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Early childhood lead exposure and exceptionality designations for students

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Abstract

The achievement gap continues to be an important educational issue, with disadvantaged groups exhibiting poorer school performance. Recently, literature has shown that even very low levels of early lead exposure affect cognitive and academic performance. As individuals at the lower end of the socioeconomic spectrum are more likely to be exposed to lead, this exposure may be an important contributor to the achievement gap. In this paper, we explore whether early childhood blood lead levels are associated with membership in exceptionality designation groups. In addition, we examine the racial and socioeconomic composition of these exceptional groups. Data from the North Carolina Childhood Lead Poisoning Prevention Program surveillance registry were linked at the individual child level to educational outcomes available through the North Carolina Education Research Data Center. Designation into exceptionality groups was obtained from the end-of-grade (EOG) data. Both standard bivariate and multivariate analyses were employed. Bivariate analyses indicate that blood lead levels and reading EOG scores differ by exceptionality, as well as by race and enrollment in free/reduced lunch. Logistic regression confirmed the relationship between blood lead levels and likelihood of exceptionality. Contextual factors – enrollment in the free/reduced lunch program, race, and parental education – are also significant with regard to exceptionality. This study demonstrates that early childhood lead exposure significantly influences the likelihood of being designated exceptional. These results provide additional evidence that early childhood lead exposure is a significant explanator of the achievement gap.

Keywords

Academic achievement; lead levels; exceptional student status; achievement gap

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INTRODUCTION

The achievement gap persists as an important educational issue, in light of and in spite of the "No Child Left Behind Act" from 2001. Disadvantaged groups continue to exhibit poorer school performance compared with middle and upper-class whites in the United States' educational system (1,2). Blacks, on average, score lower on tests than whites, with the trend starting in childhood and continuing throughout the educational process (3).

These relationships may be explained by family background effects (4). The influence of parental education on child educational attainment has been shown repeatedly; yet, the disparity remains even after controlling for parental education and income. Children's reading levels (5), placement in high-achievement curricular tracks (6), not dropping out of high school (7), college matriculation directly from high school (8), elite college attendance (8), and college graduation (8), are all positively correlated with socioeconomic status as measured by occupation, income, education, wealth (3,9) or home ownership(9).

Environmental exposures may represent an important explanator of the achievement gap. For example, childhood lead exposure has been associated with multiple adverse cognitive outcomes, including reduced performance on standardized intelligence quotient (IQ) tests (10), decreased performance on cognitive functioning tests (11), adverse neuropsychological outcomes (12), neurobehavioral deficits (13), and decreased end-of-grade (EOG) test scores (14). In addition, higher lead levels have been associated with students being more inattentive, hyperactive, disorganized, and having problems following directions (15). These children later exhibit lower high school graduation rates and greater absenteeism (16). Higher lead levels have also been associated with delinquent behavior and aggression (15).

Those at the lower end of the SES spectrum are more likely to be exposed to lead (17). Further, Singer and colleagues found that lead exposure had additive effects on multiple outcomes, suggesting continued risk to poor exposed children (18). These findings are particularly pertinent to the classification of exceptionality.

In this paper, we explore the relationship between school exceptionality designation and lead exposure. We are specifically interested in whether blood lead levels are associated with membership in exceptional status groups. In addition, we examine the racial and socioeconomic composition of these exceptional groups.

METHODS

This study uses end-of-grade testing data for the State of North Carolina that has been linked to childhood blood lead surveillance data available from a statewide registry. We used the data to evaluate the impact of lead exposure across types of exceptionality, as defined by the North Carolina Department of Public Instruction. This research was conducted under the auspices of the Children's Environmental Health Initiative at Duke University, according to a research protocol approved by the university's institutional review board.

In previous work, we used the North Carolina end-of-grade and childhood blood lead surveillance data to determine how EOG distributions as a whole shifted in response to lead exposure (19). That work found that lead exposure shifted the EOG distribution to the left and stretched out the lower tail. Using the same data, this analysis focuses on children who carry an exceptionality designation. We repeat here the description of the data and the data linkage process from the previous study.

The North Carolina Childhood Lead Poisoning Prevention Program (NCCLPPP) maintains a state registry of blood lead surveillance data. Through a negotiated confidentiality

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agreement, the Children's Environmental Health Initiative has access to individual blood lead screening data from 1995 to present. The NCCLPPP blood lead surveillance data include child name, birth date, race, ethnicity, test date, blood lead level (BLL), and home address.

The North Carolina Education Research Data Center (NCERDC) maintains a database with records of all EOG test results for all public school systems in North Carolina for tests from the 1995–1996 school year to present. These data include name, birth date, and test scores, as well as data on parental education, race, ethnicity, participation in the free or reduced lunch program, English proficiency, testing condition modifications, and school district. North Carolina EOG testing data also contain information indicating exceptionalities, such as academically and intellectually gifted, learning and behavioral disorders, and physical impairments (hearing, speech-language, vision). All data can be linked longitudinally for all years each child has taken EOG tests in North Carolina.

To construct our integrated database, children who were screened for lead between the ages of 9–36 months from 1995 through 1999 in all 100 NC counties (318,068 records for 263,403 children) were linked to records in the EOG testing data in age-corresponding years (2001–2005). Our process linked 38.8% of screened children to at least one EOG record. Analysis was restricted to students who self-reported race as either non-Hispanic white (NHW) or non-Hispanic black (NHB) and who did not report limited English proficiency.

We conducted all analyses on 4th-grade scores, for both reading and mathematics. The final linked dataset for 4th-grade reading and mathematics results contained 57,678 and 57,840 observations, respectively.

Table 1 provides summary statistics on subgroups within the final linked data set for fourth grade reading test scores. Of the total linked children: 45.5% were black (55.5% are white); 52.9% were enrolled in the free or reduced lunch program; 8.1% had parents who did not complete high school; 45.3% had parents who completed high school; and 46.6% had parents who had more than high school education (some college, college degree, graduate school). Because lead screening is not universal in North Carolina and because we are only able to link children who were screened for lead, the demographics of our sample are different from the population of children in the North Carolina public school system. If data are limited to NHB and NHW students only (as is done in this study), approximately 32% of the statewide sample is NHB, and approximately 68% is NHW. So NHB are overrepresented in the dataset of total linked children. Summary statistics for math scores are very similar.

Exceptional designations are given to provide appropriate education for every child in the public school system. These exceptional designations are intended to best serve the student. There are fifteen exceptional designations in North Carolina. From these, we constructed four distinct groups based on exceptionality status: 1) those students with no exceptional status designated (not designated, ND); 2) students designated exceptional due to their placement in advanced and intellectually gifted programs (AIG); 3) students designated exceptional due to learning or behavioral classifications (Learning and Behavioral Exceptional Designated, LBED); and 4) students designated exceptional for other reasons (i.e., not AIG and not learning or behavioral classifications – Exceptional Designated Other, EDO).

The LBED group contains children designated as behaviorally-emotionally handicapped, educable mentally handicapped (mildly impaired in general intellectually functioning and his/her development reflects a reduced rate of learning) (20), and specific learning disabled. The AIG group contains students who have been classified as having superior intellectual

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development and are capable of high performance (20). The EDO group contains students identified to have any other exceptional designation, such as: visual, hearing, or speech impairments; physical or health handicaps; autism; or trainable or severe mental handicaps.

Table 2 provides summary statistics on each of the four exceptionality subgroups within the final linked data set for fourth grade reading test scores, as well as separate equivalent statistics for NHW and NHB, as well as children enrolled in the free or reduced lunch program. Results for math scores are very similar. The composition of these groups is noteworthy. NHB students are overrepresented in the LBED group and underrepresented in the EDO group. Students enrolled in the free or reduced lunch program are also overrepresented in the LBED group. In contrast, NHB children and those enrolled in the free/reduced lunch are dramatically underrepresented in the AIG group.

To analyze the relationship between blood lead levels and exceptionality designations, we began by using simple t-tests. These assess whether the average blood lead level differs for those with an exceptionality designation and those without it. We also used logistic regression to predict the presence of exceptionality from blood lead levels.

RESULTS

Figure 1 shows the percentage of children with exceptionality designations (AIG, LBED, EDO) according to blood lead levels. The figure shows a clear negative relationship between percentage of AIG children and blood lead levels; i.e., higher blood lead levels are associated with lower proportion of AIG children, in a clear dose-response fashion. The figure also demonstrates a dose-response effect between blood lead levels and percentage of children designated LBED. Higher blood lead levels in early childhood are associated with membership in the LBED group. The EDO group shows substantially less variation in blood lead levels. Both the LBED and EDO groups have higher percentages of their members with higher blood lead levels than does the AIG group.

Figures 2 and 3 show that within any of the four exceptionality groups, NHB children and those enrolled in the free/reduced lunch have higher mean BLL. The higher mean blood lead levels for NHB children compared to NHW children is statistically significant ($p<.0001$) for all four exceptionality groups (figure 2). Similarly, children served by the free/reduced lunch program have significantly ($p<.0001$) higher mean BLL than those students not served by the free/reduced lunch program (Figure 3). These students, then, are multiply disadvantaged (by both poverty and environmental exposures) and may be more likely to accumulate further decrements over time, thereby continuing the cycle of disadvantage.

A series of t-tests was performed (see table 3) to compare blood lead levels and EOG scores between the ND groups and the LBED, EDO, and AIG groups. The ND students scored significantly higher ($p<.0001$) on their reading EOG tests and had significantly lower ($p<.0001$) blood lead levels than the LBED and EDO groups. Based on earlier research on the effects of lead exposure in early childhood, this finding is extremely important. It is possible that these students may not have been placed in these exceptionality categories had they not been exposed to lead during early childhood. The AIG students had the lowest blood lead level of all the groups, significantly lower than the ND students ($p<.0001$). Not surprisingly, their reading EOG scores were significantly higher than the ND students ($p<.0001$).

While figures 1–3 and the t-tests provide interesting insights, the complicated question of how lead exposure might affect membership in the exceptionality groups requires multivariate analysis. Using logistic regression, we confirmed the relationship between blood lead levels and likelihood for exceptionality displayed in figure 1. We ran three different logistic regressions that each used ND as the reference group (see table 4). The

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regressions control for race, sex, enrollment in the free/reduced lunch program, parental education, charter school status, and a separate dummy variable for each of the school systems in the state. In addition, a series of dummy variables are entered for blood lead levels (BLL=2, 3, …9, 10+) with a blood lead level of 1 set as the reference group.

Table 4 provides the odds ratios and 95% confidence intervals for the logistic regressions. When comparing across NC, AIG, LBED, and EDO groups, a clear pattern emerges. At each blood lead level, going as low as a level of 2 ug/dL, blood lead reduces the likelihood that children will be designated as AIG. In contrast, blood lead levels as low as 4 ug/dL significantly increase the likelihood that a child will be designated LBED. Blood lead levels as low as 8 ug/dL significantly increase the likelihood that a child will be designated EDO.

Contextual factors are also significant with regard to exceptionality. Enrollment in the free/reduced lunch program makes it less likely that a child will be designated AIG and more likely that he/she will be designated LBED or EDO. NHB race does not have an impact on the likelihood that a child will be designated LBED. Importantly, when blood lead levels are removed from the model, NHB race becomes highly significant in predicting LBED designation; this represents important evidence regarding how lead exposure contributes to the achievement gap. NHB race decreases the likelihood that a child will be designated EDO or AIG. Parental education significantly influences the likelihood of being designated LBED in a step-wise function. Low parental educational attainment increases the likelihood, and high parental educational attainment decreases the likelihood, of being designated LBED. The results are very similar for EDO designation. In contrast, low parental educational attainment significantly decreases the likelihood of being designated AIG, and high parental educational attainment significantly increases the likelihood.

DISCUSSION

Earlier research has demonstrated that teachers' expectations and students' self-confidence are important to the achievement process beyond socio-economic status (21). In an environment where children receive special services because of an exceptional classification, the downside is the process of labeling, lowering teacher expectations and decreasing self-confidence. As one of the predictors of exceptional classification is higher blood lead levels, this is a preventable negative cycle.

Our findings demonstrate the importance of recognizing the effect of even very low levels of lead exposure in early childhood and the disparity in that exposure. When mean BLL is examined by race within the exceptionality subgroups, black children have higher mean BLL than white children in all subgroups. Similarly, when examined within subgroups, children enrolled in the free or reduced lunch program have higher mean BLL than those not enrolleed in all exceptionality categories.

This study demonstrates that early childhood lead exposure significantly influences the likelihood of being designated exceptional. In particular, our results suggest that even very low levels of early lead exposure increase the likelihood of having a LBED exceptional designation. This represents another example of how lead may be contributing to the achievement gap.

While we typically think of exceptionality as it pertains to children with disabilities or learning or behavioral disorders, school systems also use the term to designate placement into advanced and intellectually gifted programs. Because EOG score are used ubiquitously in the United States to place students into AIG programs, even low level lead exposure can push some children out of the score range that would make them eligible for these special

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programs. To the extent that low income and minority children are systematically exposed to more lead (22), then AIG programs become less economically and racially diverse (23).

Parts of our student population are in double jeopardy. The LBED exceptional children are predominantly low-income and minority students who may also have higher levels of early childhood lead exposure. Thus, early childhood lead exposure, which we have previously shown is related to performance on EOG tests, also significantly influences the likelihood that students will be designated exceptional. These results provide additional evidence that early childhood lead exposure is a significant explanatory of the achievement gap.

Acknowledgments

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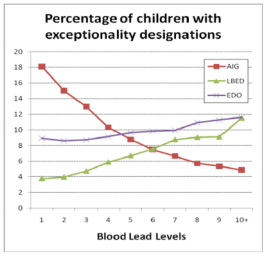

Figure 1.
Percentage of children with exceptionality designations

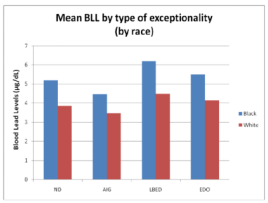

Figure 2. Mean BLL by type of exceptionality designation by race

***Differences in mean blood lead levels significant (p<.0001) for all exceptionality groups.

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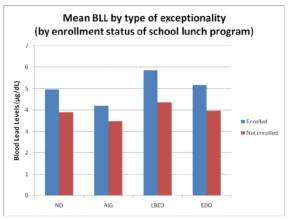

Figure 3. Mean BLL by type of exceptionality designation by enrollment status in free/reduced lunch program

***Differences in mean blood lead levels significant (p<.0001) for all exceptionality groups.

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Table 1

Summary statistics on subgroups in the final linked fourth grade reading dataset

Variable	Subcategory	Avg. Reading EOG	Proportion (%)		
			Overall	Black	White
Race	White	254.6	44.5		
	Black	248.5	55.5		
Household Income	Not enrolled in free/reduced lunch program	255.3	47.1	21.2	66.8
	Enrolled in free/reduced lunch program	249.0	52.9	78.8	33.2
Parental Education	Completed graduate school	260.1	3.5	0.9	5.4
	Completed college	257.2	18.5	9.8	25.1
	Some post-high school education	252.7	24.6	23.7	25.2
	Completed high school	249.8	45.3	55.5	37.7
	Some high school education	246.5	8.1	10.1	6.6

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Table 2

Summary statistics on exceptionality subgroups

Exceptionality Category	Avg. Reading EOG	Proportion (%)			
		Overall	Black	White	Free/Reduced Lunch
All students	250.5	100.0	44.5	55.5	54.6
ND	250.0	73.54	47.6	52.4	56.7
AIG	261.5	11.00	17.3	82.7	22.3
LBED	241.0	6.09	57.6	42.4	73.5
EDO	244.9	9.38	43.4	56.6	63.3

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TABLE 3

Blood lead levels and reading scores by specific exceptionality designation

	Blood Lead Level		Reading score	
	Mean	**Pr(|T|>|t|)**	**Mean**	**Pr(|T|>|t|)**
ND	4.5	0.0000	250.0	0.0000
LBED	5.5		241.0	
ND	4.5	0.0000	250.0	0.0000
EDO	4.7		244.9	
ND	4.5	0.0000	250.0	0.0000
AIG	3.6		261.5	

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Table 4

Odds Ratios - Exceptional designations versus not designated (ND)

	Learning and behavioral exceptional designation (LBED)	Exceptional designation other (EDO)	AIG
BLL of 2	NS	NS	.88 .82–.94
BLL of 3	NS	.92 (.86–1.00)	.88 (.83–.94)
BLL of 4	1.16 (1.04–1.30)	NS	.80 (.75–.85)
BLL of 5	1.24 (1.11–1.39)	NS	.78 (.73–.84)
BLL of 6	1.33 (1.18–1.49)	NS	.76 (.69–.83)
BLL of 7	1.51 (1.33–1.71)	NS	.71 (.64–.79)
BLL of 8	1.50 (1.31–1.73)	1.13 (1.01–1.26)	.68 (.60–.78)
BLL of 9	1.49 (1.28–1.74)	1.19 (1.04–1.35)	.65 (.55–.77)
BLL of 10+	1.87 (1.66–2.12)	1.26 (1.14–1.39)	.65 (.58–.74)
Black	NS	.71 (.68–.75)	.34 (.32–.35)
Male	2.37 (2.26–2.48)	2.25 (2.17–2.33)	NS
Free/Reduced lunch	1.35 (1.28–1.42)	1.47 (1.41–1.54)	.58 (.55–.61)
Parental education Some HS	2.37 (2.25–2.51)	1.47 (1.40–1.55)	.35 (.31–.41)
Parental education HS	.56 (.52–.59)	.82 (.78–.85)	2.28 (2.18–2.39)
Parental education Some college	.19 (.17–.23)	.87 (.87–.99)	5.19 (4.93–5.46)
Parental education Post-College	.23 (.16–.35)	NS	9.59 (8.79–10.45)