The Association between Elevated Blood Lead and School Readiness among Children attending Universal Pre-Kindergarten in Cleveland

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Key Findings

- Among 620 children enrolled in Universal Pre-Kindergarten (UPK) during the 2012-2013 academic year with Bracken data available at two time points, 64.7% had an elevated blood lead level (EBLL) >0 but < 5 µg/dL at some point in their life from birth to Bracken pre-test. An additional 13.2% had an EBLL >= 5 µg/dL and 22.1% of children had no lead test.
- Regardless of blood lead level, children made statistically significant gains on each Bracken subscale from fall to spring assessment during the 2012-2013 UPK year.
- However, at pre-test and post-test, children without a lead test outperformed children with past lead exposure, and children with lead exposure < 5 µg/dL but > 0 outperformed children with lead exposure >= 5 µg/dL.
- The rate of change from Bracken pre-test to post-test was consistent across all three groups of children.
- Taken together, these analyses suggest that lead poisoned children are experiencing gains during UPK, however, on all five Bracken subscales, children with EBLL>=5.0 µg/dL exited UPK behind where their 'no test' peers entered the program.

Introduction

Among environmental risks, lead exposure is perhaps the most serious threat to a child's development. Adverse health effects of lead include damage to the brain and nervous system, slowed development, learning and behavioral problems, and hearing and speech problems[1]. Children can contract lead poisoning by ingesting or inhaling lead, commonly present in housing stock built before 1978.

Lead exposure is measured against thresholds set by the public health community. In 1991, the U.S. Centers for Disease Control and Prevention

(CDC) established 10 micrograms per deciliter (µg/dL) as the level of action for public health intervention[2]. In 2007, the Greater Cleveland Lead Advisory Council advocated for the adoption of a more stringent level of 5.0 µg/dL[3]. While the CDC and the greater public health community currently considers blood lead levels >=5.0 µg/dL elevated, there is no safe level of lead in a child's blood. Cognitive deficits have been associated with blood lead concentrations below the 5.0 µg/dL standard[4].

The present study was undertaken to explore the association between blood lead level and educational gains among children attending a Universal Pre-Kindergarten (UPK) program in Cuyahoga County between 2012 and 2013.

UPK was launched in the fall of 2007, through the County's Office of Early Childhood/Invest in Children. UPK is delivered throughout the county in a variety of early care and education settings, including Cleveland Metropolitan Schools, private child care centers, Head Start sites, and family child care homes. All UPK sites meet a series of standards, demonstrated through research to be the hallmarks of quality that result in improved school readiness. These standards include increased teacher qualifications and commensurate compensation, lower staff to child ratios, use of approved curricula, engagement of families, and family linkages to necessary supportive services.

Measures

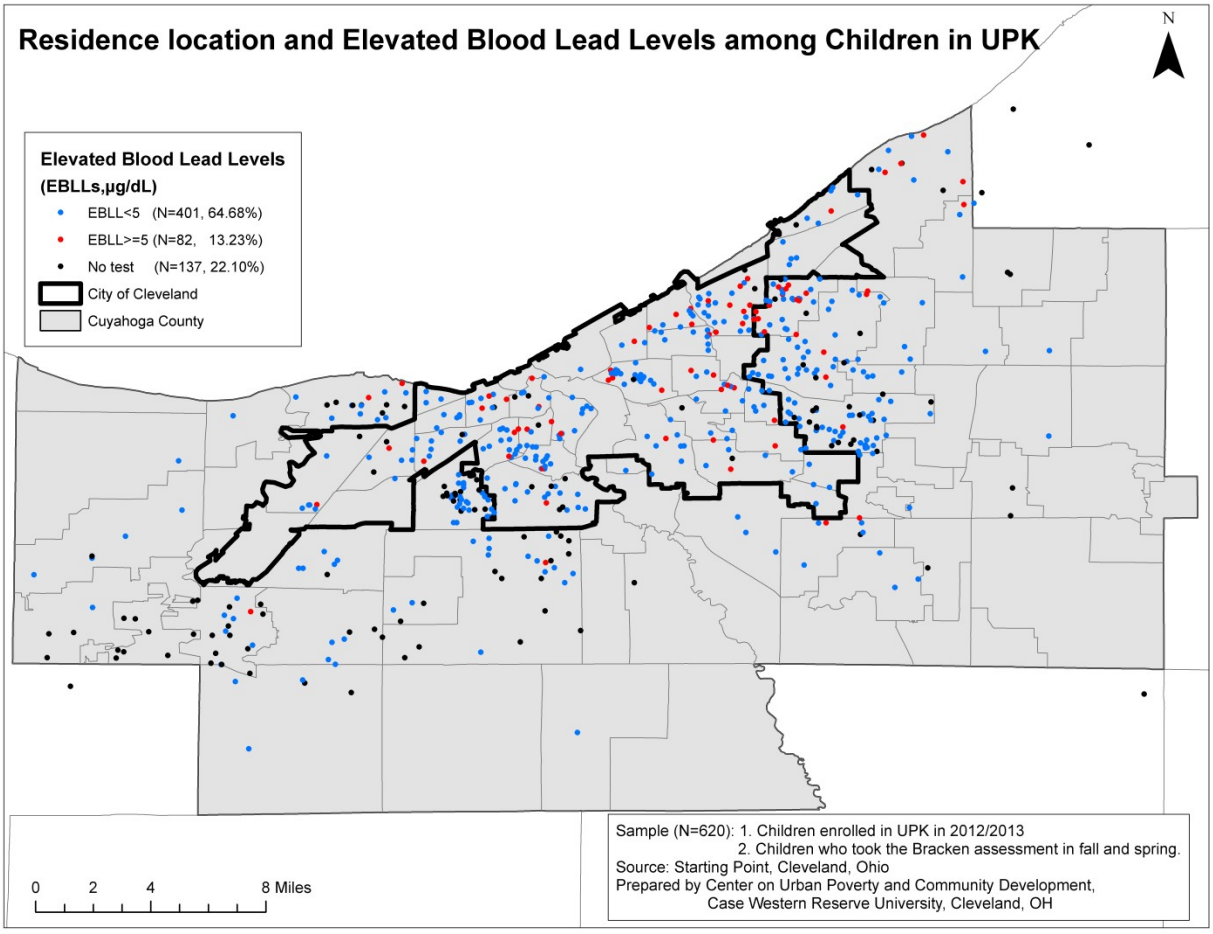
The Bracken School Readiness Assessment was used to measure cognitive development among children attending UPK. The Bracken is an age normed instrument; scores from the Bracken are scaled according to the age of the child. This age standardization allows for comparison of child scores over time by comparing a child to their same-age reference group at each time point. The Bracken consists of five subtests that measure basic concepts related to school readiness: colors (10 items), letters (15 items), numbers/counting (18 items), size/comparison (12 items), and shapes (20 items). Subscale scores are computed by taking the number of correct answers over the number of items in the subscale.

In addition to examining subscale scores (% correct and change), the Bracken categorizes each student by overall performance in relation to their age cohort. These categorical ratings take into account that older children should know more than younger children and are expected to be able to get more items correct. Categorical ratings include *Very advanced, Advanced, Average, Delayed,* and *Very delayed*. Due to small sample sizes, we combined Very advanced and Advanced as well as Very delayed and Delayed.

The Bracken was administered by independent consultants at two points in time, in the fall when a child first entered UPK (Pre-test) and again in the spring of the year prior to the child's entry into kindergarten (Post-test).

Analysis

Using 10 years of data obtained from the Ohio Department of Health (ODH), highest confirmed lifetime elevated blood lead level (EBLL) was calculated for children attending UPK in the 2012-2013 academic year. That is, we explored each child's lifetime history of lead tests from birth to initial Bracken assessment. For children with multiple lead tests, we used the highest confirmed lifetime EBLL. This method produced three categories of children: 1) those without a lead test between birth and initial Bracken assessment, n=137 (i.e., children enrolled in UPK who did not appear in the 10 years of ODH lead data); 2) children with a confirmed EBLL > 0.0 but < 5.0 µg/dL, n=401; and 3) children with a confirmed EBLL >=5.0 µg/dL, n=82. The map below shows the location of residence at UPK entry for children in each lead group. Lead groups are not distributed evenly throughout the county. Proportionately more children with EBLL live in the City of Cleveland than in the surrounding suburbs. Within the City of Cleveland, EBLL is concentrated on the City's east side.



Results

Table 1 presents average percent correct scores for each group of children by Bracken subscale at pre- and post-assessment. Change scores, or differences between post- and pre-assessments are shown in the last column. Positive change scores represent cognitive gains acquired between Pre- and Post-Bracken assessment. As illustrated in Table 1, all three groups of children made gains on each Bracken subscale.

Table 1. Bracken Pre- and Post-Test Mean Scores by EBLL Group

Bracken Subscale	Group	Fall Assessment (Pre-)		Spring Assessment (Post-)		Change (Post-Pre)	
		M	*SD*	M	*SD*	M	*SD*
Color	No lead test	97.2	14.7	98.8	8.8	1.5	8.4
	EBLL >0 and <5	93.2	20.0	95.5	16.5	2.2	14.1

	EBLL >=5	87.4	26.0	91.1	21.0	3.7	17.1
Letter	No lead test	71.5	30.8	82.0	23.6	10.5	19.2
	EBLL >0 and <5	65.6	35.1	74.4	30.6	8.8	19.2
	EBLL >=5	50.4	36.3	63.3	35.4	12.9	22.1
Number	No lead test	70.7	29.7	80.3	25.7	9.6	15.2
	EBLL >0 and <5	61.1	34.9	72.8	31.2	11.7	19.1
	EBLL >=5	43.9	35.7	59.2	33.7	15.3	19.7
Size	No lead test	110.8	36.0	127.7	33.7	16.9	30.2
	EBLL >0 and <5	101.2	41.9	118.7	40.6	17.6	31.5
	EBLL >=5	83.4	39.1	104.2	38.3	20.7	34.0
Shape	No lead test	69.2	18.5	76.4	16.4	7.3	15.0
	EBLL >0 and <5	64.8	21.0	70.8	20.5	6.0	15.2
	EBLL >=5	57.0	20.8	62.9	20.6	5.9	16.3

Note. No lead test group, n=137; EBLL>0.0 µg/dL and <5.0 µg/dL, n=401; EBLL>=5.0 µg/dL, n=82.

At the individual child level, cognitive gains during the UPK year were statistically significant. That is, in general, regardless of lead status, children made statistically significant gains on each subscale from fall to spring assessment. Average subscale gains ranged from a low of 1.5% (Color subscale, no lead test group) to a high of 20.7% (Size subscale, EBLL>=5.0 µg/dL group).

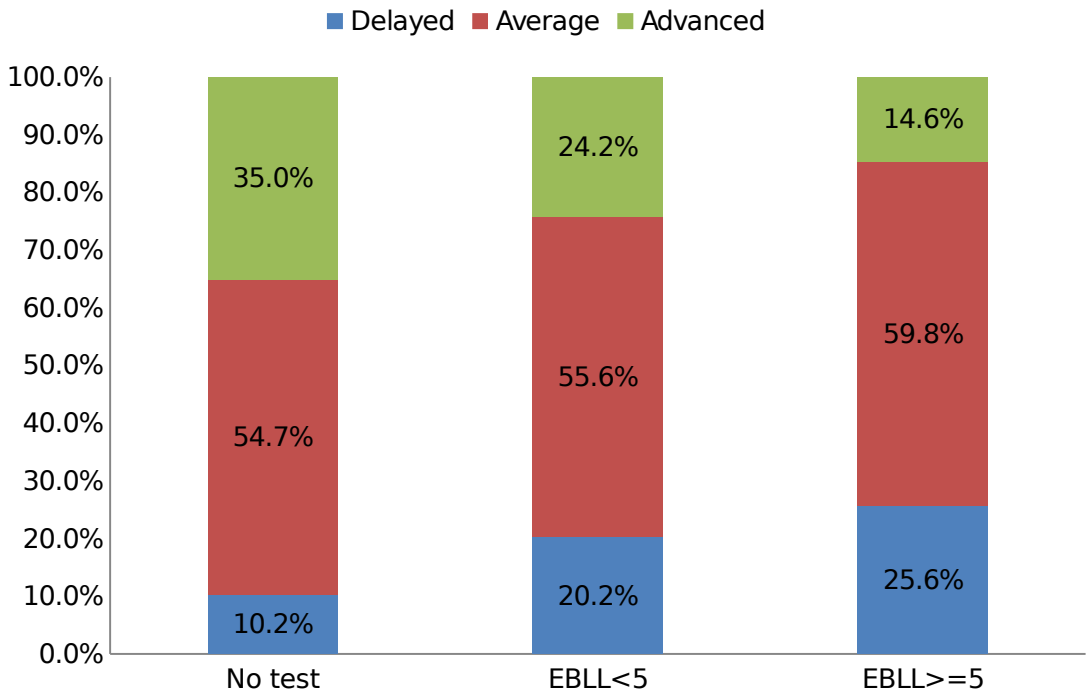
In addition, we found statistically significant differences at Pre- and Post-test between groups of children on all five Bracken subscales. The ‘no lead test’ group performed statistically significantly better on each subscale than both EBLL groups at both time points. In addition, the group of children with EBLL>0.0 µg/dL and <5.0 µg/dL performed statistically significantly better on each subscale than the group of children with EBLL>=5.0 µg/dL.

Lastly, we explored the interaction between Bracken subscale change and lead group to determine whether the rate of change made during the UPK year varied by lead status. Differences were not statistically significant suggesting that all children progressed at an equivalent rate.

Categorical groupings (i.e., Delayed, Average, Advanced) within each lead group mimicked mean scores discussed above (see **Figure 1**)**.** At Pre-test, compared to the EBLL >=5 µg/dL, 20% more children in the ‘no test’ lead

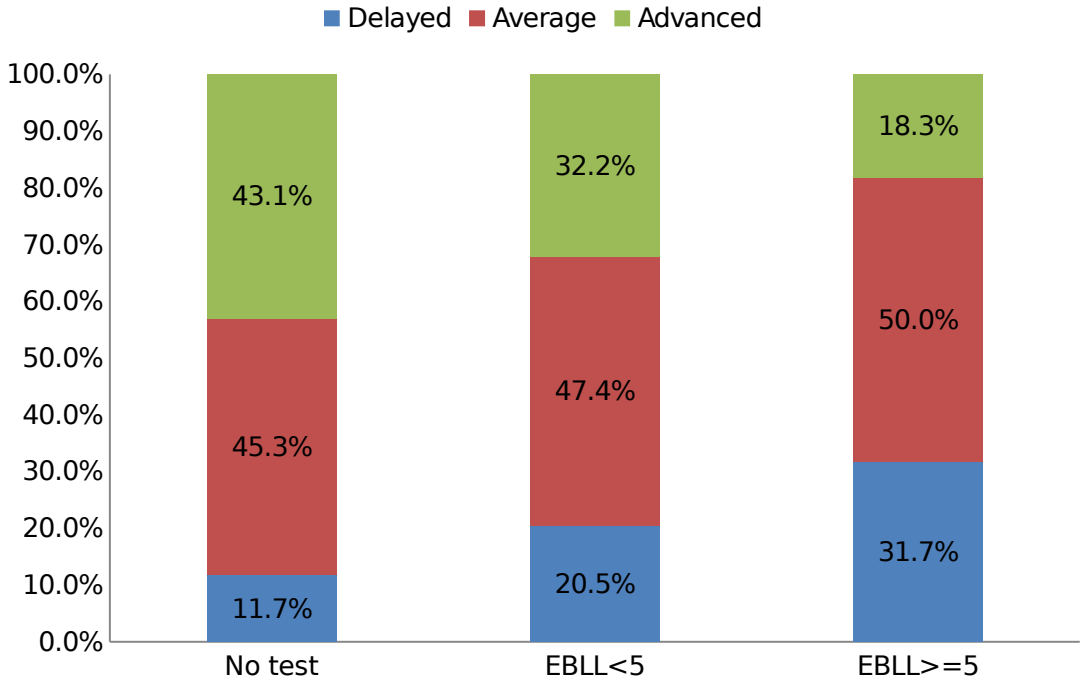
group were categorized as “Advanced” while 15.4% more children in the EBLL >=5 µg/dL were categorized as “Delayed”.

Figure 1. Percent of UPK students by Lead Level and Bracken Category at Pre-Test



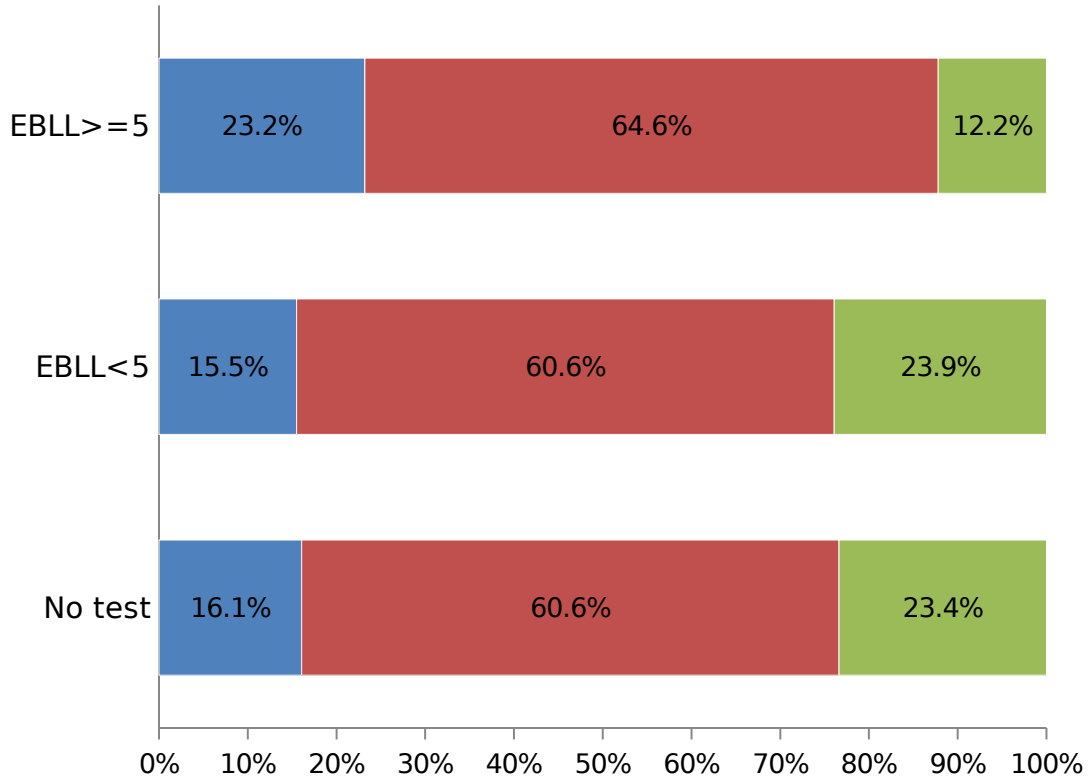
Differences between lead groups increased at Post-test (see **Figure 2**). At Pre-test, 20% more children in the ‘no test’ compared to EBLL >=5 µg/dL were “Advanced.” At Post-test, the difference increased by 4.8% to 24.8%. In addition, whereas 25.6% of children with EBLL >=5 µg/dL were considered “Delayed” at Pre-test, at Post-test 31.7% of children in this group fell into that category while the percent change in the ‘no test’ group was 1.5%.

Figure 2. Percent of UPK students by Lead Level and Bracken Category at Post-test



Finally, nearly one quarter of children with EBLL >=5 µg/dL lost ground from Pre-test to Post-test, whereas 16.1% of children in the 'no test' group performed more poorly at Post-test than Pre-test. As the Bracken is an age normed instrument, 'lost ground' implies that a child performed the same and pretest and posttest while his or her peers performed better at posttest. Therefore, this child 'lost ground' by not keeping pace with his or her peers. The pattern was reversed among children who 'made gains' (see **Figure 3**).

Figure 3. Percent of UPK Students by Lead Level who Lost Ground, Stayed the Same, and Made Gains from Bracken Pre-Test to Bracken Post-Test



Conclusions and Limitations

Taken together, these analyses suggest that lead poisoned children are learning during UPK, however, on all five Bracken subscales children with EBLL>=5.0 µg/dL exited UPK behind where their 'no test' peers entered the program (see **Table 1**). For example, children without a lead test averaged 70.7% correct on the number subscale and UPK entry. In comparison, children with EBLL>=5.0 µg/dL averaged 59.2% correct at UPK exit indicating these children enter kindergarten significantly behind their peers.

In contrast to a previous UPK finding reported by Fischer, Lalich, and Coulton (2013), in which 'the most delayed children show the largest gains by the spring term,' these results suggest children with lead exposure >= 5 µg/dL are not able to catch up to their 'untested' peers.

These results are correlational, not causal. As demonstrated by the Map, children with EBLL are not distributed evenly throughout the region but rather concentrated in areas with higher levels of poverty. Therefore, the effect of lead cannot be disassociated from the effect of poverty on cognitive development.

Endnotes

[1]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

[2]Lanphear, B. P., Dietrich, K., Auinger, P., & Cox, C. (2000). Cognitive deficits associated with blood lead concentrations < 10 µg/dL in US children and adolescents. *Public Health Reports, 115,* 521-529.

[3]Centers for Disease Control and Prevention. CDC's national surveillance data, 1997-2012. Available at http://www.cdc.gov/nceh/lead/data/national.htm .

[4]Centers for Disease Control and Prevention. Blood lead levels in children aged 1-5 years - United States, 1999-2010. MMWR 2013; 62: 245-248.

Note. This study includes data provided by the Ohio Department of Health which should not be considered an endorsement of this study or its conclusions.