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Chicago's Lead Crisis

New Policy Approaches

Environmental Research Group
University of Chicago

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Executive Summary

Lead contamination in drinking water remains a pressing concern, especially in the state of Illinois and the city of Chicago, which has around 400,000 lead service lines–the most of any U.S. city. We conducted a review of relevant local, state, and federal legislation on water quality. Our analysis focuses on the impact of lead contamination on schoolchildren and touches on the effects of redlining on this issue. Methods included both (a) an examination of the current policy landscape and (b) a cost-benefit analysis regarding the impact of lead in Chicago water lines. Analysis of past legislation's successes and failures aims to motivate new methods or replicate old ones, mainly focusing on the Clean Water Act (1972), Safe Drinking Water Act (1974), Public Act 099-0922 (2017), and the Lead and Copper Rule (1991/2021). In our cost-benefit analysis, we gather data relating to economic, social, and health costs which all point to lead line replacement as the solution.

We recommend preventative and mitigative measures and quantify associated costs. Notably, the service line replacement program implemented in Newark, New Jersey saw significant successes that should be replicated in Chicago. These successes were the result of both specific technical tools such as trenchless replacement techniques and improved corrosion control systems. Additionally, socio-legal tools, including policies to allow replacement with homeowner consent, were crucial in the process. There is also an opportunity to significantly improve health by expanding the use of activated carbon filters in public buildings including schools. Lead-contaminated drinking water continues to negatively affect residents across Chicago. Solving this problem requires vast reform of current policy and public infrastructure across the city's various communities.

Costs of Lead in Drinking Water

High-profile examples of lead poisoning in American cities, namely in Flint, Michigan, have raised public awareness of the impact of lead in drinking water. However, the broader economic and health costs of lead poisoning remain understudied.

Economic Costs of Lead

Lead contamination has been shown to have detrimental economic effects: the economic impact of lead in the US and Europe is large–$50.9 billion and $55 billion, respectively.[1] Early childhood lead exposure has been linked by multiple studies to increased crime. In the US, the direct cost of lead-linked crimes is $1.8 billion, with an additional $11.6 billion being lost through indirect costs.[2] Early childhood lead exposure has also been linked to the development of ADHD; in fact, costs relating to lead-linked ADHD total $267 million annually.[3] Early childhood lead exposure can even lead to decreased IQ, a metric that is correlated with lifetime earnings.

Furthermore, efforts to remediate or prevent lead poisoning have been shown to have clear positive economic benefits. A study published in *Environmental Health Perspectives* found that every dollar invested in lead paint hazard control has a return of $17-$221, or net savings of $181-$269 billion.[4] Efforts to mitigate lead poisoning are not only impactful from a welfare perspective, but are also a smart economic choice.

Schools and Childcare Facilities

Lead's detrimental impact on children has been extensively documented. Lead contamination within children is linked to anemia, as well as kidney and brain damage. A report from the U.S. Government Accountability Office found that over 40% of K-12 school districts had not tested for lead in 2016-2017.[5] Thirty-seven percent of school districts in the report were found to have elevated lead levels.[6] These districts serve millions of children, which makes annual testing all the more important.

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[1] Attina, Teresa M., and Leonardo Trasande. "Economic Costs of Childhood Lead Exposure." *Environmental Health Perspectives* 121, no. 9 (September 2013): 1097–102. doi.org/10.1289/ehp.1206424.

[2] Gould, Elise. "Childhood Lead Poisoning: Social and Economic Benefits of Lead Hazard Control." *Environmental Health Perspectives* 117, no. 7 (July 2009): 1162–67. doi.org/10.1289/ehp.0800408.

[3] Attina, Teresa M., and Leonardo Trasande. "Economic Costs of Childhood Lead Exposure." *Environmental Health Perspectives* 121, no. 9 (September 2013): 1097–102. doi.org/10.1289/ehp.1206424.

[4] Ibid.

[5] Nowicki, Jacqueline, and J. Alfredo Gómez. *Lead Testing of School Drinking Water*. Government Accountability Office, July 2018. gao.gov/assets/gao-18-382.pdf.

[6] "Testing at Schools and Child Care Facilities." Illinois Department of Public Health. dph.illinois.gov/topics-services/environmental-health-protection/lead-in-water/testing-schools-child-care-facilities.html.

Children can come into contact with lead in many different ways, such as lead paint, pipes, and certain dust particles. Notably, buildings built before the 1980s are more likely to contain one or more of these potential lead contaminants due to the common usage of products containing lead and relaxed housing policies. Stricter lead provisions have been enacted in recent years. For instance, in 2017, all Illinois child-care facilities and schools constructed before 2000 were required to test their water sources for lead by December 2018.[4] While a survey conducted in 2017 showed that all school districts were consistently self-reporting compliant, the GAO study showed that 41% of school districts, serving about 12 million students, had not tested for lead within the year before the survey was completed.[7]

Lead and Environmental Justice

Due to residential segregation and underinvestment in public infrastructure, Black and brown communities bear the brunt of lead poisoning. Even accounting for economic differences between neighborhoods, communities with highe percentages of Black and brown residents are at a higher risk of lead exposure.[6,7] Black children nationwide are 2.8 times more likely than their white counterparts to have an elevated blood lead level (EBLL), and children in poverty are particularly susceptible. EBLL is present within 1 in 6 Black children living below the poverty line.[8]

Black children are three times as likely to develop lead poisoning as white children, while Hispanic children are twice as likely.[8] Other minority groups such as Asians and Pacific Islanders have also shown high rates of EBLL in recent years.[9] Despite these higher rates, children from minority groups–especially Black children–continue to be under-tested in comparison to white children. This shortage raises issues for these minority groups, since testing is the means by which access to health services and specialized care is granted. To resolve this issue, state governments can boost investment into public testing, and lower the threshold to gain access to medical services for lead treatment.[10]

From an environmental justice perspective, the rate of lead service lines in schools becomes even more troubling. Chicago Public Schools are highly segregated; the vast majority of schools have a single dominant racial group within their student populations. This is despite the racial diversity of students within the district as a whole. Of Chicago's 659 public schools, 179 have dangerously high levels of lead in their water. Every one of these schools has a student population that is majority

[7] Ibid.
[8] Clements-Boyd, Diane. *Environmental Injustice: Lead Poisoning in Indiana*. U.S. Commission on Civil Rights, November 2020. usccr.gov/files/2020/2020-11-12-Report-Lead-Poisoning-in-Indiana.pdf.
[9] Ibid.
[10] Ibid.

Black and/or low-income.[11] This disparity is of particular concern as Black children compose just 35.8% of the CPS student body.[12]

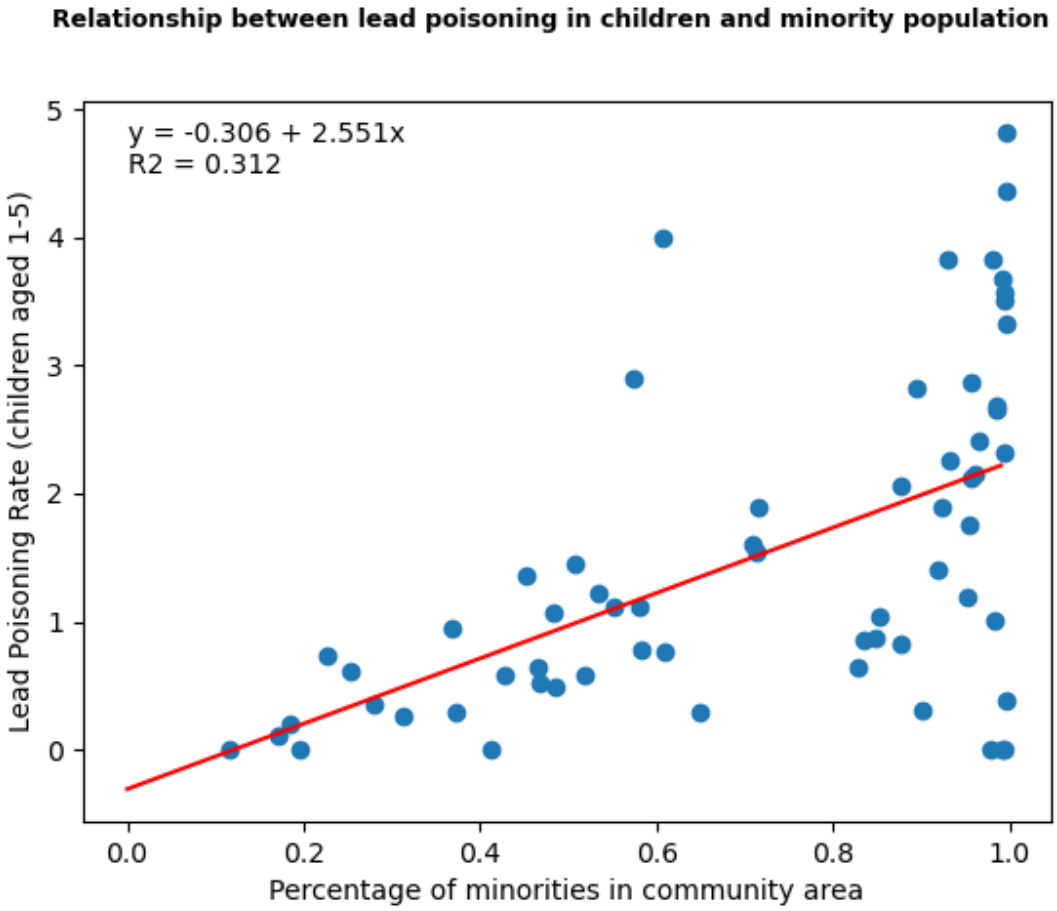

Figure 1: Child Lead Poisoning and Minority Population in Chicago Community Areas Graph by Ishaan Goel

The same racial disparity is visible among pregnant women, for whom exposure to metals can be especially harmful. Black and Black-Hispanic women exhibit lead levels that are 35% higher than white, non-Hispanic women, raising concerns about perinatal and infant mortality.[13]

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[11] "Stats and Facts." Chicago Public Schools, October 2022. cps.edu/about/stats-facts/

[12] Demirchyan, Armand. "Examining the Relationship Between Race, Income, School Quality, and Lead Contamination in Chicago Public Schools." Master's Thesis, Georgetown University, 2019. repository.library.georgetown.edu/bitstream/handle/10822/1055097/Demirchyan_georgetown_0076M_14257.pdf?sequence=1.

[13] Geron, Mariel, Whitney Cowell, Chitra Amarasiriwardena, Syam S. Andra, Kecia Carroll, Itai Kloog, Robert O. Wright, and Rosalind J. Wright. "Racial/Ethnic and Neighborhood Disparities in Metals Exposure During Pregnancy in the Northeastern United States." *Science of the Total Environment* 820 (May 2022): 153249. doi.org/10.1016/j.scitotenv.2022.153249.

Lead Regulation Policy Landscape

Clean Water Act | 1972

Works to monitor water quality standards and control discharge from point sources

GOVERNING BODY: EPA

AMENDMENTS: 1977, 1987 (original Federal Water Pollution Act passed 1948)

POWER TO REGULATE LEAD: The power to set water quality standards, which the states and EPA monitor.[14] States can classify bodies of water by designated use and create a plan to make sure water meets the standards for use. The EPA must approve this plan set by the states. The CWA also included Code 301, which made the discharge of pollutants from point sources illegal without an NPDES permit. These permits must be renewed every five years.

SUCCESSES: The regulation of mine drainage, as well as reducing pollution that enters lakes and rivers from point sources.[15] [16]

FAILURES: Include a shortcoming of assessment, as only half of US waters have been assessed to date. Also, groundwater discharge isn't consistently regulated, and the CWA does not regulate nonpoint source pollution at all.

[14] LII / Legal Information Institute. "Clean Water Act (CWA)." Accessed January 3, 2023. https://www.law.cornell.edu/wex/clean_water_act_(cwa).

[15] Office, U. S. Government Accountability. "50 Years After the Clean Water Act—Gauging Progress." Accessed January 3, 2023. https://www.gao.gov/blog/50-years-after-clean-water-act-gauging-progress.

[16] US EPA, OW. "What EPA Is Doing to Reduce the Adverse Impacts of Surface Coal Mining in Appalachia." Overviews and Factsheets, July 1, 2016.

Safe Drinking Water Act | 1974

Regulation of water supply and drinking water quality

GOVERNING BODY: EPA

AMENDMENTS: 1986 (increased EPA power and regulations), 1996 (increased funding, regulations, education)

POWER TO REGULATE LEAD: The "Primary Drinking Water Regulations" include regulations on water contamination and treatment, while "Secondary Drinking Water Regulations" involve parameters dictating non-health related qualities of drinking water or aesthetic effects.[17] This is supplemented by a mandated report and public notification of contamination in water supply to release for public use as well as academia-intended purposes.[18]

SUCCESSES: The USA saw a threefold increase in the number of contaminants being regulated. This reduced the risk of naturally occurring chemicals, including microbial and chemical contamination, and improved the taste, odor, and appearance of drinking water. The act also reduced corrosion in pipes.[19] Overall, these changes lifted an economic burden off many constituents, including the costs of boiling water, buying bottled water, purchasing a water filter, etc.[20]

FAILURES: This act does not regulate fracking (since it is governed by states themselves) which negatively affects the safety of water extracted through this process by exposing it to contaminants.[21] There is also a lack of adequate staffing and funding, which prevents states from fully implementing regulations. Certain smaller systems are not covered under SDWA regulations which creates holes in the larger scheme of safe drinking water.[22] More specifically, there is a lack of location or context-specific resolutions.

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[17] Congressional Research Service. (1999, February 8). "Safe drinking water act amendments of 1996: Overview of P.L. 104-182." EveryCRSReport.com. https://www.everycrsreport.com/reports/96-722.html

[18] Weinmeyer, Richard, Annalise Norling, Margaret Kawarski, and Estelle Higgins. "The Safe Drinking Water Act of 1974 and Its Role in Providing Access to Safe Drinking Water in the United States." AMA Journal of Ethics 19, no. 10 (October 1, 2017): 1018–26. https://doi.org/10.1001/journalofethics.2017.19.10.hlaw1-1710.

[19] "President Signs Safe Drinking Water Act Amendments." *EPA*, Environmental Protection Agency, 11 Aug. 2016, https://www.epa.gov/archive/epa/aboutepa/president-signs-safe-drinking-water-act-amendments.html.

[20] "The Safe Drinking Water Act - GovInfo." Accessed January 4, 2023. https://www.govinfo.gov/content/pkg/CPRT-106SPRT67528/pdf/CPRT-106SPRT67528.pdf.

[21] Tulane. "EPA's Report on Fracking and Water Quality," October 25, 2021. https://online.law.tulane.edu/blog/epa-fracking-report-water-quality.

[22] Duhigg, Charles. "Clean Water Laws Are Neglected, at a Cost in Suffering." The New York Times, 12 Sept. 2009. NYTimes.com, https://www.nytimes.com/2009/09/13/us/13water.html.

Public Act 099-0922 | 2017

Required all Illinois schools constructed before 2000 to test all sources of potable water for lead and submit results

GOVERNING BODY: Illinois General Assembly

AMENDMENTS: Sections 9-246, 5.9, 35.5, 19.3, 17.11

POWER TO REGULATE LEAD: Requires school districts and chief school administrators to test for lead in the drinking water of school buildings. The act mandates a minimum of two samples of 250 ml for each potable water source. From there, the samples would be sent to an Illinois Environmental Protection accredited laboratory for analysis. If any of the samples exceed 5 parts per billion, school districts/chief school administrators would be required to provide written notification of the lead sample test results to the parents or legal guardians of the students. Along with this, the owner or operator of each community water system in the state must develop a water distribution material inventory to be submitted in written and/or electronic form to the EPA on an annual basis. The agency may conduct separate audits to identify the progress that the community water system has made.[23]

SUCCESSES: School buildings constructed prior to January 1, 1987 and December 31, 2018 were sampled by December 31st, 2017 and buildings constructed between January 2 1987 and January 1, 2000 were sampled by December 31, 2018. The Department of Health posted mitigation actions for lead in drinking water and advice on ongoing water management. This success allowed for further elimination of contaminated water from thousands of young children's water sources.

[23] "Public Act 099-0922." Public Act 0922 99th General Assembly. Accessed November 20, 2022. https://www.ilga.gov/legislation/publicacts/99/099-0922.htm.

Lead and Copper Rule (LCR) | 1991

A set of rules that specifically tackle reducing lead and copper levels in pipes

GOVERNING BODY: EPA

AMENDMENTS: Lead and Copper Rule Improvements (LCRI) (2021)

POWER TO REGULATE LEAD: Allows for sampling of lead lines and water quality; gives EPA enforcement and legal precedence.[24]

SUCCESSES: Allowed stricter regulations on lead concentration levels allowed in water; standardizes the expectations across the country. Also, LCR gives the EPA the power to regulate state and local lead service line replacement plans, as well as their progress.

FAILURES: The largest issue is exemplified by how there is no "safe" level of lead in drinking water. LCR still allows "permissible levels" meaning it doesn't actually eradicate lead or copper in water systems. Other issues include the numerous exceptions that allow groups to apply to be held to inconsistent standards.

Optimal corrosion control treatment (OCCT) includes options that are not lead service line replacement. If a test reveals high levels of lead in the water, the LCR does not mandate a change in pipe material, and rather gives the option to perform other smaller-scale treatment methods that could keep bad pipes in the circulation. For example, this relaxed regulation could include treating the pipes with solutions that reduce erosion into the waterflow, without replacing the pipe itself. Additional exceptions in the LCR allows for copper and lead to be present in drinking water, consequently slowing the eradication of these metals in water sources.[25]

Another significant issue with the LCR is the economic burden that falls directly on the states to deal with pipes despite the regulation stemming from a federal level. This is especially problematic for Chicago, which has an inadequate water pipe replacement budget. Much of the city's focus is directed towards pressing issues instead of compounding issues like contaminated water.

[24] "40 CFR Part 141 Subpart I -- Control of Lead and Copper." Accessed January 3, 2023. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-141/subpart-I.

[25] US EPA, OW. "Revised Lead and Copper Rule." Overviews and Factsheets, December 21, 2020. https://www.epa.gov/ground-water-and-drinking-water/revised-lead-and-copper-rule

Policy Recommendations

Lead Testing

Testing water for the presence of lead is a crucial step to ensuring the safety of drinking water traveling through water service lines throughout Chicago. As a city with nearly 400,000 lead water service lines, thousands of Chicago's residents are consistently exposed to dangerously high levels of lead despite Chicago's government officials being well aware of the issue.[26] In order to combat the social, physiological, psychological, and economic ramifications of unmitigated lead pollution in drinking water, the city should implement policies that encourage increased testing rates for lead. Among these include further promoting public awareness surrounding lead contamination, encouraging cooperation between government and local organizations, and increasing the Water Funds total budget.

Increasing the frequency of lead testing in drinking water would help the City of Chicago better understand the scope of its lead contamination crisis and reduce the number of people directly impacted by lead contamination. Lead testing techniques currently deployed by the city are effective at detecting the presence of lead but are not employed to a large enough extent to properly combat lead contamination. The current testing initiative is restrictive in its accessibility for city residents and has thus far failed to make lead testing appealing to residents. The program has had little success in raising awareness of its existence, requires residents to stop their water use for upwards of 6 hours, and has a very long turnaround time for testing results. These compounding factors contribute to the initiative being significantly less wide-reaching than what is needed. Ideally, the city should expand its scope of testing and implement strategies to promote testing initiatives. Doing so would effectively increase rates of lead testing and allow the city to have a better understanding of where lead contamination is concentrated.

The City of Chicago has introduced helpful lead testing services to city residents at no cost and subsequently distributed the tests' results to the general public. Yet, despite the tests being free and administered by qualified professionals, Chicago residents have not taken advantage of this service in an exceptionally meaningful way. Just 33,656 tests have been conducted since the program's implementation on December 18th, 2019. While this statistic may appear like a large amount, it actually

[26] Chase, Brett. "Hundreds of Millions to Remove Lead Pipes Flowing into Illinois as City Replaced Just a Fraction of Total This Year." Chicago Sun-Times. Last modified December 6, 2021. Accessed May 2, 2023. https://chicago.suntimes.com/2021/12/6/22821374/infrastructure-bill-water-lead-pipes-replace-lori-lightfoot-rahm-emanuel.

represents only ~3.11% of households.[27] When also considering the existence of private spaces not used for housing, less than 3% of potential sources of lead contamination have been tested within the past 3 years.[28] This is a major shortcoming on behalf of the city. The advertisement of free opportunities for lead testing has potential to resolve this detrimental issue.

Working with local organizations to make information readily available and easy to understand for community members, as demonstrated by Cincinnati, Ohio and Washington DC, facilitates an increase in lead-contamination testing. Similarly to Chicago, Cincinnati also suffers from tens of thousands of lead pipes contaminating its water supply and has introduced initiatives to fully cover the cost of replacements. In order to locate specific homes that need lead-pipe replacement, Cincinnati developed an online map of the city that clearly demonstrates whether a home has (a) tested positive for lead, (b) tested negative for lead, or (c) not tested at all. The city launched the site in 2016, making all information easily accessible to all residents; it only requires them to input an address. Similarly and in the same year, Washington, DC also launched its own map. Although the majority of the homes in the District are safe from lead-pipes, the government launched the site to provide all citizens with readily accessible information. Social science research indicates that graphics and other visual figures–like the online map–are very efficient methods of communicating necessary information.

Increasing the City of Chicago's Water Fund budget would help the city better achieve reduced lead contamination in drinking water. This proposal would work in tandem with the recommendations thus far proposed, allowing the city to adequately finance public awareness initiatives and increased testing rates. Currently, the Water Fund is allocated a total appropriation of $933,864,000 for 2023.[29] While this may seem like a significant amount, just under 65% ($598,827,514) is devoted solely to appropriations, which encompass personal services ($41,650,568), financial services aimed primarily at paying off loans and bonds ($260,530,731), transfers and reimbursements aimed towards corporate funds ($94,658,000), etc. Even though these expenses are necessary to ensure the continuing operation of the Water Fund, the reality is that only approximately 36% of the budget is directly used in a manner that directly aids in the mitigation of lead contamination and exposure. In addition, the Water Fund itself only receives about 7.93% of Chicago's total

[27] City of Chicago, Annual Comprehensive Financial Report for Year Ended December 31, 2021, 2022, at 1-248 (Ill. June 29, 2022). Accessed May 2, 2023. https://www.chicago.gov/content/dam/city/depts/fin/supp_info/CAFR/2021CAFR/ACFR_2021.pdf.

[28] City of Chicago Department of Water Management. "Know Your Water." Chicago Water Quality. Accessed May 2, 2023. https://chicagowaterquality.org/home#results.

[29] City of Chicago, 2023 Budget Ordinance, , at 1-532 (Ill.) https://www.chicago.gov/content/dam/city/depts/fin/supp_info/CAFR/2021CAFR/ACFR_2021.pdf.

appropriate fund of $11,777,110,000. To further put the insufficient funding in context, just 2.84% of the city budget is allocated to services that could combat lead contamination in drinking water, and this amount is further distributed among all of the operations that the Water Fund is responsible for handling. Reallocating funding toward the Water Fund would provide the city with an avenue to complete objectives instrumental in combating lead pollution and thus is a desperately needed and extremely desirable proposition for achieving this goal.

A prime solution to combat the threat of Chicago's lead-contaminated drinking water is that of increased lead testing. In order to enact this reality and ensure its success, it is critical that the city enact policy changes that work to increase public awareness on the issue, implement changes in its budget to better fund Chicago's Water Fund, and work with local organizations to better educate and protect the public. Instituting these reforms would ensure that Chicago would experience increased testing for lead in drinking water. This would allow the city to be better positioned to both understand the extent of the city's lead contamination crisis and gain a better sense as to what other strategies must be enacted to solve this issue.

Case Study: Learning from Newark, New Jersey

The city of Chicago is not on track to meet its goal of full lead service line (LSL) replacement by 2077. By December 2022, the city had replaced 280 of its 390,000 total lead service lines.[30] Currently, the city is mandated to replace LSLs *only* if these service lines break; otherwise, replacement is not mandatory, which limits progress. Newark, New Jersey faced similar problems, and in response, adopted a mandated LSL replacement program, which warranted right of entry into residences by the city and required proof of LSL replacement during succeeding real estate transfer or sale. Following this program, Newark successfully replaced over 23,000 LSLs in under three years.[31]

Newark launched their replacement program in 2019, but due to its voluntary nature and the $1000-per-replacement cost to homeowners, only 650 lead service lines were replaced from March to September of the same year.[32] However, this rate of replacement changed once the City Council passed a local ordinance that mandated LSL replacement.[33] Additionally, the city received a $120 million municipal bond facilitated by the Essex County Improvement Authority to provide lead replacement services free of charge for residents, thus accelerating the program's lifespan from 8 to 3 years. On average, trenchless LSL replacement costs from $5,000 to $10,000 in Newark.[34] However, because of its "dense urban setting" and focus on open-trench replacement, Chicago has failed thus far to lower the $30,000 cost per lead line replacement.[35] [36]

Newark prioritized ensuring there was sufficient workforce to help replace lead service lines. They employed the help of groups like the Laborers' International Union

[30] Brett Chase, "Lightfoot's plan to replace Chicago's lead water pipes has switched out 280 of an estimated 390,000 service lines," Chicago Sun-Times, December 2, 2022, https://chicago.suntimes.com/2022/12/2/23488902/lead-water-service-line-replacement-chicago.

[31] Maureen Cunningham, "Echoing Newark: How American Cities Can Replicate Newark's Success in Replacing Over 23,000 Lead Pipes in Under Three Years," Environmental Policy Innovation Center, accessed May 3, 2023, https://www.policyinnovation.org/blog/echoing-newark-how-american-cities-can-replicate-newarks-success-in-replacing-over-23000-lead-pipes-in-under-three-years.

[32] Cunningham, "Echoing Newark: How American Cities Can Replicate Newark's Success in Replacing Over 23,000 Lead Pipes in Under Three Years".

[33] "City of Newark, NJ: Mandatory Replacement of Lead Service Line," City of Newark, NJ Code, accessed May 3, 2023, https://ecode360.com/36709572.

[34] "Lead Service Line Replacement Program," Newark's Lead Service Line Replacement Program, accessed May 3, 2023, https://www.newarkleadserviceline.com/replacement.

[35] "Crews Have Replaced Less Than 0.5% of Lead Service Lines Shown to Contaminate Tap Water in Chicago Homes: Data," WTTW News, accessed May 3, 2023, news.wttw.com/2022/09/20/crews-have-replaced-less-05-lead-service-lines-shown-contaminate-tap-water-chicago-homes.

[36] Chase, "Lightfoot's plan to replace Chicago's lead water pipes has switched out 280 of an estimated 390,000 service lines."

of North America (LIUNA) and began an apprenticeship program that trained local residents to ensure laborers were more representative of the city that was 50% Black and 36% Latino.[37] LIUNA worked with the city to train residents and to prioritize hiring Minority and Women-Owned Businesses. Involving residents in the replacement process helps the community form trust and subsequently reduces backlash in the mandate.

In 2022, through the Illinois Lead Service Line Replacement and Notification Act, Evanston showed that this is possible in Illinois when they enacted a similar apprenticeship program—hiring, training, and paying six apprentices to replace city-owned LSLs. It is then important that Chicago looks to do the same.[38]

Furthermore, the City of Newark kept comprehensive records of the location and past replacements of lead service lines. Because of this, they were able to efficiently begin targeting existing LSLs. Chicago, on the other hand, does not have a complete inventory of its LSLs.[39] The necessity of having a complete inventory could incur further costs and delays in Chicago.

Our goal is to mandate lead service line replacement in the City of Chicago at no cost to homeowners. Giving the city the authority to replace LSLs without waiting for individual homeowners to gather funds and hire private contractors will expedite the process of LSL replacement and help Chicago meet its replacement goals. The city should also provide information to residents whose LSLs are being replaced, filters to those who might experience water contamination due to LSLs, and orthophosphate (a corrosion control inhibitor) for corrosion control.

Efficiently attaining the target line replacement goal would greatly decrease the amount of lead present in Chicago's drinking water. Further, by providing LSL replacement for free in addition to filtration means for homeowners—amongst others—Chicago would be able to mitigate the health risks associated with lead pipelines while lessening barriers to replacement. Limitations of this policy recommendation include conflicting priorities regarding proportioning the city budget. These policy recommendations rely on the LSL replacement service

[37] Cunningham, "Echoing Newark: How American Cities Can Replicate Newark's Success in Replacing Over 23,000 Lead Pipes in Under Three Years."
[38] Adina Keeling, "City discusses workforce development program to replace lead pipes - Evanston RoundTable," Evanston RoundTable, accessed May 3, 2023, https://evanstonroundtable.com/2022/03/28/city-talks-about-how-best-to-replace-lead-water-pipes/.
[39] Brianna Gonzalez, "Has the city done all it can to make its lead service line replacement program accessible?," Chicago Policy Review, accessed May 3, 2023, https://chicagopolicyreview.org/2023/01/23/has-the-city-done-all-it-can-to-make-its-lead-service-line-replacement-program-accessible/.

remaining free to homeowners. Sufficient budget allocation is essential; without funding, the entire project fails.

Even when lead service line replacement is enacted and the budget is allocated, the City of Chicago often fails to enforce these policies. In order to reach replacement goals, however, enforcement should be prioritized. Potential methods of enforcement include requirements on LSL replacement in order to buy or sell property and strict monthly goals set by the city. In the last two years, Chicago replaced only 280 lines in the last two years, which is approximately 11 lines per month.[40] For a 50% increase in replacement rate, the city must replace 17 lines per month; or a 100% increase in replacement rate, Chicago should aim to replace 22 lines per month. These simplified numbers help us understand the scope of what we should aim for per month.

Furthermore, the city should make every effort to educate citizens on the health impacts of lead service lines and the efforts in place to replace them. This can be done through several channels as also explored in the previous section. To communicate with apartment tenants, landlords should be required to communicate up-to-date information about LSL presence and replacement in their apartment buildings. Furthermore, the city can cooperate to share information with community leaders, such as leaders of religious groups, activist groups, and grassroots organizations, so that residents learn through various channels of community involvement. The focus should be on accessible content built to help the resident engage with the LSL replacement process.

In an effort to model after policy in Newark, Chicago can look to Newark's 2019 city council ordinance that not only mandated LSL replacement but also warranted right of entry into residences by the City and required proof of LSL replacement during succeeding real estate transfer or sale.

[40] Chase, "Lightfoot's plan to replace Chicago's lead water pipes has switched out 280 of an estimated 390,000 service lines."

Water Filtration

Chicago's water is sourced from Lake Michigan and undergoes several filtration steps and treatments to ensure its safety: water is passed through traveling screens, undergoes flocculation to remove solid particles, filters through graded sand, and receives several chemical applications..[41] Lastly, blended polyphosphate is used to coat pipes to prevent lead leaching.[42] Although Chicago's water is filtered by the city in treatment facilities, water is consequently contaminated by lead via corroded pipes. Point of source water filter methods include reverse osmosis filtration, activated carbon absorption, and distillation.

Reverse Osmosis

Reverse osmosis filtration systems pass water through a semipermeable membrane, but reverse the flow of water in the natural process of osmosis. As water passes from a more concentrated solution to a more dilute solution, and through the pre and post filters often involved in the system beyond the reverse osmosis membrane, the water is effectively removed of viruses, bacteria, and protozoa.[43]

Activated Carbon

Activated carbon filters include mixed media that can remove heavy metal contaminants. Activated carbon works by absorbing organic contaminants into their millions of pores and a large surface area through a process called adsorption– chemicals attach to the outside of a surface rather than being soaked into it.[44]

Distillation

Distillation utilizes evaporation as a method for purifying water. Contaminated water is heated to form steam. Inorganic impurities are large non-volatile organic molecules that do not evaporate with the water and are left behind. The steam consequently cools and condenses resulting in purified water.[45]

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[41] Water Treatment. (n.d.). City of Chicago. https://www.chicago.gov/city/en/depts/water/supp_info/education/water_treatment.html

[42] Water Treatment. (n.d.). City of Chicago. https://www.chicago.gov/city/en/depts/water/supp_info/education/water_treatment.html

[43] Choosing Home Water Filters & Other Water Treatment Systems | Drinking Water | Healthy Water | CDC. (n.d.). Centers for Disease Control and Prevention. https://www.cdc.gov/healthywater/drinking/home-water-treatment/water-filters/step3.html

[44] Activated Carbon Filters | Activated Charcoal | Sentry Air Systems. (n.d.). Air Filtration Systems | Fume Hoods | Sentry Air Systems. https://www.sentryair.com/activated-carbon-filters.htm#

[45] WQ-12. (n.d.). Purdue Extension. https://www.extension.purdue.edu/extmedia/wq/wq-12.html

Recommendation: Activated Carbon

Verhougstraete et al. investigated these three point-of-use devices as a method for lead reduction in households of Flint, Michigan. The authors conclude that all three filtration methods have a removal rate of 95% accuracy. However, activated carbon is significantly more affordable to install, operate, and maintain relative to other point source filtration options. Additionally, Verhougstraete et al. approximated the breakeven point for each given method: the lead concentration at which the lifetime economic loss due to lead equals total filter cost. Activated carbon had a lower breakeven point than both reverse osmosis and distillation respectively: 3.73 µg/L, 7.31 µg/L, and 12.0 µg/L.[46] Accordingly, we recommend Chicago Public Schools utilize this filtration method in the form of water bottle filling stations.

[46] Verhougstraete, Marc P., Joe K. Gerald, Charles P. Gerba, and Kelly A. Reynolds. "Cost-benefit of point-of-use devices for lead reduction." Environmental Research 171 (2019): 260-265. ISSN 0013-9351.

Chicago Public Schools

Replacing lead pipes in a timely manner has proven to be an improbable option for the City of Chicago. In order to provide an accessible, affordable, and swift solution to adolescent lead poisoning, we propose implementing activated carbon water filtration systems in Chicago Public Schools with lead concentrations above 2 ppm. Water bottle filling stations have proven to be a practical, safe, and cost-efficient method of supplying clean drinking water to both schools and public buildings. The per unit capacity of each water bottle filling station is approximately 100 students.[47] There are 322,106 students currently enrolled in the CPS system.[48] We approximate that across all public schools, 32,200 water bottle filling stations would be required to provide clean drinking water to CPS. Additionally, the median cost for purchasing a water bottle filling station is $1000 per unit, with an additional maintenance fee of $100 a year on average.[49] Combining these metrics, we estimate the *maximum* cost of implementation would be $3.2 million dollars and $322,000 annually for filter replacements. However, we anticipate that this figure will be lower given we have not accounted for schools that have lead levels below the lead threshold goal set by CPS and buildings currently equipped with water bottle filling stations.

We believe these recommendations are feasible within the budgetary constraints and goals established by CPS for the upcoming school year. Per the CPS website, the CPS budget for fiscal year 2023 is $9.4 billion.[50] Additionally, "schools will see a per-pupil funding increase of 8 percent, and $240 million more in school level funding over FY2022." One initiative of this budget increase is aimed at ensuring students have access to a healthy learning environment. As outlined above, lead poses an urgent health threat, and the children K-12 are especially vulnerable to its neurotoxicity. Therefore, allocating funding for the widespread installation of water bottle filling stations meets the criteria for funding allocation.

In addition to affordability, there are economic benefits to reducing exposure to lead contamination. Verhougstraete et al., 2019 concluded that continuous exposure to increased lead concentration throughout the lifetime decreases IQ, and consequently, lifetime earnings. Verhougstraete et al. estimate economic impact per

[47] "Filter First: Ensuring Safe and Lead-Free Drinking Water in Schools with Filtered Drinking Water Stations." Ecology Center, accessed March 28, 2023, https://www.ecocenter.org/filter-first-ensuring-safe-and-lead-free-drinking-water-schools-filtered-drinking-water-stations.
[48] "Stats and Facts." Chicago Public Schools, accessed March 28, 2023, https://www.cps.edu/about/stats-facts/.
[49] "Lead in Water: Frequently Asked Questions." Elkay - Bottle Filling Stations, accessed March 28, 2023, https://pages.bottlefillingstations.com/lead-in-water/
[50] "Budget 2023." Chicago Public Schools, accessed March 28, 2023, https://www.cps.edu/about/finance/budget/budget-2023/

individual in Flint Michigan to range between $183,955 and $234,460.[51] The authors further concluded that the use of filters could mitigate lifetime earning losses of $14,284 per person for someone consuming water with 25 µg/L of lead. One in twenty recent Chicago water tests found lead levels of more than 15 µg/L, with this increasing to one in ten on Chicago's South side.[52] The estimation provided above, while striking, is not comprehensive. The economic implications of chronic lead exposure are broad and far-reaching; therefore, this figure is likely an underestimate of the true economic cost of lead contamination.

[51] Verhougstraete, Marc P., Joe K. Gerald, Charles P. Gerba, and Kelly A. Reynolds. "Cost-benefit of point-of-use devices for lead reduction." Environmental Research 171 (2019): 260-265. ISSN 0013-9351. https://doi.org/10.1016/j.envres.2019.01.016.

[52] "Revealed: the 'shocking' levels of toxic lead in Chicago tap water." The Guardian, September 21, 2022, https://www.theguardian.com/us-news/2022/sep/21/lead-contamination-chicago-tap-water-revealed

Cover Photo: Workers with East Bay Municipal Utility District install a new water pipe on April 22, 2021 in Oakland, California. (Justin Sullivan/Getty)

Authors: Ethan Jiang, Theo Lesser, Juliet Cairney, Noah Crutchfield, Hannah Rogers, Elliot Sher, Jesenia Parthasarathy, Gabby Haywood, Yoohan Ko, Clark Kovacs, Yona Litwin, Meera Dasgupta

Environmental Research Group
University of Chicago
enviroresearchgroup.github.io/erg/