



Early Childhood Lead Exposure in Cuyahoga County and the Impact on Kindergarten Readiness

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Key points:

- Although rates of children with elevated blood lead levels above the current public health threshold for concern have been on the decline, children in Cuyahoga County still account for 41% of the children in Ohio with elevated lead levels.
- Despite Medicaid rules that mandate testing at ages 1 and 2, only 50% of the children on Medicaid in Cuyahoga County were tested at age 1 and only 34% were tested at age 2.
- Of 11,560 children born in Cuyahoga County in 2012 and screened at least once by age 5, 1,237 children (10.7%) had an elevated blood lead level by age 5. Most of these children lived in Cleveland.
- Children with elevated lead levels are half as likely as their peers to score on track for language and literacy on the kindergarten readiness assessment, even after controlling for a range of background factors.

Note: The birth and lead data used in this report come from the Ohio Department of Health. This should not be considered an endorsement of this study or these conclusions by the Ohio Department of Health.

Lead is an environmental neurotoxin associated with cognitive deficits, even at low levels of exposure. These negative effects have been well documented¹ and include damage to the brain and nervous system, slowed development and decreased IQ, learning and behavior problems, and hearing and speech problems.² The importance of screening, prevention and intervention is well documented in the literature. This report contributes by focusing specifically on Cuyahoga County to document the extent to which screening is occurring, the prevalence of exposure, and preliminary local evidence around the detrimental effects of exposure on kindergarten readiness. The aim is to more fully inform local efforts to both prevent further exposure and implement effective interventions for those exposed.

Today, the primary source of lead exposure comes from paint dust and chips in homes built prior to 1978,³ when lead was commonly added to paint. Children can be exposed to lead

¹ Zhang, N., Baker, H. W., Tufts, M., Raymond, R. E., Salihu, H., & Elliott, M. R. (2013). Early childhood lead exposure and academic achievement: Evidence from Detroit Public Schools, 2008–2010. *American Journal of Public Health*, 103(3), e72–e77.

² Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological profile for lead. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Services. <http://www.atsdr.cdc.gov/toxprofiles/tp13.pdf>

³ Centers for Disease Control and Prevention. Sources of Lead. <http://www.cdc.gov/nceh/lead/tips/sources.htm>

when lead dust is inhaled or when lead is ingested. For cities with much pre-1978 housing stock⁴ like Cleveland and its inner ring suburbs, the risk to children remains a serious concern. Childhood lead exposure is measured against thresholds set by the public health community. Although the federal government established 5 µg/dL (micrograms per deciliter) of lead in children's blood as the threshold for public health concern in 2012, there is no safe level of lead in a child's blood.^{5 6} In Ohio and other states, the Action Level by which a mandatory in-home public health lead investigation is triggered is 10 µg/dL.⁷

It is crucial to screen children for lead at very young ages for several reasons. First, though lead can be ingested in a number of ways including via contaminated water (as was the case in Flint, MI when the water source was switched between April 2014 and October 2015),⁸ children living in areas with older housing stock are most at risk of lead exposure, particularly when they begin to explore their environments through crawling. While crawling and pulling themselves up to stand, young children are more likely to come into contact with and subsequently ingest dust and chips from lead-based paint. Second, critical brain development is occurring at this same time and can be significantly negatively affected by the toxin. Therefore, the greatest likelihood of exposure to this environmental neurotoxin occurs at the precise time when it can do the most lasting damage to the child's brain.⁹ Third, testing is critical so that appropriate interventions can take place that remove children from the presence of the toxin and trigger a public health response to prevent future exposures to other children.

What is the prevalence of elevated blood lead levels in Cuyahoga County?

In Cuyahoga County, thousands of children have been and continue to be exposed to lead due primarily, to poorly maintained aging and deteriorating housing stock. In fact, in 2016, Cuyahoga County accounted for 14% of Ohio's lead tested children, but 41% of all children found to have an elevated blood lead level (EBLLs) ≥ 5 µg/dL.¹⁰ The problem of lead exposure is not evenly distributed throughout Ohio. The number of children in just the Cleveland suburbs with EBLLs (n=303) exceeds the total number of children with EBLLs in

⁴ Centers for Disease Control and Prevention. Lead Prevention Tips. <http://www.cdc.gov/nceh/lead/tips.htm>

⁵ D. Bellinger. (2008). Very low lead exposures and children's neurodevelopment. *Current Opinion in Pediatrics*, 20, 172-177.

⁶ C. Cole, A. Winsler (2010), "Protecting Children from Exposure to Lead: Old Problem, New Data, and New Policy Needs." *Social Policy Report* 24(1).

⁷ Ohio public health lead investigations include visual assessment of the environment where exposure occurred, x-ray fluorescence analysis of deteriorated paint, and analysis of other items that may contain lead (e.g., ceramic cookware, toys), and in some cases analysis of dust and soil samples. Retrieved from <http://codes.ohio.gov/oac/3701-30-07>

⁸ Gomez, H. F., Borgialli, D. A., Sharman, M., Shah, K. K., Scolpino, A. J., Oleske, J. M., & Bogden, J. D. (2018). Blood lead levels of children in Flint, Michigan: 2006-2016. *The Journal of Pediatrics*, 197. 158-164. [https://www.jpeds.com/article/S0022-3476\(17\)31758-4/fulltext](https://www.jpeds.com/article/S0022-3476(17)31758-4/fulltext)

⁹ World Health Organization. 2010. "Childhood Lead Poisoning." Geneva, Switzerland: World Health Organization. <http://www.who.int/ceh/publications/leadguidance.pdf>.

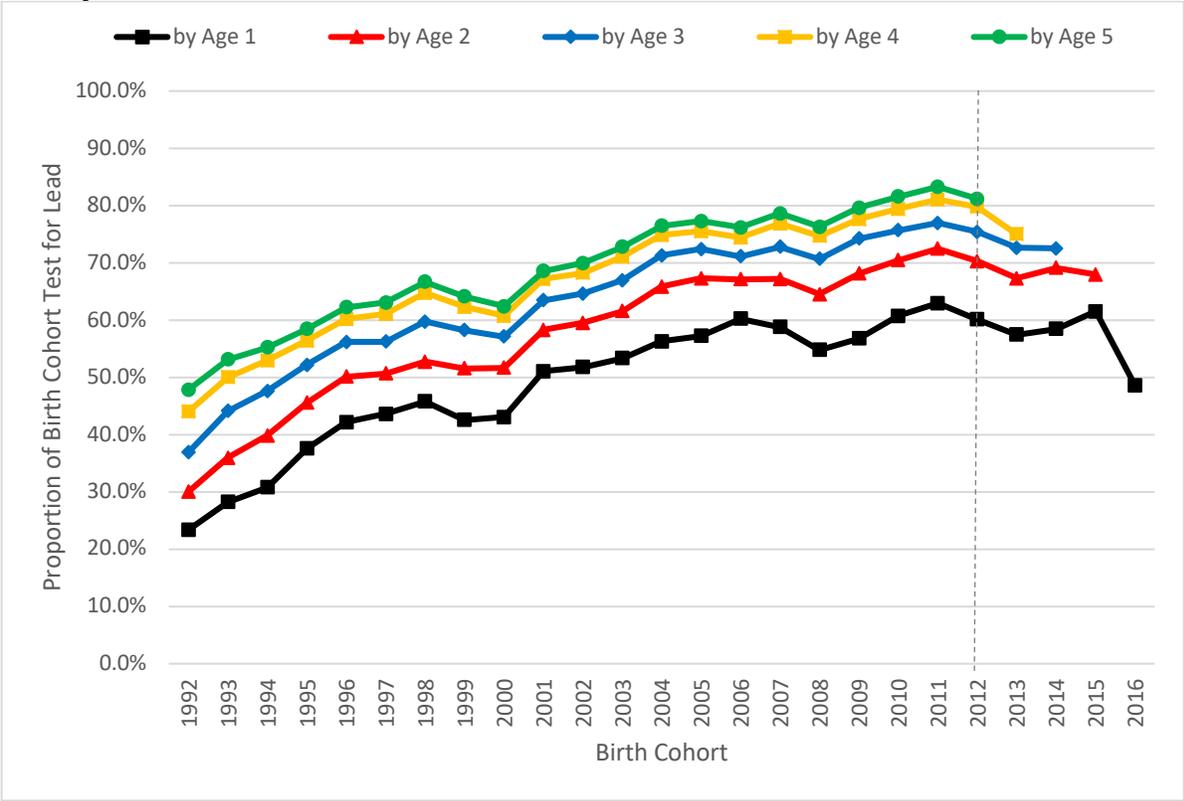
¹⁰ Ohio Department of Health, Public Health Data Warehouse. <http://publicapps.odh.ohio.gov/EDW/DataBrowser/Browse/LeadData>

all other counties in Ohio except Lucas and Hamilton Counties.¹¹ As documented by the Cuyahoga County Board of Health’s 2016 Child Elevated Blood Lead Level report, which draws on data from the Ohio Department of Health, suburbs with the most children with EBLs ≥ 5 $\mu\text{g}/\text{dL}$ were East Cleveland (n=129), Cleveland Heights (n=58), Lakewood (n=43), and Euclid (n=34).¹²

To what extent are children being screened for lead?

Using birth certificate and lead testing records from the Ohio Department of Health, Figure 1 illustrates that the proportion of a birth cohort screened at least once for lead by key ages has increased from 1992 to the present. In the early 1990’s, approximately half of all children born in Cuyahoga County had received a blood lead test by age 5. Today, 81.2% of the 2012 birth cohort had been screened by age 5 (that is, by 2017, which is the most recent year of data from the Ohio Department of Health available to the Center on Urban Poverty and Community Development). Because the age at which children are being screened is critically important, it is encouraging to see that 70% of children tested in the 2012 birth cohort received their first test by age 2.

Figure 1. Lead Testing Rates by Age and Birth Cohort for Children Born in Cuyahoga County



¹¹ Ohio Department of Health, Public Health Data Warehouse. <http://publicapps.odh.ohio.gov/EDW/DataBrowser/Browse/LeadData>

¹² <http://www.ccbh.net/wp-content/uploads/2018/06/Report-2016-Children-residing-Cuyahoga-County.pdf>

In each of the birth cohorts depicted in Figure 1, approximately 11,500 children were screened for lead at least once between birth and age 5.

Are children on Medicaid being tested for lead according to Medicaid guidelines?

Medicaid guidelines¹³ require that enrolled children be tested for lead exposure at 12 AND 24 months of age and that any child between 24 and 72 months of age with no record of a previous blood lead screening be tested. As mentioned above, these early ages are critical for testing because it is when children are most prone to lead exposure and are most susceptible to its harmful effects. Additionally, when children are not tested at these high-risk ages, it is difficult to ascertain in a later test what their level of exposure was previously.

Examining kindergarteners attending public schools in Cleveland and 11 inner-ring suburban districts from 2011-2012 to 2016-2017¹⁴ (N=35,334), researchers used monthly Medicaid enrollment records to identify children who had been covered for at least 22 of their first 24 months of life. Just over half of the kindergarteners met this criteria (N=18,070). As shown in Table 1, 90% of children receiving Medicaid had been tested for lead at least once between birth and kindergarten entry. However, only half of children were tested at age 1¹⁵ and just over 34% were tested at age 2.¹⁶ Approximately 1 in 5 children were tested at both age 1 AND age 2. By age 2, one-third of children on Medicaid who were screened at least once had an EBLL ≥ 5 $\mu\text{g}/\text{dL}$. The average (geometric mean) blood lead level among children who were screened as elevated at age 1 was 7.7 $\mu\text{g}/\text{dL}$ and 8.2 $\mu\text{g}/\text{dL}$ among children screened as elevated at age 2. Approximately 5.4% of screened children on Medicaid had an EBLL ≥ 10 $\mu\text{g}/\text{dL}$ by age 2, meeting the Action Level that triggers a mandatory in-home Public Health Lead Investigation.

Table 1. Lead Testing Rates compared to Medicaid Guidelines among Kindergarteners Covered by Medicaid for the First Two Years of Life, N=18,070

	%	Count (n)
Tested at least once between birth and kindergarten entry	90.0	16,263
Tested at age 1 ¹⁴	50.0	9,035
Tested at age 2 ¹⁵	34.6	6,252
Tested at both age 1 AND age 2, consistent with Medicaid guidelines	21.5	3,892
EBLL ≥ 5 $\mu\text{g}/\text{dL}$ at least once by age 2	33.9	6,125
EBLL ≥ 10 $\mu\text{g}/\text{dL}$ at least once by age 2	5.4	969

¹³ <https://www.medicaid.gov/medicaid/benefits/epsdt/lead-screening/index.html>

¹⁴ Inner ring suburban districts include Bedford, Berea, Brooklyn, Cleveland Heights, East Cleveland, Garfield Heights, Lakewood, Maple Heights, Richmond Heights, South Euclid/Lyndhurst, and Warrensville Heights. Approximately 56% of the kindergarteners in this sample attended CMSD and 44% attended one of the 11 suburban districts.

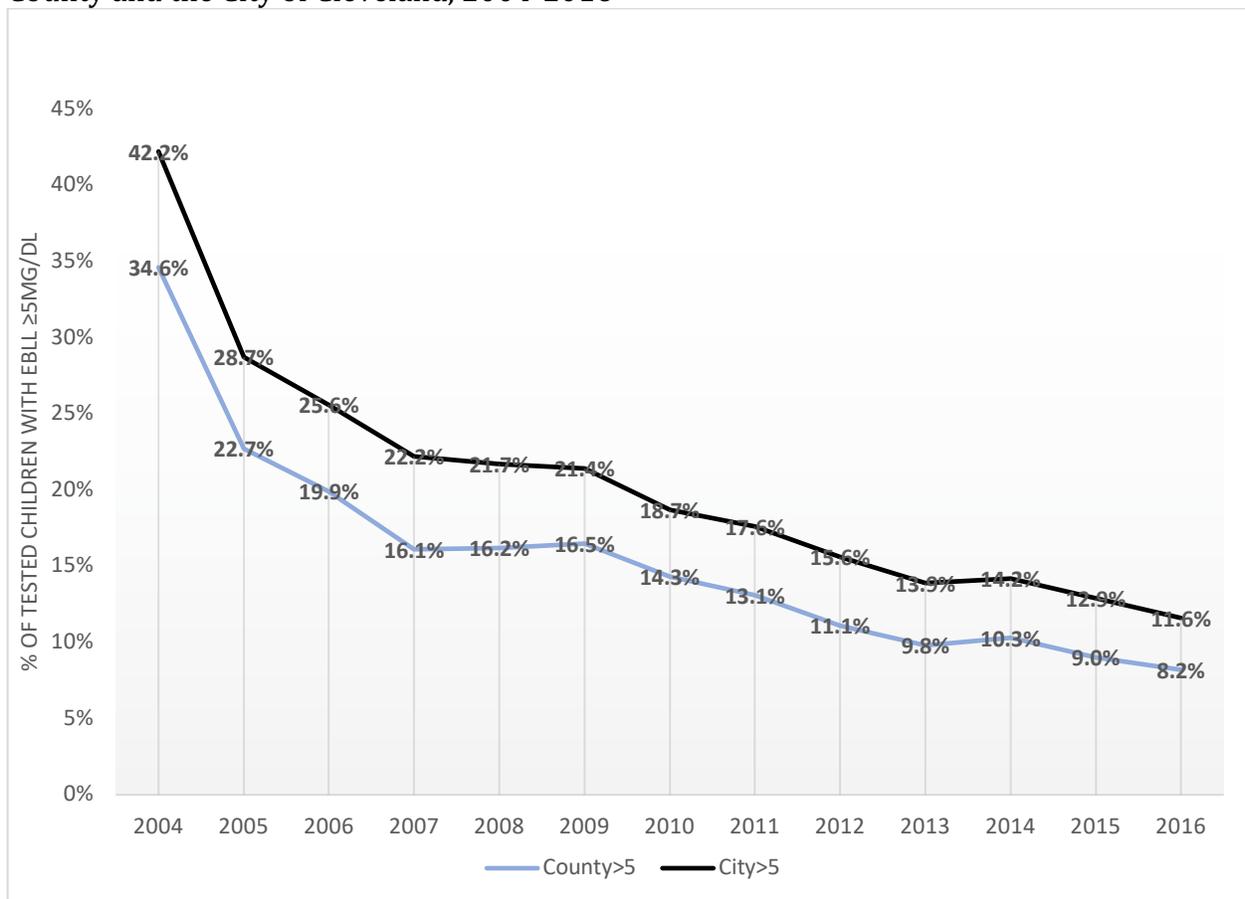
¹⁵ A three-month buffer before and after the child's 1st birthday was used in looking for any testing record between 9 and 15 months of age.

¹⁶ A three-month buffer before and after the child's 2nd birthday was used in looking for any testing record between 21 and 27 months of age.

How many children have blood lead levels above 5 µg/dL?

Public attention is often focused on the number of children who have an elevated blood lead test result in a given year.¹⁷ These annual snapshots indicate that the percent of children with EBLs ≥ 5 µg/dL has been on the decline for many years. According to Figure 2, in 2016, 11.6% (n=1,563) of screened children under the age of 6 living in Cleveland had an EBL ≥ 5 µg/dL compared to 42.2% in 2004; county-wide, the rates dropped to 8.2% (n=1,866) in 2016 from 34.6% in 2004. While a notable decline, children living in Cuyahoga County continue to be disproportionately impacted by lead exposure. By way of perspective, 6.9% of tested children in Toledo, 2.6% of tested children in Cincinnati, and 1.3% of tested children in Columbus¹⁸ were found to have an EBL ≥ 5 µg/dL in 2016.

Figure 2. Annual Rates of Children under the age of 6 with EBL ≥ 5 µg/dL: Cuyahoga County and the City of Cleveland, 2004-2016



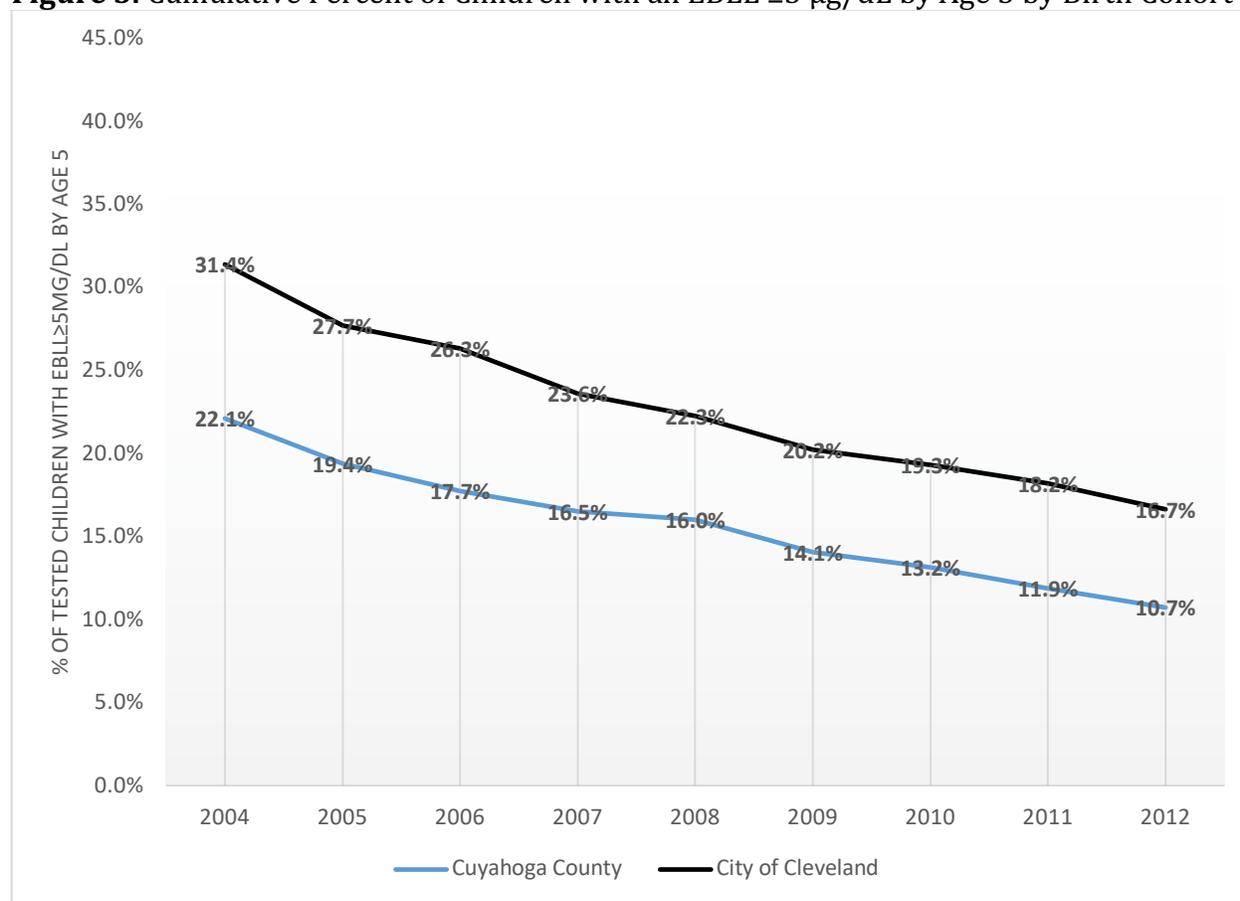
While the decline shown in Figure 2 is encouraging, it does not tell the whole story. Examining only annual testing results masks the cumulative effect of environmental lead

¹⁷ It is important to note that testing data do not indicate *when* a child was lead exposed, but rather, when a test returned an EBL ≥ 5 µg/dL.

¹⁸ Ohio Department of Health, Public Health Data Warehouse.
<http://publicapps.odh.ohio.gov/EDW/DataBrowser/Browse/LeadData>

exposure over the entire early childhood period. Figure 3 displays a longitudinal picture of EBLs among children born in Cuyahoga County and Cleveland between 2004 to 2012. As shown in Figure 3, by age 5, 10.7% (n=1,237) of children in the 2012 Cuyahoga County birth cohort who were screened for lead at least once during the first five years of their life had an EBL ≥ 5 $\mu\text{g}/\text{dL}$. Proportionately more children born in the City of Cleveland have elevated lead levels. In comparison to the county, by age 5, 16.7% (n=952) of children in the 2012 Cleveland birth cohort who were screened for lead at least once during the first five years of their life had an EBL ≥ 5 $\mu\text{g}/\text{dL}$. This rate is an average across all neighborhoods in Cleveland; however, as mentioned previously about screening rates, the rates of children with EBLs vary widely across neighborhoods. In some areas, like St. Clair-Superior and Clark-Fulton, approximately a quarter of the children screened in a given year are found to have an EBL ≥ 5 $\mu\text{g}/\text{dL}$.¹⁹

Figure 3. Cumulative Percent of Children with an EBL ≥ 5 $\mu\text{g}/\text{dL}$ by Age 5 by Birth Cohort



How do children with an EBL ≥ 5 $\mu\text{g}/\text{dL}$ fare when they get to kindergarten?

¹⁹ <http://www.ccbh.net/wp-content/uploads/2018/06/Report-2016-Children-residing-in-the-City-of-Cleveland.pdf>

Recent research on the effects of lead exposure have consistently shown its detrimental impact on academic outcomes.²⁰ In kindergarten, children with EBLLs ≥ 5 $\mu\text{g}/\text{dL}$ performed worse on kindergarten reading readiness assessments than did children with lower levels of exposure.²¹ To date, no formal evaluations have examined whether early childhood educational interventions help ameliorate the harmful effects of lead exposure on later academic performance; however, evidence does exist demonstrating that high-quality preschool programs are especially helpful to children who have experienced cognitive and developmental deficits associated with exposure to poverty and trauma.^{22,23} Many children with EBLLs experience these same deficits. Thus, it is plausible that high quality early childhood educational experiences may help to remediate the harmful effects of lead.

We conducted a retrospective analysis looking at the relationship between lead exposure and kindergarten readiness, focusing on kindergartners among a sample of children receiving a high dose of high quality preschool.²⁴ Drawing on data from the ChildHood Integrated Longitudinal Data (CHILD) System,²⁵ we estimated the odds of scoring 'On-track' for language and literacy as measured by the state-mandated kindergarten readiness assessment (KRA-L and KRA language and literacy subscale) for children with and without a lifetime history of EBLL ≥ 5 $\mu\text{g}/\text{dL}$. Using a sample of kindergartners attending public schools in Cleveland and 11 inner ring suburban districts from 2011-2012 to 2016-2017²⁶

²⁰ Zhang, N., Baker, H. W., Tufts, M., Raymond, R. E., Salihu, H., & Elliott, M. R. (2013). Early childhood lead exposure and academic achievement: Evidence from Detroit Public Schools, 2008–2010. *American Journal of Public Health, 103*(3), e72-e77.

²¹ McLaine, P., Navas-Acien, A., Lee, R., Simon, P., Diener-West, M., and Agnew, J. (2013). Elevated blood lead levels and reading readiness at the start of kindergarten. *Pediatrics, 131*(6), 1081-1089. <http://pediatrics.aappublications.org/content/pediatrics/early/2013/05/08/peds.2012-2277.full.pdf>

²² Magnuson, K. A., Meyers, M. K., Ruhm, C. J., and Waldfogel, J. (2004). Inequality in Preschool Education and School Readiness. *American Educational Research Journal, 41*(1), 115-157.

²³ https://www.pewtrusts.org/-/media/assets/2017/08/hip_childhood_lead_poisoning_report.pdf

²⁴ A high dose is defined as attending for 18 or more months in the two years before entering kindergarten. High-quality preschools are rated as 3, 4, or 5 stars in the state's quality rating system, Step Up To Quality.

²⁵ The CHILD System is a comprehensive integrated data system comprised of linked individual-level administrative records on residents born or living in Cuyahoga County since 1989. It is among the most complete integrated data systems available for children within a county. The CHILD System contains nearly 200 million records from 35 public and nonprofit entities. The following types of records were used in this analysis: birth certificates and lead testing records from the Ohio Department of Health, child abuse/neglect reports from Cuyahoga County Children and Family Services, food assistance and child care subsidy receipt from Cuyahoga County Job and Family Services, homeless services receipt from Cuyahoga County Office of Homeless Services, and participation in Invest in Children IIC programming, specifically Welcome Newborn Home Visit and Universal Pre-Kindergarten. In addition, this analysis drew on public school data also contained in the CHILD System to assess several academic outcomes. Data use agreements with all data providing agencies allow for the legal transfer of individually identifiable data on children and families to the CHILD System. Each DUA outlines the pertinent legal standards (e.g., FERPA, HIPAA, Ohio Revised Code) governing confidentiality, privacy, and acceptable uses of the data for research purposes. The data acquisition process is also fully governed by the authority vested in Case Western University's Institutional Review Board.

²⁶ Inner ring suburban districts included Bedford, Berea, Brooklyn, Cleveland Heights, East Cleveland, Garfield Heights, Lakewood, Maple Heights, Richmond Heights, South Euclid/Lyndhurst, Warrensville Heights. Approximately 56% of the kindergartners in this sample attended CMSD and 44% attended one of the 11 suburban districts.

(N=35,334), we found that children with a history of EBLL ≥ 5 $\mu\text{g}/\text{dL}$ were half as likely to score 'On-track' for language and literacy compared to children without a history of an EBLL ≥ 5 $\mu\text{g}/\text{dL}$ even after controlling for individual, family and neighborhood characteristics known to be associated with kindergarten readiness.²⁷

These findings indicate that even with a significant dose of high quality preschool, lead exposure still has a substantial negative impact on school readiness. Further, a previous research study examining cognitive development (as measured by the Bracken School Readiness Assessment) during a single year of high quality preschool found that while children with an EBLL ≥ 5 $\mu\text{g}/\text{dL}$ made sizable gains during the year, they exited preschool knowing less about letters, numbers, colors, sizes and shapes than their peers without an EBLL ≥ 5 $\mu\text{g}/\text{dL}$ knew when they entered preschool.²⁸

Discussion

In both number and proportion, children in Cleveland and Cuyahoga County are more at risk for lead exposure than children almost anywhere else in Ohio. Statistics show that the proportion of children with EBLs has declined over time, yet the number of children facing the detrimental impacts of lead exposure is still significant. Moreover, we may not fully see the extent of the problem, given that one-fifth of the most recent birth cohort were never tested for lead exposure by age 5 and a very large percentage of Cuyahoga County children receiving Medicaid are not tested at mandated, high-risk ages.

The seriousness of this problem cannot be overstated, especially when we understand the consequences of lead exposure for a child's well-being and success in later years. The analysis of kindergarten readiness shows that, even among children receiving a high dose of high-quality preschool, children with EBLs remain at a significant disadvantage on school readiness assessments when they enter kindergarten. It is possible that the detrimental impact of lead exposure on school readiness is even larger among children who attend preschool in a low-quality setting. We were unable to examine that comparison here, but the larger picture suggests that high-quality preschool alone cannot reverse the impact of early lead exposure.

The goal should be primary prevention of lead exposure to ensure children are never at risk. Early identification of lead exposure in children can contribute to more effective primary prevention efforts by identifying housing or other structures where the toxin is present. Given the low rates of lead screening among very young children on Medicaid, this report is a call to action for members of the medical community serving families using Medicaid. Until primary prevention efforts have eliminated the risk of exposure, public health interventions are necessary to help exposed children reach their full potential.

²⁷ The logistic regression models controlled for the following covariates: Individual-level (Age at kindergarten entry, gender, race/ethnicity, birth weight, premature birth, substantiated maltreatment, receipt of newborn home visiting, lead testing and blood lead level); Family-level (SNAP receipt, child care subsidy receipt, whether or not a child was born to a teenage mother, maternal education, homeless service use, residential mobility); Neighborhood level (concentrated neighborhood disadvantage).

²⁸ <https://assets.documentcloud.org/documents/2475227/upkleadbracken.pdf>

Although a clear evidence base for early childhood interventions for exposed children is not yet fully established, preliminary evidence in other locales point to the potential for reducing the negative long-term outcomes associated with early life exposure through multi-faceted intensive interventions (e.g., including other types of environmental, medical, and nutritional interventions) immediately following an elevated screening result.²⁹ More research is needed, but these interventions, coupled with educational interventions such as a high quality preschool experience, may help support children with EBLs to be ready for kindergarten.

²⁹ Billings, S. B., & Schnepel, K. T. (2018). Life after lead: Effects of early interventions for children exposed to lead. *American Economic Journal: Applied Economics*, 10(3), 315-344.