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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 documented[1] 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.

[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

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 when lead dust is inhaled or when lead is ingested. For cities with much pre-1978 housing stock[4] 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.

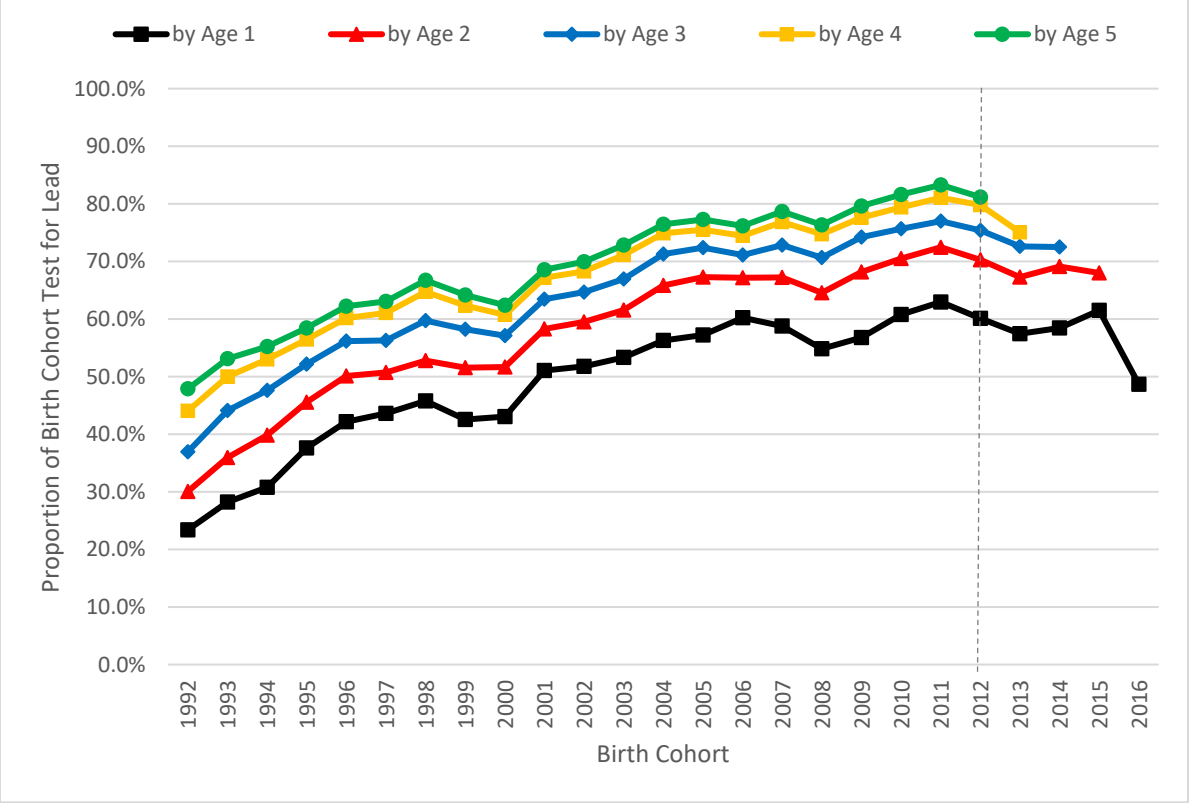
<u>What is the prevalence of elevated blood lead levels in Cuyahoga County?</u>
In Cuyahoga County, thousands of children have been and continue to be exposed to lead due primarily, to poorly maintained aging and deteriorating housing stock. In fact, in 2016, Cuyahoga County accounted for 14% of Ohio's 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

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

Cleveland suburbs with EBLLs (n=303) exceeds the total number of children with EBLLs in 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 EBLLs ≥5 µg/dL were East Cleveland (n=129), Cleveland Heights (n=58), Lakewood (n=43), and Euclid (n=34).[12]

<u>To what extent are children being screened for lead?</u>
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 guidelines[13] 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 2016-2017[14] (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 1[15] 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 μg/dL. The average (geometric mean) blood lead level among children who were screened as elevated at age 1 was 7.7 μg/dL and 8.2 μg/dL among children screened as elevated at age 2. Approximately 5.4% of screened children on Medicaid had an EBLL ≥10 μg/dL by age 2, meeting the Action Level that triggers a mandatory in-home Public Health Lead Investigation. Based on previous research we have conducted on the rate of kept well-child visits for children on Medicaid, we hypothesize that the low screening rates at 12 and 24 months of age are primarily due to the fact that many of these children are not completing the recommended well-child visits at those ages. Due to limits in our access to data, we are currently unable to confirm our hypothesis.

[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.

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[15]	50.0	9,035
Tested at age 2[16]	34.6	6,252
Tested at both age 1 AND age 2, consistent with Medicaid guidelines	21.5	3,892
EBLL ≥5 µg/dL at least once by age 2	33.9	6,125
EBLL ≥10 µg/dL at least once by age 2	5.4	969

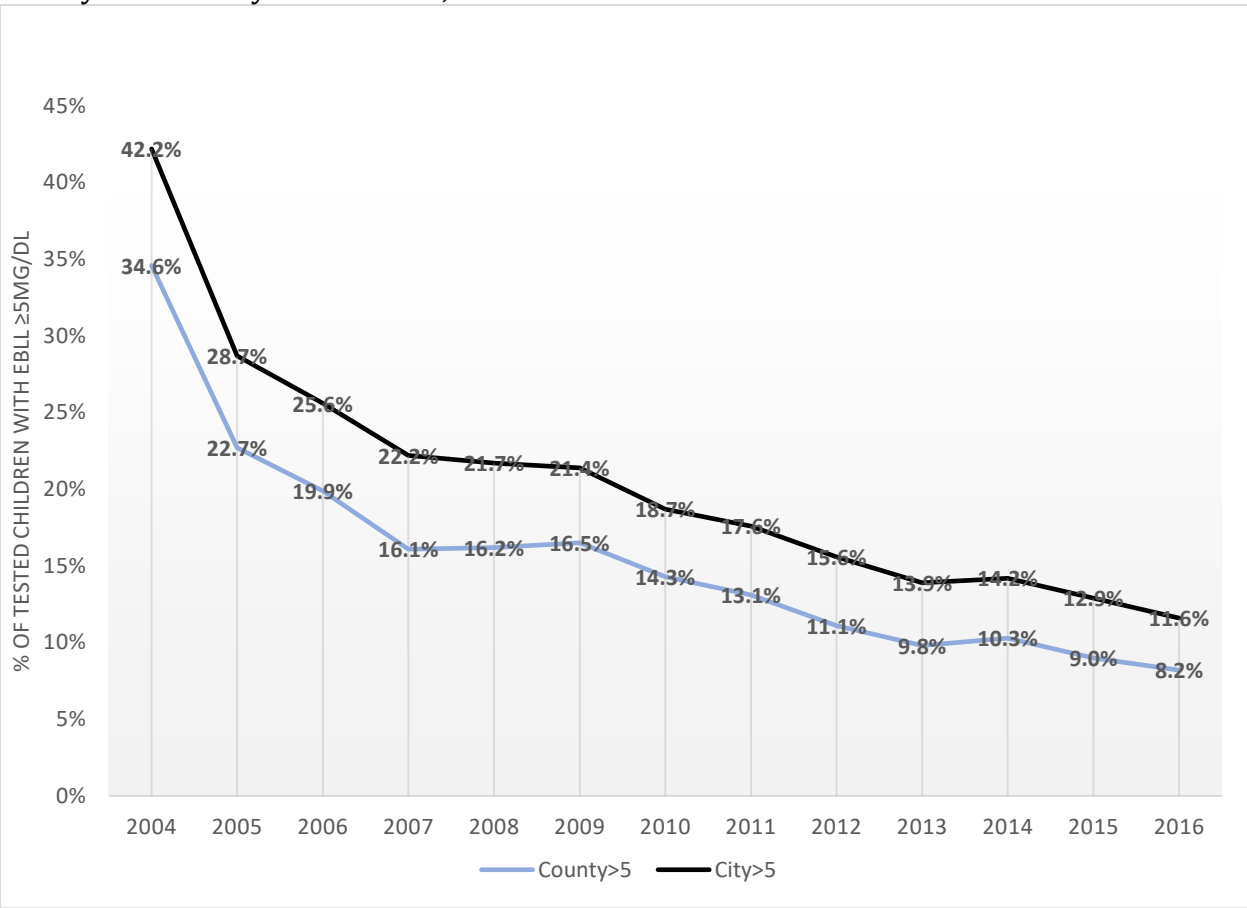
How many children have blood lead levels above 5 µg/dL?

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 EBLLs ≥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 EBLL ≥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 Columbus[18] were found to have an EBLL ≥5 µg/dL in 2016.

[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 EBLL ≥ 5 µg/dL.

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

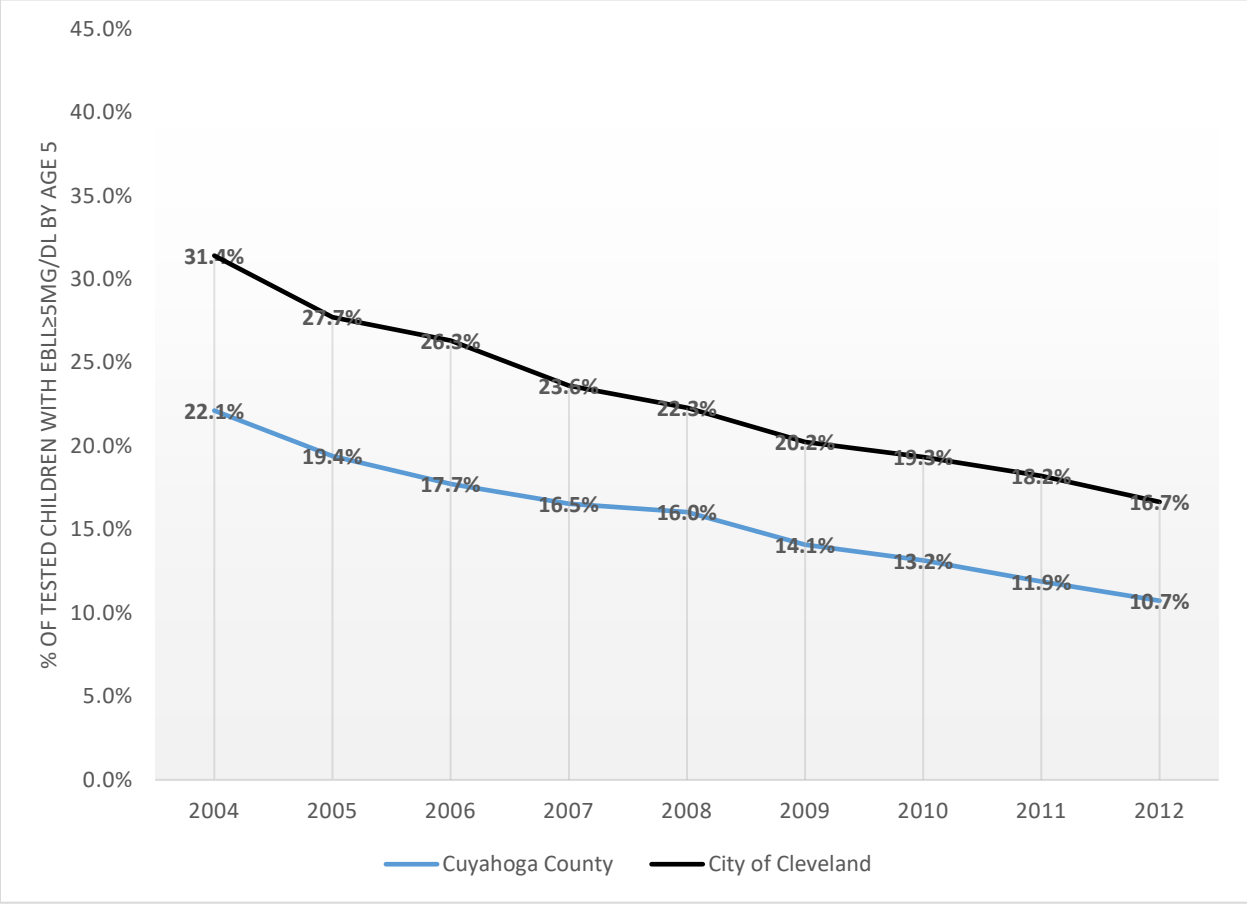
Figure 2. Annual Rates of Children under the age of 6 with EBLL ≥5 µg/dL: Cuyahoga County and the City of Cleveland, 2004-2016



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 exposure over the entire early childhood period. Figure 3 displays a longitudinal picture of EBLLs 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 EBLL ≥5 µg/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 EBLL ≥5 µg/dL. This rate is an average across all neighborhoods in Cleveland; however, as mentioned previously about screening rates, the rates of children with EBLLs 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 EBLL ≥5 µg/dL.[19]

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

Figure 3. Cumulative Percent of Children with an EBLL ≥5 µg/dL by Age 5 by Birth Cohort



How do children with an EBLL ≥5 µg/dL fare when they get to kindergarten?

Recent research on the effects of lead exposure have consistently shown its detrimental impact on academic outcomes.[20] In kindergarten, children with EBLLs ≥5 µg/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

[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

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, among a sample of kindergartners who received 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 µg/dL. Using a sample of kindergarteners attending public schools in Cleveland and 11 inner ring suburban districts from 2011-2012 to 2016-2017[26] (N=35,334), we found that children with a history of EBLL ≥5 µg/dL were half as likely to score 'On-track' for language and literacy compared to children without a history of an EBLL ≥5 µg/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 µg/dL made sizable gains during the year, they exited preschool

[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 kindergarteners in this sample attended CMSD and 44% attended one of the 11 suburban districts.

[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).

knowing less about letters, numbers, colors, sizes and shapes than their peers without an EBLL ≥5 μg/dL knew when they entered preschool.[28]

It is important to note that in the retrospective analysis, a minority of children with EBLLs ≥5 μg/dL did score "On-track" according to the KRA language and literacy subscale, despite their elevated lead exposure. There was no statistically significant mean difference in the highest confirmed blood lead test result between this group of children and their peers who also had an EBLL ≥5 μg/dL, but did not score "On-track." That is, the actual amount of lead in the children's blood at the highest confirmed test does not explain why some children scored "On-track" and others did not. The fact that these children scored "On-track," however, does not mean that lead exposure had no impact on their kindergarten readiness. It is possible that their scores would have been even higher without the lead exposure; the "On-track" designation simply tells us that their underlying score was high enough to meet this benchmark.

Differences between the two groups of children with EBLLs were found in areas that suggest children who are not kindergarten-ready are more likely to face other adversities in the early childhood period in addition to lead exposure. For example, proportionately fewer lead exposed children who scored "On-track" were born prematurely, at a low birth weight, or spent more than half their life prior to kindergarten in poverty. These children were also less likely to have moved residences in the preschool years. These differences suggest that it may be possible for children with EBLLs to be ready for kindergarten if other life experiences do not exacerbate the impact of elevated lead. Furthermore, for those "On-track" lead exposed children, it may be possible that high quality preschool did play a role in helping them be prepared for kindergarten, although we cannot make that claim with assurance. In order to have more conclusive evidence, we would need to compare this "On-track" group to a group who also had EBLLs but attended a low-quality preschool setting for at least 18 months. There are so few children who received this high dose of low-quality preschool that we are unable to make that comparison.

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 EBLLs 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 retrospective analysis of kindergarten readiness shows that, even among children receiving a high dose of high-quality preschool, children with EBLLs remain at a significant disadvantage on school readiness assessments when they enter kindergarten. It is possible

[28] https://assets.documentcloud.org/documents/2475227/upkleadbracken.pdf

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.