Distribution Agreement

Change in Neighborhood Deprivation, Residential Mobility, and Early Academic Achievement among First Grade Students in Georgia

By

Lauren Owens
Master of Public Health

Epidemiology

____

Michael Kramer, PhD
Committee Chair

Change in Neighborhood Deprivation, Residential Mobility, and Early Academic Achievement among First Grade Students in Georgia

By

Lauren Owens

B.A., University of Pittsburgh, 2006

Thesis Committee Chair: Michael Kramer, PhD

An abstract of
a thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
[Master of Public Health/Master of Science in Public Health]
in Epidemiology
2014

Abstract

Change in Neighborhood Deprivation, Residential Mobility, and Early Academic Achievement among First Grade Students in Georgia
By Lauren Owens

Background: Early childhood cognitive development is an important component in establishing a solid foundation that affects the trajectory of a person's life. Early childhood cognitive development is impacted by and/or associated with socioeconomic status, maternal education level, nurturing and enrichment in the home environment, household stability, and neighborhood disadvantage. This analysis examined the association of change in neighborhood deprivation with the odds of failure of the three Criterion-Referenced Competency Tests (CRCT).

Methods: Data are from the Georgia Birth to School Cohort; 19,805 students with linked birth and first grade school records were included. Multivariable logistic regression was used to investigate the association between census tract level deprivation and the odds of failing the three CRCTs.

Results: The logistic regression models indicated that change in neighborhood deprivation, while controlling for baseline deprivation, gender, maternal marital status, maternal race, and an interaction term between change in deprivation and marital status, was predictive of failure of the CRCT. Compared to those who did not move or had no net change in deprivation, the odds of failing for those with the biggest increase in deprivation was 1.50 (95% CI: 1.15, 1.97) for reading; 1.45 (95% CI: 1.16, 1.82) for English language arts, and 1.64 (95% CI: 1.29, 2.08) for math. The odds of failure increased across all three tests when examining the interaction term of change in deprivation and marital status.

Conclusion: In addition to change in neighborhood deprivation and residential mobility being significant predictors of failure of the CRCT, the multiplicative interaction between change in neighborhood deprivation and marital status was also significant. Further research should investigate the relationship between neighborhood deprivation, residential mobility, and marital status, and their effects on early childhood development.

Change in Neighborhood Deprivation, Residential Mobility, and Early Academic Achievement among First Grade Students in Georgia

By

Lauren Owens

B.A., University of Pittsburgh, 2006

Thesis Committee Chair: Michael Kramer, PhD

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology
2014

Acknowledgements

Though these words are my own, this was not a journey I traveled solo and I am in the debt of those who helped me along the way.

Many thanks to my thesis advisor Dr. Michael Kramer, whose thoughtful guidance and insight were invaluable in conceptualizing and completing this thesis.

Thank you to my family for your love and support, and believing in my ability to do this.

And to my friends and the community I found at RSPH, I have no words to describe how inspiring you are or how lucky I feel to have met you.

Table of Contents

Literature Review

Introduction

Early childhood cognitive development is an important component in establishing a solid foundation that impacts the trajectory of a person's life, including school readiness, grade retention, overall educational attainment, employment and higher earnings, lower rates of involvement with the criminal justice system and substance abuse, and overall health (1-4). Early childhood cognitive development is impacted by and/or associated with socioeconomic status, maternal education level, nurturing and enrichment in the home environment, household stability, and neighborhood disadvantage (5-9). One of the first opportunities to assess cognitive development on a large scale is in a school setting where both school readiness and academic achievement can be evaluated as indicators of development. Since cognitive development at this level is associated with a multitude of success and health factors later in life, it is important to understand the factors that contribute to this development.

One growing area of research is that of neighborhood factors and their effects on cognitive development. Previous research on neighborhood effects show their association with cognitive development, as well as with a number of health outcomes, including child well-being, infant mortality, low birth weight, obesity, diabetes, hypertension, behavioral problems, depression, suicide, and other mental health problems (7, 8, 10-12). The neighborhood effect of deprivation is an emerging field of study, but has already been associated with cognitive development and academic achievement (1).

Logically related to the concept of neighborhood as exposure is that of residential mobility. Residential mobility in childhood and adolescence is associated with behavioral and educational problems, and alcohol and drug use (13, 14). Though there is research examining the relationship between how a change in residence impacts early childhood academic achievement, there is more to learn about the specific combination of neighborhood deprivation and residential mobility. Many factors contribute to changing residences, including change in housing structure (e.g., marriage or divorce), poverty, mental health issues, and substance abuse, which can be confounders when studying the effects of change of residence (15-17). The purpose of this analysis is to examine whether the change in neighborhood deprivation is associated with early childhood academic achievement in the context of residential mobility, baseline deprivation, and other factors that contribute to cognitive development.

Neighborhood effects

Where people choose to live is not random, and therefore the effects of residential distribution are not random either. The neighborhoods in which people choose to live are shaped by a number of factors including, but not limited to, decisions related to individual socioeconomic status and racial identity as well as public policy, an effect that has been described as "geography of opportunity" (11, 18, 19). Given the distribution of geographic patterns of disparities, neighborhood effects can be markers for many inequalities, including health, as well as employment and education opportunities. The study of these indicators on populations aims to identify these social and structural predictors of health and other outcomes that are common at the neighborhood level.

The interest in research on neighborhood effects started appearing in the second half of the twentieth century, then in the 1990s, interest in the subject became much more popular and continues in popularity through present day (10). Results from this research show that neighborhood-level effects have been associated with, and are indicators for, a number of health outcomes, including child well-being, infant mortality, low birth weight, obesity, diabetes, hypertension, behavioral problems, depression, suicide, and other mental health problems (7, 10, 11). Part of the utility of determining neighborhood level effects is that their results are policy-relevant, from urban planning to housing policy and school zoning (11). In a broader context, due to the social and physical contexts neighborhoods provide, it is important to understand the associations between neighborhood characteristics and health in comparison to the associations between individual characteristics and health (11).

Because of this, neighborhood data have also been linked to educational outcomes in children. Longitudinal studies following the life-course of individuals, starting as infants through adulthood, with relevant neighborhood data history linked to outcomes can be costly and difficult logistically, but linking school data to birth records is a logical and relevant way to perform retrospective research (11). Birth records include the mother's address at the time of delivery from which a child's census tract can be identified. Census tracts have been used as proxies for neighborhoods in research due to their size – approximately 4,000 people on average – and relative permanence (20, 21). Neighborhood-level indicators are associated with readiness for school in both early childhood and adolescence, cognitive ability/development, intelligence quotient (IQ), and grade retention (7, 22-24).

Cognitive development and life course theory

Neighborhood effects considered as an exposure in early childhood are important when considering life course theory. Elder's life course theory posits that one's trajectory in life is shaped by the aggregation of events in historical context; that experiences for different people in different time periods result in differing endpoints and achievements (25). This would suggest that early exposures, such as childhood deprivation as discussed with regard to his Great Depression cohort, would have significant effects over the course of a person's life.

Bronfenbrenner's bioecological theory of human development builds on Elder's conception of time and place, and identifies four areas that define a person's development: process, person (their disposition, resources, and demands), context (environmental), and time (as in time period) (26). According to this theory, the processes a person experiences as he goes through life shapes his development. How these processes are navigated is shaped by a person's personality, his skills and abilities in handling situations, how much he demands of others, his neighborhood environment, and the time period during which the development takes place. Applied to an educational setting, being able to achieve academically early-on will put someone on a different life course trajectory than that of someone who does not achieve in an academic setting.

For example, it has been shown that children who were retained in a grade while their peers advanced are more likely to have less educational attainment as teenagers and adults (24). In that same study, a differential effect by gender is also seen in that among children who were retained in a grade, the girls did better than the boys in reading but not mathematics while in the elementary grades. Another study found a significant correlation with experiencing neighborhood level poverty during early childhood as a predictor of adult income (27). Persistent, rather than temporary, poverty during childhood also has a negative effect on children's cognitive abilities – especially affecting verbal skills (23, 28, 29). Finally, level of education attainment is linked with behaviors that are known to be associated with a shorter lifespan. Those with more education tend to smoke cigarettes less, be less obese, and drink less alcohol than their less-educated peers (3, 30). Beyond those frequently discussed risk behaviors, the same study showed that more education was positively correlated with preventive health behaviors in adults, like obtaining age-appropriate health screening and obtaining immunizations. To prevent any of these adverse health outcomes, it is important to understand the nuances of life course exposures that are opportunities for intervention.

Other childhood exposures related to neighborhood and living situation are residential mobility and stability. For adolescents, there is support in the literature suggesting that teens who have less residential stability are more likely to have poorer mental health and worse relationships later in life, while in younger children, residential stability is positively correlated with good self-rated health as an adult (31). Other research showed that moving in early childhood was associated with lower achievement in math and behavioral problems, after controlling for decreased quality of the home, increased maternal depression, and decreased maternal responsiveness/sensitivity (32). Furthermore, evidence from a study examining the effects of hyper/high residential mobility found an association with educational issues even when controlling for factors that contribute to residential mobility, like poverty or change in parental marital status (14). The timing of the move was important as well, as it appeared that moves occurring between birth and a child's second birthday had more of a negative impact than those occurring between ages 2 and 9 (33). Instability and residential mobility are driven by a number of factors including family structure at birth and change in that structure (cohabitating parents versus single parents versus married biological parents), pregnancy and childbirth, quality-of-life motivations, and poverty (15, 16, 34, 35). Research on the complete spectrum of residential mobility is incomplete due to the difficulty of recruiting and retaining families with low stability and/or high residential mobility. However, studies suggest that further evaluation of the effects of low stability and high mobility is warranted.

Racial disparities exist in academic achievement, socioeconomic status markers, and geographic distribution, making race an important factor in this and other analyses of social constructs. Research has shown that Hispanic and African American students have worse performance than their white peers, mostly related to the skills, support, and resources available to the different groups (36). Until the disparities between the groups are less glaring, examining race in the context of a social analysis is required.

Neighborhood Deprivation Index

One specific indicator to investigate with regard to educational achievement is neighborhood level deprivation. Neighborhood deprivation is a construct that embodies contextual socioeconomic status, including the construct of poverty and access to resources. It can be characterized by metrics such as income, education attainment among adults, unemployment, and crowding (37). Many of these data can be found in the information collected in the United States Census, a widely used source for studying socioeconomic status. Since socioeconomic status is not a well-defined term, the application of census data has not been consistent across the literature, thus making comparisons between studies difficult (38, 39). Individually, a number of factors have been used to study socioeconomic status, for example, federally defined poverty, median rent, and use of public assistance (38). At the same time, neighborhood indicators are often related to one another, which means they could be combined into a single deprivation index (10).

Dr. Lynne C. Messer at University of North Carolina – Chapel Hill headed a team in 2006 to develop such an index. Messer's neighborhood deprivation index (NDI) is composed of eight census variables: percent of males in management and professional occupations, percent of crowded housing, percent of households in poverty, percent of female headed households with dependents, percent of households on public assistance and households earning less than $30,000 per year (estimating poverty), percent of adults with less than a high school education, and the percent unemployed (38). It is standardized with a mean of 0 and a standard deviation of 1. Positive numbers above 1 (one standard deviation) indicate above-average deprivation, and negative numbers below -1 indicate below-average deprivation. It was developed using principal component analysis and factor analysis that resulted in that final model. It is a validated scale and has been studied with preterm birth, prostate cancer, red meat consumption and mortality, food retail environment in rural America, and the availability of nutritious food at small urban stores (38, 40-42). It has promise to be widely applicable in the United States and studies should apply it to further its use as a predictive factor.

Georgia and the Criterion-Referenced Competency Tests

Criterion-Referenced Competency Tests (CRCT) are standardized tests that have been used to assess students' skills and knowledge in Georgia since 2000, when testing was started in grades four, six, and eight (43). Testing was expanded to all grades from one through eight in 2002. The CRCTs assessed reading, English language arts (ELA), and mathematics ability against standards defined by the Common Core Georgia Performance Standards for all grade levels, with grades three through eight also testing on social studies and science. The tests are given toward the end of the school year; for 2014 they were scheduled during the months of April and May (44). Georgia's schools receive funding from Federal, state, and local sources. Federal funding is focused on historically at-risk students, including those needing special education services, those living in poverty, and English language learners, and is the smallest piece of funding (45). It also includes funding from the No Child Left Behind Act, to which the CRCT scores are tied (46). Georgia allocates its state funding based on how much it costs to put a teacher in each setting, with those with more needs or younger students increasing that cost. Local systems are funded through property taxes, bonds, and sales tax (as approved by voters), which leave poorer districts more reliant on state and federal funding. This creates the opportunity for there to be great inequality between schools, and schools serving students from low-income areas are recognized as facing more challenges than schools serving a higher-income population, which contradicts the idea that education is the great American equalizer (47). The differences in low-income and high-income are no small matter. In a recent analysis done by the Brookings Institution on data from 2012, Georgia's capital, Atlanta, was named the city with the highest level of income inequality - showing that the richest 5 percent of those in Atlanta earned more than 18 times as much as those in the poorest 5 percent (48).

Starting in 2003, budgetary constraints caused the state of Georgia to decrease the amount of funding school districts receive (49). As a result, first and second grade students have not been assessed with CRCTs since 2010 (50).

Like any standardized testing system, the data provided to teachers, schools, and the state of Georgia by the CRCTs helps the educational system assess itself on a regular basis. It also faces the same criticism of all standardized testing, which is that "pressure to raise test scores has resulted in practices which pollute the inferences we make from these scores" (51). Therefore, it is an imperfect tool to accurately assess individual cognitive development. However, the relative ease of access to this type of school administrative data makes these results a good starting point to study child development.

First grade students were tested on vocabulary and comprehension for the reading portion; on grammar/phonological awareness/phonics, sentence construction, and research for the English language arts portion; and on number and operations, measurement, geometry, and data analysis and probability for the mathematics portion (52-54). Students had to pass all three portions to pass the test, though scores and pass/fail rates are available for each individual section. Advancing to the next grade is not solely based on passing the CRCT (55).

Research question

Neighborhood deprivation, residential mobility, and early academic achievement are important social and public health issues for the reasons discussed above. While there is significant research covering both neighborhood deprivation and residential mobility and their impacts on cognitive development and early academic achievement, there is more to learn about how the two interact over time – how the change in neighborhood deprivation caused by a move relates to cognitive development. This analysis aims to answer the following question:

1. Is the change in neighborhood deprivation, caused by a move of residences in early childhood, associated with poor cognitive development, as measured by first grade standardized test failure?

Answering this question will add to the body of research attempting to identify and intervene on risk factors contributing to poor cognitive development among children. This analysis will also provide a basis for further population-based research to examine how both neighborhood deprivation and residential mobility influence child development.

Methods

Data

The Georgia Birth to School dataset contains data on a retrospective cohort and is composed of birth records linked to school administrative records for first grade. The birth records are from the Georgia Department of Public Health for children born in the state of Georgia from 1998 through 2003. The school records are from the Georgia Department of Education and include first grade CRCT scores for reading, math, and English language arts for the years 2004 through 2010. In the initial linking, 53% of births in the state of Georgia were matched with a school record. The study was approved by the Emory University Institutional Review Board.

Inclusion/exclusion criteria

The study population was defined as all of the first index children (index children) of mothers who had two or more children. Data from the second child's birth was used to determine exposures, including change in residence, change in NDI, and maternal marital status. To start, a subset of the original dataset was defined as all observations that had a valid maternal longitudinal identification number (ID) that was needed to link children to a shared mother. Using this maternal ID, the number of children born to each mother was counted and all observations where a maternal ID was only linked to one child were dropped. For mothers who had at least two children in the dataset, the first two observations for each maternal ID were included. At this point the data were concatenated by matching on maternal ID. Then, observations where the birthdates for the two siblings were the same (indicating a plural birth) were dropped since that second birth does not provide a second time point for this particular longitudinal study. The data were further restricted to include only those where the mother's race/ethnicity was defined as Hispanic, non-Hispanic black, or non-Hispanic white. Finally, the data were restricted to exclude observations with unlikely or missing values for the outcomes or covariates of interest. Observations were dropped for having missing values for any of the CRCT scores, maternal education, marital status, and outlier child test ages.

Exposures

The change in neighborhood deprivation following a move in residences in early childhood is the exposure of interest for this study. The census tracts where the mother lived at the time of birth for both the index and second child were used as the proxy for neighborhood as has been done in previous research due to their size and relative permanence (56). The move was determined by using the second child's birth as a second neighborhood measure in the life of the index child. If the census tract IDs for the two siblings were the same, the index child was defined as having not moved. If the census tract IDs were different, then the arithmetic difference in their deprivation index values was determined.

To determine the change in neighborhood deprivation, the birth dataset was first merged with an area-based dataset containing NDI values for each census tract for each birth year for each sibling. This was when baseline NDI was determined and then categorized into three levels: average deprivation (0±1), below-average deprivation (<-1 standard deviation), and above-average deprivation (>1 standard deviation). The NDI at birth for this population had a mean of 0.015, a minimum of -1.62 and maximum of 4.53. The change in deprivation was determined by subtracting the baseline deprivation value from the deprivation value at the second time point. For analysis purposes, the final distribution of change in deprivation was divided into quintiles, with the first quintile indicating the biggest move from high deprivation to low deprivation and the fifth quintile indicating the biggest move from low deprivation to high deprivation. The third quintile represented those individuals who experienced a move but had no net change in deprivation, which served as the referent group. Those who did not move were initially categorized separately from the five quintiles, but after preliminary analyses were performed, it was determined that the association was the same if they were included in the referent group – the third quintile.

Outcomes

The outcomes of interest for this study are failure of any, or all, of the three first grade CRCTs – reading, English language arts, and math. The Georgia Department of Education divides the scores for the CRCT into three categories: does not meet standards, meets standards, and exceeds standards. For this study, the outcome was dichotomized. Those whose scores fell into the category of does not meet standards were categorized as having failed the test, while those who met or exceeded standards were categorized as passing the test.

Covariates

Other variables of interest were gleaned from both the birth and school record portions of the data set including race/ethnicity for both student and mother, student's birth date, gender, year the CRCT was taken, gestational age, birth weight, maternal age, mother's marital status, and education level attained by the mother.

The change in marital status between the index child's birth and that of the second child became a variable of interest. After preliminary analyses were performed using a four-level treatment of marital status (married-married, married-unmarried, unmarried-married, and unmarried-unmarried), the longitudinal marital status variable was dichotomized as always married (married-married) versus ever unmarried (married-unmarried, unmarried-married, and unmarried-unmarried).

To calculate the child's age at testing, it was assumed, on average, the CRCT was given on April 15 of the testing year. The arithmetic difference in days between date of birth and the average date of testing was divided by 365.25 and rounded down to estimate age at last birthday of the students.

The inter-pregnancy interval was calculated by taking the arithmetic difference, in days, between the birth dates of the index and second children matched by maternal ID. Weeks were calculated by dividing the number of days by 7; months were calculated by dividing the number of days by 30; years were calculated by dividing the number of days by 365.25. Those observations with fewer than 196 days (28 weeks) between the two siblings were excluded as implausible on the basis of fertility not returning until at least 6 weeks after childbirth and the earliest preterm birth of 22 weeks.

Maternal age was categorized into five-year time intervals. Maternal education was categorized into less than high school (0 to 11 years), high school (12 years), some college (13 to 15 years), and college or more (16 or more years).

Gestational age was dichotomized into preterm birth status, where those born before 37 weeks gestation were categorized as being born preterm, and those reaching 37 or more weeks gestation at birth were categorized as being born term. Similarly, birth weight was dichotomized to low birth weight (2,500 grams and under) or not (over 2,500 grams).

Data Analysis

All analyses were performed using SAS 9.3 (Cary, NC) (57). Descriptive statistics for the exposure, outcomes, and all covariates were computed using PROC FREQ and PROC UNIVARIATE. Chi-square tests were evaluated at p-value of α=0.05 and used to assess significant differences for variables across test failure and NDI quintile categories. Using PROC GENMOD, generalized estimating equation models were used to obtain odds ratios for the change in NDI as adjusted for the covariates (58). The odds ratios were assumed to approximate risk ratios (59, 60). Modeling the failure of the reading CRCT was accomplished using a series of multivariable logistic binomial generalized estimating equation (GEE) models that included a repeated statement to account for those living in the same census tract. This was to account for the non-independence cluster of similar outcomes of those living in the same neighborhood.

A series of models were run using this method to assess the association between the change in NDI and probability of failing the CRCT. The first three were baseline models for each reading, English language arts, and math CRCT that included the NDI quintiles and baseline NDI; baseline NDI was included since it better informed the variable of change in NDI. The next models solely assessed the probability for failing the reading CRCT to determine the final model. The fourth model included the crude model variables and all covariates with the exception of child's age at test and birth year. The fifth model included change in NDI, baseline NDI, and gender. The sixth model included change in NDI, baseline NDI, and marital status. The seventh included change in NDI, baseline NDI, maternal race, and maternal education. The eighth and final model included change in NDI, baseline NDI, gender, marital status, maternal race, and an interaction term between change in NDI and marital status to assess multiplicative interaction between that exposure and covariate. Upon determining this final model for failing the reading CRCT, the same model was used for models 9 and 10 for the ELA and math CRCTs.

Results

The original linked birth-to-school dataset contained 341,979 observations for children who took the CRCT in the state of Georgia. Due to lack of valid maternal longitudinal ID numbers, 75,105 were excluded. Out of the 266,874 with valid maternal longitudinal identification numbers required to link index and second children, 242,176 were unique women (duplicates removed). There were 47,186 observations relating to the first and second birth events for women who had two or more births in the state of Georgia. When the siblings were linked by maternal longitudinal identification numbers, this resulted in 23,593 observations. In the subsequent data cleaning, 2,872 observations were dropped because of identical birthdates (indicating plural births) for the index and second child; another 77 were dropped due to an inter-pregnancy interval less than 28 weeks between the mother's index child and second child (6 weeks of postpartum amenorrhea plus 22 weeks of gestation) (61). Other observations were dropped due to missing values: 351 were dropped for missing maternal education, 21 were dropped for missing CRCT scores for reading, 21 were dropped for missing CTCT scores for math, 4 were dropped for missing CRCT scores for ELA, 441 were dropped for having a maternal race/ethnicity that was not one of the three used in the analysis, five were dropped for child's testing age being 4, and one was dropped for missing marital status. The final dataset for analyses contained 19,805 observations.

Descriptive statistics about the final study population are included in Table 1. A majority (68%) of the population had an average level of neighborhood deprivation and 47% of the population experienced a residential move prior to taking the CRCT. The population was evenly distributed between females and males, and a majority of the students were born in 1999, though births occurred in every year from 1999 through 2001. The range of age at testing spanned from 5 to 9 years old; the majority (63%) of the students were 7 years old at the time of testing. The largest proportion of the population was non-Hispanic white (49%) followed by non-Hispanic black (40%); these proportions were mirrored in the race/ethnicity of the student's mothers. The majority (81%) of mothers were between the ages of 15 and 29 at time of birth of the index child, with the average age being 24 years old. About 58% of the population had mothers who were married at both time points whereas the remainder of the population had mothers who were unmarried at one or both time points. More than 60% of the students had mothers who obtained a high school education or less. About 10% of the population was born preterm and about 7% had low birth weight.

The English language arts section of the CRCT had the highest level of failure at 19% (n=3,815); 15% (n=2,991) of students failed the math section and about 12% (n=2,332) failed reading. Compared to roughly equal distributions of below- (16%) and above-average (15%) deprivation at baseline in the entire population, there were three to four times more students with above-average baseline deprivation compared to those below-average baseline deprivation among the students who failed the three CRCTs. Across all three tests, a larger proportion of those who failed were male – 63% male versus 37% female for reading, 55% male versus 45% female for math, and 61% male versus 39% female for ELA. In contrast to the total population where the largest proportion were non-Hispanic white, the largest proportion of those who failed each of the CRCTs were non-Hispanic black (60% of those who failed reading, 64% of those who failed math, and 55% of those who failed ELA). The maternal education level achieved at time of childbirth was lower among the population who failed the tests. Where 20% of the total population had mothers who finished college (16+ years of school), that level comprised 3% of those who failed reading, 3% of those who failed math, and 4% of those who failed ELA. Conversely, those with mothers with less than a high school education (up to 11 years of education) comprised 31% of the total population, 51% of those who failed reading, 50% of those who failed math, and 49% of those who failed ELA.

The descriptive statistics of the population across the main exposure is found in Table 2; Table 3 describes the main exposure, change in NDI. The average change in NDI between the two time points (index child's birth and the birth of a subsequent sibling) was -0.11, with a range from -4.71 to 4.76, indicating that, on average, the deprivation level of the students decreased as a result of a move. The proportion of the genders across all quintiles of change in NDI plus those who did not move was equal. The median inter-pregnancy interval was 21.17 months, with a minimum as defined in the data cleaning as 6.56 months and a maximum of 44.5 months (3 years and 8.5 months). This indicates that most students spent more time at the second residential location if they moved.

Table 4 contains the three baseline models examining the association between the failure of each of the three CRCTs, the change in NDI, and baseline NDI. Compared to the referent group (quintile 3, containing those with no net change in NDI and also those who did not experience a move), the odds of failing the reading CRCT if a child experienced the biggest increase in deprivation (quintile 5) increased by 1.46 (95% CI: 1.26, 1.69); for ELA it was 1.51 (95% CI: 1.34, 1.70), and for math it was 1.53

(95% CI: 1.34, 1.76). Compared to the referent group, the odds of failure for a child in the fourth quintile of change in NDI was 1.19 (95% CI: 1.03, 1.39) for reading, 1.27 (95% CI: 1.11, 1.44) for ELA, and 1.23 (95% CI: 1.07, 1.42) for math. For those whose level of deprivation was decreased after moving residences, the risk of failing in the second and first quintiles, respectively, compared to the referent were 1.10 (95% CI: 0.94, 1.28) and 0.99 (95% CI: 0.84, 1.14) for reading, 1.05 (95% CI: 0.93, 1.19) and 1.04 (95% CI: 0.91, 1.19) for ELA, and 1.08 (95% CI: 0.94, 1.24) and 1.00 (95% CI: 0.87, 1.14) for math.

Table 5 contains a series of models that build on baseline model 1 for the reading CRCT that adjust for various demographic variables and end up with the fully adjusted final model, number 8. To start, model 4 includes the baseline model and adjusts for gender, mother's marital status, maternal race/ethnicity, maternal education attainment, child's race/ethnicity, maternal age, preterm birth, and low birth weight. Adjusting for all these variables in Model 4 resulted in a non-significant p-value for the chunk test for the odds ratios. Adjusting for gender (Model 5) showed a decrease in the odds of failure by about 40% (OR: 0.59, 95% CI: 0.54, 0.65) for females compared to males. Adjusting for marital status alone (Model 6) and for maternal race and education (Model 7) resulted in non-significance in the GEE chunk test. The final adjusted model (Model 8) included change in NDI, baseline NDI, gender, marital status, maternal race, and an interaction term between change in NDI and marital status. In this model, controlling for the other factors, the risk odds of failure was highest among students whose change in NDI was in the fifth quintile compared to the referent quintile (no move/no net change in deprivation) (OR: 1.50, 95% CI: 1.15, 1.97). In this model, the odds of failure of the reading CRCT was 0.46 (95% CI: 0.37, 0.57) for those whose baseline deprivation was below average compared to those living in an area with average deprivation. The maternal race that predicted the highest risk of failing was among students whose mothers were Hispanic (OR: 2.34, 95% CI: 1.96, 2.80), compared to those with non-Hispanic white mothers. The odds of failing the reading CRCT were twice as high among students whose mothers were ever unmarried compared to those who were married at both time points (95% CI: 1.77, 2.35). These patterns were similar for predicting the risk of failure of the ELA and math CRCTs as well (Table 6: Models 9 and 10).

The multiplicative interaction between change in NDI and marital status is explored in Table 7. The p-value for the generalized estimating equation chunk test for the interaction term was 0.009, suggesting the significance of the interaction between these two changes in early childhood. The risk of failing any of the tests was higher among the students with mothers who were ever unmarried compared to always married and in the fifth quintile of NDI change (biggest increase in deprivation): 1.93 (95% CI: 1.59, 2.34) compared to 1.50 (95% CI: 1.15, 1.97) for reading; 2.20 (95% CI: 1.86, 2.61) compared to 1.45 (95% CI: (1.17, 1.82) for ELA; and 1.95 (95% CI: 1.64, 2.33) compared to 1.64 (95% CI: 1.29, 2.08) for math.

Discussion

The results of this analysis suggest that, compared to no change in neighborhood deprivation (by either not moving or not changing deprivation level after a move), an increase in neighborhood deprivation as a result of a residential move in early childhood increases the odds of failing any of the three CRCTs taken in first grade in Georgia when controlling for baseline NDI, gender, marital status, and maternal race. In those final models, marital status is also a strong predictor of failure of any of the CRCTs, with the risk of failure doubling for students with mothers who were ever unmarried compared to those who were married at both time points, controlling for change in NDI, baseline NDI, gender, and maternal race. Additionally, the results also suggest that there is a multiplicative effect between change in NDI and marital status when predicting the failure of any of the CRCTs.

The increased odds of failure of any of the CRCTs for students with change in NDI in quintiles 2, 4, and 5 (compared to the combined group of those with no net change in NDI and those who did not move) have varying meanings. Students whose change in NDI put them in quintile 2 saw a moderate decrease in their neighborhood deprivation but an increase in their odds of failing, which would point to the disruptive force of moving and possibly to a decrease in social capital (change in friendships and support) for both the child and parents (17, 32). Those with a change in NDI in quintile 4 (moderate increase in deprivation) would have that same disruption from moving and decrease in social capital with the added effect of moving to a worse neighborhood; however, only for the ELA CRCT was the fourth quintile odds higher than that of the second quintile – it was lower for reading and about equal for math. Across all three

CRCTs, those students who experienced the largest increase in deprivation (quintile 5) had the highest odds of failing compared to the other quintiles, indicating that the move, loss of social capital, and high deprivation have a cumulative negative effect on cognitive development. Higher deprivation can also mean fewer resources given to schools through the mechanisms in place relating to local property taxes or less supportive parents (47).

Baseline deprivation level was included in the models since it informs the change in deprivation as mediated by the move in residence. Controlling for other factors, including the change in deprivation, having lived in an area with below-average deprivation at birth reduced the risk of failure by more than half for all three CRCT subject areas. This is consistent with other studies looking at deprivation from the single time point of birth, with those from more affluent areas having a lower risk of failure (62). This also confirms prior research showing that neighborhood level socioeconomic inequality had a stronger effect than other influences closer to the individual in the social-ecological model, like individual socioeconomic status (1).

As a measure of household stability, the variable representing the student's mother's marital status was also significant in the model. Compared to students whose mothers were married at both their birth and that of their younger sibling, students whose mothers were ever unmarried at either time point had a two-fold increase in risk of failure. This is similar to a study that showed having a single parent increased the risk of repeating a grade by a factor of two (63). For those students whose household experienced a divorce, this result is also consistent with studies that have shown that the dissolution of a family and increased instability have negative effects on children's academic performance and increase emotional distress (64). Previous studies have indicated that growing up with married biological parents results in better outcomes for children across many domains – including cognitive and emotional development – compared to children who grow up with a single parent or parents that divorce (65). Patterns of coupling and marriage vary by race, with white adults reporting the highest percentage of being married compared to black or Hispanic, and black adults reporting the highest percentage of never being married compared to white or Hispanic adults (66). Additionally, black children experience their parents separating (divorce or break up) at a higher frequency than white or Hispanic children (67).

The interaction between change in deprivation and marital status behaved as would be expected based on the individual effects of each exposure. Those who moved to more deprived areas with a mother who was married at both time points had, minimally, 20% less risk than those who moved with a mother who was unmarried at either time point.

Having an ever-unmarried mother increased the risk of CRCT failure among those who made residential moves to less deprived areas as well, indicating that the instability of single parenthood or disruption of divorce was enough of a destabilizing factor to nearly double the risk of failure. This may also be the effect of moving at all, since even a move to a better place can still be disruptive socially and with regard to familiar surroundings. The risk was greatest for the ELA portion of the CRCT, which also had the highest percentage of failure among this population overall. Among those with ever-unmarried mothers, the risk among those who moved to the fifth quintile level of deprivation had a slightly smaller risk than those whose move resulted in a change placing them in the fourth quintile, which could indicate that the marital status was the more important factor of the two. Since moves are associated with single parenthood and sometimes caused by divorce, the level of deprivation is unimportant.

Female gender and maternal race appear to have the most significant effect on the odds of failing any of the CRCTs among all of the covariates analyzed for this project. Being female decreased the risk of failure by 19% for the math CRCT (95% CI: 0.75, 0.88) and by nearly half (reading: 0.57, ELA: 0.59) for the other two models that controlled for gender. This is consistent with research done by Leventhal and Brooks-Gunn that showed that girls did better than boys in subjects other than math, with the bigger difference between gender occurring in the reading and ELA CRCTs (24).

Students whose mothers were either Hispanic or non-Hispanic black had higher odds of failure compared to students with non-Hispanic white mothers on all three tests, which is consistent with previous studies examining overall testing performance (36). However, for subject-specific testing, the higher odds of failure on the math CRCT for students with Hispanic mothers is inconsistent with other research showing that, when compared to non-Hispanic white students, Hispanic students have a smaller gap than non-Hispanic black students for math and a larger gap than non-Hispanic black students for reading (68). This result could be due in part to students with Hispanic mothers only comprising 6.9% of the study population, which could exaggerate the effect of that group. Also, if Hispanic race is at all a proxy for a language barrier, that could also produce this result since the first grade CRCT questions are read aloud to students by the teacher, and that language barrier could carry across all three tests rather than being lifted when math is done on paper.

In the absence of a standardized measure of socioeconomic status, educational attainment has been used in previous studies as the proxy for socioeconomic status (9, 37). Therefore, it was somewhat surprising that maternal education was not a significant confounder for change in NDI in the final model. This suggests that the neighborhood effect of deprivation is not affected by individual lack of resources, as proxied by maternal education attainment. In Model 4 (Table 5), maternal education appears to have a linear relationship with risk of failure, with children of mothers with the least amount of education having the highest odds of failure, but the variable was non-significant upon further analysis using the GEE chunk test.

The implications of this analysis are that knowing a child's history up until the start of schooling is important when attempting to allocate resources to help out the students most likely to struggle. A history of moving, of single parenthood or divorce, and of moving to a worse neighborhood, are all important factors that predict the risk of test failure, this study's proxy for cognitive development.

Strengths and Limitations

This analysis adds to the body of research that investigates the impacts of neighborhood deprivation, residential mobility, and marital status on early childhood academic achievement and cognitive development.

In addition to adding to the body of work examining the risk factors for early academic achievement and cognitive development, this study has many strengths. The sample is large and population based, following a birth cohort (born from 1999 through 2001) through first grade. Recall bias is reduced since the data are from administrative records rather than a survey of the participants.

Several limitations of this analysis exist, starting with the data. Since only 53% of the initial births were linked with school records, a large portion of the population born in Georgia from 1998 to 2003 are missing from the analysis. This could happen for a number of reasons. First, a child could move out of the state before entering first grade and for that reason would not be captured. Also, only public schools are required to administer CRCTs, so those outside the public school system would be missed. Also missing would be children who died before reaching first grade testing. Finally, if the linking failed to match a birth record with its corresponding school record, then those students are missing.

Since data on the actual number of times a student moved between birth and first grade was not collected, the comparison of the address at birth of an index child was compared to the birth address of a sibling to capture one move before a child entered first grade. This required that the siblings each had a valid maternal longitudinal ID and that they matched. Observations for students who had no sibling in the data set were excluded, thus removing only children from the study. Observations would also have been excluded for students whose siblings were not born until after taking the CRCT, but none were discovered in the data cleaning and linking stage.

Being able to link index children and second children to a mother based on longitudinal maternal ID also had many of the same issues regarding being born in Georgia. This analysis only captured families where siblings shared a mother and took the CRCT between the years 2004 and 2009. Children in the same household but not sharing the same mother would not be matched on maternal ID in this analysis. This analysis would also miss any pair of children not born to a single woman, which includes, but is not limited to, adoptions, children being raised by extended family, and some families with gay or lesbian parents.

Given that only data on a single move can be gleaned from two birth records, hypermobility and its impact on these children's lives cannot be assessed. Similarly, the variable of marital status is also crude. A mother could have had the same status at each time point, but we do not know the extent of what happened in the intervening years. Both a marriage and divorce (or divorce and marriage) could have occurred, but it would appear that the status remained unchanged due to the limited measure. Per how this variable was defined, this would falsely inflate the number of students in the category of having mothers who were always married.

Since students who fail the CRCT are given an opportunity to retest, it is unclear which set of results are included in this dataset. There could have been a higher number of failures that are masked by passing retesting.

Finally, the scores from the CRCT are not a true measure of cognitive development. As a standardized test, the CRCT is designed to not just evaluate the children but to also evaluate the performance of the school. In light of that, the cheating scandal that occurred in the Atlanta Public Schools in Fulton County is an important perspective to discuss. Due to the funding that is linked to the results of standardized testing, many jurisdictions feel the pressure to improve their scores. Educators from 30 schools in the county confessed to cheating, and investigators discovered that it occurred in 78.6% of elementary and middle schools that they looked into in 2009. As reported in the special investigation ordered by Georgia Governor Nathan Deal, teachers cited unrealistic testing targets and unreasonable pressure placed on teachers and principals to meet those targets, and intimidation and retaliation for unmet targets (46). The scandal reached the whole way to the school superintendent and 178 educators were believed to have been involved.

Further Directions

This exploratory analysis supports the importance of this kind of ecological study and the factors that contribute to initiating an optimal life trajectory. What this subject needs is a prospective population-based longitudinal study to fully collect all relevant data missing from either school administrative records or birth records, including total number of moves and stability of parental units. The results of this analysis suggest that moving, and a move to a more-deprived area, as well as an unstable family structure all increase the risk for impeding cognitive development in young children. Information like this has strong policy implications for early intervention programs like Head Start, as well as any that support single parents and provide social support for children.

In conclusion, there is evidence of an effect of change in neighborhood deprivation and marital status on the potential for failure of all three portions of Georgia's CRCT.

References

1. Sastry N, Pebley AR. Family and Neighborhood Sources of Socioeconomic Inequality in Children's Achievement. *Demography* 2010;47(3):777-800.
2. Belfield CR, Kelly IR. Early education and health outcomes of a 2001 U.S. birth cohort. *Economics and human biology* 2013;11(3):310-25.
3. D'Onise K, McDermott RA, Lynch JW. Does attendance at preschool affect adult health? A systematic review. *Public health* 2010;124(9):500-11.
4. Ackerman BP, Brown ED. Income poverty, poverty co-factors, and the adjustment of children in elementary school. In: Robert VK, ed. *Advances in Child Development and Behavior*: JAI, 2006:91-129.
5. Burger K. How does early childhood care and education affect cognitive development? An international review of the effects of early interventions for children from different social backgrounds. *Early Childhood Research Quarterly* 2009;25.
6. Lloyd JEV, Li L, Hertzman C. Early experiences matter: Lasting effect of concentrated disadvantage on children's language and cognitive outcomes. *Health & place* 2010;16(2):371-80.
7. Duncan GJ, Brooks-Gunn J, Klebanov PK. Economic deprivation and early childhood development. *Child development* 1994;65(2 Spec No):296-318.
8. Carpiano RM, Lloyd JEV, Hertzman C. Concentrated affluence, concentrated disadvantage, and children's readiness for school: A population-based, multi-level investigation. *Social Science & Medicine* 2009;69(3):420-32.
9. High PC. School readiness. *Pediatrics* 2008;121(4):e1008-15.

10. Sampson R, Morenoff J, Gannon-Rowley T. Assessing "Neighborhood Effects": Social Processes and New Directions in Research. *Annual Review of Sociology* 2002;28:37.

11. Diez Roux AV, Mair C. Neighborhoods and health. *Annals of the New York Academy of Sciences* 2010;1186:125-45.

12. Mair C, Diez Roux AV, Galea S. Are neighbourhood characteristics associated with depressive symptoms? A review of evidence. *Journal of epidemiology and community health* 2008;62(11):7.

13. DeWitt DJ. FREQUENT CHILDHOOD GEOGRAPHIC RELOCATION: ITS IMPACT ON DRUG USE INITIATION AND THE DEVELOPMENT OF ALCOHOL AND OTHER DRUG-RELATED PROBLEMS AMONG ADOLESCENTS AND YOUNG ADULTS. *Addictive Behaviors* 1998;23(5):14.

14. Adam EK. Beyond Quality: Parental and Residential Stability and Children's Adjustment. *American Psychological Society* 2004;13(5):5.

15. South SJ, Crowder KD, Trent K. Children's residential mobility and neighborhood environment following parental divorce and remarriage. *Soc Forces* 1998;77(2):667-93.

16. Geist C, McManus PA. Geographical mobility over the life course: Motivations and implications. *Popul Space Place* 2008;14(4):283-303.

17. Pribesh S, Downey DB. Why are residential and school moves associated with poor school performance? *Demography* 1999;36(4):521-34.

18. Briggs XdS. *The Geography of Opportunity: Race and Housing Choice in Metropolitan America*. Washington, D.C.: The Brookings Institution; 2005.

19. Madden JF. Changing Racial and Poverty Segregation in Large US Metropolitan Areas, 1970-2009. *Int Reg Sci Rev* 2014;37(1):9-35.

20. Census. USBot. 2010 Geographic Terms and Concepts - Census Tract - Geography - U.S. 2012. (http://www.census.gov/geo/reference/gtc/gtc_ct.html). (Accessed 3/7/2014).

21. Massey DS, White MJ, Phua VC. The dimensions of segregation revisited. *Sociol Method Res* 1996;25(2):172-206.

22. Leventhal T, Brooks-Gunn J. The neighborhoods they live in: the effects of neighborhood residence on child and adolescent outcomes. *Psychological bulletin* 2000;126(2):309-37.

23. Schoon I, Jones E, Cheng H, et al. Family hardship, family instability, and cognitive development. *Journal of epidemiology and community health* 2012;66(8):716-22.

24. Leventhal T, Brooks-Gunn J. A randomized study of neighborhood effects on low-income children's educational outcomes. *Developmental psychology* 2004;40(4):488-507.

25. Elder GH. The Life Course as Developmental Theory. *Child development* 1998;69(1):1-12.

26. Bronfenbrenner U, Morris P. The Bioecological Model of Human Development. In: Damon W, Lerner RM, eds. *Handbook of child psychology*. Hoboken, N.J.: John Wiley & Sons, 2006:35.

27. Vartanian T, Buck P. Childhood and Adolescent Neighborhood Effects on Adult Income: Using Siblings to Examine Differences in Ordinary Least Squares and Fixed-Effect Models. *Social Science Review* 2005;79:34.

28. Farah MJ, Shera DM, Savage JH, et al. Childhood poverty: specific associations with neurocognitive development. *Brain research* 2006;1110(1):166-74.

29. Noble KG, McCandliss BD, Farah MJ. Socioeconomic gradients predict individual differences in neurocognitive abilities. *Developmental science* 2007;10(4):464-80.

30. Cutler DM, Lleras-Muney A. Understanding differences in health behaviors by education. *Journal of health economics* 2010;29(1):1-28.

31. Bures RM. Childhood residential stability and health at midlife. *American journal of public health* 2003;93(7):1144-8.

32. Anderson S, Leventhal T, Dupere V. Residential mobility and the family context: A developmental approach. *Journal of Applied Developmental Psychology* 2014;35(2):70-8.

33. Rumbold AR, Giles LC, Whitrow MJ, et al. The effects of house moves during early childhood on child mental health at age 9 years. *BioMed Central* 2012;12:11.

34. Cavanagh SE, Huston AC. Family instability and children's early problem behavior. *Soc Forces* 2006;85(1):551-81.

35. Tunstall H, Cabieses B, Shaw R. The characteristics of mobile families with young children in England and the impact of their moves on neighbourhood inequalities in maternal and child health. *Health & place* 2012;18(3):657-70.

36. Steele-Johnson D, Leas K. Importance of race, gender, and personality in predicting academic performance. *Journal of Applied Social Psychology* 2013;43(8):1736-44.

37. Yen IH, Syme SL. The social environment and health: a discussion of the epidemiologic literature. *Annual review of public health* 1999;20:287-308.

38. Messer LC, Laraia BA, Kaufman JS, et al. The development of a standardized neighborhood deprivation index. *Journal of urban health : bulletin of the New York Academy of Medicine* 2006;83(6):1041-62.

39. Oakes JMK, J. *Methods in Social Epidemiology*. San Francisco, CA: Jossey-Bass; 2006.

40. Major JM, Cross AJ, Doubeni CA, et al. Socioeconomic deprivation impact on meat intake and mortality: NIH-AARP Diet and Health Study. *Cancer causes & control : CCC* 2011;22(12):1699-707.

41. Gustafson AA, Lewis S, Wilson C, et al. Validation of food store environment secondary data source and the role of neighborhood deprivation in Appalachia, Kentucky. *BMC public health* 2012;12:688.

42. Kersten E, Laraia B, Kelly M, et al. Small food stores and availability of nutritious foods: a comparison of database and in-store measures, Northern California, 2009. *Preventing chronic disease* 2012;9:E127.

43. McLeod R. Criterion-Referenced Competency Tests (CRCT). Atlanta, GA; 2014. (http://www.gadoe.org/Curriculum-Instruction-and-Assessment/Assessment/Pages/CRCT.aspx). (Accessed 1/15/2014 2014).

44. Barge JD. Georgia’s Criterion-Referenced Competency Tests (CRCTs): Questions and Answers for Parents of Georgia Students in Grades 3–8. In: Education GDo, ed. Atlanta, GA, 2013.

45. Georgia School Council Institute. The Basics of Georgia School Finance. Georgia School Council Institute, 2007.

46. Office of the Governor. Atlanta Public Schools Special Investigation. Atlanta, GA, 2011.

47. Lee VE, Burkam DT. *Inequality at the Starting Gate: Social Background Differences in Achievement as Children Begin School (Executive Summary)*. Washington, D.C.: Economic Policy Institute; 2002.

48. Berube A. All Cities Are Not Created Unequal. Washington, D.C.: The Brookings Institution, 2014.

49. Hassel B, Doyle D, Locke G. Smarter Funding, Better Outcomes: Georgia's Roadmap for K-12 Finance Reform. Chapel Hill, NC

Atlanta, GA: Public Impact

Georgia Chamber of Congress, 2012.

50. Barge JD. 2013 CRCT Score Interpretation Guide Grades 3 through 8. In: Education GDo, ed, 2013:76.

51. Haladyna TM, Nolen SB, Haas NS. Raising Standardized Achievement Test Scores and the Origins of Test Score Pollution. *Educational Researcher* 1991;20(5):2-7.

52. Cox K. CRCT Content Descriptions based on the Georgia Performance Standards: Mathematics Grades 1 - 8. In: Education GDo, ed. Atlanta, GA, 2007.

53. Cox K. CRCT Content Descriptions based on the Georgia Performance Standards: English/Language Arts Grades 1 - 8. In: Education GDo, ed. Atlanta, GA, 2005.

54. Cox K. CRCT Content Descriptions based on the Georgia Performance Standards: Reading Grades 1 - 8. In: Education GDo, ed. Atlanta, GA, 2007.

55. Georgia Department of Education. Fact Sheet: Understanding State and Local Testing. In: Education GDo, ed. Atlanta, GA, 2011.

56. United States Bureau of the Census. *Geographic areas reference manual*. Washington, D.C.: U.S. Dept. of Commerce, Economics and Statistics Administration, Bureau of the Census; 1994.

57. SAS Institute I. SAS 9.3. Cary, NC: SAS Institute, Inc., 2011.

58. Smith T, Smith, B. PROC GENMOD with GEE to Analyze Correlated Outcomes Data Using SAS. 2006.

59. Hanley JA, Negassa A, Edwardes MDD, et al. Statistical analysis of correlated data using generalized estimating equations: An orientation. *American journal of epidemiology* 2003;157(4):364-75.

60. Kleinbaum DG, Klein M. *Logistic Regression: A Self-Learning Text*. Third Edition ed. New York, NY: Springer; 2010.

61. Jackson E, Glasier A. Return of ovulation and menses in postpartum nonlactating women: a systematic review. *Obstetrics and gynecology* 2011;117(3):657-62.

62. Dupere V, Leventhal T, Crosnoe R, et al. Understanding the positive role of neighborhood socioeconomic advantage in achievement: the contribution of the

home, child care, and school environments. *Developmental psychology* 2010;46(5):1227-44.

63. Kim HJ. Family resources and children's academic performance. *Children and Youth Services Review* 2004;26(6):529-36.

64. Hampden-Thompson G. Family policy, family structure, and children's educational achievement. *Soc Sci Res* 2013;42(3):804-17.

65. Lopoo LM, DeLeire T. Family structure and the economic wellbeing of children in youth and adulthood. *Soc Sci Res* 2014;43:30-44.

66. U.S. Census Bureau. America's Families and Living Arrangements: Table 56. Marital Status of the Population by Sex, Race, and Hispanic Origin: 1990 to 2010. *Current Population Reports*. Washington, D.C., 2012.

67. Smock PJ, Greenland FR. Diversity in Pathways to Parenthood: Patterns, Implications, and Emerging Research Directions. *J Marriage Fam* 2010;72(3):576-93.

68. Bali VA, Alvarez RM. Schools and educational outcomes: What causes the "race gap" in student test scores? *Soc Sci Quart* 2003;84(3):485-507.

Tables

Table 1. Descriptive statistics of the first grade students in Georgia overall and among those who failed the reading, math, and ELA CRCTs

	All		Failed Reading			Failed Math			Failed ELA		
	N=19,805		n=2,332			n=2,991			n=3,815		
	n	**%**	**n**	**%**	**p-value**	**n**	**%**	**p-value**	**n**	**%**	**p-value**
Deprivation at birth					<.0001			<.0001			<.0001
Below average	3,267	16.50	130	5.57		158	5.28		257	6.74	
Average	13,530	68.32	1,637	70.20		2,087	69.78		2,708	70.98	
Above average	3,008	15.19	565	24.23		746	24.94		850	22.28	
Moved	9,237	46.64	1,212	51.97	<.0001	1,578	52.76	<.0001	1,992	52.21	<.0001
Gender					<.0001			<.0001			<.0001
Female	9,569	48.32	870	37.31		1,338	44.73		1,481	38.82	
Male	10,236	51.68	1,462	62.69		1,653	55.27		2,334	61.18	
Child's birth year					0.0106			<.0001			0.0165
1999	12,227	61.74	1,489	63.85		1,661	55.53		2,432	63.75	
2000	6,456	32.60	698	29.93		1,132	37.85		1,174	30.77	
2001	1,122	5.67	145	6.22		198	6.62		209	5.48	
Child's age at testing					<.0001*			<.0001*			<.0001*
5	5	0.03	0	0.00		1	0.03		0	0.00	
6	6,451	32.57	893	38.29		985	32.93		1,384	36.28	
7	12,648	63.86	1,271	54.50		1,773	59.28		2,160	56.62	
8	696	3.51	167	7.16		229	7.66		268	7.02	
9	5	0.03	1	0.04		3	0.10		3	0.08	
Child's race/ethnicity					<.0001			<.0001			<.0001
Hispanic	1,641	8.29	282	12.09		318	10.63		505	13.24	
Non-Hispanic black	7,858	39.68	1,395	59.82		1,903	63.62		2,114	55.41	

Non-Hispanic white	9,700	48.98	594	25.47		706	23.60		1,105	28.96	
Other	606	3.06	61	2.62		64	2.14		91	2.39	
Gestational age					0.0004			<.0001			<.0001
< 37 weeks	2,050	10.35	290	12.44		409	13.67		508	13.32	
≥ 37 weeks	17,755	89.65	2,042	87.56		2,582	86.33		3,307	86.68	
Birth weight					<.0001		0.00	<.0001		0.00	<.0001
≤ 2,500 grams	1,394	7.04	241	10.33		340	11.37		384	10.07	
> 2,500 grams	18,411	92.96	2,091	89.67		2,651	88.63		3,431	89.93	
Maternal age (Mean=24.19, SD=5.52)					<.0001			<.0001			<.0001
Under 15 years	82	0.41	17	0.73		19	0.64		20	0.52	
15-19 years	4,638	23.42	789	33.83		1,006	33.63		1,250	32.77	
20-24 years	6,486	32.75	899	38.55		1,202	40.19		1,499	39.29	
25-29 years	4,849	24.48	391	16.77		495	16.55		652	17.09	
30-34 years	2,875	14.52	184	7.89		215	7.19		307	8.05	
35-39 years	810	4.09	48	2.06		51	1.71		82	2.15	
40-44 years	65	0.33	4	0.17		3	0.10		5	0.13	
Maternal race/ethnicity					<.0001			<.0001			<.0001
Hispanic	1,365	6.89	237	10.16		270	9.03		427	11.19	
Non-Hispanic black	7,889	39.83	1,394	59.78		1,896	63.39		2,108	55.26	
Non-Hispanic white	10,551	53.27	701	30.06		825	27.58		1,280	33.55	
Maternal marital status					<.0001			<.0001			<.0001
Always married	11,549	58.31	817	35.03		1,006	33.63		1,442	37.80	
Ever unmarried	8,256	41.69	1,515	64.97		1,985	66.37		2,373	62.20	
Maternal education					<.0001			<.0001			<.0001
Less than high school	6,206	31.34	1,184	50.77		1,505	50.32		1,884	49.38	
High school	6,391	32.27	872	37.39		1,116	37.31		1,406	36.85	
1-3 years of college	3,336	16.84	199	8.53		281	9.39		374	9.80	
Finished college	3,872	19.55	77	3.30		89	2.98		151	3.96	

Chi-square p-values for all tests except *= Fisher's exact test; CRCT=Criterion-Referenced Competency Test; ELA=English Language Arts

Table 2. Descriptive statistics for those students whose census tract did not change between their birth and that of the next younger sibling and across the quintiles of change in NDI

	Non-movers (same census tract at birth and second time point)		**1st Quintile** Greatest decrease in deprivation		**2nd Quintile** Moderate decrease in deprivation		**3rd Quintile** No net change in deprivation		**4th Quintile** Moderate increase in deprivation		**5th Quintile** Greatest increase in deprivation		
	n=10,568		n=1,848		n=1,848		n=1,848		n=1,848		n=1,848		
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**p-value**
Deprivation at birth													<.0001
Below average	2,182	20.65	0	0.00	70	3.79	320	17.32	354	19.16	341	18.45	
Average	6,959	65.85	896	48.48	1,511	81.76	1,408	76.19	1,377	74.51	1,379	74.62	
Above average	1,427	13.50	952	51.52	267	14.45	118	6.39	116	6.28	128	6.93	
Gender													0.8013
Female	5,103	48.29	878	47.51	881	47.67	898	48.59	898	48.59	911	49.30	
Male	5,465	51.71	970	52.49	967	52.33	948	51.30	949	51.35	937	50.70	
Child's birth year													0.7745
1999	6,255	59.19	1,164	62.99	1,209	65.42	1,194	64.61	1,217	65.85	1,188	64.29	
2000	3,667	34.70	588	31.82	549	29.71	556	30.09	532	28.79	564	30.52	
2001	646	6.11	96	5.19	90	4.87	96	5.19	98	5.30	96	5.19	
Child's age at testing													0.9999*
5	3	0.03	2	0.11	0	0.00	0	0.00	0	0.00	0	0.00	
6	3,414	32.31	608	32.90	596	32.25	609	32.95	600	32.47	624	33.77	
7	6,834	64.67	1,167	63.15	1,174	63.53	1,162	62.88	1,166	63.10	1,145	61.96	
8	315	2.98	70	3.79	78	4.22	74	4.00	81	4.38	78	4.22	
9	2	0.02	1	0.05	0	0.00	1	0.05	0	0.00	1	0.05	
Child's race/ethnicity													<.0001
Hispanic	808	7.65	165	8.93	145	7.85	163	8.82	174	9.42	186	10.06	

NH black	3,751	35.49	1,088	58.87	725	39.23	577	31.22	677	36.63	1,040	56.28	
NH white	5,713	54.06	539	29.17	900	48.70	1,048	56.71	952	51.52	548	29.65	
Other	296	2.80	56	3.03	78	4.22	58	3.14	44	2.38	74	4.00	
Gestational age													0.1126
< 37 weeks (preterm)	1,038	9.82	219	11.85	207	11.20	172	9.31	200	10.82	214	11.58	
≥ 37 weeks (term)	9,530	90.18	1,629	88.15	1,641	88.80	1,674	90.58	1,647	89.12	1,634	88.42	
Birth weight													0.1885
≤ 2,500 grams	664	6.28	159	8.60	153	8.28	122	6.60	144	7.79	152	8.23	
> 2,500 grams	9,904	93.72	1,689	91.40	1,695	91.72	1,724	93.29	1,703	92.15	1,696	91.77	
Maternal age (Mean=24.19, SD=5.52)													<.0001
Under 15 years	47	0.44	9	0.49	8	0.43	5	0.27	3	0.16	10	0.54	
15-19 years	2,040	19.30	538	29.11	477	25.81	466	25.22	482	26.08	635	34.36	
20-24 years	3,035	28.72	712	38.53	671	36.31	629	34.04	705	38.15	734	39.72	
25-29 years	2,873	27.19	392	21.21	438	23.70	430	23.27	404	21.86	312	16.88	
30-34 years	1,954	18.49	156	8.44	205	11.09	252	13.64	197	10.66	111	6.01	
35-39 years	568	5.37	39	2.11	46	2.49	59	3.19	52	2.81	46	2.49	
40-44 years	51	0.48	2	0.11	3	0.16	5	0.27	4	0.22	0	0.00	
Maternal race/ethnicity													<.0001
Hispanic	690	6.53	142	7.68	109	5.90	132	7.14	142	7.68	150	8.12	
NH black	3,769	35.66	1,094	59.20	728	39.39	575	31.11	673	36.42	1,050	56.82	
NH white	6,109	57.81	612	33.12	1,011	54.71	1,139	61.63	1,032	55.84	648	35.06	
Maternal marital status													<.0001
Always married	6,910	65.39	759	41.07	1,035	56.01	1,126	60.93	1,026	55.52	693	37.50	
Ever unmarried	3,658	34.61	1,089	58.93	813	43.99	720	38.96	821	44.43	1,155	62.50	
Maternal education													<.0001
Less than high school	2,774	26.25	756	40.91	642	34.74	584	31.60	648	35.06	802	43.40	

High school	3,247	30.72	644	34.85	601	32.52	602	32.58	628	33.98	669	36.20
1-3 years of college	1,885	17.84	260	14.07	320	17.32	318	17.21	299	16.18	254	13.74
Finished college	2,662	25.19	188	10.17	285	15.42	342	18.51	272	14.72	123	6.66

*Fisher's exact test; NDI=neighborhood deprivation index; NH=Non-Hispanic; SD=standard deviation

The quintiles describe how the NDI changed over a move in residences between birth of the index child (baseline) and the second indicator child; NDI is measured at the census tract level. A negative number indicates that the deprivation at the second time point (second child's birth) is lower than at baseline; the move was to a less deprived area. A positive number indicates that the deprivation increased between the child's birth and the second time point; the move was from a less deprived area to a more deprived area. Thus, those in the first quintile comprise those who had the greatest decrease in deprivation and the fifth quintile comprises those who had the greatest increase in deprivation; the third quintile straddles the mean, representing move in residences with essentially no net change in deprivation.

Table 3. Distribution of change in NDI at the census tract level between a student's birth and that of a subsequent sibling in the linked cohort

Mean	-0.1065
Standard Deviation	0.9811
Minimum	-4.7076
Maximum	4.7629
Quintile cut points	
1	-0.7802
2	-0.2811
3	0.0784
4	0.5581
5	4.7629

NDI = Neighborhood Deprivation Index

The quintiles describe how the NDI changed over a move in residences between birth of the index child (baseline) and the second indicator child. A negative number indicates that the deprivation at the second time point (second child's birth) is lower than at baseline; the move was to a less deprived area. A positive number indicates that the deprivation increased between the child's birth and the second time point; the move was from a less deprived area to a more deprived area. Thus, those in the first quintile comprise those who had the greatest decrease in deprivation and the fifth quintile comprises those who had the greatest increase in deprivation; the third quintile straddles the mean, representing move in residences with essentially no net change in deprivation.

Table 4. Baseline logistic models of the failure of the reading, math, and ELA CRCTs controlling for change in NDI and baseline NDI

	Reading / Model 1			**ELA / Model 2**			**Math / Model 3**		
Variables	**Odds ratio**	**CI**	**p-value**	**Odds ratio**	**CI**	**p-value**	**Odds ratio**	**CI**	**p-value**
Change in NDI									
1 (greatest decrease)	0.99	(0.85, 1.14)	0.8461	1.04	(0.91, 1.19)	0.5838	1.00	(0.87, 1.14)	0.9536
2 (moderate decrease)	1.10	(0.94, 1.28)	0.2267	1.05	(0.93, 1.19)	0.4160	1.08	(0.94, 1.24)	0.2515
3 (referent, no net change)	1	-	-	1	-	-	1	-	-
4 (moderate increase)	1.19	(1.03, 1.39)	0.0224	1.27	(1.11, 1.44)	0.0003	1.23	(1.07, 1.42)	0.0033
5 (greatest increase)	1.46	(1.26, 1.69)	<.0001	1.51	(1.34, 1.71)	<.0001	1.53	(1.34, 1.76)	<.0001
Baseline deprivation									
Below average	0.30	(0.25, 0.37)	<.0001	0.34	(0.29, 0.40)	<.0001	0.28	(0.23, 0.33)	<.0001
Average (referent)	1	-	-	1	-	-	1	-	-
Above average	1.75	(1.54, 2.00)	<.0001	1.63	(1.44, 1.85)	<.0001	1.89	(1.66, 2.16)	<.0001

CI=confidence interval; CRCT=Criterion-Referenced Competency Tests; ELA=English language arts; NDI=neighborhood deprivation index

The quintiles describe how the NDI changed over a move in residences between birth of the index child (baseline) and the second indicator child; NDI is measured at the census tract level. A negative number indicates that the deprivation at the second time point (second child's birth) is lower than at baseline; the move was to a less deprived area. A positive number indicates that the deprivation increased between the child's birth and the second time point; the move was from a less deprived area to a more deprived area. Thus, those in the first quintile comprise those who had the greatest decrease in deprivation and the fifth quintile comprises those who had the greatest increase in deprivation; the third quintile straddles the mean, representing move in residences with essentially no net change in deprivation.

Table 5. Modeling evolution for CRCT Reading scores

	Model 4*			Model 5			Model 6*		
	OR	**CI**	**p-value**	**OR**	**CI**	**p-value**	**OR**	**CI**	**p-value**
Change in NDI									
1 (greatest decrease)	0.97	(0.84, 1.13)	0.7052	0.98	(0.85, 1.14)	0.7996	0.98	(0.84, 1.14)	0.7924
2 (moderate decrease)	1.08	(0.93, 1.26)	0.3296	1.09	(0.94, 1.27)	0.2475	1.07	(0.92, 1.25)	0.3749
3 (no net change, ref)	1	-	-	1	-	-	1	-	-
4 (moderate increase)	1.00	(0.85, 1.17)	0.9726	1.20	(1.03, 1.40)	0.0198	1.08	(0.92, 1.26)	0.3472
5 (greatest increase)	0.95	(0.82, 1.10)	0.5086	1.47	(1.27, 1.70)	<.0001	1.15	(0.99, 1.33)	0.0626
Baseline deprivation									
Below average	0.74	(0.60, 0.92)	0.0068	0.30	(0.24, 0.37)	<.0001	0.41	(0.33, 0.51)	<.0001
Average (referent)	1	-	-	1	-	-	1	-	-
Above average	0.98	(0.85, 1.12)	0.7272	1.76	(1.55, 2.01)	<.0001	1.25	(1.10, 1.43)	0.001
Female (male = referent)	0.56	(0.51, 0.62)	<.0001	0.59	(0.54, 0.65)	<.0001			
Ever unmarried (always married=referent)	1.27	(1.11, 1.45)	0.0003				2.38	(2.15, 2.65)	<.0001
Maternal race/ethnicity									
Hispanic	1.11	(0.79, 1.56)	0.5340						
Non-Hispanic black	1.29	(0.91, 1.82)	0.1564						
Non-Hispanic white (referent)	1	-	-						
Maternal education									
Less than high school	1.38	(1.24, 1.54)	<.0001						
High school (referent)	1	-	-						
1-3 years of college	0.46	(0.39, 0.54)	<.0001						
Finished college	0.19	(0.15, 0.24)	<.0001						
Child's race/ethnicity									
Hispanic	1.66	(1.20, 2.30)	0.0024						
Non-Hispanic black	1.57	(1.09, 2.27)	0.0154						

Non-Hispanic white (referent)	1	-	-
Other	1.12	(0.84, 1.49)	0.4559
Maternal age			
Under 15 years	0.87	(0.49, 1.56)	0.6420
15-19 years	0.90	(0.80, 1.01)	0.0684
20-24 years	1	-	-
25-29 years	1.02	(0.89, 1.17)	0.7780
30-34 years	1.09	(0.91, 1.32)	0.3422
35-39 years	0.94	(0.68, 1.29)	0.6892
40-44 years	1.01	(0.36, 2.83)	0.9799
Preterm birth	0.95	(0.82, 1.11)	0.5172
Low birth weight	1.39	(1.18, 1.65)	0.0001

*non-significant GEE chi-square p-value for terms

CI=confidence interval; NH=Non-Hispanic; NDI=neighborhood deprivation index; OR=odds ratio

The quintiles describe how the NDI changed over a move in residences between birth of the index child (baseline) and the second indicator child; NDI is measured at the census tract level. A negative number indicates that the deprivation at the second time point (second child's birth) is lower than at baseline; the move was to a less deprived area. A positive number indicates that the deprivation increased between the child's birth and the second time point; the move was from a less deprived area to a more deprived area. Thus, those in the first quintile comprise those who had the greatest decrease in deprivation and the fifth quintile comprises those who had the greatest increase in deprivation; the third quintile straddles the mean, representing move in residences with essentially no net change in deprivation.

Table 5. Modeling evolution for CRCT Reading scores, continued						
	Model 7*			Model 8 - Final		
	OR	**CI**	**p-value**	**OR**	**CI**	**p-value**
Change in NDI						
1 (greatest decrease)	0.98	(0.84, 1.14)	0.7765	0.83	(0.61, 1.13)	0.2467
2 (moderate decrease)	1.09	(0.93, 1.27)	0.2740	1.29	(1.03, 1.63)	0.0301
3 (no net change, ref)	1	-	-	1	-	-
4 (moderate increase)	1.01	(0.86, 1.18)	0.9173	1.06	(0.81, 1.38)	0.6709
5 (greatest increase)	0.97	(0.84, 1.12)	0.6892	1.50	(1.15, 1.97)	0.0029
Baseline deprivation						
Below average	0.73	(0.59, 0.91)	0.0045	0.46	(0.37, 0.57)	<.0001
Average (referent)	1	-	-	1	-	-
Above average	1.02	(0.89, 1.16)	0.8214	1.09	(0.95, 1.25)	0.2218
Female (male = referent)				0.57	(0.52, 0.63)	<.0001
Ever unmarried (always married=referent)				2.04	(1.77, 2.35)	<.0001
Maternal race/ethnicity						
Hispanic	1.78	(1.49, 2.13)	<.0001	2.34	(1.96, 2.80)	<.0001
Non-Hispanic black	2.12	(1.89, 2.36)	<.0001	1.79	(1.58, 2.02)	<.0001
Non-Hispanic white (referent)	1	-	-	1	-	-
Maternal education						
Less than high school	1.39	(1.27, 1.54)	<.0001			
High school (referent)	1	-	-			
1-3 years of college	0.45	(0.38, 0.53)	<.0001			
Finished college	0.18	(0.14, 0.23)	<.0001			
Interaction terms						
Change in NDI 1 * Ever unmarried				1.21	(0.86, 1.71)	0.2775
Change in NDI 2 * Ever unmarried				0.76	(0.56, 1.02)	0.0649

Change in NDI 4 * Ever unmarried	1.02	(0.73, 1.42)	0.9222
Change in NDI 5 * Ever unmarried	0.63	(0.46, 0.86)	0.0043

*non-significant GEE chi-square p-value for terms
CI=confidence interval; NH=Non-Hispanic; NDI=neighborhood deprivation index; OR=odds ratio

The quintiles describe how the NDI changed over a move in residences between birth of the index child (baseline) and the second indicator child; NDI is measured at the census tract level. A negative number indicates that the deprivation at the second time point (second child's birth) is lower than at baseline; the move was to a less deprived area. A positive number indicates that the deprivation increased between the child's birth and the second time point; the move was from a less deprived area to a more deprived area. Thus, those in the first quintile comprise those who had the greatest decrease in deprivation and the fifth quintile comprises those who had the greatest increase in deprivation; the third quintile straddles the mean, representing move in residences with essentially no net change in deprivation.

Table 6. Final adjusted models for failing ELA and Math CRCTs

	ELA / Model 9			Math / Model 10		
	Odds ratio	**CI**	**p-value**	**Odds ratio**	**CI**	**p-value**
Change in NDI						
1 (greatest decrease)	1.00	(0.80, 1.26)	0.9792	1.11	(0.87, 1.40)	0.4016
2 (moderate decrease)	1.14	(0.95, 1.38)	0.1663	1.22	(0.98, 1.52)	0.0763
3 (no net change, ref)	1	-	-	1	-	-
4 (moderate increase)	1.35	(1.11, 1.64)	0.0028	1.21	(0.97, 1.51)	0.0966
5 (greatest increase)	1.45	(1.16, 1.82)	0.0009	1.64	(1.29, 2.08)	<.0001
Baseline deprivation						
Below average	0.50	(0.43, 0.58)	<.0001	0.47	(0.39, 0.56)	<.0001
Average (referent)	1	-	-	1	-	-
Above average	1.05	(0.92, 1.20)	0.4371	1.08	(0.94, 1.23)	0.2836
Female (male=referent)	0.59	(0.54, 0.63)	<.0001	0.81	(0.75, 0.88)	<.0001
Ever unmarried (always married= referent)	2.19	(1.96, 2.45)	<.0001	2.16	(1.90, 2.45)	<.0001
Maternal race/ethnicity						
Hispanic	2.64	(2.31, 3.02)	<.0001	2.28	(1.93, 2.68)	<.0001
Non-Hispanic black	1.54	(1.40, 1.70)	<.0001	2.20	(1.97, 2.46)	<.0001
Non-Hispanic white (referent)	1	-	-	1	-	-
Interaction terms						
Change in NDI 1 * Ever unmarried	1.00	(0.77, 1.31)	0.9827	0.84	(0.63, 1.11)	0.2176
Change in NDI 2 * Ever unmarried	0.85	(0.66, 1.10)	0.2280	0.82	(0.62, 1.08)	0.1618
Change in NDI 4 * Ever unmarried	0.75	(0.58, 0.96)	0.0251	0.86	(0.64, 1.14)	0.2885
Change in NDI 5 * Ever unmarried	0.69	(0.53, 0.90)	0.0066	0.55	(0.41, 0.74)	<.0001

*non-significant GEE chi-square p-value for terms
CI=confidence interval; CRCT=Criterion-Referenced Competency Tests; ELA=English language arts; NDI=neighborhood deprivation index

The quintiles describe how the NDI changed over a move in residences between birth of the index child (baseline) and the second indicator child; NDI is measured at the census tract level. A negative number indicates that the deprivation at the second time point (second child's birth) is lower than at baseline; the move was to a less deprived area. A positive number indicates that the deprivation increased between the child's birth and the second time point; the move was from a less deprived area to a more deprived area. Thus, those in the first quintile comprise those who had the greatest decrease in deprivation and the fifth quintile comprises those who had the greatest increase in deprivation; the third quintile straddles the mean, representing move in residences with essentially no net change in deprivation.

Table 7. Odds ratios of strata of change in NDI among ever unmarried and always married mothers for all three CRCT tests

	Reading			
	Ever Unmarried		Always Married	
Quintile of Change in NDI	**OR**	**CI**	**OR**	**CI**
1 (greatest decrease)	2.06	(1.70, 2.50)	0.83	(0.61, 1.13)
2 (moderate decrease)	2.00	(1.61, 2.48)	1.29	(1.03, 1.63)
3 (referent, no net change)	2.04	(1.77, 2.35)	1	-
4 (moderate increase)	2.20	(1.78, 2.72)	1.06	(0.81, 1.38)
5 (greatest increase)	1.93	(1.59, 2.34)	1.50	(1.15, 1.97)
	English Language Arts			
	Ever Unmarried		**Always Married**	
Quintile of Change in NDI	**OR**	**CI**	**OR**	**CI**
1 (greatest decrease)	2.21	(1.86, 2.62)	1.00	(0.80, 1.26)
2 (moderate decrease)	2.14	(1.79, 2.57)	1.14	(0.95, 1.38)
3 (referent, no net change)	2.19	(1.96, 2.45)	1	-
4 (moderate increase)	2.21	(1.85, 2.63)	1.35	(1.11, 1.64)
5 (greatest increase)	2.20	(1.86, 2.61)	1.45	(1.17, 1.82)
	Math			
	Ever Unmarried		**Always Married**	
Quintile of Change in NDI	**OR**	**CI**	**OR**	**CI**
1 (greatest decrease)	2.00	(1.67, 2.39)	1.11	(0.87, 1.40)
2 (moderate decrease)	2.16	(1.78, 2.63)	1.22	(0.98, 1.52)
3 (referent, no net change)	2.16	(1.90, 2.45)	1	-
4 (moderate increase)	2.23	(1.83, 2.71)	1.21	(0.97, 1.51)
5 (greatest increase)	1.95	(1.64, 2.33)	1.64	(1.29, 2.08)

CI=confidence interval; CRCT=Criterion-Referenced Competency Tests; NDI=neighborhood deprivation index; OR=odds ratio

Other variables controlled for in each of these models are: change in NDI and marital status individually, baseline deprivation, child's gender, and maternal race/ethnicity.

Appendix – IRB Letter

EMORY UNIVERSITY

Institutional Review Board

TO: Lauren Owens
Principal Investigator
MedInfect

DATE: December 30, 2013

RE: **Expedited Approval**
IRB00071264
Neighborhood Deprivation, Residential Mobility, and Early Academic Achievement in the Atlanta Metropolitan Statistical Area

Thank you for submitting a new application for this protocol. This research is eligible for expedited review under 45 CFR.46.110 and/or 21 CFR 56.110 because it poses minimal risk and fits the regulatory category F(5)(7) as set forth in the Federal Register. The Emory IRB reviewed it by expedited process on December 30, 2013 and granted approval effective from **12/30/2013 through 12/29/2014**. Thereafter, continuation of human subjects research activities requires the submission of a renewal application, which must be reviewed and approved by the IRB prior to the expiration date noted above. Please note carefully the following items with respect to this approval:

- A complete waiver of authorization has been granted by the Emory University IRB for the purpose of determining eligibility or recruiting subjects for this protocol. This waiver was reviewed and approved under the review procedure noted above. The approval is granted based on this boards determination that all criteria for waiver of authorization have been met. The PHI that may be used or disclosed for this use is limited to: Pass / Fail records from Georgia Department of Education, Hospital records,

- Title 45 CFR 46.404 Subpart D, 21 CFR 50.51 Subpart D, with one parent signature required.

- Documents included with this approval:
  Protocol version 11.20.2013

Any reportable events (e.g., unanticipated problems involving risk to subjects or others, noncompliance, breaches of confidentiality, HIPAA violations, protocol deviations) must be reported to the IRB according to our Policies & Procedures at www.irb.emory.edu, immediately, promptly, or periodically. Be sure to check the reporting guidance and contact us if you have questions. Terms and conditions of sponsors, if any, also apply to reporting.

Before implementing any change to this protocol (including but not limited to sample size, informed consent, study design, you must submit an amendment request and secure IRB approval.

In future correspondence about this matter, please refer to the IRB file ID, name of the Principal Investigator, and study title. Thank you

Brandy Covington, CIP
Sr. Research Protocol Analyst
This letter has been digitally signed

Emory University
1599 Clifton Road, 5th Floor - Atlanta, Georgia 30322
Tel: 404.712.0720 - Fax: 404.727.1358 - Email: irb@emory.edu - Web: http://www.irb.emory.edu/
An equal opportunity, affirmative action university