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A Possible Nocebo Effect in Children Following the Flint Water Crisis: Evidence From Schoolteacher Perceptions and Neuropsychological Evaluations

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Abstract

Objective: Special education enrollment increased in Flint following the 2014–2015 Flint Water Crisis, but lead exposure is not plausibly responsible. Labeling Flint children as lead poisoned and/or brain damaged may have contributed to rising special education needs (ie, nocebo effect). To better document this possibility, we surveyed schoolteachers and reviewed neuropsychological assessments of children for indications of negative labeling.

Methods: A survey of Flint and Detroit (control) public schoolteachers using a modified Illness Perception Questionnaire was conducted 5 years post-crisis. We also examined neuropsychological assessments from a recently settled class lawsuit.

Results: Relative to Detroit (n = 24), Flint teachers (n = 11) believed that a higher proportion of their students had harmful lead exposure (91.8% Flint vs 46% Detroit; $P = 0.00034$), were lead poisoned (51.3% vs 24.3%; $P = 0.018$), or brain damaged (28.8% vs 12.9%; $P = 0.1$), even though blood lead of Flint children was always less than half of that of Detroit children. Neuropsychological assessments diagnosed lead poisoning and/or brain damage from water lead exposure in all tested children (n = 8), even though none had evidence of elevated blood lead and a majority had prior learning disability diagnoses.

Conclusion: Teachers' responses and neuropsychological assessments suggest Flint children were harmed by a nocebo effect.

The Michigan cities of Flint and Detroit used treated Lake Huron water as their primary water source for over 50 years, except for 18 months during April 2014–October 2015, when Flint switched to a local river water source. A failure to adequately treat the river water and implement lead corrosion control was associated with a spike in water lead (Pb) levels above federal standards, a slightly higher incidence of blood lead over 5 µg/dL in children for about 3 months in 2014, and a Legionnaire's Disease outbreak tied to at least 13 fatalities.^{1–6}

After some of the authors (Edwards, Roy) helped expose lack of corrosion control, elevated lead in water throughout the city, the elevation in blood lead of Flint children for a few months in summer 2014 and malfeasance of government officials, the Flint Water Crisis (FWC) became a media sensation. Thereafter, Flint children were frequently described as “lead “poisoned” and permanently “brain damaged” by community leaders, teachers, activists, scientists, and the media.^{1,6–13} (For a representative list, see Table S1 in Roy et al., 2023¹⁴). The superintendent of Flint Community Schools predicted the FWC would significantly increase disabilities and adverse educational outcomes, which was echoed by a claim that “in five years, these kids are going to have problems with special education.”¹⁵ These prophecies were realized after special education enrollment in Flint increased sharply to nearly 1.6 times the national average in the next 5 years,¹⁴ at which point a veteran Flint teacher told *The New York Times* that in Flint schools, “All that's left are damaged kids.”¹¹ Similar messaging has been repeated within the community for over 6 years,¹⁴(Table S2) amidst reports of higher rates of depression, post-traumatic stress disorder (PTSD), substance use, and other mental health problems in the general Flint population.^{16–24}

Beliefs about the effect of the FWC lead exposure on children's cognitive abilities cannot be reconciled with data on blood lead levels in Flint children. Research demonstrated that children's blood lead levels in Flint were not significantly different from the State of Michigan's average and were dramatically lower than children in neighboring Detroit.¹⁴ The incidence of childhood elevated blood lead (ie, ≥ 5 µg/dL or “%EBL”) pre-crisis (2012–2013: 3–3.9%) was comparable to

that during the FWC (2014–2015: 3–3.7%). In fact, the net effect of the FWC was to raise %EBL in Flint children up to that observed in the State of Michigan during the FWC worst lead exposure year of 2014. The %EBL of Flint children dropped 66% from 2011–2019, was consistently lower than for the state of Michigan, and was always less than half of that of children in nearby Detroit.^{6,14,25}

There are many reasons why the elevated lead in Flint water did not cause greater elevations in blood lead of children. First, widespread fears of the Flint River source water caused some residents to vow they would never drink the water even before the switch.^{26–29} Immediately after the switch, the water was obviously discolored and distasteful, causing more residents to avoid using the water for cooking or drinking and switching to bottled water.^{30–34} Finally, water lead levels varied markedly in Flint homes dependent on the type of plumbing present, and most homes never had elevated lead in their water. For instance, our citywide water sampling conducted during the worst of the water crisis (August 2015) showed 6% of samples (total $n = 831$) had water lead levels above the threshold of 24 $\mu\text{g/L}$,³⁵ a level that could elevate blood lead in the average 1- to 2-year-old child above 5 $\mu\text{g/dL}$ from continuous consumption.³⁶ Moreover, 56% of homes (and 74% of all samples) tested below the Food and Drug Administration's water lead threshold for bottled water of 5 $\mu\text{g/L}$.³⁵ Thus, the vast majority of Flint children were not at risk of elevated blood lead from drinking tap water even if they were consuming it. None of the above should be construed as downplaying the criminality or wrongdoing that some of the authors helped expose but, rather, puts into perspective an erroneous perception that most Flint children were lead poisoned or seriously lead exposed.

Paradoxically, in the most recent academic year (2021–2022), the percentage of children enrolled in special education in Flint schools (23.2%; $n = 705$) rose to 66–72% higher than that in Detroit schools (14%; $n = 6811$) or in all Michigan schools (13.5%; $n = 194\,514$).³⁷ The anomalous spike in special education enrollment observed in Flint (compared to children in Detroit with similar socioeconomic and racial composition or to the State of Michigan) is almost always directly attributed to lead exposure, despite overwhelming evidence that cannot be the case.¹⁴

If it was not water lead exposure, what caused the higher special education enrollments in Flint children? To explain a prior mystery, as to how Flint children living in homes with lead service lines had no differences in academic performance than those without them, Trejo et al. speculated that psychosocial effects of the FWC must have been dominant.²³ We later demonstrated that all necessary elements for a powerful nocebo effect were also present, due to repeated negative labeling of children who internalized the message of “poisoning” and “brain damage” by the media, parents, clergy, celebrities, experts, and school officials.^{14,38,39} Prior research into the nocebo effect has documented adverse health effects from false claims associated with a drug, clinical treatment, exposure to perceived toxins, or other environmental threats.^{40–44} Most recently, a meta-analysis of coronavirus disease (COVID-19) vaccine randomized controlled trials data revealed high rates of adverse events in the control group (ie, those who did not get the actual vaccine) due to the nocebo effect, from side effects mentioned in leaflets and media stories.^{45,46}

Controlled research on the nocebo effect is justifiably limited due to ethical concerns. But it is now established that the FWC represents an unfortunate real-world experiment, in which a media and community perception was created about an unprecedented harmful environmental exposure, for a contaminant continuously monitored in children's blood, which demonstrates much lower exposure than a nearby control city of Detroit and normal exposure

relative to the State of Michigan. It therefore presents an unprecedented opportunity to document biases and the evolution of community beliefs following false messaging during a well-publicized crisis. The aims of this study were the following:

- (1) *To document and analyze teacher perceptions on the impacts of lead exposure for children in the Flint and Detroit (control) public schools through an anonymous survey from before publication of the nocebo hypothesis.* We hypothesized that Flint schoolteachers would believe that a higher proportion of their students had been lead poisoned and brain damaged, compared to teachers in Detroit. Our survey was supplemented by a systematic online search of public statements of Flint teachers from 2015–2023.
- (2) *To compile and summarize data in neuropsychological assessments of all Flint children from a now settled class action lawsuit.* We hypothesized that neuropsychological assessments and associated expert testimony admitted into evidence for the *D.R. v. Michigan Dept. of Education* lawsuit filed in October 2016 and settled for \$641.25 million in November 2021, would provide evidence from the most compelling cases of water lead causing brain damage or learning disabilities.^{47,48}

Methods

Schoolteacher Perceptions: Survey Instrument and Publicly Available Statements

The survey instrument (Text S1) contained single-answer, multiple-choice, Likert scale and open-ended questions on teachers' demography, perceptions, and classroom experiences. The well-established and validated Illness Perception Questionnaire⁴⁹ with 11-point (0-10) rating scales was modified to evaluate schoolteacher perceptions on the impacts of lead exposure on educational achievement and behavior in their students. The primary study endpoints were differences between Detroit and Flint schoolteachers' perceptions of lead exposure and its effects on learning outcomes of children as measured in responses on 11-point rating scales. The 10-minute survey was administered online through the Qualtrics® (Provo, UT, USA) platform.

The websites of Detroit Public Schools Community District (www.detroitk12.org/domain/152; “Detroit schools”) and Flint Community Schools (www.flintschools.org; “Flint schools”) were manually screened for schoolteacher directories with names and email addresses. This search effort revealed online teacher directories for all 65 Detroit schools, but only 4 of 12 Flint schools. To manage participation from Detroit schools, only teachers teaching Pre-K through fourth grade were targeted in schools with “Elementary” in their names. A public LinkedIn search with the filter “Current Company = ‘Flint Community Schools’” was conducted, search results were manually screened for schoolteachers, and, in the absence of a listed email address, survey participation emails were sent to email addresses crafted as “[first name initial][last name]@flintschools.org.” One initial recruitment and 2 follow-up reminder emails were sent to schoolteachers in Detroit ($n = 28$ schools) and Flint ($n = 4$ schools). For the remaining 8 Flint schools with no online teacher directories, school principals were sent 2 emails requesting that a flyer with study details and a survey link be forwarded to staff teachers (Text S2).

The survey was anonymous, and all responses were automatically decoupled from the respondent email addresses in Qualtrics.

Table 1. Characteristics of respondents to online questionnaire of schoolteachers in Flint and Detroit. Values are numbers (percentages) of subjects unless indicated otherwise

Characteristics	Total	Flint	Detroit	P value (Flint vs Detroit)
Respondents: N	35	11	24	N/A
Gender				
Male	0	0	0	$P = 1.0^{**}$
Female	35 (100%)	11 (100%)	24 (100%)	
Race/ethnicity (can overlap)				
White	22	10	12	N/A
Black or African American	11	1	10	
Hispanic or Latino	1	0	1	
American Indian or Alaskan Native	2	1 [†]	1 [‡]	
Asian	2	0	2	
Age (years): mean (SD)	53.5 (9.1)	57.2 (10.1)	51.8 (8.3)	$P = 0.106^*$
Teaching experience[^] (years): mean (SD)	18.7 (11.4)	25.2 (14.1)	15.7 (9.1)	$P = 0.0219^*$
Subject area				
General education	29 (82.9%)	9 (81.8%)	20 (83.3%)	N/A
Special education	5 (14.3%)	1 (9.1%)	4 (16.7%)	
Both	1 (2.8%)	1 (9.1%)	0	
Grades taught (can overlap)				
Pre–K	4	0	4	N/A
K–8	31	10	21	
Grades 9–12	1	1	N/A [#]	

*Unpaired 2-tailed t-test.

**Fisher's exact test.

[†]Only 1 Flint teacher was of mixed race (American Indian or Alaska Native and white).[‡]Only 1 Detroit teacher was of mixed race (American Indian or Alaska Native, Asian, and white).[^]"X+" entries (eg, 15+) were rounded up 1 year to "X+1" (eg, 16) years.[#]The survey was targeted toward Flint teachers at all grades and Detroit teachers up to fourth grade.

All survey respondents, except 2 teachers who completed the survey using the flyer survey link but not the last compensation step, received a US \$20 Amazon.com gift card upon completion. Human subjects research approval was obtained from Virginia Tech's Human Research Protections Program prior to conducting this study (VT IRB #20-292).

Public perceptions already compiled from our recent study¹⁴ were further mined for statements of teachers, and additional online searches were conducted using a simple search term ("flint teacher" + "lead" + "crisis") for the October 2015–October 2023 period.

Neuropsychological Evaluations and Expert Testimony

Two psychologists formally administered neuropsychological assessments, which are "performance-based methods to assess cognitive functioning"⁵⁰ to 8 "representative plaintiff" children (of 15 children total) in *D.R. v. Michigan Dept. of Education*.⁵¹ The 8 evaluations and supporting written testimonies of the 2 psychologists and 2 special education experts were obtained from the United States Public Access to Court Electronic Records (<https://pacer.uscourts.gov/>) portal at a cost of 10¢ per page.

Statistical Analyses

Survey data were downloaded from Qualtrics® as comma separated value (CSV) files. All statistical analyses were conducted in RStudio

(version 3.3.2), Minitab (version 19), and Microsoft® Excel® (version 2019). The data were checked for normality using the Shapiro–Wilk test prior to the analysis. Pearson's chi square and Student's t-tests were used to conduct demographic comparisons for categorical and continuous variables, respectively. Flint and Detroit teacher perception ratings and other responses were compared using Student's t-tests or Mann–Whitney U tests. Pearson's chi square and Fisher's exact tests were used as appropriate for questions with categorical responses (ie, "Yes," "No," "I don't know"). The statistical significance level was set at an alpha value (α) of 0.05; no adjustments for multiplicity were made. For survey questions not completed by all participants, the actual respondent count *n* is shown. Content analysis was conducted for responses to open-ended questions using established qualitative research guidelines.⁵²

Results

Teacher Demographics

In Detroit, 24 of 296 eligible schoolteachers (8.1% [95% CI: 5.5, 11.8] response rate) completed the survey (Table 1; see Table S1). In Flint, repeated efforts (Text S3) yielded 11 respondents of an estimated⁵³ 161 (6.8% [95% CI: 3.7, 11.9] response rate) teachers (see Table 1 and Table S1). The risk difference between Flint and Detroit was 1.3% (95% CI: -3.7, 6.3), indicating the response rates were not much different.

Table 2. Schoolteacher perceptions about (A) primary sources of lead exposure for children in their classes, (B) proportion of children in classes affected by lead, and (C) effects of lead exposure on their students

	Flint (n = 11) Mean (95% CI)	Detroit (n = 24) Mean (95% CI)	P value*
A. Teacher perceptions about lead exposure sources for children in their classes Perception scale: 0 (not important) to 10 (extremely important)			
Lead paint	7.4 (5.3, 9.5)	7.4 (6.3, 8.5)	0.88
Lead dust/soil	5.5 (3.2, 7.8)	6.7 (5.4, 8.1)	0.28
Drinking water	8.4 (6.6, 10.1)	7.8 (6.6, 9.0)	0.67
B. How many students in your class do you think ... Percentage scale: 0–100%			
1. Have been “exposed to lead”?	91.8 (83.6, 100.1)	46 (31.7, 60.4)	0.00034
2. Have been “lead poisoned”?	51.3 (26.0, 76.6)	24.3 (13.6, 35.1)	0.0179
3. Have “brain damage” from lead?	28.8 (10.6, 47.1)	12.9 (5.9, 19.9)	0.10
4. Exhibit learning difficulties from lead?	54.9 (31.8, 78.0)	36.5 (24.6, 48.3)	0.10**
C. Teacher perceptions on the effects of lead exposure in students			
Q1. How much does lead affect their educational attainment? Scale: 0 (no effect at all) – 10 (severely)	7.9 (6.1, 9.7)	8.2 (7.4, 9.0) [†]	1.0
Q2. How long will these educational and behavior effects continue? Scale: 0 (very short time) – 10 (forever)	7.0 (5.3, 8.7)	7.5 (6.4, 8.6)	0.42
Q3. How much can remedial education/ support help repair the effects of lead? Scale: 0 (not at all) – 10 (extremely)	7.2 (5.0, 9.4)	5.2 (3.9, 6.5)	0.09
Q4. How well do you feel you understand effects of lead exposure? Scale: 0 (don't understand at all)– 10 (understand very clearly)	7.9 (6.6, 9.2)	6.9 (5.9, 8.0)	0.31
Q5. How concerned are you about the effects of lead exposure in the students you teach? Scale: 0 (not at all)– 10 (extremely)	8.6 (7.0, 10.3)	7.9 (6.7, 9.1)	0.48

*Mann–Whitney U Test, unless stated otherwise.

**Unpaired t-test.

[†]n = 23 for Detroit.

All respondent teachers from Detroit and Flint schools taught primarily general education classes, were female, and were in their 50s (see Table 1). Flint teachers, on average, were 5 years older than Detroit teachers ($P = 0.141$). Flint teachers also had nearly 10 more years of teaching experience, on average, than Detroit teachers ($P = 0.0599$). Detroit teachers were almost evenly split by ethnicity (white = 12/24; black = 10/24), but the Flint teachers were predominantly white (10/11).

All Flint and all but 1 Detroit schoolteacher respondents completed the perception ratings portion or the primary study endpoints, whereas 91% ($n = 10/11$) of Flint and 83.4% (20/24) of Detroit teachers reached the end of the survey.

Schoolteacher Perceptions on Lead Exposure and Learning Difficulties

Drinking water was perceived as the top source of lead exposure in schoolchildren (ie, higher than lead paint and lead dust or soil) according to both Flint and Detroit teachers, although the differences were not significant (Table 2).

Flint teachers believed a higher percentage of their students had been “exposed to lead” ($P = 0.00034$) and were “lead poisoned” ($P = 0.0179$), than Detroit teachers, with a minimum 2X difference (see Table 2). Flint teachers also believed more children in their classes had “brain damage” from lead ($P = 0.10$) and exhibited learning

difficulties from lead exposure ($P = 0.10$), than Detroit teachers, but the differences were not significant.

Flint and Detroit teachers’ perception ratings on a 0–10 scale were comparable ($P > 0.05$) for questions on how much lead affects educational attainment. This included the duration of educational and behavioral effects in children resulting from lead, the role of remedial education and support in repairing health effects from lead, their personal understanding of the effects of lead exposure, and their levels of concern on how lead exposure is impacting their students (see Table 2).

One third ($n = 8$ of 24) of Detroit teachers said they would allow students to drink tap water at home (Figure 1). No Flint teacher (ie, 0%) agreed with that statement even though the survey was executed after Flint had been meeting Federal drinking water lead standards for 4 years and had been using the same water source as Detroit for 5 years ($P = 0.0146$). Similarly, 42% ($n = 10$) of Detroit teachers said they would allow students to drink tap water at school against 9% ($n = 1$) in Flint, but the difference was not significant ($P > 0.05$) (see Figure 1).

In response to the question of whether the lead-exposed students in their classes would recover, a majority of Detroit (79.2%; $n = 19$) and Flint teachers (63.6%; $n = 7$) said “I don’t know,” followed by “No” (16.7% [$n = 4$] for Detroit and 27.3% [$n = 3$] for Flint), and “Yes” (4.2% [$n = 1$] for Detroit and 9.1% [$n = 1$] for Flint) (Figure 2). More Detroit teachers (83%; $n = 20$) than Flint teachers

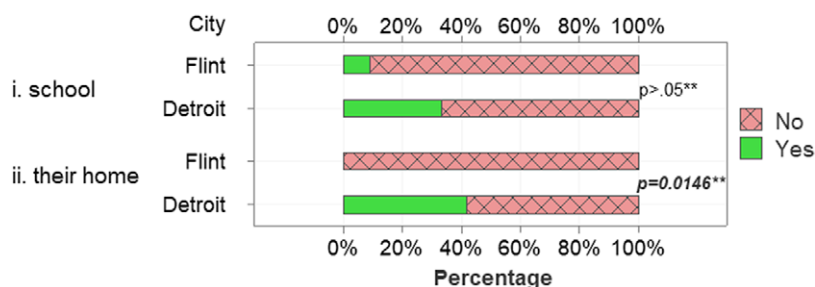


Figure 1. Would you let children in your class drink tap water at (1) school or (2) their home today?
**Fisher’s exact test.

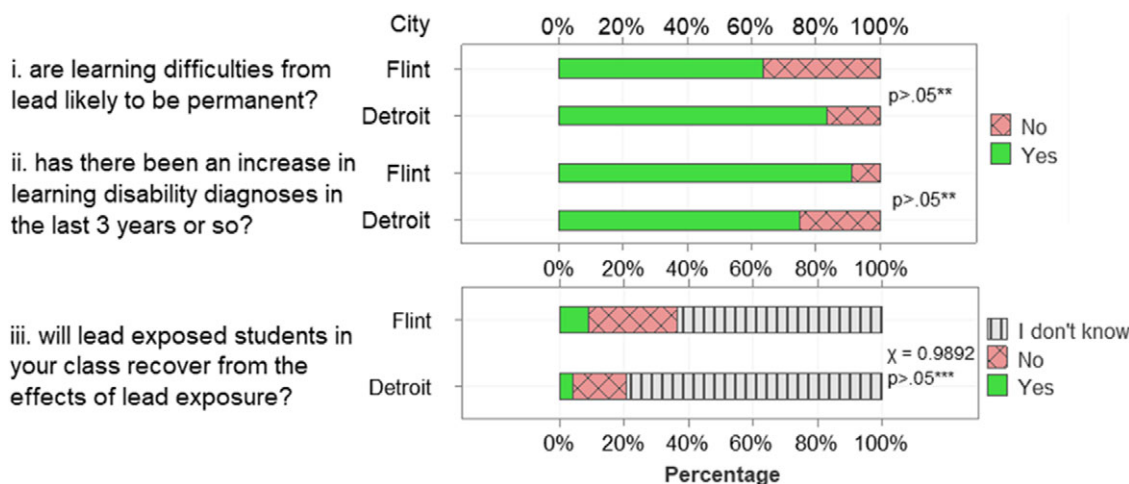


Figure 2. Schoolteacher perceptions on (1) permanency of learning difficulties from lead, (2) trends in learning disability diagnoses, and (3) likelihood of the recovery of lead-exposed students.
Fisher’s exact test. *Pearson’s chi-square test.

(64%; n = 7) believed that learning difficulties from lead are likely to be permanent, but a higher proportion of Flint teachers (90.9%; n = 10) reported increased learning disability diagnoses in the past 3 years than Detroit teachers (75%; n = 18), but these differences were not significant ($P > 0.05$) (see Figure 2).

Beliefs on Learning Disabilities, Diagnoses, and Sources of Information

The top learning disability symptoms observed and reported by Flint teachers (n = 44 responses from 11 teachers) in students were attention deficit (n = 11), memory (n = 7), behavioral issues (n = 4), and impulsivity (n = 3) (see Table S3). For Detroit teachers (n = 82 responses from 24 teachers), the top symptoms included “learning difficulties” (n = 13), memory (n = 11), hyperactivity (n = 8), attention deficit (n = 7), speech (n = 7), behavior issues (n = 6), and cognitive or developmental delays (n = 5) (see Table S3).

Teachers were asked to provide specific examples of what their students believed about the harmful effects of exposure to lead, and how lead exposure had affected them. Consistent with reporting in *The New York Times* and elsewhere,^{11,54} Flint teachers reported that their students believed lead exposure caused their bad behavior (n = 4). Still, other students believed they might get sick or die if they consumed or bathed in the water (n = 2) (Table 3).

Four Flint schoolteachers elaborated on their responses with written comments, as follows:

- They know that they can’t drink the water at school or home. They know they can’t bathe with the water. They are scared that it will make them sick or that they will die.
- My students believe that they were poisoned, that they have no control over their behaviors and that they will never recover from have lead exposure. Many families will never use Flint water again, even for bathing and hand washing.
- I don’t think that students understand to much about the harm of the lead exposure, they are mainly following the adults that don’t allow them to drink the water in all places.
- My students are young and don’t really comprehend it all. They will tell me what mom told them.

The above anonymous survey comments are also remarkably consistent, with the overwhelming negativity of quotes from Flint teachers in our search of media (see Table S2). The search revealed 17 quotes indicating expectations of brain damage and learning disabilities for children due to the lead and none with a contrary message.

In contrast, Detroit teachers primarily felt their students were very young or did not understand (n = 3) (see Table 3). Of the 24 surveyed Detroit teachers, only 1 mentioned lead exposure from consuming tap water, and significantly, that was in reference to a Flint-born child who moved to Detroit in first grade. The negative labeling of the Flint children by teachers therefore persisted even after they had moved.

Table 3. Examples of what students believe about the harmful effects of lead exposure, and how it has affected them

Count	Flint (10 of 11 teachers gave examples)	Detroit (9 of 24 teachers gave examples)
4*	Bad behavior Responses: (a) acting out then apologizing because “they didn’t mean to”; (b) “no control [...] and will never recover”; (c) physical aggression, (d) “They blame their behavior on lead exposure. I blame it on bad parenting.”	
3	Students are very young or do not understand.	Students are very young or do not understand.
2 each	Believe what their mother, parents, or adults tell them. Scared may get sick or die from water. Know not to drink water or bathe in it.	
1 each	Abdominal pain; do not know people used to drink from kitchen tap; eat non-food items like paint chips; “lead is bad”; loss of appetite; poisoned; rashes or skin infections early in crisis; sluggishness; weight loss.	ADHD; attention deficit; bad behavior; feel water is “dirty,” “brown,” and “tastes funny”; know water not safe to drink; scared may get sick or die; speech impairment; stomach aches; “the water makes me dumb” gathered from adults and media.

*Of the 4 mentions of bad behavior, 1 is attributed by a respondent teacher to “bad parenting,” not lead exposure.

When asked to elaborate on the perceived meaning of “lead poisoned” and “brain damaged” in relation to learning outcomes (see Table S4), both Flint (n = 10-11 of 11 teachers) and Detroit teachers (n = 13-16 of 24 teachers) associated the term with learning difficulties, behavioral issues, cognitive impairments, and developmental delays. Two Flint teachers mentioned ingesting of Flint water as a lead source, whereas 1 Detroit teacher noted lead paint and lead pipes.

The primary information sources (see Table S5) for Flint teachers on their children being “lead poisoned” and “brain damaged” were parents, their own judgment, their schools, media, personal observations, Individualized Education Plans, and testing. Some sources from within Flint’s school district included counselors, school nurses, superintendents, “phamplets (sic) at school” and “literature that was provided to us stated that up to 75% of our students could be affected.” The primary information sources were similar for Detroit teachers: parents, personal assumptions, medical records, City of Detroit, media, their schools, Individualized Education Plans of students, special education testing, student records, and psychologists.

Social or Environmental Factors Besides Lead That Contribute to Learning Difficulties

Flint teachers reported that the top social and environmental factors besides lead that contribute to learning difficulties in their students (36 responses from 9 teachers) included: parents or family (n = 9), home environment (n = 5), poverty (n = 5), poor diet or nutrition (n = 3), poor health care (n = 2), low school attendance (n = 2), and drugs (n = 2) (see Table S6). For Detroit teachers (79 responses from 19 teachers), the ranked list of responses (see Table S6) included poverty (n = 11), parents or family (n = 10), poor diet or nutrition (n = 9), home environment (n = 8), environmental factors (n = 6), low school attendance (n = 4), drugs (n = 4), lack of sleep (n = 3), lack of support (n = 3), and school district (n = 2). One Flint teacher responded that, while her students blamed their behavior on lead exposure, she considered “bad parenting” to be a cause (see Table 3).

Neuropsychological Evaluations and Expert Testimony

Eight plaintiff children were put forth in the lawsuit to make the case for health harm and permanent brain damage from water lead

exposure during the FWC.⁵⁵ Significantly, at least 7 children had prior learning disability diagnoses, including many from before the FWC even began (Table 4). Four of these children had mothers who admittedly smoked and/or consumed alcohol or other drugs during their pregnancy. Seven children had no blood lead records whatsoever. The eighth child’s highest recorded blood lead was below the CDC’s “level of concern” in effect during the crisis (5 µg/dL). Nonetheless, during testing after the water crisis, all 8 children performed poorly on administered intelligence and adaptive behavior tests—all were diagnosed by experts as suffering from brain damage due to lead poisoning (see Table 4). While one psychologist admitted in the expert report that lead exposure was “only one of multiple risk factors” for brain damage, this expert still attributed problems to lead exposure for all 4 children they evaluated. The second psychologist’s professional opinion regarding the other 4 children they evaluated was their inability “to progress and acquire age appropriate behaviors” as “consistent with lead poisoning.”

Later testimony from 2 special education experts relied exclusively on the above psychologists’ evaluations of the children. The first expert testified that “academic and behavioral difficulties caused by Flint lead poisoning, found by neuropsychologists, reported by teachers and parents, and apparent in Flint test scores, should result in an increase in the number of students identified for special education services.” The second expert alleged “proven and prolonged lead poisoning of all the students and [teachers].”

After the settlement, these special education experts asserted that: “These funds will provide resources to support the significant needs of the students impacted by lead. And, most importantly, this settlement acknowledges that this community has suffered tremendously”—in an article asserting that their efforts were being “applauded around the country.”⁵⁶ They then co-authored a paper for special educators 1 month after the case was settled, emphasizing “there is no safe blood lead level,”⁵⁷ a popular misrepresentation of CDC’s original conclusion (“no safe blood lead threshold has been identified”) that may itself lead to a nocebo effect.^{39,58}

Finally, in the lawsuit, both special education experts, also attributed reductions in reading proficiency in Flint students starting in 2014–2015 to the FWC lead exposure. But this same decrease also occurred in Detroit students who did not experience a water crisis, and it was clearly due to the fact that Michigan implemented a different statewide evaluation program in that academic year.¹⁴

Table 4. Age, blood lead measurements, case histories, and final neuropsychological evaluation of Flint children conducted in September 2017 and admitted into evidence for class action lawsuit

No.	Patient, age at evaluation, and blood lead levels (BLLs)	Medical and educational history gathered BEFORE conducting neuropsychological evaluation	Final evaluation based on performance on intelligence and behavior tests
1	CDM 9 years, 1month* No BLL	<i>Prenatal:</i> Mother smoked cigarettes during pregnancy. <i>Prior diagnoses:</i> ADHD at age 4 (pre-FWC); on medication. <i>Individualized Education Program (IEP**)</i> classification: other health impairment.	“Ingested lead [...] suffered brain damage. Injury [from lead] is permanent.”
2	ON 9 years, 1 month* No BLL	<i>Prenatal:</i> Mother “smoked cigarettes and marijuana” and drank alcohol during pregnancy/lost custody at 2 months due to neglect. <i>Prior diagnoses:</i> ADHD at age 7 and on medication. <i>IEP classification:</i> speech/language impairment.	“Ingested lead [...] suffered brain damage. Injury [from lead] is permanent.”
3	DT 14 years, 5 months No BLL	<i>Prenatal:</i> Mother “smoked cigarettes, took drugs and drank [alcohol]” during pregnancy/lost custody at 6 months due to neglect. <i>Prior diagnoses:</i> ADHD, bipolar disorder and adjustment disorder at undisclosed age; on medication. <i>IEP classification:</i> none, but “struggling in core [eighth grade] subject areas.”	“Ingested lead [...] suffered brain damage. Injury [from lead] is permanent.”
4	JT 8 years, 9 months No BLL	<i>Prenatal:</i> Mother “smoked cigarettes during the first trimester.” <i>Prior diagnoses:</i> ADHD at age 5 (pre-FWC); on medication. <i>IEP classification:</i> other health impairment.	“Ingested lead [...] suffered brain damage. Injury [from lead] is permanent.”
5	DR 13 years, 3 months No BLL	<i>Prenatal:</i> no information available. <i>Prior diagnoses:</i> ADHD, Asperger’s syndrome and impulse disorder at undisclosed age and prescribed medication. <i>IEP classification:</i> other health impairment.	“Consistent with lead poisoning”
6	CW 5 years 4.8 µg/dL (max)	<i>Prenatal:</i> no information available. <i>Prior diagnoses:</i> no information available. <i>IEP classification:</i> no information available.	“Consistent with lead poisoning”
7	DK 8 years, 2 months No BLL	<i>Prenatal:</i> no information available. <i>Prior diagnoses:</i> autism spectrum disorder, ADHD at undisclosed age. <i>IEP classification:</i> speech/language impairment.	“Consistent with lead poisoning”
8	JB 6 years, 4 months No BLL	<i>Prenatal:</i> no information available. <i>Prior diagnoses:</i> autism spectrum disorder at age 5. <i>IEP classification:</i> unclear.	“Consistent with lead poisoning”

*CDM and ON have the same birthdate.

**IEP: “A written document for students with disabilities ages 3 through 25 that outlines the student’s educational needs and goals and any programs and services the intermediate school district and/or its member district will provide to help the student make educational progress.”⁸⁹

All of the above quotations, surveys, and expert testimony and diagnosis were completed, before publication of our paper showing that lead exposure was not consistent with trends in special education in Flint versus Detroit or the State of Michigan, and which first raised the possibility of a placebo effect arising from negative labeling of Flint children brain damaged from water lead exposure.¹⁴

Discussion

This study confirms that a significant number of Flint teachers may believe that their students had severe lead poisoning and associated brain damage. The public statements of teachers (see Table S2) are also consistent with the negative beliefs established in media coverage, movies, and statements of medical professionals.¹⁴ Flint teachers and students (according to the teachers) attribute attention deficit, memory problems, bad behavior, and learning difficulties to lead exposure from the FWC. A comprehensive review of neuropsychological assessments from the now settled *D.R. v. Michigan Dept. of Education* class action lawsuit that labeled Flint defendant minors “lead poisoned” and “brain damaged” suggests significant bias in identifying water lead exposure as a causal factor. Such results are not unexpected given our prior documentation of hyperbolic and biased media reporting.¹⁴

Until December 2020, 2641 Flint children had already been referred to the newly established Neurodevelopmental Center for Excellence, which has an 80% learning disability diagnosis rate.¹³ One criterion of the area’s public mental health provider to refer children to be evaluated at this center is whether a child was exposed to “lead contaminated Flint water [...] until September 2021.”^{59,60} In other words, it is assumed that the harmful exposure to lead in water continued for 5 years after Flint water met federal standards and 6 years after switching to the same source water as Detroit. During this time, bottled water and filters were also widely distributed. Thus, the labeling of children as “lead exposed” has been extended to a time period in which water lead exposure was probably never lower.⁶¹

This survey was also conducted during the COVID-19 global pandemic in 2020, nearly 4 years after the water began to comply with federal law and 85%+ lead pipe replacements.⁶¹ However, no Flint teacher in this survey was comfortable recommending that students consume unfiltered tap water in their homes, and only 1 approved the same in schools, where only bottled water was offered. This is consistent with multiple surveys demonstrating pervasive distrust of Flint tap water, change in bathing and showering habits, and widespread use of bottled water for drinking, cooking, and cleaning.^{22,62–64} Perceived tap water quality has been found to also

be predictive of PTSD symptomatology among Flint residents.⁶⁵ Separately, trust in tap water safety amongst minority children had been increasing nationally, until the FWC media coverage reversed the trend and caused the increased use of bottled water. In fact, non-Hispanic black children showed a “dramatic increase in bottled water intake corresponding to the Flint water crisis.”⁶⁶

Several studies have documented poor psychological health in the Flint population following the FWC, including higher psychological trauma (29%) and depression/anxiety (26.3%) in surveyed adults²¹ and perceived stress scores among Flint Registry participants ($n = 11\,012$ adults) to be much higher than those of the general US population.⁶⁷ These results are consistent with a longitudinal study that found that exposure to media coverage of distressful images, emotional responses, and perceptions, following the 2008 Sichuan earthquake in school children (91% under 15 years of age), primarily from family, friends, schoolteachers and television, was predictive of PTSD.⁶⁸ Similar findings have been reported during and after wars, natural disasters, and terrorist attacks, including in New York City (9/11), Israel, and the 2004 tsunami in Southeast Asia.^{69–73}

Other studies have investigated the effect of media coverage on negative health reports and symptoms. Nielsen and Nordestgaard (2016)⁷⁴ used data from the Danish Registry of Medicinal Products and Danish Patient Registry to show that, after negative statin stories in the Danish media, more patients stopped their statin tablets and that discontinuation was associated with an increased risk of a heart attack and a risk of death from cardiac causes. MacKrill *et al.* (2020)⁷⁵ showed an increase in drug side effect reporting following media stories publicizing that some patients were reporting side effects following a nationwide switch to a generic medicine. The negative publicity and media stories from Flint also may have led to a negative contagion effect in at least 1 town. In Chatham, Michigan, where the source water was switched pre-FWC in 2012, leading to Manganese-related taste and odor complaints, the broader population began reporting health symptoms identical to those in publications about Flint’s water issues.⁷⁶

Our strong qualitative responses from Flint teachers are consistent with what we witnessed during a school outreach event in Flint, where several teachers described to us how “there was no point in trying to teach [students]” due to brain damage.^{77,78} The misattribution of low academic performance to FWC’s lead exposure could have induced long-term learned helplessness and feelings of victimization,^{79–81} affecting the educational experience, which may alter the life trajectory of Flint children much more than the slight elevation in blood lead to the average for the rest of Michigan during 2014.

The good news is that the hyperbolic media coverage helped raise more than \$1.2 billion in relief funding and lawsuits in Flint. While we have no doubt that this occurred with good intentions, difficult questions of results and unintended consequences now deserve consideration. What if the long-term psychological harm done to Flint children from false messaging outweighs the benefits of extra special education? Since the percentage of special education enrollments in Michigan remained unchanged from 2015–2022, how is it justified to increase Flint enrollments by 39%, at the cost of decreasing enrollment by 21% for Detroit children who had twice the blood lead over that same period?

As a point of comparison, we consider harm from lifelong nocebo effects, as documented in the infamous 1930s Iowa Monster Study.^{82,83} Six victims in that experiment were awarded \$925 000 nearly 70 years after they were falsely told they had difficulties

speaking.⁸⁴ In comparison, Flint had more than 2000 times more children at risk of a the nocebo effects (6 Iowa orphaned children vs 13 000+ Flint children⁸⁵), the false messaging was about lead poisoning and permanent brain damage, and the duration of the false messaging was more than 16 times longer (6 months vs 8+ years and counting). The lead exposure during the FWC has recently been compared to the environmental disasters of Minamata, Japan (at least 900 deaths and over 2 million injured from methylmercury poisoning)⁸⁶ and Bhopal, India (15,000–20,000 deaths and over half a million injured from a methyl isocyanate gas leak)⁸⁷, continuing a hyperbolic narrative of catastrophic harm that never occurred. When, and how, could we correct the scientific and public record to mitigate the possible harm from a nocebo effect?

Limitations

This study has important limitations. The low sample size, despite repeated efforts to maximize participation over 5 months (Text S3), is a limitation that can bias findings. Participation from schoolteachers was limited due to a lack of support from the Flint school district to make the survey available to all teachers. However, the response rates between Flint and Detroit teachers were not much different, which could suggest similar disincentives to participate in Detroit or a general disinclination to engage among schoolteachers. At the time, the Flint school district was a key beneficiary of the class action lawsuits seeking damages due to alleged brain damage arising from the water lead exposure, even as it also had the conflicting obligation to defend against the lawsuit, creating a significant financial conflict of interest. Nonetheless, there are strong and significant perception differences observed between Flint and Detroit schoolteachers on the individual and aggregate-levels, which confirm extensive media reporting of teacher and parent perceptions (see Table S2). The rating questions were modified from the Brief Illness Perception Questionnaire, which has been cited over 3000 times and, following use in over 500 studies, has shown a moderate to strong relationship between “belief in serious consequences, a strong illness identity, stronger emotional representations and concern” and “depression, anxiety, [and] low quality of life.”⁸⁸ Future studies should continue to consider and probe all aspects of the Flint nocebo effect, including how to effectively identify, diagnose, treat, and prevent ill effects of negative perceptions, in the aftermath of environmental disasters. The de-identified neuropsychological evaluations of Flint children being conducted at the newly established Flint Neuropsychological Center of Excellence could provide a basis for such research, if a nocebo effect were explicitly considered. It is important to note that the earliest evaluations from this center attributed all documented learning disabilities exclusively to water lead exposure.¹³

Conclusions

This study documents strong negative beliefs and labeling of Flint children, as permanently harmed by unprecedented lead poisoning that did not occur, among Flint schoolteachers and in neuropsychological assessments in a settled Flint class action lawsuit. Negative labeling of children, who are potential victims in unfolding environmental disasters, can be readily internalized—it might even cause damage that is worse than that caused by the actual exposure to contaminants. The media should carefully consider how they publicize such events, and society should consider adverse effects of unintended consequences that might sometimes come with relief funding.

Supplementary material. The supplementary material for this article can be found at <http://doi.org/10.1017/dmp.2024.106>.

Abbreviations. %EBL, Percentage of children < 6 years of age with elevated blood lead ($\geq 5 \mu\text{g}/\text{dL}$), the CDC's blood lead level of concern during 2012–2021); CDC, US Centers for Disease Control and Prevention; FWC, Flint Water Crisis (April 2014–October 2015).

Data availability statement. The anonymized survey data are available on request from the corresponding author. The neuropsychological evaluations were obtained through the United States Courts' PACER portal.

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Competing Interests. M.A.E. and S.R. 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. M.A.E. has been subpoenaed as a fact witness in many of the lawsuits but has refused all financial compensation for time spent on those activities. S.R. is serving as a scientific consultant on the use of biosolids to track water lead exposure, a topic unrelated to this manuscript, in Flint lawsuits and has been financially compensated for that work by VNA. E.J, K.J.P and G.D.G have no conflicts to disclose.

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