lead_v1.0.pdf Published November 2019. Accessed September 27, 2020.

Sanburn J. The Poisoning of an American City. TIME Magazine. <https://time.com/4188328/the-poisoning-of-an-american-city/> Published January 2016. Accessed June 21, 2020

Shell ER. 2016a. Flint's Lead-Tainted Water May Not Cause Permanent Brain Damage. Scientific American. <https://www.scientificamerican.com/article/flint-s-lead-tainted-water-may-not-cause-permanent-brain-damage/> Published March 2016. Accessed June 21, 2020

Shell ER. 2016b. The Brains of Flint's Children, Imperiled by Lead, Could Still Escape Damage. Scientific American. <https://www.scientificamerican.com/article/the-brains-of-flint-s-children-imperiled-by-lead-could-still-escape-damage/> Published July 2016. Accessed September 27, 2020

Simpson-Mersha I. Flint children exposed to lead suffer from dental problems, learning disabilities, other issues. Mlive. <https://www.mlive.com/news/flint/2020/10/flint-children-exposed-to-lead-suffer-from-dental-problems-learning-disabilities-other-issues.html> Published October 2020. Accessed September 20, 2021

Smith D. 'It was just left to the people': behind a chilling documentary on the Flint water crisis. The Guardian. <https://www.theguardian.com/film/2020/mar/09/flint-water-crisis-documentary-anthony-baxter> Published March 2020. Accessed June 21, 2020

Sochocki T, Owczarzak B. Residents react to Flint water crisis settlement. WNEM. https://www.wnem.com/news/flint_water_crisis/residents-react-to-flint-water-crisis-settlement/article_02107848-e321-11ea-8694-135f6d853f25.html Published August 2020. Accessed September 27, 2020

Spence R. Learning disabilities, developmental problems increase amid Flint Water Crisis. NBC25. <https://nbc25news.com/features/learning-disabilities-developmental-problems-increase-amid-flint-water-crisis> Published August 2019. Accessed June 21, 2020

Stateside Staff. Pediatrician says “poisoned” is an accurate description of what happened to Flint children. Michigan Radio. <https://www.michiganradio.org/post/pediatrician-says-poisoned-accurate-description-what-happened-flint-children> Published August 2018. Accessed June 21, 2020

Statistics Canada. Lead, mercury and cadmium concentrations in Canadians, 2012 and 2013. <https://www150.statcan.gc.ca/n1/pub/82-625-x/2015001/article/14209-eng.htm> Published November 2015. Accessed September 27, 2020.

Stillman S. Can Behavioral Science Help in Flint? The New Yorker. <https://www.newyorker.com/magazine/2017/01/23/can-behavioral-science-help-in-flint> Published January 2017. Accessed June 21, 2020

Strauss V. How the Flint water crisis set back thousands of students. The Washington Post. <https://www.washingtonpost.com/education/2019/07/03/how-flint-water-crisis-set-back-thousands-students/> Published July 2019. Accessed June 21, 2020

Taylor C. Michigan says Flint water is safe to drink, but residents’ trust in government has corroded. The Conversation. <https://theconversation.com/michigan-says-flint-water-is-safe-to-drink-but-residents-trust-in-government-has-corroded-95358> Published May 2018. Accessed June 21, 2020

The New Yorker. The Lasting Fear of Flint’s Water Crisis. The New Yorker. <https://www.newyorker.com/video/watch/the-lasting-fear-of-flint-s-water-crisis> Published March 2016. Accessed September 22, 2022

Travis T. Flint water crisis led to “anxiety, fear, distrust and anger over the events of the last seven years,” Judge Levy states as she hands down ruling to proceed with settlement. East Village Magazine. <https://www.eastvillagemagazine.org/2021/01/26/flint-water-crisis-led-to-anxiety-fear-distrust-and-anger-over-the-events-of-the-last-seven-years-judge-levy-states-as-she-hands-down-ruling-to-proceed-with-settlement/> Published January 2021. Accessed September 22, 2021

Tsoi MF, Cheung CL, Cheung TT, Cheung BM. Continual decrease in blood lead level in Americans: United States National Health Nutrition and examination survey 1999-2014. The American journal of medicine. 2016 Nov 1;129(11):1213-8.

TV Series Finale. 60 Minutes: Season 52 Ratings (2019-20). TV Series Finale. <https://tvseriesfinale.com/tv-show/60-minutes-season-52-ratings/> Published June 2020. Accessed September 27, 2020

US Census Bureau. (2022). Census Bureau Data. *US Census*. <https://www.data.census.gov/> Published 2022. Accessed December 04, 2022

US Department of Agriculture. (2016). USDA Increases Assistance to Flint Families with Delivery of Nutritious Food Packages. *USDA Food and Nutrition Service Press Release FNS 0010.16*. <https://www.fns.usda.gov/pressrelease/2016/fns-001016> Published June 2016. Accessed July 04, 2021.

Wells K. After 3 years, lawsuit over Flint schools’ special needs crisis moving to trial. Michigan Radio. <https://www.michiganradio.org/post/after-3-years-lawsuit-over-flint-schools-special-needs-crisis-moving-trial> Published December 2019. Accessed September 27, 2020

- Wells K. Exposed to lead in infancy, now Flint's youngest students face challenges in school. Michigan Radio. <https://www.michiganradio.org/post/exposed-lead-infancy-now-flints-youngest-students-face-challenges-school> Published December 2019. Accessed June 21, 2020
- Wisely J. Flint water settlement includes \$9M for special education programs. Detroit Free Press. <https://www.freep.com/story/news/education/2020/08/20/flint-water-crisis-settlement-special-education/5617453002/> Published August 2020. Accessed September 22, 2021
- Wood MR. How the Flint water crisis set students back. The Conversation. <https://theconversation.com/how-the-flint-water-crisis-set-students-back-116125> Published June 2019. Accessed September 27, 2020
- Zinnes, S., Scorsone, E., & Schulz, M. (2020). Flint Community Schools: Fiscal and Service Solvency. *MSU Extension*. Available at: https://www.canr.msu.edu/center_for_local_government_finance_and_policy/uploads/files/Flint_schools_white_paper-FINAL.pdf Published February 2020. Accessed July 04, 2021.