Office Visits Preventing Emergency Room Visits: Evidence From the Flint Water Switch

Shooshan Danagoulian, Department of Economics, Wayne State University
Daniel Grossman, Department of Economics, West Virginia University
David Slusky, Department of Economics, University of Kansas

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Abstract

Emergency department visits are costly to providers and to patients. We use the Flint water crisis to test if an increase in office visits reduced avoidable emergency room visits. In September 2015, the city of Flint issued a lead advisory to its residents, alerting them of increased lead levels in their drinking water, resulting from the switch in water source from Lake Huron to the Flint River. Using Medicaid claims for 2013–2016, we find that this advisory, which became national news, increased the share of enrollees who had lead tests performed by 1.7 percentage points. Additionally, it increased office visits immediately, and led to a reduction of 4.9 preventable, non-emergent, and primary-care-treatable emergency room visits per 1000 eligible children (8.3%). This decrease is present in shifts from emergency room visits to office visits across several common conditions. Our analysis suggests that children were more likely to receive care from the same clinic following lead tests and that establishing care reduced the likelihood parents would take their children to emergency rooms for conditions treatable in an office setting. Our results are potentially applicable to any situation in which individuals are induced to seek more care in an office visit setting.

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Affiliations:

Danagoulian (corresponding author): Department of Economics, Wayne State University, 656 W. Kirby St. 2905 Faculty Administrative Building, Detroit, MI 48202, fr4523@wayne.edu
Grossman: Department of Economics, West Virginia University, 1601 University Ave., Box 6025, 411 College of Business and Economics, Morgantown, WV, 26506-6025, daniel.grossman@mail.wvu.edu
Slusky: Department of Economics, University of Kansas, 1460 Jayhawk Blvd., 415 Snow Hall, Lawrence, KS, 66045, david.slusky@ku.edu

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Introduction

Emergency departments (ED) are structured to diagnose and treat emergent conditions. As such, they may be an expensive alternative to primary care, for both the individual patient and the health care system. For those who lack access to primary care, however, they are the only option for healthcare (Grumbach, Keane, and Bindman, 1993). Many of these individuals are of low socio-economic status, and may be eligible for Medicaid. Those who are of low socio-economic status and seeking care for their children are almost certainly eligible for Medicaid. While multiple studies have demonstrated that expanded access to Medicaid increases emergency room usage paid for by Medicaid (Taubman et al., 2014; Nikpay et al., 2017),[1] no study has been able to isolate the causal link between increased primary care and emergency room usage for those who are already eligible for Medicaid.

In this paper, we exploit a shock to primary care (measured by office visits) resulting from the Flint water contamination. On April 25, 2014, under state-appointed emergency management, the city of Flint switched its water source from Lake Huron to the Flint River. Water from the Flint River required treatment with strong disinfectants, which made it substantially more corrosive than the old water, leaching lead out of the existing delivery system into residential water (Masten et al., 2016). However, during the period in which water was sourced from the Flint River, local officials stressed that the city water was safe for consumption. Despite warnings and boil advisories in August and September 2014, and an EPA violation for exceeding organic chemical thresholds in December 2014, the water's high level of lead content was largely unconfirmed until September 2015. We use this last date as the start of the "treatment" period for our analysis,

[1] Some argue that ED visits increase, while others argue the increase is simply a shift in payer case mix (see, e.g., (Antwi et al., 2015; Finkelstein et al., 2016; Sommers et al., 2016; Sommers and Simon, 2017).

because it represents the point at which city officials first issued a lead advisory in the face of a preponderance of evidence that Flint's drinking water was hazardous to its residents' health.[2] We treat this public lead advisory and the accompanying national news event as an information shock.

The goals of this paper are twofold. First, we establish the extent to which knowledge of the water problems affected health care receipt. Then, we examine whether a change in primary care use causes a reduction in ED visits or a change in the distribution of those visits when they are treatable or preventable through primary care visits.

Whether, and to what extent, environmental disasters result in greater medical expenditures for affected populations remains an open empirical question. We determine the amount of medical services received by individuals in the affected areas before, during, and after a water change and a revelation of exposure to contaminated water. We find that Medicaid enrollees in Flint received lead tests at rates nearly 50 percent higher than enrollees from control cities following the national news event. The share of enrollees who had any office visit increased by 4 percent and 11 percent, respectively, in the first two quarters immediately following the shock, before decreasing in subsequent quarters. ED visits for preventable, non-emergent, and primary-care-treatable conditions (which we aggregate as "avoidable") decreased by 4.9 visits per 1000 eligible children per month (8.3%). This decrease in avoidable ER visits is present in shifts from ED visits to office visits across several common conditions.

Analyzing utilization patterns at the individual level, we find that children in Flint who received lead tests were 15 percentage points (23.6%) more likely to return to that clinic in the 3 months that followed. Furthermore, using the American Academy of Pediatrics (AAP) definition,

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[2] We also estimate a flexible time form specification using two time periods – January to August 2015 and September 2015 to December 2016 – with similar findings. We present these results in Appendix A.

we analyze delays in primary care for infants and toddlers in our sample, finding a 4.1–4.6 percentage point (8.4–8.9%) decline in probability of such delays in Flint in the after period. This suggests that establishing care at a specific clinic or with a given physician is associated with a decreased likelihood of receiving care in an ED for a condition that is treatable in an office setting.

Our results are robust to many additional specifications, including varying the cohorts we analyze, the start of the treatment period, and a more flexible measure of the treatment window. We show that limiting our analysis to individuals born before the initial water switch in April 2014, who are less likely to be biased by exposure to the water source causing differential fertility effects or worse health at birth due to living in Flint, does not affect our results. Nor does beginning our analysis using a control period that begins *after* April 2014, or even directly controlling for different potential windows of treatment, including time periods after the water switch, but before the information shock. Taken together, these results make the case that our results are specific to the information shock in September 2015 and are not likely to be driven by pre-trends in health care utilization in Flint.

In this study we contribute to several literatures, including those investigating lead exposure, the Flint water crisis, the unintended consequences of environmental or informational shocks on healthcare, and the substitutability of healthcare sources for emergency care. We discuss each in turn below.

Prior to the 1980s, lead was used extensively in household paint and plumbing, particularly in the lining and soldering joints of copper pipes to help avoid leaks. Because of health risks, such materials have been banned from new housing. Communities with older housing, such as those in Flint, are particularly vulnerable to lead contamination due to lack of investment in new plumbing.

Chronic exposure to lead has significant health consequences. High levels of lead in the bloodstream are associated with cardiovascular problems, high blood pressure, and developmental impairment affecting sexual maturity and the nervous system (ATSDR, 2007; Zhu et al., 2010). Newer research, however, shows adverse outcomes at low levels of exposure as well (Canfield et al., 2003; Jusko et al., 2008; Lanphear et al., 2005; Menke et al., 2006; Navas-Acien et al., 2007; Tellez-Rojo et al., 2006; Hollingsworth and Rudik, 2019). Reports from Flint suggest that children's blood lead levels increased within a few months following the water change (Hanna-Attisha et al., 2016; Zahran et al., 2017), while fertility rates dropped substantially (Grossman and Slusky, 2019). Lead also has negative impacts on birth outcomes, both in Flint (Abouk and Adams, 2018; Grossman and Slusky, 2019; Wang et al. 2019) and more recently in Newark (Dave and Yang, 2020). Furthermore, stress associated with the water quality changes during the Flint contamination negatively impacted maternal behaviors, such as smoking and breastfeeding (Danagoulian and Jenkins, 2021).

We also contribute to the literature investigating unintended consequences of environmental and informational shocks. While these unintended consequences are generally negative, this is not always the case. Deryugina and Molitor (2020) find that Medicare beneficiaries displaced by Hurricane Katrina who moved to lower mortality areas had lower mortality rates following the disaster. Additionally, this research relates to a strand of literature studying behavioral responses to health information. For example, Oster (2018) finds that individuals decrease calorie count of purchased food immediately after receiving a diabetes diagnosis and shift to a healthier diet long term, while Chang (2018) finds that parents are more likely to delay or forego vaccinations for their children following (false) information about autism risk.

In our study, we find that the news of the lead advisory induced children to visit a primary care physician. The likelihood of seeking preventive care and access to primary care physicians are correlated positively with household income (Sommers et al., 2017; Pitts et al., 2010) and negatively with ED visits (Cecil et al., 2016). Others have attempted to study the causal effect of primary care on ED visits by incentivizing patients to visit their primary care physician (Bradley et al., 2012, 2018; Bradley and Neumark, 2017) and by temporally increasing Medicaid reimbursements (Polsky et al., 2015; Candon et al., 2018; Decker, 2018; Neprash et al., 2018; Alexander and Schnell, 2019). The effects of these interventions depend on participants' insurance status. Using an RCT design, Bradley et al. (2018) find that those receiving cash incentives are more likely to see a primary care physician and less likely to have a preventable ED visit. However, they find no change in overall costs due to an increase in outpatient visits. We build on this research by investigating a national news event to explore a similar research question in a quasi-experimental setting.

Lastly, this paper studies the effect of creating a linkage to the healthcare system in the form of having a source of usual care. Children who have a usual source of care are more likely to receive preventive care and have higher quality of care, as well as less likely to receive care from the ED (Ettner, 1996; Xu, 2002; Starfield and Shi, 2004; Paustian et al., 2014). This informational shock induces parents to take children for lead tests and provides them with potential alternate places of service to the ED. Previous work has focused on the partial Medicaid expansion to study the effects of gaining insurance coverage on low-income individuals' ED and primary care usage (e.g., DeLeire et al., 2013; Sharma et al., 2017; Sommers et al., 2016; Gingold et al., 2017; Jacobs, Kenney, and Selden, 2017; Klein et al., 2017; McConville et al., 2018; Ladhania et al., 2019; Pickens et al., 2019), or how the availability of retail clinics affects both primary care and ED utilization (e.g., Ashwood et al. 2016; Alexander, Currie, and Schnell, 2019; Allen, Cummings, and Hockenberry 2019). Our paper differs from these studies in multiple ways. First, our population of interest is eligible for Medicaid throughout this time period, so there are no formal coverage expansions. Second, we know of no major changes in clinics' locations or availability in this time period. Third, our affected population experiences a national news event about them specifically that results in additional primary care usage. We focus our analyses on this variation.

The remainder of the paper proceeds as follows. First, we summarize the events surrounding the Flint water contamination. Next, we discuss the data and methods used to identify changing utilization of medical services. The following section presents results. We then discuss our findings in the context of the Flint contamination and conclude.

Background on the Flint Water Switch

In spring 2013, as part of an effort to reduce the budget of a city under emergency management, the state-appointed manager of Flint ordered the city to change its water supply to the Flint River by April 25, 2014 (Kennedy, 2016). Previously, the Detroit Water and Sewerage Department (DWSD) provided water to the city sourced from Lake Huron. The switch was intended to be a temporary measure until a proposed pipeline could be completed to supply Flint with water from Lake Huron independently.[3] The Flint Water Service Center (FWSC), however, was ill-equipped to supply adequate quality water to the city. It had not supplied the city since 1967 and was not given a sufficient transition period to build up materials, facilities, and expertise to do so (Masten et al., 2016).

[3] The pipeline was expected to take approximately 2 years.

The shortcomings of the new facility became apparent soon after the switch. Initially, the water was underchlorinated, resulting in water boil advisories issued in July and August 2014 to counteract E. coli and coliform bacteria detected in the water supply. While chlorine levels were adjusted throughout the summer months to address the bacterial presence, corrosion inhibitor levels were not. In October 2014, the General Motors engine plant in Flint switched to an alternate water source because the water's corrosiveness was adversely affecting its engine parts.

During this time, the water supply was highly corrosive, causing red water and other discoloration throughout the water system, as well as an unusually large number of water main breaks (Masten et al., 2016). The heavily chlorinated water corroded the lining of city and residential pipes, leaching lead from the outdated water pipes into the water supply.

The first high lead measurements in the city were detected in February 2015. City authorities assured residents that these measurements were outliers and that the water was safe to drink. By August 2015, Marc Edwards at Virginia Polytechnic Institute and State University had analyzed 120 samples from Flint homes, finding that 20% of samples exceeded the EPA action level of 15 μg/L. In September 2015, city authorities acknowledged the widespread lead contamination of the water supply and issued a lead advisory. The city switched back to Lake Huron water treated by the DWSD on October 16, 2015.[4] This story began to receive national attention, culminating in the governor of Michigan apologizing to city residents in January 2016.

The timeline of the water contamination presents an interesting challenge to our analysis. While the water supply switch occurred in April 2014 and the city first disclosed high lead measurements in February 2015, residents did not have confirmation of the contamination until September 2015. Although other studies measure the effect of exposure to lead contamination, we

[4] A more detailed history of Flint and the water contamination timeline is presented in Appendix B.

focus on the behavioral response to knowledge of the contamination. Thus, our analysis focuses on medical utilization after the city's lead advisory in September 2015, which represents our "treatment" period.

Data

Through an agreement with the Michigan Department of Health and Human Services (MDHHS), we link vital records for all children born in Michigan in 2013–2015 with their Medicaid claims files for any enrollees in the sample.[5] This unique dataset has several advantages. First, the dataset includes geocoded maternal residential address at the time of birth. Second, it contains birth certificate information on parental demographic characteristics (e.g., race, age, and educational attainment). Third, the Medicaid data is at the claim level, with detailed information regarding all diagnoses recorded and procedures performed at every visit, as well as provider information. The data also includes monthly eligibility information, which allows us to create a longitudinal panel for each enrollee—even those who abstain from medical use. Fourth, the Medicaid data includes information about payment made for all fee-for-service claims, allowing us to extrapolate payments to the managed-care claims for complete cost information.[6] Fifth, the linkage of birth records to claims allows us to track children who were born in Flint, irrespective of where they received their care in the years that followed, thus avoiding selection due to migration out of the city.[7] These data include Medicaid claims for the years 2013–2016. [8]

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[5] The sample includes both fee-for-service and managed care enrollees, as well as those who do not indicate type of plan.

[6] We apply cost information for managed care claims by matching procedure codes with payment made for fee-for-service procedures. Therefore, our cost estimates represent the upper range of costs to Medicaid, though they are closer in line with costs for those who are privately insured.

[7] We can track medical care received by children covered by Medicaid as long as they did not move out of state.

[8] We have received approval to supplement our analysis with Medicaid claims data covering 2017 and 2018 once the data become available.

We classify all claims for care provided in the emergency department (ED) using the New York University Emergency Department (NYU ED) visit severity algorithm.[9] To develop the algorithm, emergency physicians reviewed ED records from the 1990s and categorized diagnosis codes (that did not include any alcohol, drug, injury, or mental health elements) into the following categories (Billings, Parikh, and Mijanovich, 2000; validated by Ballard et al., 2010):

- Emergent, ED care needed and non-preventable (e.g., appendicitis)
- Emergent, ED care needed, but would have been preventable given adequate previous non-emergency care (e.g., diabetes, asthma)
- Emergent, care needed within 12 hours, but primary care would suffice (e.g., heartburn, eye pain)
- Non-emergent, care within 12 hours unnecessary (e.g., rubella, sunburn, jaw pain)

These categories are not mutually exclusive, however. Depending on the complexity of the presenting patient most diagnoses should include a mix of these categories. For example, based on other details on the discharge record, out of 100 cases of:

- Croup: 57% are emergent and non-preventable, 19% are primary care treatable, and 24% are non-emergent.
- Cough: 12% are emergent and non-preventable, 24% are primary care treatable, and 65% are non-emergent
- Acute tonsillitis: 6% are emergent but preventable, 28% are primary care treatable, and 66% are non-emergent.

Finally, some diagnoses could not be assigned to a category and so are listed as “unclassified”.[10]

[9] https://wagner.nyu.edu/faculty/billings/nyued-background

[10] In Appendix C, we present results incorporating a “patch” that captures and classifies a share of uncategorized diagnosis codes (Johnston et al., 2017).

Methodology

This research allows us to track the use of medical services by children born in Flint between 2013 and 2015,[11] and compare them to similarly aged children born elsewhere in Michigan. Because we classify children based on the city in which they were born, our estimates are an intent to treat. A priori, we expect to identify higher incidence of adverse health outcomes, increased use of primary care, and increased costs for patients and insurers because of care received following the informational shock described above.[12]

Since the data are observational, we adjust for differences between Flint residents and those in the rest of the state. We follow the estimation method used by Grossman and Slusky (2019), which compares Flint to a subset of other large cities in Michigan. We focus exclusively on Michigan because we have complete Medicaid data for this state. Because we are interested in the behavioral response to the national news event as well as changes in water quality, we focus on September 2015, when Flint first released a public lead advisory.[13,14]

We employ the difference-in-differences empirical strategy presented below:

$$Outcome_{ict} = a + \beta_1 Flint * After_{ct} + \beta_2 X_{ict} + \alpha_c + \delta_t + \varepsilon_{ict} \qquad (1)$$

in which *Outcome* is the medical service or procedure for individual *i* in city *c* at time *t* aggregated over the calendar month. *Flint*After* is a binary variable equal to 1 for claims after September

[11] Given the result of Grossman and Slusky (2019) that the Flint water switch affected fertility rates, one might be concerned about compositional changes driving our results. In Appendix D, we limit our analysis to the sample of children born before April 2014 (and so unaffected by the fertility effects of the water switch) and find comparable results.

[12] i.e. Flint announcing a potential increase in lead in their water source.

[13] Mona Hanna-Attisha, a Flint pediatrician, held a press conference to announce her findings of a substantial increase in children with high blood lead levels in September 2015; Marc Edwards of Virginia Tech released his team's findings of high blood lead levels in Flint households in August 2015. Flint switched off Flint River water on October 16, 2015.

[14] In Appendix E, we show that the results are robust to starting the treatment period in January 2016, when the Governor of Michigan apologized for the crisis.

2015 to children born in Flint and 0 otherwise. We include a binary variable for the city in which an individual lived at time of birth, α_c, which controls for time-invariant characteristics of a city, and fixed effects for claim year, claim month, birth year, and birth month, δ_t, which control for general trends and seasonality in receipt of medical services. City fixed effects subsume the main effects for $Flint$ and $After$. X_{ict} are individual-level characteristics including child's gender, and maternal race, age, and education.[15]

A potential confounder in our study is that the state of Michigan expanded Medicaid coverage through the ACA in 2014. To the extent that this expansion affected all parts of Michigan equally, time fixed effects will account for overall trends in Michigan. This issue is further mitigated in that the ACA expansion affected adults and did not change federal poverty-level coverage thresholds for those in our age cohort.[16] While Michigan Medicaid approved a higher income eligibility threshold for children affected by the Flint water crisis in March 2016, the program was not immediately implemented. The number of robustness checks we perform testing sensitivity to the time-period used in the analysis allows us to believe that changes in eligibility implemented in May 2016 do not affect the conclusions that we draw.

We conduct our analysis in two ways. First, we investigate the percentage of the sample reporting: any lead test, any office visit, any vaccine, any ED visit, any claim, and any payment.

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[15] The analyses do not include individual fixed effects. This decision is driven by substantive as well as computational motivations. Substantively, children undergo rapid developmental and health changes in this age group. Including time-invariant fixed effects does little to account for the health care needs of these children. Computationally, including 61,784 fixed effects would likely result in over fitting and undermine the precision of our estimates. As individual fixed effects would undermine the precision of estimates without adding substantively to our understanding of healthcare utilization, we excluded them from our analyses. That said, in extensions to main analyses, we track individual children across time to link utilization patterns, taking advantage of the longitudinal nature of our data.

[16] While there is evidence of spillover effects of increases in parental coverage on child take up of Medicaid and child receipt of wellness visits (Hamersma et al., 2019; Sacarny et al., 2020; Venkataramani et al., 2017), we provide evidence of robust effects using our full sample and using a sample composed of only post April 2014 data (when Michigan expanded Meidcaid), which should therefore not be affected by differential changes in Medicaid expansions across Michigan localities (Appendix G).

We also investigate the total number of lead tests, office visits, vaccines, ED visits, and claims, as well as the total payments made.[17] Standard errors are clustered at the city level to allow for serial correlation (Abadie et al., 2017). Additionally, we use wild bootstrap methods to adjust our inference because we only have one treated area (Cameron, Gelbach, Miller, 2008). As an additional robustness check, we perform randomized inference permutation tests (see e.g. Fisher, 1935; Cunningham and Shah, 2018; Hess 2020).

We use a modified version of the above equation to investigate the impact of the water switch on different types of ED visits, as defined by the NYU algorithm. For each category, we construct a per capita outcome variable at the individual-month level by summing the fractional shares of each claim in that category. For example, if an individual had two discharges in a given month, one that was 20% preventable with primary care and another that was 70% preventable with primary care, we assign a value of 0.9, representing 90% of a primary-care-preventable visit. Anyone without an ED claim in that category (or with no ED claims at all) receives a value of 0.

While coding those with no claims as having zero visits in a linear specification may bias the results (as some of the individuals would ideally have a negative number of emergency room visits), this bias would be toward zero, and so we consider our set up to be a lower bound on the true effect. We establish our intuition for this setup with three thought experiments. First, imagine that all ED visits are 100% preventable with primary care. Then, to estimate the reduction in per capita ED visit results from a shock to primary care, one would assign 0 to those without an ED visit, and the number of visits to anyone with an ED visit.

[17] We exclude urgent care centers in the analysis, as these are observed in only 2.46% of enrollee-months, ranging between 1.58% in 2013 to 2.74% in 2017. As comparison, ED visits are observed in 7.05% of enrollee-months. Of 225,898 claims for lead testing in the data, only 4 are performed in an urgent care clinic. Thus, we conclude, analysis of urgent care clinics would not offer insights into lead testing or subsequent care.

For the second thought experiment, imagine that some ED visits are 100% non-preventable. The primary care shock should not affect these visits, and so individuals with only these visits should still be assigned a value of 0 for the outcome variable.

Finally, consider our actual situation, in which certain diagnoses are sometimes preventable and sometimes not. We only care about the preventable parts for our primary estimate, and so in aggregate we can add up the preventable shares of each one to get the outcome variable.

A final note is that the NYU ED algorithm is designed for the entire population, not specifically for children. This is a known limitation of the algorithm, recognized by its developers (Billings, Parikh, and Mijanovich, 2000). However, lacking a child-specific algorithm, we consider this a valid proxy of avoidable ED visits for our analysis.

We estimate the elasticity of substitution by comparing magnitudes of the effect of the Flint water contamination shock on ED visits and primary care visits relative to their respective means.[18]

A potential challenge to our identification is that the estimated differences could be attributed to the emergency management in Flint that began in December 2011, rather than the water contamination. To rule out a trend in outcomes of interest prior to September 2015, as well as to explore its dynamics month to month, we estimate an extended form of specification (1) where the time period is disaggregated into monthly indicators:

$$Outcome_{ict} = a + \sum_j \beta_{1j} Flint * Month_{cj} + \beta_2 X_{ict} + \alpha_c + \delta_t + \varepsilon_{ict} \qquad (2)$$

[18] Appendix F describes in detail the standard procedures for lead tests. While there is a plausible concern that parents might bring children to the ED for lead tests, our data does not show any lead tests performed in the ED. Furthermore, our interviews with ED physicians show that even if a blood draw was performed in the ED to be sent out to an outside laboratory for lead testing, unless severe lead poisoning was suspected, patients would be directed to their primary care physician to receive the results of the test.

where $Flint * Month_{cj}$ is a monthly indicator for an individual residing in Flint and β_{1j} estimates the difference in claims in month j between children born in Flint and control cities with respect to September 2015.[19]

Results

Before proceeding with the analysis, we use an event study specification to justify selection of September 2015 as the beginning of the treatment period. Figure 1 shows results for our event study specification, showing differences in monthly lead tests for children born in Flint compared to those in control cities.[20,21] Each point shows the difference in number of lead tests for children born in Flint compared to control cities with respect to September 2015.[22] The whiskers on each estimate provide the 95% confidence interval. The graph shows a clear rise in lead tests after September 2015, with a sharp peak in January and February 2016. The graph also shows no significant trend prior to September 2015, suggesting that despite ongoing speculation, the announcement of elevated residential tests by city authorities marked the beginning of Flint residents changing their behavior with respect to health care receipt for their children.

[19] We perform similar analyses at the quarterly level as well. These results are presented in Table 4 and Figure 2.

[20] To ease potential concerns of increased volatility in lead test results before May 2014 (as shown in Figure 4, Panel C). Appendix G shows consistent results starting with the pre-period in May 2014.

[21] The primary control cities are the other most populous cities in Michigan (Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming). Appendix H shows comparable results using alternative control cities with histories of high lead levels in their drinking water (Detroit, Grand Rapids, Kalamazoo, Lansing, Wyoming, Battle Creek, Port Huron, Hamtramck, and Saginaw; see Urban, 2018).

[22] The American Academy of Pediatrics (AAP) recommends that children be tested for lead levels at ages 1 and 2; it also suggests lead screening for older children who have not been tested. During the period covered by this study, the AAP changed its recommendation to venous blood draws for testing, noting that finger-prick sample testing yielded a high rate of false positives. The AAP lists Lead Screening in Children using CPT Code 83655, which we use in our analysis. The code does not allow for differentiation between finger-prick or venous blood tests. Because venous tests are more difficult to administer, this may introduce more heterogeneity among children who receive the test in Flint compared to other cities after the contamination became known. Though we would like to account for different methods of testing, we are unable to do so.

Table 1 shows summary statistics and unadjusted difference-in-differences estimates. In Panel A, we see minimal statistically significant changes in the demographic characteristics in our sample population, with the exception of a small in magnitude 0.13 year (6.5 week) decrease in maternal age. Following the national news event, receipt of any lead test nearly doubles in Flint compared to a small increase in comparison areas. The unadjusted difference-in-differences results show a 1.6 percentage point increase in lead tests among children in Flint compared to others, but much more modest changes in other types of health care, except ED visits, which we discuss in greater detail below. We also see a small increase in payments in Flint compared to other cities. In Panel B, we find no change in unavoidable ED visits, but decreases in all three of the avoidable or non-emergent categories.

Main Results

Table 2 shows our primary difference-in-differences results. Using September 2015 as the treatment date (when the independent evidence of increases in lead exposure became public), the likelihood of receiving any lead test increased by 1.7 percentage points (pp), a 49 percent increase. We estimate a small, statistically insignificant decrease in the share of individuals having any office visits. However, we show later that this hides important immediate increases in office visits (Table 4). Interestingly, given our results below, we see a slight, marginally significant decrease in the share of children with an ED visit. This is possibly because ED visit is a heterogeneous measure including both avoidable and unavoidable visits, which could be dampening the power of our analysis. Any claims and any payments increase by 1.9 and 1.8 pp, respectively. These represent a 4 percent increase in both categories.

In panel B we examine the total number rather than an indicator for any receipt. The results are unsurprisingly quite similar for lead claims, as individuals likely only receive at most one lead test per month. However, vaccinations demonstrate a potential positive spillover effect of receiving primary care for other services, with vaccinations increasing 12 per 1000 person-months (3.6%) in Flint compared to other areas following the national news event (Carpenter and Lawler, 2019). Finally, claims increase by 6.6 per 1000 person-months (2%).

Table 3 contains results using the per capita measures of ED visits calculated using the method described above. We find no change in the number of non-preventable ED visits. For each of the other three types, our estimates indicate a decrease of between 1 and 2 visits per thousand enrollees per month. All are statistically significant at the 10% level, with non-emergent and preventable statistically significant at the 5% and 1% level, respectively. We create two composite metrics: (1) PC sensitive, a combination of primary care treatable and non-emergent; and (2) Avoidable, a combination of primary care preventable, primary care treatable, and non-emergent. The national news event is associated with nearly 5 fewer avoidable ED visits per enrollee-month in Flint, a decrease of 8.3 percent.

We perform quarterly analyses on office visits, avoidable ED visits, and payments in Table 4 and Figure 2. The motivation for this analysis is that in Figure 1 we find a very large increase in lead tests only at specific times, most notably September 2015 and January 2016. To test our hypothesis that this increase in lead tests should also increase office visits, we separate our results by post-national news event quarter. Our results suggest that immediately following the national news event, office visits increase by 0.9 pp (4%), while they increase by 2.7 pp (11%) in the first quarter of 2016. Office visits decrease in the last two quarters of treatment in Flint compared to control areas. Avoidable ED visits initially remain constant, but then decrease substantially and with statistical significance for the rest of the treatment period. This suggests an initial increase in office visits having a prolonged effect on ED visits. One way to explain these results is that this initial increase in office visits created a link between the patient (and his or her parents) and the healthcare system.[23] We explore this idea in more detail in the mechanism section.

To further explore whether these substitutions are driven by lead-sensitive conditions or reflect a more general shift in utilization, we repeated the analysis, restricting the sample to the most common Clinical Classification Software (CCS)[24] categories in the ED prior to September 2015. CCS categories were developed by the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality to classify ICD-9 diagnoses and procedures into clinically meaningful categories.

For this analysis, we identified the 10 most commonly occurring CCS categories in the ED that correspond to claims predating September 2015 with diagnoses classed by the NYU algorithm as avoidable.[25] These CCS categories encompass over 86% of all avoidable claims in the ED and are listed in Table 5. Next, we aggregated claims to the person-month-CCS category, so that for each individual in our data, we have monthly use indicators, now split by CCS category. We excluded all individuals with no claims in the CCS category for that month. As with the person-month analysis, we sum the NYU Algorithm indicators for preventable and non-preventable ED care. We re-estimate our specification for two venues of care: office visits (all diagnoses in each CCS category) and ED (only avoidable shares as defined above).

[23] For example, care for a child who was previously brought in to the ED for asthma flare-ups has shifted to a physician's office. An in-office inhaler prescription not only prevents future flare-ups that would necessitate ER visits, but also reduces future office visits, as the condition is appropriately maintained.

[24] https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp

[25] For this classification, we limited claims to those with any avoidable component in diagnoses, then identified the 10 most common CCS categories within that subsample of claims. We chose to focus on CCS categories because classifying diagnoses is too specific and not sufficiently informative. This also allows us to impute avoidability of CCS category based on these most common diagnoses, but by including all diagnoses in a given CCS category we avoid defining this category too narrowly.

We present results from this analysis in two formats. Figure 3 shows coefficient estimates by CCS category for any office visits (Panel A), avoidable ED visits (Panel B), and a scatterplot by category (Panel C). Table 6 then tests the hypothesis that in each CCS category the increase in office visits is accompanied by a decrease in avoidable ED visits. Looking at Figure 3, we see that in 6 of 9 CCS categories, office visits (Panel A) increase, with 5 of those 6 increases being statistically significant. Preventable ED visits (Panel B), on the other hand, decline in 6 of 9 categories. Comparing specific CCS categories, we particularly notice a sharp increase in office visits for skin and subcutaneous tissue infections, and a decrease in associated preventable ED visits. Abdominal pain is another category with a sharp increase in office visits and a decrease in preventable ED visits, as is gastritis and duodenitis. Comparing the office visit and avoidable ED visits by condition (Panel C), we see a clear negative, linear relationship between the two results, with a greater increase in the share of children having any office visits causing a greater reduction in avoidable ED visits per capita.[26]

In Table 6 we present the results of a chi square test that compares the estimated change in office visits to that of preventable ED visits, (H_0: $\beta_{OfficeVisits} = -\beta_{AvoidableEDVisits}$), by CCS category. The chi square test fails to reject the null in any category, suggesting that, indeed, the increase in office visits is statistically indistinguishable from the decrease in preventable ED visits.

[26] Appendix I shows a similar relationship between total office visits and avoidable ED visits.

Mechanisms

To test the role of lead testing in the potential mechanisms for changing medical utilization, we use individuals' episodes of care to explore choices in primary and ED care following the administration of a lead test. Our main results suggest that the contamination increased awareness of primary care through increased interaction with a physician or clinic. To examine this further, our analysis focuses on treatments received in the three months following a lead test to identify changing trends in utilization in Flint after September 2015.

The results of medical utilization in the post-lead test period are reported in Table 7. Here, the sample is limited to visits in the 3-month period following a lead test (columns (1)-(4)). We find statistically significant increases in the likelihood of indicators of established care: 3.7pp increase in immunization, 2.9pp increase in well-visits, 8pp increase in seeing the same provider, 14.8pp increase in using the same clinic. These results strongly suggest that following the national news event, Flint residents who received a lead test were more likely to continue to receive regular care from the same clinic. It follows from this result that should a child become ill after having received a lead test, a parent would likely take the child back to the clinic at which he or she received this test to see the same physician. Parents who had not taken their child to receive a lead test would be more likely to take their sick child to the ED.

A concern in our analyses thus far is that our results are intent to treat and thus we cannot say whether those induced to receive more lead and primary care visits are the same children who were less likely to have an avoidable ED visit. To allay these concerns, we create a variable for children who were on schedule with their well visits, and those who were behind on well-care according to American Academy of Pediatrics recommended schedule of well-care and metrics set up for healthcare effectiveness (American Academy of Pediatrics 2020).[27] We analyze our sample using two separate age groups: infants (age 0–15 months); and toddlers (age 16–36 months). In particular, we define an infant as behind on well-care if he/she has had fewer than 6 visits by the age of 15 months.[28] We define a toddler as behind on well-care if he/she had fewer than 7 visits by the age of 36 months.[29]

We then analyze whether, following the news shock, children were less likely to be behind schedule on well visits. In Table 8, we find a decreased likelihood of being behind schedule on well-visits of 4 (4.5) pp for infants (toddlers), or an 8.8 (8.3) percent reduction. For both age groups, the news shock increased parental adherence to AAP recommendations.

We then split our sample in columns (3) and (4) based on adherence to recommendations for well visits in the period *before* the information shock, that is restricting the sample to children who were behind schedule prior to September 2015, to investigate avoidable ED visits. We find a statistically significant reduction in avoidable ED visits for both groups (i.e., those who were behind on well visits and those who were up to date on them in the pre-shock period). However, the results are larger in magnitude and statistically different at the 10% level, for children who were behind on well visits (5.6 per 1,000 fewer compared to 3.5 per 1000 fewer; which are decreases of 10.2 and 5.5 percent, respectively). This means that those who were behind on well visits prior to the information shock reduced the likelihood of an avoidable ED visit by a larger magnitude than those who were up to date. Taken together these results strongly suggest that the

[27] We define well visits using CPT© codes 99381-99385 for new patient visits, and CPT© codes 99391-99395 for established patient visits.

[28] More specifically, we define behind well care if an infant is 15 months old and has fewer than 6 well-visits, 12 months and has fewer than 5 visits, is 9 months and has fewer than 4 visits, 6 months and fewer than 3 visits, and is 4 months and has fewer than 2 visit.

[29] We are unable to perform this analysis for an older sample as our sample was born in 2013 at the earliest, meaning we would not have a sample above age 3 at the time of the news shock.

news shock in Flint induced parents to take their children to the physician more often for both lead tests and well visits, which reduced avoidable ED visits.

Pre-Trend Analysis

To test the validity of our specification, as well as to discern monthly trends of our analysis, we estimate the event study proposed in equation (2). The estimates of β_{1j} are presented graphically in Figure 4; each point represents the difference in outcome between Flint and control cities relative to September 2015. Panel (A) shows results for number of claims, Panel (B) represents any office visits, and Panel (C) reflects preventable ED visits. All three panels show that, despite seasonal variation, there is no discernable trend in these outcomes prior to September 2015, validating our use of the difference-in-differences estimation method. Furthermore, we note a sustained increase in claims and office visits in the treatment period.

An important caveat to these analyses is that our sample is composed of individuals born in 2013–2015. Thus, the figures showing a great amount of variation in pre-trends in the early time periods are likely caused by small sample sizes in Flint during those months. Additionally, as shown below, the robustness of our results to additional sample restrictions including limiting our analysis to those born before April 2014 (Table D1), limiting our analysis to only using data post April 2014 (Table G1), and including binary variables for additional time periods between the water switch and the information shock (Table A1) provide indirect evidence that our results are likely not being driven by differential trends in Flint in the early preperiod.

(Slightly) Longer Term Effects

Though quarterly analysis in Figure 2 shows declining office and avoidable ED visits in the latter half of 2016 following the immediate increase in office visits, it is untested whether the prevention effect of office visits lasts beyond this initial period. To explore the medium-term changes of the initial rise in office visits we extend the analysis to 2017 in Figure 5.[30] We find that the decline in office and avoidable ED visits persists through 2017, suggesting that the benefits of increased office care are longer lasting. The magnitude of the decreases is such that they cannot be explained by the displacement of office visits from Q32016–Q42017 to Q42015–Q12016. Consistent with the shorter-term results, however, the decline in avoidable ED visits is larger than the decline in office visits.

Robustness Checks

We include several robustness checks in the appendices, some of which have been previously mentioned above. This includes controlling for unemployment rates at the city level (Table K1), stratifying our sample to children born to black mothers (Table L1), children in fee-for-service Medicaid (Table L2), and children in managed care plans (Table L3).[31] Our estimates follow a similar pattern; we continue to see a sizable decrease in avoidable ED visits in each of these samples. We also start treatment in January 2016 instead of September 2015 (Table E1) and limit the sample to the cohort of children born before April 2014 to avoid potential bias from endogenous fertility (Grossman and Slusky, 2019) and/or worse health at birth following the water change (Abouk and Adams, 2018; Wang et al., 2019) (Table D1). Results are robust to these alternate sample definitions. We also start the pre-period in May 2014 (Table G1) and use the "patched" NYU Algorithm (Table C1), per Johnston et al. (2017). Additionally, to test the sensitivity of our findings to the treatment period, we estimated a flexible form specification, with two treatment periods – January to August 2015 and September 2015 to December 2016 – and get

[30] Appendix J contains the table form of Figure 5.

[31] The lack of a populated fee-for-service / managed care indicator for half of the claims substantially reduces our sample size and therefore statistics precision in these tables.

qualitatively and quantitatively similar results, which we report in Appendix A.

To address concerns that the substantial increase in lead tests from our main results is driven by a non-representative sample of the broader population, we investigate whether those receiving lead tests after the national news event differ from those receiving tests prior to it. Table M1 presents results for demographic characteristics including sex, race, and maternal age using a difference-in-differences framework; it shows no change in characteristics of those seeking lead tests afterwards.

One might also be concerned that choosing comparison cities by population may result in non-comparable groups with regards to lead levels. Appendix H repeats our main analysis using an alternate control group of cities (including smaller ones) with histories of high lead levels (Urban, 2018) and finds comparable results.[32]

To explore when office visits matter, we separately estimate our results by weekday (Table N1) and weekend (Table N2). Individuals are less likely to get an office visit on a weekend, so we expect to see our main results driven by changes on the weekday. Overall, we find evidence of this: rates of lead tests, office visits, and avoidable ED visits are higher on weekdays, as expected. Additionally, the lead test effects on weekdays are nearly identical to our main results, while the effect on weekends is close to zero (and this difference is statistically significant at the 0.1% level). While we find some statistically significant results for weekends, these are rare outcomes, thus very small changes may drive these effects. For avoidable ED visits, the decrease for Flint on weekdays is approximately twice as large as on weekends. However, the percentage change in these variables is not as stark (8% on weekdays compared to 6% on weekends).

[32] We additionally perform an analysis adding Pontiac and Muskegon to our main analysis, as these cities may be more comparable to Flint, with consistent results.

Finally, we perform randomization inference permutation tests for our main results: any lead test, avoidable visit, and non-preventable visit in Appendix O (following Fisher, 1935; Cunningham and Shah, 2018; and Grossman and Slusky, 2019). These tests compare the coefficient in our main analyses to a distribution of coefficients when we systematically assign treatment to each individual control city. Comparing our actual result for Flint to this distribution of treatment effects allows us to assign statistical significance if our Flint effect is an outlier. For any lead test, the Flint coefficient is the most extreme by far, suggesting statistical significance. For avoidable visits, the Flint coefficient is also the largest negative number, although there are positive coefficients of greater magnitude.[33] For non-preventable ED visits, the coefficient for Flint is closer to zero than any of the results for other cities, suggesting no effect.

Discussion

The results in Figure 2 show that definitive public information about Flint's water supply led to a 4 percent increase in office visits in quarter 4 of 2015, the first treatment quarter. Office visits increased by 11 percent in the first quarter of 2016. From Table 3, column (6), we find a decrease of 4.9 visits per thousand person-months, which on a mean of 59 per thousand represents an 8.3% decrease. Dividing the percent change in avoidable ED visits by the percent change in office visits provides us with an estimate of elasticity of substitution between primary and ED care of between -0.5 and -2.2.

Figure 3 then breaks this result down by common diagnosis classifications that are often avoidable. In addition to our results not being driven by one or two conditions, we generally see a negative relationship between the magnitude of the effect on office visits for a particular condition

[33] In Table O1, we find similar results performing randomized inference using an individual level approach (Hess 2020)

and the magnitude of the effect on avoidable ED visits for that same condition. For upper respiratory infections; skin and subcutaneous tissue infections; abdominal pain, gastritis, and duodenitis, we find precisely estimated and opposite effects. A chi-squared test of parity between the magnitudes of the estimated coefficients (H_0: $\beta_{OfficeVisits} = -\beta_{AvoidableEDVisits}$) yields statistically insignificant results, suggesting we cannot reject the null that these estimates are of equal magnitude and oppositely signed. We are hesitant in interpreting this test, as it may lack the specificity to reject our null hypothesis. However, this lends credence to our postulation that increased office visits prevent avoidable ED visits.

Despite this substitution from potentially avoidable ED visits to office visits, we also find a statistically significant increase in any Medicaid spending. We attribute this to the relative frequency of each type of visit; given the vast difference in the share of enrollees with any ED visit (0.088) in a given month vs. any office visit (0.249), the absolute increase in office visits and associated testing costs more than the savings from prevented ED visits. These results are consistent with literature that shows that increasing use of preventive care is not associated with savings in overall cost of care (Danagoulian, 2018; Jones, Molitor, and Reif, 2019). Though we do not find a statistically significant change in total costs, we know that establishing usual source of care is welfare improving, particularly for children (Ettner, 1996; Xu, 2002; Starfield and Shi, 2004; Paustian et al., 2014).

Conclusion

As the intensity of exposure to environmental pollutants decreases with improved regulation and control, health outcomes will improve and subsequent treatments associated with exposure will decrease. This, however, does not negate the burden imposed by such contaminations on communities, as the anxiety and uncertainty associated with such exposure increase, among other things, utilization of all medical services. This paper identifies the opportunities inherent when such environmental disasters expand awareness of health and health care.

The Flint water switch led to increases in lead tests and associated office visits and gives us a unique opportunity to study the substitution between office visits and potentially avoidable ED visits. While we find suggestive evidence of substitution, we do not find overall healthcare cost savings. Our results emphasize that moving care from the ED into the primary care setting should not be pursued for its cost savings but, rather, for improved quality of care. These results are specific to a cohort aged 0 to 3 years old and may not be generalizable to the general public.

This work has policy implications in two broad areas. First, as with our and others' previous work on the Flint Water Crisis, state-local fiscal policy matters, and decisions about water supply can have far reaching consequences. Proper testing, public comment periods, elected local control, and transparency in environmental testing all play substantial roles in the population health of communities.

Second, primary care is important and is underutilized, even for those on Medicaid (who are already fully insured with minimal if any cost-sharing). Our work suggests that policies that further encourage parents to ensure that their infants and toddlers are up-to-date on their well visits could help keep those children out of the emergency room. This reduces bad health outcomes for children and potentially eases capacity constraints on the emergent care system.

Broadly, this work documents the important role information can play in improving health care receipt for disadvantaged populations. Lead tests prompted parents to seek care for their children at the same clinics from which they received lead tests, reducing their likelihood of going to the ED for avoidable conditions. This may have important ramifications for any situation in which individuals are induced to seek care more often in primary care settings.

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Table 1: Summary Statistics

Panel A: Demographics and Primary Outcomes

	Before		After		Difference-in-Differences
	Flint	Other	Flint	Other	
Female	0.483	0.493	0.489	0.494	0.005*
Black	0.610	0.533	0.617	0.536	0.0036
Maternal Age	24.61	26.08	24.64	26.24	-0.1255***
	(5.29)	(5.81)	(5.20)	(5.81)	
Any Lead Test	0.030	0.029	0.055	0.038	0.016***
Any Office Visit	0.388	0.281	0.296	0.198	-0.008***
Any ED Visit	0.104	0.091	0.091	0.082	-0.0037**
# of Claims	3.814	3.766	2.335	2.305	-0.0177
	(9.53)	(8.41)	(6.40)	(5.81)	
Payment	825.8	803.6	316.8	248.1	10.43
	(3463.8)	(3447.4)	(1777.3)	(1985.1)	
Person Months	58927	762858	56549	751713	
Persons	3699	51091	3913	53914	

Panel B: Per Capita Emergency Department Visits by Type

	Before		After		Difference-in-Differences
	Flint	Other	Flint	Other	
Non-Preventable	0.0093	0.0081	0.007	0.006	-0.0001
	(0.0674)	(0.0622)	(0.0561)	(0.0510)	
Preventable	0.0088	0.0061	0.0079	0.0071	-0.0019***
	(0.0630)	(0.0546)	(0.0603)	(0.0635)	
Primary Care Treatable	0.0378	0.0294	0.0324	0.026	-0.0020**
	(0.1604)	(0.1384)	(0.1491)	(0.1297)	
Non-Emergent	0.0275	0.0248	0.0239	0.0224	-0.0012*
	(0.1311)	(0.1249)	(0.1229)	(0.1199)	
PC Sensitive	0.0653	0.0541	0.0563	0.0484	-0.0032**
	(0.2489)	(0.2274)	(0.2306)	(0.2146)	
Avoidable	0.0742	0.0602	0.0643	0.0555	-0.0052***
	(0.2789)	(0.2498)	(0.2588)	(0.2405)	
Person Months	58927	762858	56549	751713	
Persons	3699	51091	3913	53914	

Note: *** p<0.01, ** p<0.05, * p<0.1 Standard deviation in parentheses for non-dummy variables

Table 2: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1)	(2)	(3)	(4)	(5)	(6)
	Lead Claims	Office Visits	Vaccines	ED Visits	Claims	Payment
Panel A: Any						
Flint*After	0.017***	-0.003	0.002	-0.003*	0.019***	0.018***
	(0.001)	(0.006)	(0.003)	(0.002)	(0.004)	(0.004)
	[0.00]	[0.49]	[0.04]	[0.15]	[0.00]	[0.00]
R-squared	0.004	0.074	0.045	0.012	0.09	0.091
Dependent Variable Mean	0.035	0.249	0.163	0.088	0.46	0.459
Panel B: Number per Capita						
Flint*After	0.017***	-0.027	0.012*	0.0010	0.066*	0.179
	(0.001)	(0.036)	(0.006)	(0.002)	(0.032)	(7.374)
	[0.00]	[0.40]	[0.00]	[0.81]	[0.02]	[0.18]
R-squared	0.004	0.046	0.044	0.007	0.042	0.059
Dependent Variable Mean	0.039	1.056	0.335	0.138	3.063	323.646
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,601,698
Number of enrollees	61,784	61,784	61,784	61,784	61,784	61,784
Number of Cities	16	16	16	16	16	16

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Total payment is trimmed to exclude the top 1%. Robust standard errors are clustered at the city level. Brackets contain wild bootstrapped *p* values.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	-0.00001	-0.0019***	-0.0019*	-0.0011**	-0.0030**	-0.0049***
	(0.0003)	(0.0002)	(0.0009)	(0.0005)	(0.0010)	(0.0009)
	[1.00]	[0.01]	[0.28]	[0.01]	[0.06]	[0.01]
R-squared	0.004	0.003	0.008	0.006	0.01	0.01
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164
Number of enrollees	61,784	61,784	61,784	61,784	61,784	61,784
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.0072	0.0068	0.0284	0.0239	0.0523	0.0591

Notes: Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. Brackets contain wild bootstrapped *p* values. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: Separate Coefficients Estimated for Each Post-Period Quarter

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Lead Claims	(2) Office Visits	(3) Vaccines	(4) ED Visits	(5) Claims	(6) Payment
Panel A: Any						
Flint*After Qtr 1	0.013***	0.009**	-0.005*	0.005**	0.025***	0.024***
	(0.001)	(0.004)	(0.003)	(0.002)	(0.004)	(0.005)
Flint*After Qtr 2	0.084***	0.027***	0.004	-0.009***	0.033***	0.032***
	(0.001)	(0.004)	(0.003)	(0.001)	(0.006)	(0.006)
Flint*After Qtr 3	0.006***	0.0003	0.012**	-0.005**	0.016***	0.014***
	(0.001)	(0.006)	(0.005)	(0.002)	(0.004)	(0.004)
Flint*After Qtr 4	-0.012***	-0.024**	0.008	-0.007**	0.007**	0.006*
	(0.003)	(0.010)	(0.007)	(0.003)	(0.003)	(0.003)
Flint*After Qtr 5	-0.007***	-0.033***	-0.008***	-0.003	0.009	0.008
	(0.002)	(0.007)	(0.002)	(0.002)	(0.008)	(0.008)
R-squared	0.005	0.074	0.045	0.012	0.091	0.091
Dependent Variable Mean	0.035	0.249	0.163	0.088	0.461	0.46
Panel B: Number per Capita						
Flint*After Qtr 1	0.013***	0.049*	0.011*	0.004	0.127***	11.7
	(0.002)	(0.025)	(0.006)	(0.004)	(0.037)	(6.695)
Flint*After Qtr 2	0.086***	0.062**	-0.006	0.001	0.201***	9.837
	(0.001)	(0.022)	(0.009)	(0.003)	(0.043)	(8.618)
Flint*After Qtr 3	0.004***	0.015	0.026***	-0.002	0.046	-1.425
	(0.001)	(0.041)	(0.008)	(0.003)	(0.040)	(9.152)
Flint*After Qtr 4	-0.013***	-0.114*	0.033**	-0.004	0.015	-10.61
	(0.003)	(0.061)	(0.012)	(0.004)	(0.030)	(7.131)
Flint*After Qtr 5	-0.006**	-0.167***	0.004	0.002	-0.017	-13.076
	(0.003)	(0.046)	(0.004)	(0.003)	(0.044)	(9.041)
R-squared	0.005	0.046	0.044	0.008	0.042	0.062
Dependent Variable Mean	0.039	1.058	0.335	0.138	3.063	1207.274
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,601,698
Number of enrollees	61,784	61,784	61,784	61,784	61,784	61,784
Number of Cities	16	16	16	16	16	16

Panel C: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After Qtr 1	0.0011*	-0.0008***	0.0004	0.0022**	0.0025	0.0017
	(0.0006)	(0.0003)	(0.0010)	(0.0009)	(0.0017)	(0.0016)
Flint*After Qtr 2	0.0004***	-0.0004	-0.0014*	-0.0027***	-0.0040***	-0.0045***
	(0.0001)	(0.0003)	(0.0007)	(0.0008)	(0.0010)	(0.0011)
Flint*After Qtr 3	-0.0002	-0.0023***	-0.0006	-0.0028***	-0.0034***	-0.0057***
	(0.0003)	(0.0001)	(0.0007)	(0.0007)	(0.0009)	(0.0009)
Flint*After Qtr 4	-0.0008	-0.0030***	-0.0042***	-0.0027***	-0.0069***	-0.0099***
	(0.0005)	(0.0004)	(0.0014)	(0.0005)	(0.0017)	(0.0020)
Flint*After Qtr 5	0.0001	-0.0029***	-0.0016*	0.0004	-0.0012	-0.0041***
	(0.0004)	(0.0007)	(0.0008)	(0.0009)	(0.0013)	(0.0013)
R-squared	0.004	0.003	0.008	0.006	0.01	0.01
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164
Number of enrollees	61,784	61,784	61,784	61,784	61,784	61,784
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.007	0.007	0.028	0.024	0.052	0.059

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each column is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Top CCS Categories for Avoidable Claims in the ED

CCS	Description	% of Claims
126	Upper Respiratory Infection (URI)	48.51
133	Lower Respiratory Infection (LRI)	10.83
197	Skin and Subcutaneous Tissue Infection	7.16
128	Asthma	6.81
251	Abdominal Pain	3.65
83	Epilepsy, convulsions	3.82
222	Hemolytic Jaundice and Perinatal Jaundice	1.74
140	Gastritis and Duodenitis	1.39
107	Cardiac Arrest and Ventricular Fibrillation	1.28
125	Acute Bronchitis	1.25

Notes: Top 10 most frequently occurring CCS categories in claims for care identified as avoidable by the NYU Algorithm taking place in the ED prior to September 2015.

Table 6: Effect Comparison of Substitution Between Office Visits and Avoidable ED Visits by Category of Care

Description	**Any Office Visits**		**Avoidable ED Visits**		**H_0**	
	Coeff	Std. Err	Coeff.	Std. Err	Chi2	p>Chi2
All	0.027	0. 004	-0.003	0. 001	0.020	0.886
Upper Respiratory Infection (URI)	0.017	0.008	-0.044	0.014	0.030	0.852
Lower Respiratory Infection (LRI)	-0.027	0.012	0.007	0.016	0.050	0.831
Skin and Subcutaneous Tissue Infection	0.086	0.015	-0.036	0.012	0.220	0.636
Asthma	0.002	0.016	-0.031	0.014	0.020	0.877
Abdominal Pain	0.168	0.027	-0.086	0.024	0.110	0.743
Epilepsy, convulsions	-0.078	0.018	-0.001	0.020	0.060	0.811
Jaundice	0.058	0.024	-0.007	0.003	0.280	0.596
Gastritis and Duodenitis	0.100	0.024	-0.095	0.008	0.000	0.968
Acute Bronchitis	-0.020	0.010	-0.003	0.005	0.020	0.902

Note: H_0: $\beta_{OfficeVisits} = -\beta_{AvoidableEDVisits}$. Each estimate comes from a separate regression at the enrollee-month level for all children with claims in the specified CCS category. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level.

Table 7: Use of Primary Care Following Lead Testing

	(1)	(2)	(3)	(4)
	Immunization	Well	Same Provider	Same Clinic
Flint*After	0.0367*	0.0294***	0.0802**	0.1480***
	(0.0148)	(0.0050)	(0.0231)	(0.0295)
R-squared	0.0252	0.0242	0.24	0.3463
Obs.	21,413	21,413	16,820	16,820
Number of Cities	16	16	16	16
Dependent Variable Mean	0.1668	0.2004	0.5383	0.6272

Note: Each column shows estimates for specification for care received within 91 days of a lead test. The dependent variables are: Immunization – immunization as primary reason for visit (CCS code 10); Well – well child visit (CCS code 255 and 256); Same provider – provider seen was the same (National Provider Identifier) as the one administering the lead test; Same clinic – clinic was the same (National Biller Identifier) as in the one billing for the lead test. Specifications (1)-(4) limit observations to visits within 91 days of administration of lead test. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Table 8: Non-Adherence to Well-Visit Guidelines by Age Group and Avoidable ED Visits

	Behind on Well Visits		Avoidable ED Visits	
	(1)	(2)	(3)	(4)
	Infant	Toddler	Behind	Not Behind
Flint*After	-0.0406***	-0.0463***	-0.0056***	-0.0035***
	(0.0045)	(0.0041)	(0.0006)	(0.0009)
R-squared	0.036	0.041	0.009	0.011
Obs.	900,592	635,089	765,623	821,291
Number of Cities	16	16	16	16
Dependent Variable Mean	0.457	0.551	0.055	0.064

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Outcome in (1) and (2) regression is an indicator of whether a child is or has been behind on their well-visits (non-adherence) according to American Academy of Pediatricians visit schedule. Outcome in (3) and (4) is Avoidable ED visits which include Preventable, PC Treatable, and Non-Emergent; in (3) the sample was restricted to children who were behind well visits prior to September 2015. Well visits are defined by CPT© codes 99381–99385 for new patients, and CPT© codes 99391–99395 for established patients. The age categories are defined are infant (0–15 months), toddler (16–36 months), and any if child is behind as infant, toddler, or both. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. All regressions include child's gender, and maternal age, race, and education, and fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Number of Lead Tests in Flint Compared to Control Cities

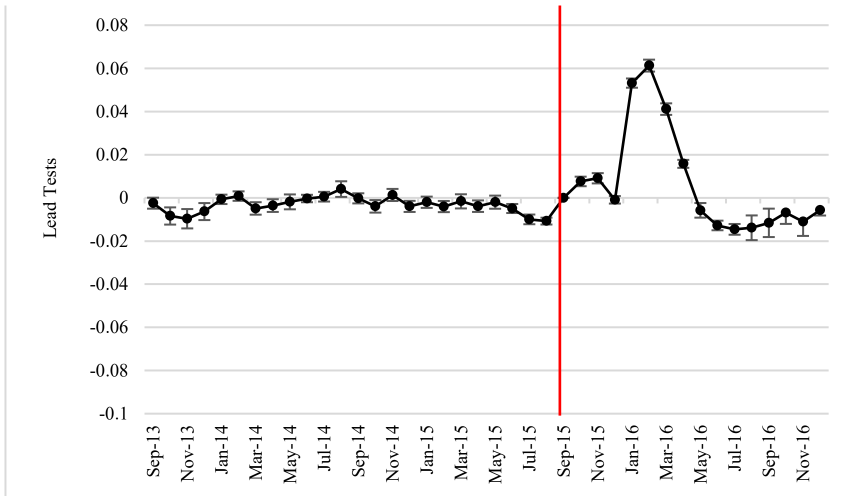
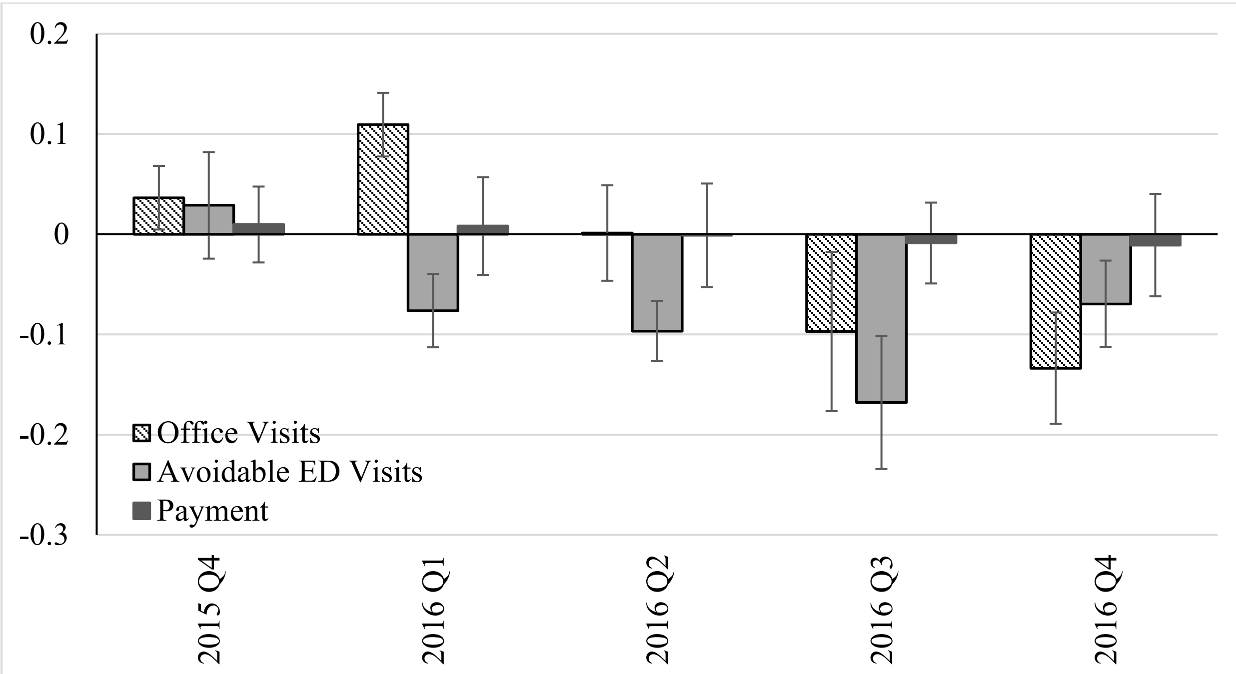


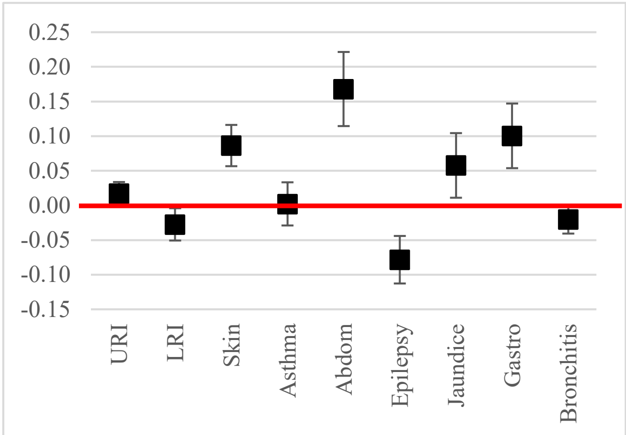
Figure 2: Quarterly Difference-in-Differences Effects on Office Visits, Avoidable ED Visits, and Payments



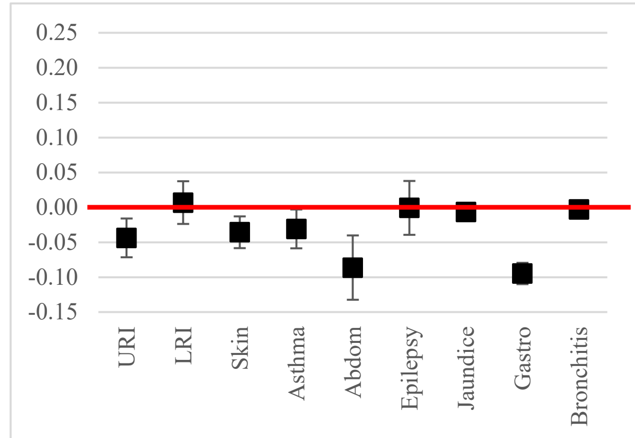
Notes: Effects from regressions for any office visits, avoidable ED visits, and total payments at the enrollee-month level for all eligible, enrolled children. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each set of effects for an outcome is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level.

Figure 3: Changes in Outcome by Diagnosis Classification

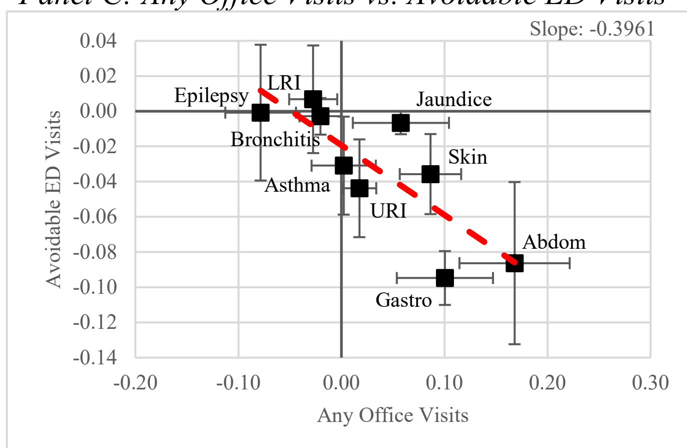
Panel A: Any Office Visits



Panel B: Per Capita Avoidable ED Visits



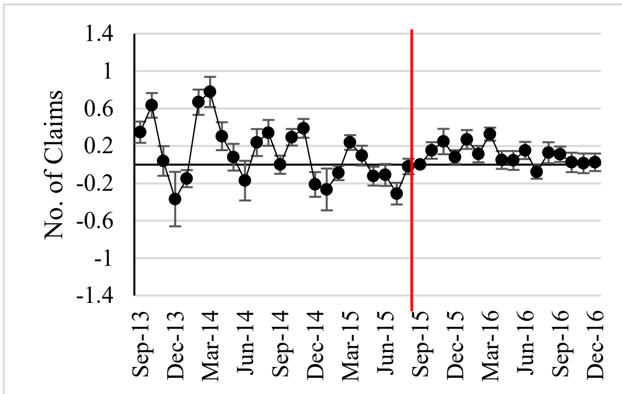
Panel C: Any Office Visits vs. Avoidable ED Visits



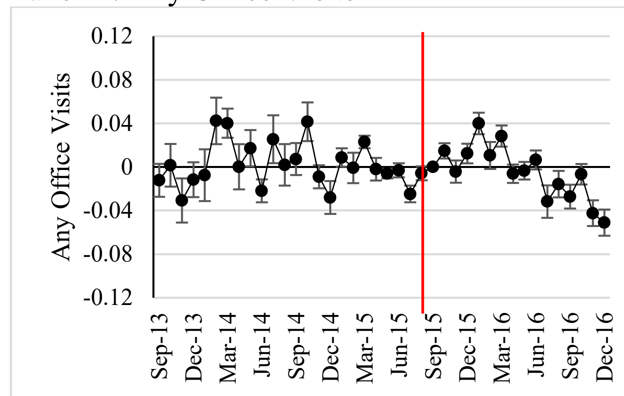
Notes: Each point is the coefficient estimate of a separate specification at the enrollee-month level for all children with claims in the specified CCS category. Treated city is Flint. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. Whiskers show a 95% confidence interval. Panel C plots any office visit on the y-axis and per capita avoidable ED visits on the x-axis from panels A and B.

Figure 4: Adjusted Monthly Differences by Outcome

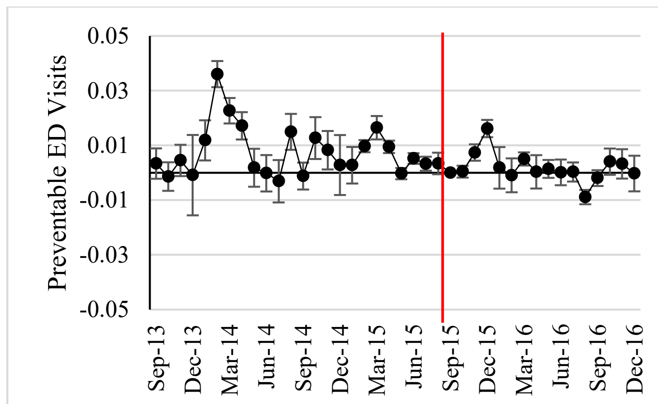
Panel A: Number of Claims



Panel B: Any Office Visits

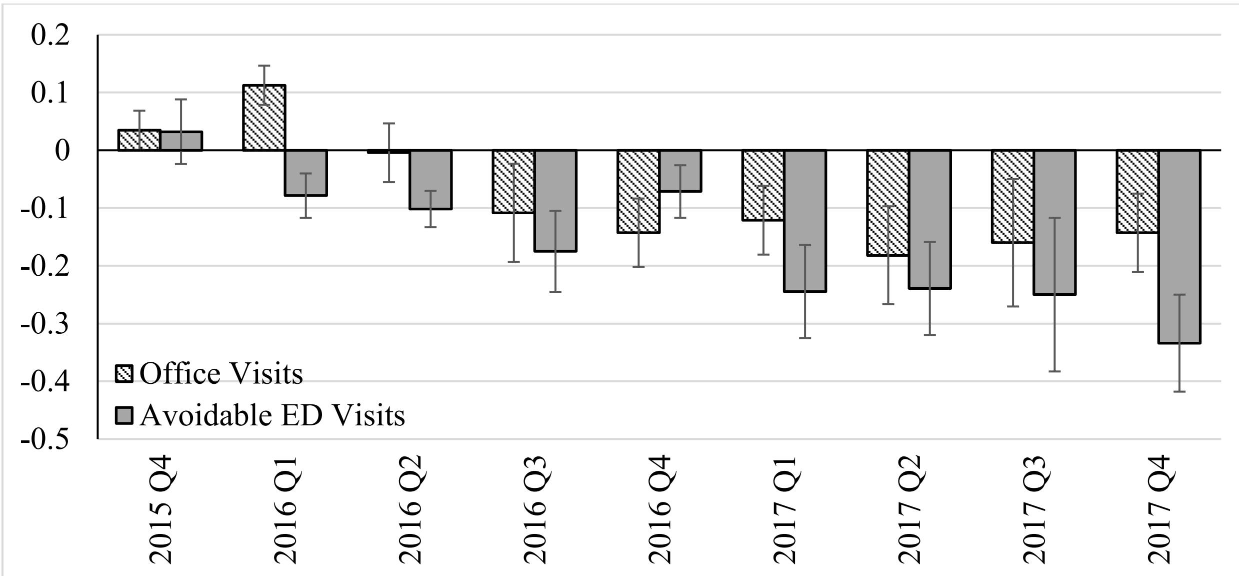


Panel C: Preventable ED visit



Notes: Each graph represents estimation results from a separate specification. Each point represents the monthly difference between treated and control, adjusted for gender, maternal race, and maternal education. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. Whiskers show a 95% confidence interval.

Figure 5: Quarterly Difference-in-Differences Effects on Office Visits and Avoidable ED Visits through 2017



Notes: Effects are from regressions for any office visits, and avoidable ED visits at the enrollee-month level for all eligible, enrolled children. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each set of effects for an outcome is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level.

Appendix A: Flexible Form Time Indicator

Table A1: Flint Dummy Interacted with Multiple Dummies for Multiple Post-Periods

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Any lead claims	(2) Any office visit	(3) Any vaccines	(4) Any ED visit	(5) # of claims	(6) Total payment ($)
Flint* Apr '14	0.005***	0.007*	-0.002	-0.001*	-0.036	12.650*
	(0.001)	(0.004)	(0.002)	(0.001)	(0.038)	(5.974)
Flint*Jan '15	0	0.002	0.006	0.001	-0.226***	5.267
	(0.001)	(0.007)	(0.004)	(0.002)	(0.042)	(8.549)
Flint*Sept '15	0.018***	-0.0003	0.004	-0.003	-0.039	6.743
	(0.002)	(0.009)	(0.005)	(0.002)	(0.056)	(11.414)
R-squared	0.004	0.067	0.045	0.01	0.042	0.059
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,601,698
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.035	0.249	0.163	0.088	3.063	323.646

Panel B: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint* Apr '14	0.0005	-0.0012**	-0.0033***	0.0012**	-0.0020*	-0.0032**
	(0.0003)	(0.0005)	(0.0006)	(0.0005)	(0.0010)	(0.0013)
Flint*Jan '15	0.0009***	-0.0012***	-0.0047**	0.0032***	-0.0015	-0.0028
	(0.0003)	(0.0002)	(0.0019)	(0.0004)	(0.0023)	(0.0024)
Flint*Sept '15	0.0006	-0.0028***	-0.0049**	0.0007	-0.0042**	-0.0070***
	(0.0005)	(0.0004)	(0.0017)	(0.0005)	(0.0017)	(0.0015)
R-squared	0.004	0.003	0.007	0.005	0.008	0.008
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.007	0.007	0.028	0.024	0.052	0.059

Notes: *Flint*Apr '14* indicates enrollee-month observations in Flint between April and December 2014, *Flint*Jan '15* indicates enrollee-month observations in Flint between January and August 2015. *Flint*Sept '15* indicates enrollee-month observations in Flint between September 2015 and December 2016. Regressions are at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix B. Background on Flint (adapted from Grossman and Slusky, 2019)

Until 1967, Flint used the Flint River as its water source. The city had shortage concerns given its expanding population (Carmody, 2016), and so began drawing water from Lake Huron through the Detroit Water and Sewerage Deparment (DWSD). In 2011, the Governor of Michigan appointed an Emergency Manager to make fiscal decisions for the city, given its precarious economic health (Longley, 2011). At this time, DWSD water rates were rising (Zahran, et al., 2017). To avoid these higher rates, the Emergency Manager explored building a pipeline directly to Lake Huron (City of Flint, 2015; Walsh, 2014). However, the project would take more than two years to complete. In the interim, Flint would use water from the Flint River (beginning in April 2014), while Genesee County continued to work with the DWSD (Carmody, 2016).

Flint had to treat the new water source, but it did not use anti-corrosive inhibitors (Pieper et al., 2017; Olson et al., 2017). Flint citizens were concerned about the appearance and odor of the water but were repeatedly assured that it was safe to drink (City of Flint, 2015a,b). While the city issued multiple boil advisories due to a positive fecal coliform tests and an EPA violation for excess trihalomethanes (TTHM) in the water (Fonger, 2014a, 2014b; Adams, 2014), Flint consistently reassured citizens the water was safe and that any issues would be fixed soon (City of Flint, 2015a,b).

In the summer of 2015, a team led by Mark Edwards began independently testing Flint's water and in August reported much higher levels of lead than previously reported, due to extremely corrosive water.[34] In September 2015, Mona Hanna-Attish, a Flint pediatrician, reported a substantial increase in children's blood lead levels (Fonger, 2015c; Hanna-Attish et al., 2016). This finally led the city to switch back to Lake Huron water on October 16, 2015 (Emery, 2015).

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Appendix Figure B1: Timeline of Important Events in Flint

1897: Flint passes ordinance that all connections with any water main be made with lead pipes (Masten et al., 2016).	1967-2014: Flint receives water from Detroit Water and Sewerage Department (DWSD).	2011: Governor appoints Emergency Manager.	2009-2013: Water rates (prices) consistently increase.	March 2014: Flint and Genesee County plan own pipeline to Lake Huron.	April 2014: Flint changes water source to Flint River; Genesee County stays with DWSD.	Aug-Sept 2014: Positive test for fecal coliform, first boil advisory.
Oct 2014: Flint GM plant switches off Flint water supply because of engine corrosion.	Jan-Mar 2015: Emergency manager stresses water is safe, refuses to return to DWSD	Jun-Jul 2015: Dr. Edwards independently tests Flint water lead levels, finding it to be 19 times more corrosive than DWSD.	Sept 2015: Dr. Hanna-Attisha holds press conference announcing higher blood lead levels in children.	Oct 2015: Flint stops receiving water from Flint River.	Jan 2016: Michigan Governor apologizes on national television.	

Source: Adapted from Grossman and Slusky (2019)

Appendix C: Results with "Patched" NYU Algorithm

Using the Johnston et al. (2017) classification of uncategorized visits, we re-estimated specification (1) for ED visits. Results are presented in Table C1; though the significance of most estimates is lost and the magnitudes are attenuated, the sign is consistent with our main results. We choose not to use this "patch" because the new classifications are not validated.

Table C1: Changes in Per Capita ED Visits by Type

	(1)	(2)	(3)	(4)	(5)	(6)
	Non-Preventable	Preventable	Primary Care Treatable	Non-Emergent	PC Sensitive	Avoidable
Flint*After	0.0000 (0.0005)	-0.001*** (0.0001)	-0.0006 (0.0009)	-0.0006 (0.0004)	-0.0012 (0.0013)	-0.0022* (0.0012)
R-squared	0.0051	0.0027	0.0079	0.0056	0.0089	0.0088
Obs.	1,326,764	1,326,764	1,326,764	1,326,764	1,326,764	1,326,764
Number of enrollees	67,167	67,167	67,167	67,167	67,167	67,167
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.0121	0.0072	0.037	0.029	0.066	0.0738

Notes: Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Appendix D: Fixed Birth Cohort

Table D1: Following the Sample of Children Born Before April 2014

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Any lead claims	(2) Any office visit	(3) Any vaccines	(4) Any ED visit	(5) # of claims	(6) Total payment ($)
Flint*After	0.030***	-0.012	0.004	-0.006**	0.112***	3.671
	(0.004)	(0.007)	(0.007)	(0.003)	(0.035)	(2.966)
R-squared	0.007	0.074	0.055	0.013	0.05	0.08
Obs.	857270	857270	857270	857270	857270	848878
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.035	0.24	0.143	0.086	2.762	281.972

Panel B: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	-0.0004	-0.0026***	-0.0046**	-0.0011	-0.0058**	-0.0084***
	(0.0005)	(0.0001)	(0.0016)	(0.0008)	(0.0022)	(0.0021)
R-squared	0.005	0.003	0.009	0.007	0.01	0.011
Obs.	857270	857270	857270	857270	857270	857270
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.0071	0.007	0.0273	0.0235	0.0508	0.0578

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Appendix E: Alternative Treatment Starting Date

Table E1: Treatment Starting in January 2016

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Any lead claims	(2) Any office visit	(3) Any vaccines	(4) Any ED visit	(5) # of claims	(6) Total payment ($)
Flint*After Jan'16	0.016***	-0.008	0.005	-0.007***	0.044	-5.329
	(0.002)	(0.006)	(0.004)	(0.002)	(0.035)	(7.614)
R-squared	0.004	0.074	0.045	0.012	0.042	0.059
Obs.	1621164	1621164	1621164	1621164	1621164	1601698
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.035	0.249	0.163	0.088	3.063	323.646

Panel B: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After Jan '16	-0.0003	-0.0020***	-0.0020**	-0.0022***	-0.0042***	-0.0062***
	(0.0002)	(0.0002)	(0.0007)	(0.0006)	(0.0009)	(0.0009)
R-squared	0.004	0.003	0.008	0.006	0.01	0.01
Obs.	1621164	1621164	1621164	1621164	1621164	1621164
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.0072	0.0068	0.0284	0.0239	0.0523	0.0591

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix F: Lead Testing in the ED

While testing for blood lead level is possible in the ED, it is done so on suspicion of lead poisoning in anticipation of inpatient admission. Treatment for exposure to high levels of lead, warranting hospital admission, is chelation therapy. Our data does not include any claims for chelation therapy. Thus, we feel confident that admissions on suspected lead exposure did not occur in Flint during the period covered by our data.

Furthermore, we do not see any blood lead tests being performed in the ED in our data.

Subacute lead exposure among children presents with nonspecific symptoms that may only involve irritability, difficulty concentrating, and fatigue. Most commonly, it is associated with constipation. Beyond admission, the recommended best practice for suspected exposure to lead is to remove the source of contamination, test for lead in an outpatient setting, and follow up with a primary care provider. For a child brought by their parent to the ED on suspicion of lead poisoning, the providers may ascertain that the child is in no immediate danger and take a blood sample to send to an off-campus testing facility with results sent to a primary care provider for follow up. Alternatively, the provider may ascertain that the child is in no immediate danger and refer the parent to primary care for testing.

In an informal interviews we conducted, 13 emergency physicians were asked: “A parent brings their child to the ED requesting a lead test. The child has no specific symptoms, maybe a mild rash or mild abdominal pain. No apparent urgency. Which would you do?” The most common answer was that the physician would refer the patient to primary care for testing. The second most common answer was even if the test was ordered in the ED, the patient would be referred to primary care to receive the results. Only two respondents said that they would order the lead test in the ED.

Therefore, we conclude that parents requesting a blood lead test for their child in the ED setting would most likely be referred to primary care.

Reference:

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Appendix G: Pre-period Starting in May 2014 for ED Visits Type

Table G1: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	-0.0001	-0.0016***	-0.0006	-0.0016***	-0.0022**	-0.0037***
	(0.0003)	(0.0001)	(0.0008)	(0.0005)	(0.0010)	(0.0009)
R-squared	0.004	0.003	0.009	0.006	0.01	0.01
Obs.	1401533	1401533	1401533	1401533	1401533	1401533
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.0067	0.007	0.0282	0.0236	0.0518	0.0589

Notes: Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Appendix H: Alternative Control Groups

Table H1: Cities with Highest Rates of Children with Elevated Blood Lead Levels in Michigan: More than 1,000 Children Tested

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Any lead claims	(2) Any office visit	(3) Any vaccines	(4) Any ED visit	(5) # of claims	(6) Total payment ($)
Flint*After	0.0151***	-0.0071	-0.0004	-0.001	0.1189**	7.0057
	(0.0010)	(0.0049)	(0.0023)	(0.0006)	(0.0388)	(11.9735)
R-squared	0.005	0.062	0.043	0.009	0.042	0.059
Obs.	1,381,022	1,381,022	1,381,022	1,381,022	1,381,022	1,362,931
Number of Cities	10	10	10	10	10	10
Dependent Variable Mean	0.036	0.226	0.159	0.096	3.081	329.458

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Detroit, Grand Rapids, Kalamazoo, Lansing, Wyoming, Battle Creek, Port Huron, Hamtramck, and Saginaw (Urban 2018). Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Total payment is trimmed to exclude the top 1%. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Panel B: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	0.0003	-0.0020***	-0.0011	-0.0005	-0.0015**	-0.0035***
	(0.0002)	(0.0002)	(0.0008)	(0.0006)	(0.0005)	(0.0005)
R-squared	0.005	0.002	0.007	0.005	0.008	0.008
Obs.	1,381,022	1,381,022	1,381,022	1,381,022	1,381,022	1,381,022
Number of Cities	10	10	10	10	10	10
Dependent Variable Mean	0.008	0.007	0.031	0.026	0.058	0.065

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Detroit, Grand Rapids, Kalamazoo, Lansing, Wyoming, Battle Creek, Port Huron, Hamtramck, and Saginaw (Urban, 2018). Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Total payment is trimmed to exclude the top 1%. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Table H2: Main Sample Including Pontiac and Muskegon

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Any lead claims	(2) Any office visit	(3) Any vaccines	(4) Any ED visit	(5) # of claims	(6) Total payment ($)
Flint*After	0.0170***	-0.0031	0.0028	-0.0034**	0.0803**	-0.8709
	(0.0013)	(0.0057)	(0.0032)	(0.0016)	(0.0292)	(6.6396)
R-squared	0.004	0.073	0.045	0.012	0.041	0.059
Obs.	1,741,174	1,741,174	1,741,174	1,741,174	1,741,174	1,720,179
Number of Cities	18	18	18	18	18	18
Dependent Variable Mean	0.034	0.25	0.164	0.089	3.087	323.781

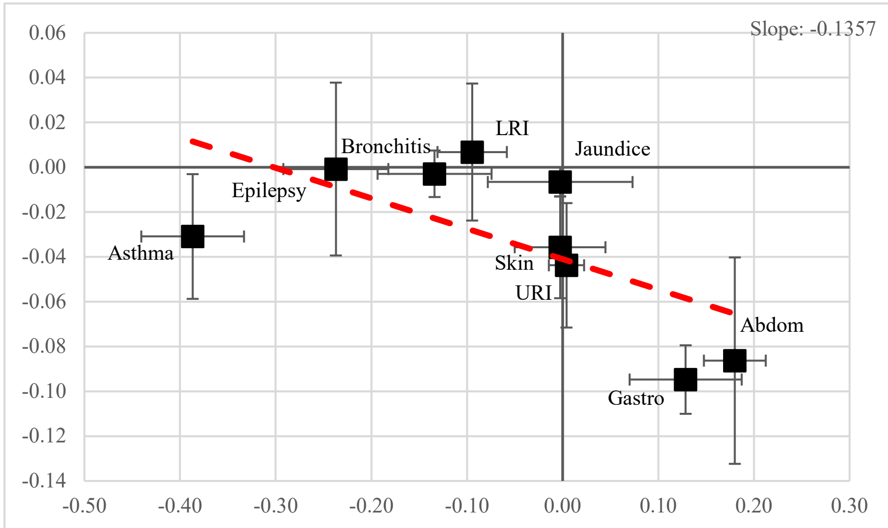
Panel B: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	-0.00003	-0.0019***	-0.0019*	-0.0013**	-0.0032**	-0.0050***
	(0.0003)	(0.0002)	(0.0009)	(0.0005)	(0.0011)	(0.0010)
R-squared	0.004	0.003	0.008	0.006	0.009	0.009
Obs.	1,741,174	1,741,174	1,741,174	1,741,174	1,741,174	1,741,174
Number of Cities	18	18	18	18	18	18
Dependent Variable Mean	0.007	0.007	0.028	0.024	0.053	0.059

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, Wyoming, Pontiac, and Muskegon. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Total payment is trimmed to exclude the top 1%. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Appendix I: Changes in Total Office Visits by Diagnosis Classification

Figure I1: Total Office Visits vs. Avoidable ED Visits



Notes: Each point is the estimate of a separate specification at the enrollee-month level for all children with claims in the specified CCS category. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. Whiskers show a 95% confidence interval.

Appendix J: Quarterly Estimates Extended

Table J1: Extending Analysis Through 2017

	(1)	(2)	(3)
	Any Office Visits	Avoidable ED Visits	Any Lead
Flint*After Qtr 1	0.008*	0.002	0.013***
	(0.004)	(0.002)	(0.001)
Flint*After Qtr 2	0.026***	-0.004***	0.084***
	(0.004)	(0.001)	(0.001)
Flint*After Qtr 3	-0.001	-0.006***	0.006***
	(0.006)	(0.001)	(0.001)
Flint*After Qtr 4	-0.025**	-0.010***	-0.012***
	(0.010)	(0.002)	(0.003)
Flint*After Qtr 5	-0.033***	-0.004***	-0.007**
	(0.007)	(0.001)	(0.002)
Flint*After Qtr 6	-0.028***	-0.014***	-0.012**
	(0.007)	(0.002)	(0.004)
Flint*After Qtr 7	-0.042***	-0.013***	-0.013**
	(0.010)	(0.002)	(0.005)
Flint*After Qtr 8	-0.037**	-0.014***	-0.005
	(0.013)	(0.004)	(0.006)
Flint*After Qtr 9	-0.033***	-0.019***	-0.004
	(0.008)	(0.002)	(0.003)
R-squared	0.065	0.011	0.004
Dependent Variable Mean	0.231	0.054	0.034
Obs.	2,207,819	2,207,819	2,207,819
Number of Cities	16	16	16

Notes: Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each column is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Appendix K: :Local Unemployment Rates

Table K1: Individual-Level Difference-in-Differences Results for all Enrolled Children with City Unemployment Rate

	(1)	(2)	(3)	(4)	(5)	(6)
	Lead Claims	Office Visits	Vaccines	ED Visits	Claims	Payment
Panel A: Any						
Flint*After	0.017***	-0.004	0.002	-0.004*	0.020***	0.019***
	(0.001)	(0.005)	(0.003)	(0.002)	(0.003)	(0.003)
R-squared	0.004	0.074	0.045	0.012	0.09	0.091
Dependent Variable Mean	0.035	0.249	0.163	0.088	0.46	0.459
Panel B: Number per Capita						
Flint*After	0.017***	-0.027	0.013*	0.0000	0.082**	4.346
	(0.001)	(0.031)	(0.007)	(0.003)	(0.034)	(13.151)
R-squared	0.004	0.046	0.044	0.007	0.042	0.059
Dependent Variable Mean	0.039	1.056	0.335	0.138	3.063	323.646

	(1)	(2)	(3)	(4)	(5)	(6)
	Non-Preventable	Preventable	Primary Care Treatable	Non-Emergent	PC Sensitive	Avoidable
Panel C: ED Use						
Flint*After	-0.00002	-0.0020***	-0.0019*	-0.0014**	-0.0032**	-0.0053***
	-0.0004	(0.0001)	(0.0009)	(0.0005)	(0.0013)	(0.0013)
R-squared	0.004	0.003	0.008	0.006	0.01	0.01
Dependent Variable Mean	0.0072	0.0068	0.0284	0.0239	0.0523	0.0591
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164
Number of enrollees	61,784	61,784	61,784	61,784	61,784	61,784
Number of Cities	16	16	16	16	16	16

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to unemployment rate and fixed effects for city, claim year, claim month, birth year, and birth month. Total payment is trimmed to exclude the top 1%. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Appendix L: Stratified Analysis

Table L1: Sample Limited to Children Born to Black Mothers

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Any lead claims	(2) Any office visit	(3) Any vaccines	(4) Any ED visit	(5) # of claims	(6) Total payment ($)
Flint*After	0.016***	-0.002	-0.003	-0.004***	0.080***	-8.021
	(0.001)	(0.003)	(0.003)	(0.001)	(0.021)	(8.420)
R-squared	0.005	0.049	0.04	0.007	0.041	0.059
Obs.	878,070	878,070	878,070	878,070	878,070	865,967
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.035	0.197	0.15	0.105	3.036	322.484

Panel B: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	-0.0002	-0.0026***	-0.001	-0.0018***	-0.0028***	-0.0055***
	(0.0002)	(0.0001)	(0.0006)	(0.0004)	(0.0006)	(0.0006)
R-squared	0.004	0.002	0.005	0.004	0.006	0.005
Obs.	878,070	878,070	878,070	878,070	878,070	878,070
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.0082	0.0089	0.0353	0.0292	0.0645	0.0733

Notes: Regressions are at the enrollee-month level for all eligible enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Table L2: Sample Limited to Children in Fee-for-Service Plans

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Any lead claims	(2) Any office visit	(3) Any vaccines	(4) Any ED visit	(5) # of claims	(6) Total payment ($)
Flint*After	0.012***	0.020**	0.007***	-0.005**	0.395***	3.22
	(0.002)	(0.008)	(0.002)	(0.002)	(0.094)	(14.160)
R-squared	0.007	0.069	0.034	0.012	0.035	0.065
Obs.	233,066	233,066	233,066	233,066	233,066	229,028
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.018	0.216	0.156	0.071	3.592	513.555

Panel B: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	0.0019***	-0.0017***	-0.0047***	0.0014***	-0.0033**	-0.0049***
	(0.0003)	(0.0002)	(0.0008)	(0.0005)	(0.0011)	(0.0011)
R-squared	0.004	0.003	0.008	0.006	0.009	0.009
Obs.	233,066	233,066	233,066	233,066	233,066	233,066
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.0063	0.0046	0.0221	0.0185	0.0405	0.0451

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Table L3: Sample Limited to Children in Managed Care Plans

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Any lead claims	(2) Any office visit	(3) Any vaccines	(4) Any ED visit	(5) # of claims	(6) Total payment ($)
Flint*After	0.019***	0.001	0.006	-0.002	0.036	-4.298
	(0.002)	(0.007)	(0.004)	(0.001)	(0.034)	(8.609)
R-squared	0.004	0.077	0.048	0.012	0.041	0.057
Obs.	1,223,226	1,223,226	1,223,226	1,223,226	1,223,226	1,208,705
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.04	0.275	0.176	0.098	3.177	309.951

Panel B: Changes in Per Capita ED Visits by Type

	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	-0.0001	-0.0020***	-0.0011	-0.0012*	-0.0023**	-0.0043***
	(0.0004)	(0.0003)	(0.0009)	(0.0006)	(0.0009)	(0.0008)
R-squared	0.005	0.003	0.009	0.007	0.01	0.01
Obs.	1,223,226	1,223,226	1,223,226	1,223,226	1,223,226	1,223,226
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.0079	0.0077	0.0316	0.0267	0.0584	0.0661

Notes: Regressions are at the at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Appendix M: Patient Characteristics for Lead Tests

Table M1: Characteristics of Patients Receiving a Lead Test

	Before		After		Difference-in-Differences
	Flint	**Other**	**Flint**	**Other**	
Female	0.493	0.476	0.502	0.466	0.018
Black	0.559	0.339	0.545	0.352	-0.027
Maternal Age	24.766	26.842	25.067	27.32	-0.177
	(5.456)	(5.797)	(5.186)	(5.715)	
Claims	1300	9511	56549	9063	

Note: *** p<0.01, ** p<0.05, * p<0.1 Standard deviation in parentheses for non-dummy variables. Other cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. All regressions include child's gender, and maternal age, race, and education where appropriate, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level.

Appendix N: Weekday vs. Weekend Effects

Table N1: Results Restricted to Only Weekday Visits

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1)	(2)	(3)	(4)	(5)	(6)
	Lead Claims	Office Visits	Vaccines	ED Visits	Claims	Payment
Panel A: Any						
Flint*After	0.017***	-0.005	0.004	-0.002	0.015***	0.014***
	(0.001)	(0.006)	(0.003)	(0.001)	(0.004)	(0.004)
R-squared	0.004	0.071	0.027	0.009	0.088	0.088
Dependent Variable Mean	0.034	0.243	0.063	0.065	0.436	0.435
Panel B: Number per Capita						
Flint*After	0.017***	-0.039	0.013***	0.0020	0.043	-13.456**
	(0.001)	(0.034)	(0.004)	(0.002)	(0.026)	(4.968)
R-squared	0.004	0.044	0.018	0.006	0.038	0.045
Dependent Variable Mean	0.038	1.024	0.082	0.097	2.714	243.003

Panel B: Changes in Per Capita ED Visits by Type

	(1)	(2)	(3)	(4)	(5)	(6)
	Non-Preventable	Preventable	Primary Care Treatable	Non-Emergent	PC Sensitive	Avoidable
Flint*After	0.0002	-0.001***	-0.002**	-0.001***	-0.002***	-0.004***
	(0.0002)	(0.0002)	(0.001)	(0.0002)	(0.001)	(0.001)
R-squared	0.003	0.002	0.006	0.005	0.008	0.009
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.005	0.005	0.02	0.017	0.037	0.049

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Table N2: Results Restricted to Only Weekend Visits

Panel A: Individual-Level Difference-in-Differences Results for all Enrolled Children

	(1) Lead Claims	(2) Office Visits	(3) Vaccines	(4) ED Visits	(5) Claims	(6) Payment
Panel A: Any						
Flint*After	0.0001	0.003***	0.0004***	-0.002***	0.004	0.004
	(0.0001)	(0.001)	(0.0001)	(0.001)	(0.003)	(0.003)
R-squared	0.0005	0.016	0.001	0.003	0.019	0.019
Dependent Variable Mean	0.001	0.011	0.001	0.029	0.073	0.073
Panel B: Number per Capita						
Flint*After	0.0001	0.013***	0.001***	-0.002**	0.023	0.642
	(0.0001)	(0.004)	(0.0001)	(0.001)	(0.014)	(0.372)
R-squared	0.0004	0.006	0.001	0.002	0.006	0.003
Dependent Variable Mean	0.001	0.033	0.002	0.04	0.348	11.715

Panel B: Changes in Per Capita ED Visits by Type

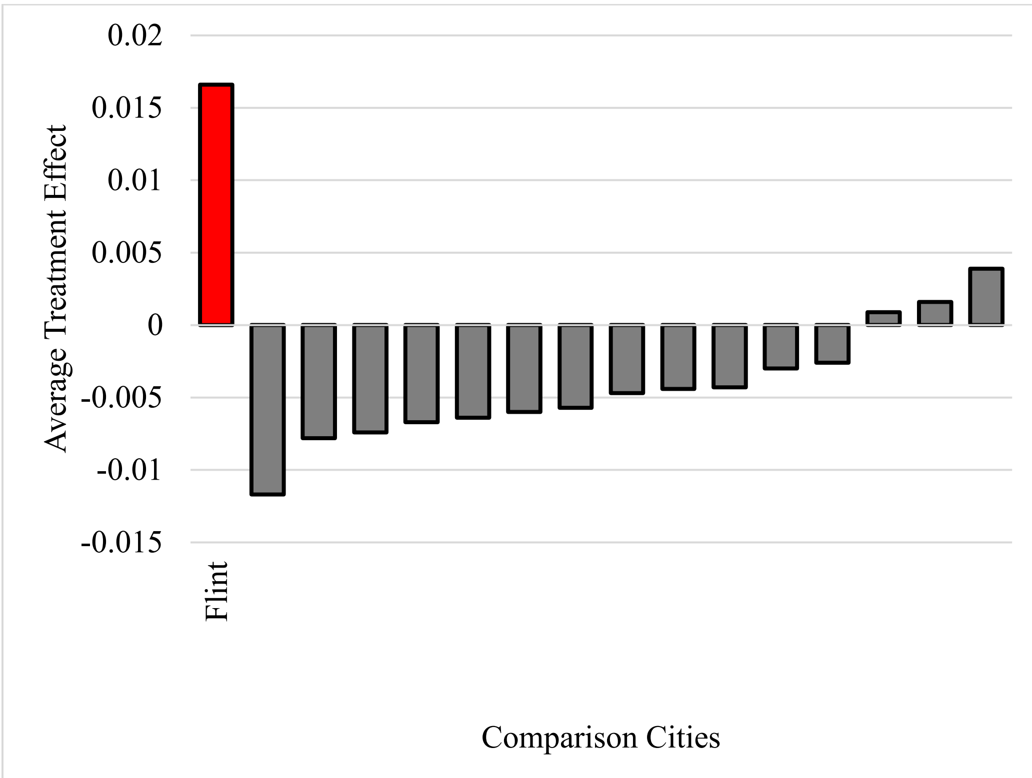
	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	-0.0002**	-0.001***	-0.0003	-0.0003	-0.0007*	-0.002***
	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0003)	(0.001)
R-squared	0.001	0.001	0.002	0.002	0.003	0.007
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164
Number of Cities	16	16	16	16	16	16
Dependent Variable Mean	0.002	0.002	0.008	0.007	0.015	0.034

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, in addition to fixed effects for city, claim year, claim month, birth year, and birth month. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

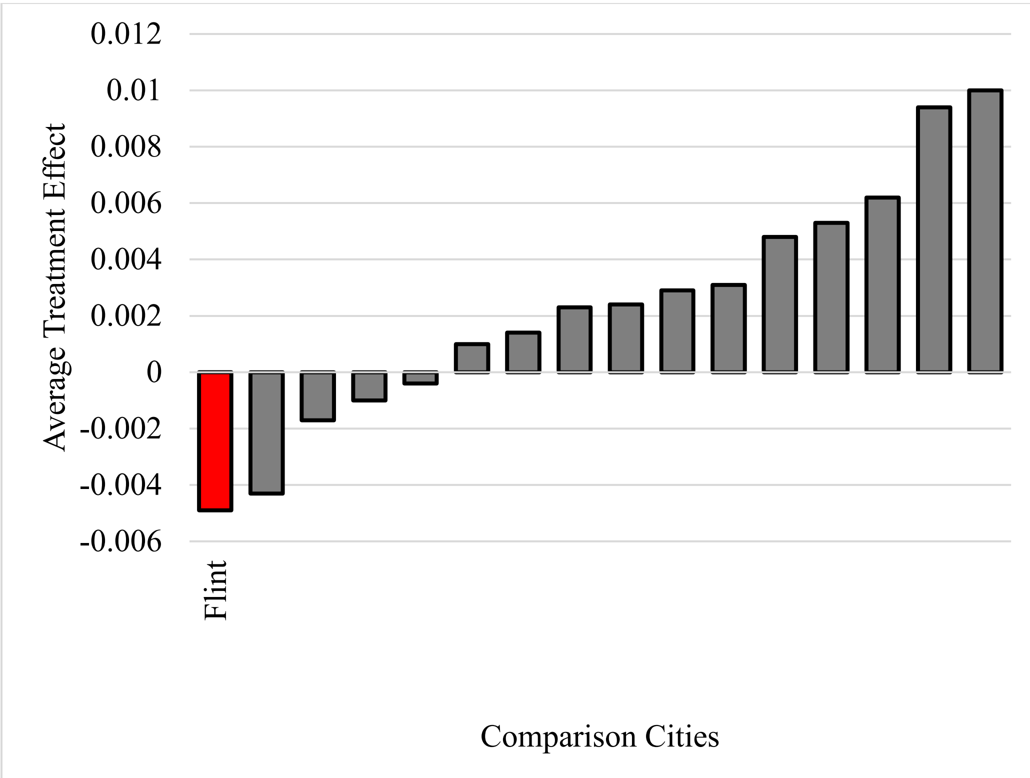
Appendix O: Randomized Inference

Figure O1: Average treatment effect of random assignment of treatment city

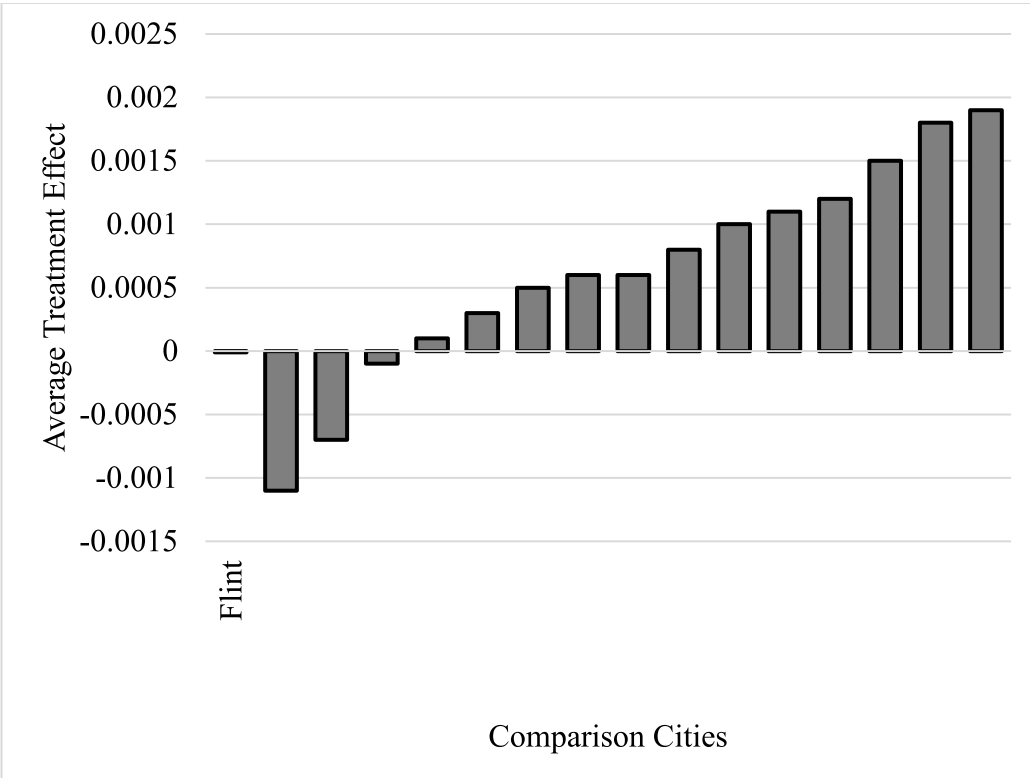
Panel A: Any Lead



Panel B: Avoidable Visits



Panel C: Non-Preventable Visits



We repeated randomized inference for the main specification in Tables 2 and 3 using the method and code developed by Simon Hess for Stata. The results of the application of this method are presented in the following table:

Table O1: Randomized Inference using Hess method.

	(1) Lead Claims	(2) Office Visits	(3) Vaccines	(4) ED Visits	(5) Claims	(6) Payment
Flint*After	0.0169	-0.0266	0.0123	0.0007	0.0661	0.9586
p-value	0.03	0.92	0.78	1	0.84	1
	(1) Non-Preventable	(2) Preventable	(3) Primary Care Treatable	(4) Non-Emergent	(5) PC Sensitive	(6) Avoidable
Flint*After	-0.00001	-0.0019	-0.0019	-0.0011	-0.003	-0.0049
	1	0.01	0.73	0.84	0.63	0.31
Iterations	100	100	100	100	100	100
Obs.	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164	1,621,164
Number of Cities	16	16	16	16	16	16

Notes: Regressions are at the enrollee-month level for all eligible, enrolled children. Primary Care (PC) Sensitive visits include PC Treatable and Non-Emergent. Avoidable visits include Preventable, PC Treatable, and Non-Emergent. Regressions are at the enrollee-month level for all eligible, enrolled children. Treated city is Flint. Control cities are Ann Arbor, Dearborn, Detroit, Farmington Hills, Grand Rapids, Kalamazoo, Lansing, Livonia, Rochester Hills, Southfield, Sterling Heights, Troy, Warren, Westland, and Wyoming. Each coefficient is from a separate regression. All regressions include child's gender, and maternal age, race, and education, and fixed effects for city, claim year, claim month, birth year, and birth month. Total payment is trimmed to exclude the top 1%. Robust standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1.