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A Two Decade Examination of Historical Race/Ethnicity Disparities in Academic Achievement by Poverty Status

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Abstract

Research on achievement gaps by race/ethnicity and poverty status typically focuses on each gap separately, and recent syntheses suggest the poverty gap is growing while racial/ethnic gaps are narrowing. In this study, we used time-varying effect modeling to examine the interaction of race/ethnicity and poverty gaps in math and reading achievement from 1986–2005 for poor and non-poor White, Black, and Hispanic students in three age groups (5–6, 9–10, and 13–14). We found that across this twenty-year period, the gaps between poor White students and their poor Black and Hispanic peers grew, while the gap between non-poor Whites and Hispanics narrowed. We conclude that understanding the nature of achievement gaps requires simultaneous examination of race/ethnicity and income.

Keywords

Achievement gap; Time-varying effect models; Poverty gap; Academic achievement

Introduction

Gaps in academic achievement between Black and White children have been widely documented (e.g., Fryer and Levitt 2004; Reardon and Robinson 2008), and have been the focus of several national and state-based educational policies (Barton and Coley 2010). Recently, researchers and policymakers have turned their attention to two other achievement gaps: the Hispanic-White gap, and the income/poverty gap. Recent reports (Reardon 2011;

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Data Sharing Declaration The datasets analyzed during the current study are available from the Bureau of Labor Statistics, https://www.bls.gov/nls/nlsy79ch.htm

Conflicts of Interest The authors declare that they have no conflict of interest.

Ethical Approval This study reports on publicly available secondary data. The authors did not have access to personally identifying information or contact with participants.

Informed Consent This study reports on publicly available secondary data. The authors did not have contact with participants.

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Reardon and Robinson 2008) have suggested that the gaps by race/ethnicity have slowly narrowed in recent years, while the poverty gap has widened. Additionally, studies consistently report that gaps grow as children progress through school (Neal 2006; Phillips et al. 1998; Reardon 2011). These changes indicate minimal progress over time toward educational equity across racial/ethnic lines, growing disparities between low and high-income students, and little impact of educational policy efforts to ameliorate the gaps once children enter school (Reardon and Galindo 2009; Reardon and Portilla 2016).

Despite the amount of past research on achievement gaps, some aspects of our understanding of achievement gaps are limited, and these limitations in turn impact our ability to appropriately address gaps through policy. For instance, researchers have attempted to understand the gap by examining the extent to which socioeconomic factors explain the race/ethnicity gaps, finding that these factors do explain moderate-to-large portions of the gap, but that the explanatory power weakens as children progress through school (Fryer and Leavitt 2004, 2005; Reardon and Galindo 2009). While these findings can help education policies address some of the underlying roots of achievement disparities, they often ignore the interaction between race/ethnicity and socioeconomic factors. That is, while research has shown that achievement gaps by race/ethnicity have decreased over time, it is unknown if that true for both poor and non-poor families. Previous studies which concluded that the income gap explained the gaps between Whites and Blacks and between Whites and Hispanics have not detailed the income gap *within* racial/ethnic groups. Nor have changes in gaps been documented in continuous historical time; studies to date have relied on extrapolations between data points separated by years, sometimes decades, a fact that makes it difficult to pinpoint exactly when gaps are closing or expanding. As we discuss below, the current study is designed to redress these drawbacks in previous research on achievement gaps.

Research to date on achievement gaps has focused on three separate operationalizations of gaps, namely by race (Black vs. White), by ethnicity (Hispanic vs. White), or by income (poor vs. non-poor). There have been some efforts to examine whether income gaps explain race or ethnic gaps, but few systematic efforts to determine the extent to which there are variations within race and ethnic groups by income or poverty status. Below, we describe the research to date on each of the individual gaps and then highlight the need to understand interactions among them in order to advance our understanding of how to address achievement gaps.

Black-White Gaps

The Black-White achievement gap has been a central issue in both American educational policies and in research for decades. Several federal efforts have been aimed at closing the achievement gap, while researchers have undertaken efforts to not only trace the size of the gaps, but also to explain their mechanisms. Federal programs, such as Head Start, and policies, such as No Child Left Behind, were designed to close the gaps in school readiness and achievement for both low-income children and Black children, but research has demonstrated that these efforts have not reached their aims (Barton and Coley 2010). Studies using data from the Early Childhood Longitudinal Study—Birth Cohort (ECLS-B), the

Early Childhood Longitudinal Study—Kindergarten Cohort 1998 (ECLS-K), the Study of Early Child Care and Youth Development (SECCYD), and National Longitudinal Study of Youth 79—Child and Young Adult Cohort (CNLSY) all find sizeable Black-White gaps at kindergarten entry, with estimates ranging from .40 to .76 standard deviations (Fryer and Levitt 2004; Burchinal et al. 2011; Murnane et al. 2006; Reardon and Portilla 2016). Data from nationally-representative samples indicate that the Black-White gap at kindergarten has narrowed slightly from 1998 to 2010 (Reardon and Portilla 2016). These estimates, however, were based on three separate cohorts of kindergarteners, from 1998, 2006, and 2010 entry cohorts; thus, any discussion of historical variation is limited to these three discrete time points. Importantly, the use of few time points may miss important time-varying fluctuations in the achievement gap that occurred between data collection waves.

The National Assessment of Education Progress (NAEP) has collected achievement gap data from 9 and 13-year old students since the 1970s, allowing for estimation of gap changes by child age (9 vs. 13), subject (reading vs. math) across historical time. For instance, Reardon and Robinson (2008) compiled NAEP data finding that, in 1988, the Black-White reading gap for 9-year olds was .71 of a standard deviation (SD) and was .53 SD for 13 year olds. Between 1988 and 2004, the gap fluctuated in size for both groups, with a widening period between 1990 and 1996, followed by a narrowing until 2008. In math, the Black-White gap for 9 and 13-year olds in 1986 was similar, at around .75 SD. The gap grew in size for both age groups until 1999, and then narrowed until 2012. The gap in 2012, though, remained sizeable (.71 for 9-year olds and .80 for 13-year olds). Thus, it is clear that looking across historical time by age and subject reveal important differences in changes to the achievement gap. Furthermore, in Reardon and Robinson (2008) study, they report on achievement gaps on a nearly biennial basis from 1971 to 2012, however some of the time gaps between testing years are larger, such as the jump from 1971 to 1975, and 1999 to 2004. These time gaps may contain important fluctuations in achievement gaps, and thus, more detailed study of historical changes with additional data is warranted.

Hispanic-White Gaps

Significantly less is known about the achievement gap between Hispanic and White students. Estimates from the 1998 ECLS-K sample show that the gaps in math and reading ability at school entry between Hispanic and White students were similar to gaps between Black and White students at approximately .70 SD for math, and .50 SD for reading (Reardon and Robinson 2008). As with estimates of the Black-White gap at school entry, data is largely available from only a few select cohorts of kindergarteners. In fact, data on math achievement is only available at 1998, 2006, and 2010, with estimates showing a slight narrowing in the Hispanic-White gap (approximately .20 SD); data on reading gaps are available only for 2010, and are estimated at .56 SD (Reardon and Portilla 2016). As with the estimates of the kindergarten Black-White achievement gap, using only three time points to estimate changes to math achievement is problematic, as it may mask changes to the achievement gap between the years of 1998 to 2006; furthermore, the lack of data on Hispanic kindergartener's math achievement has limited researchers' ability to describe changes to the math achievement gap across historical time. Thus, our current understanding

regarding kindergarten Hispanic-White achievement gaps in math, and particularly reading, is very limited.

As children progress through school, the Hispanic-White gap appears to narrow. Using data from the ECLS-K, Reardon and Galindo (2009) found that the gaps in math and reading that are present at kindergarten (ranging from .66 to .92 SD) narrow by one-third in the first two years of schooling. According to estimates from NAEP, the Hispanic-White math gaps in 2009 were .21 SD at fourth grade, and .26 SD at eighth grade, and the reading gaps were .25 SD at fourth grade and .24 at eighth grade, suggesting increasing gaps in math but small stagnant gaps in reading (Hemphill and Vanneman 2011). Looking across historical time, the Hispanic-White gap in math and reading at 4th and 8th grade has narrowed slightly over the past 20 years (Reardon et al. 2013). In sum, preliminary evidence suggests that the Hispanic-White gap in math and reading for children ages 9 (around fourth grade) and 13 (around eighth grade) is comparable across subjects, and potentially narrows across time; little is known about the Hispanic-White gap in kindergarten, and, thus, using additional data is warranted.

Income or Poverty Gaps

Closing the poverty-based academic gap by kindergarten has been prominent in national policy since the launch of President Johnson's War on Poverty in 1965 and the creation of Head Start. To date, however, only a few studies provide estimates regarding the size of income/poverty gaps in math and reading at various stages in children's schooling. Reardon and Portilla (2016) estimated the income achievement gap (defined as the average gap between children from families at the 90th percentile of the income distribution and children from families at the 10th percentile of the income distribution; henceforth referred to as the 90/10 gap) for the same three cohorts of kindergarteners mentioned above—1998, 2006, and 2010. They found very large gaps (1.3 SD) at 1998 and slightly smaller gaps (1.10–1.20 SD) by 2010, indicating a slight narrowing of achievement gaps. In an investigation using data from 19 studies of children and youth spanning 1940–2000, Reardon (2011) reported growth in the 90/10 income gap (aggregated across child and youth age). Notably, Reardon reports the 90/10 income gap in 2001 was nearly double the size of the Black-White gap.

Little information is available regarding the size and stability of the income gap as children progress through school. Reardon (2011) estimated the gap by compiling data across six longitudinal studies, and found that the income achievement gap remained relatively stable as children progressed from kindergarten to high school. The most recent report on the NAEP math assessment found that the scores for 4th grade students eligible for free lunch through the National School Lunch Program (a marker for low family income) have been statistically significantly lower than those for children not eligible for free lunch for all 7 years for which data were available (biennially from 2003–2015), with the gap between groups growing between 2009 and 2015. For 8th graders, the school lunch eligibility gap was even wider and was larger in 2015 than in 2005 (U. S. Department of Education 2017). Similar patterns of gaps were found for NAEP reading scores across this same period (U.S. Department of Education 2017).

Taken together, studies to date suggest that the income or poverty achievement gap has grown over historical time and is stable from middle to late elementary school; however, only two studies provide data on the income or poverty gap at school entry, and both note large achievement gaps.

Interactions Between Race/Ethnicity and Poverty Gaps

The growth in achievement gaps by income or by poverty status is often discussed in tandem with evidence for the slow narrowing of Black-White and Hispanic-White gaps. Collectively, the current discourse on educational inequality suggests that racial/ethnic gaps are narrowing at a glacial pace, while the income gap is widening at a moderate pace (Reardon and Portilla 2016). When examined separately, these two conclusions may signal that racial/ethnic inequality is less of an issue in education than income inequality. Indeed, several researchers have aimed to explain the Black-White and Hispanic-White achievement gaps by implicating family income. Studies range in their estimates of how much variability in the Black-White and Hispanic-White gap can be explained by family income or socioeconomic status. For instance, Fryer and Levitt (2004, 2005) found that socioeconomic status (a composite of household income, parental education, and occupational status) explained 85% of the Black-White math gap, and nearly 100% of the reading gap at kindergarten entry, but only 60% of the math and reading gaps by third grade. Using the ECLS-K dataset, Murnane and colleagues (2006) reported that 33% of the Black-White math gap and 15% of the reading gap in third grade was accounted for by socioeconomic status differences. Other researchers report similar-sized reductions of race-based gaps (between 15–33%) in math and reading at eighth grade (Clotfelter et al. 2006; Phillips et al. 1998; Rothstein and Wozny 2013). Less research has focused on the interplay of income and achievement gaps for Hispanic vs. White students. Using ECLS-K data, Fryer and Leavitt (2006) reported that the Hispanic-White gap in achievement at kindergarten was nearly entirely explained (75–85%) by socioeconomic factors. In a study using the same dataset, Reardon and Galindo (2009) found that, conditional on socioeconomic status, the Hispanic-White gaps in academic achievement were largest at kindergarten and narrowed across elementary school.

While these studies help explain the reason for gaps in academic achievement, they are based solely on differences in socioeconomic factors aggregated at the racial/ethnic level. However, the use of factors such as average differences in household income or socioeconomic status obscure the fact that there is economic variability within racal and ethnic groups; given the importance of income for educational achievement generally (Duncan et al. 2011; Lacour and Tissington 2011), we do not yet know if all poor groups have not fared well over time, regardless of race or ethnicity, or if there is an interaction between race/ethnicity and poverty status.

In the current study, we examined race/ethnicity by poverty status to understand if poverty is differentially associated with academic achievement gaps across racial/ethnic lines. This is important because looking at the intersection of poverty and race/ethnicity may illuminate disparities that are hidden by aggregate scores. That is, achievement gaps may be dependent upon the combination of race/ethnicity and income, because racial/ethnic groups vary in

their experiences of poverty, including their likelihood of experiencing poverty, their length of stay in poverty, and the association between poverty and other family and education resources (Magnuson and Duncan 2006; Pac et al. 2017). For instance, a study of low-income Black and White families found a substantial gap in achievement as early as child age three along racial lines, suggesting that even among families with similar incomes, the achievement gap by race is still prominent (Burchinal et al. 2011).

It is also useful to look separately at subpopulations of race/ethnicity by poverty because there remain questions about why gaps have seemed to widen or narrow (Reardon 2016). It could be because subpopulations of Black and Hispanic students are performing better, driving up the average scores, or that poor populations of White students are doing worse, driving down the average scores. In the current study, we modeled how poverty is differentially associated with achievement scores for Whites, Blacks, and Hispanic students to examine whether race/ethnicity or poverty status is driving observed achievement gaps. Additionally, our analysis allows us to understand if the associations between poverty and math and reading achievement for each racial/ethnic group have also varied across historical time, across developmental age, and across academic domain (math and reading). Our findings will add nuance to the understanding of historical variation in achievement gaps.

This study contributes to the literature in three ways. First, by using a historical lens, we provide a perspective on the potential efficacy of child-directed policies in reducing academic disparities. We examined the time frame of 1986 to 2005, during which several child-and family-directed policies were signed into law, including the Personal Responsibility and Work Reform Act (PROWRA; i.e., welfare reform) (1996), the State Children's Health Insurance Program (S-CHIP, later changed to CHIP; 1997), and No Child Left Behind (NCLB; 2001). Second, this study addresses a critical shortcoming in the previous work on racial/ethnic and income gaps at kindergarten; in particular; estimates of the achievement gaps at kindergarten are based typically on only a few cohorts of children, often those represented in the ECLS-K and ECLS-B studies (e.g., Reardon and Portilla 2016). Thus, our current understanding of gaps at kindergarten entry has been limited to average estimates from 3 cohorts of kindergartners from 1998, 2006, and 2010. In the current study, we seek to address this shortcoming by using data from the National Longitudinal Study of Youth—Child and Young Adult Cohort (CNLSY). This dataset was chosen for this study, because it is the only available dataset that includes achievement scores from 20 consecutive cohorts of kindergarten-aged children from 1986 to 2005. The evidence from this study will complement previous findings, filling in the gaps on historical changes particularly for kindergarten-aged students and Hispanic students. Furthermore, the dataset and analyses allowed us to include achievement data from nearly every month from 1986 to 2005, allowing for estimation of nuanced time-varying effects across historical years. Third, we utilized a novel method for modeling the interaction between racial/ethnic group and poverty status, which allowed us to identify if racial/ethnic gaps are explained by poverty differences, and to examine poverty differences within racial/ethnic groups across time.

Present Study

In this investigation, we aimed to add additional detail to the understanding of historical achievement gaps by modeling 20 years of math and reading achievement across groups based on interactions between race/ethnicity and poverty for three different age groups of children (5–6, 9–10, and 13–14 year olds). In pursuit of this aim, this study employed time-varying effect modeling (TVEM), a unique descriptive analysis that estimates the intercept of a construct as a flexible function of time, with month-to-month achievement data from a large, longitudinal dataset. TVEM is a descriptive analysis, and thus, no a priori hypotheses were proposed. Results are presented graphically, and interpreted in light of similar investigations with NAEP and other large secondary datasets.

Method

Data

We used 14 biennial waves of data (1986–2012) from a subset of the National Longitudinal Study of Youth 1979 (NLSY79), namely the Child and Young Adult Cohort (CNLSY). The NLSY79 was a nationally representative study designed by the United States Department of Labor to study variations in labor market behavior and experiences; the children born to mothers from the NLSY79 comprise our sample. The mothers of the children we studied were between the ages of 14 and 22 when first interviewed in 1979 and constituted a representative sample of women born between 1957 and 1965. The NLSY79's initial design oversampled Black, Hispanic, and economically disadvantaged White youth.

Beginning in 1986, interviewers administered an extensive set of assessment instruments to the age-eligible co-resident children of all the female respondents. These assessments included information about cognitive, socio-emotional, and psychological aspects of the child's development as well as the quality of the home environment (Baker et al. 1993). In 1986, the assessments were completed by 4971, or about 95%, of the co-resident children of mothers interviewed in 1986. These same children, plus newly age-eligible children, were interviewed again biennially through 2014. The first reported birth was in 1970, and very few children were born after 2000. Thus, our target sample consists of children who had valid poverty status data and were observed between 1986–2005 at any or all of the following age ranges: 5–6 years (55–77 months; $n = 3250$; 53.1% White, 27.9% Black, 18.9%); 9–10 years (103–125 months $n = 3157$; 50.4% White, 30.6% Black, 19.0% Hispanic); and 13–14 years (151–175 months $n = 2644$; 46.1% White, 33.32% Black, 20.58% Hispanic). Details regarding the sample size for each grouping (race/ethnicity by poverty status) by age across the 20-year period is available in online supplemental materials Tables 1-6.

The age range of 5–6 was chosen to represent kindergarten, the marker of children's entrance into formal education in the United States; many educational studies collect data at this time point. The ages 9–10 and 13–14 were chosen because they align with the NAEP data collection ages and because both represent transitions in schooling. First, in recent years, the ages of 9–10 represent the time when children tend to begin formal school testing, particularly with the onset of NCLB in 2001. Second, the ages 13–14 represent children's

transition from middle school to high school. We chose a 23-month range for each age both to capture the ranges of ages within a grade and to ensure a sufficient sample size for analysis.

Across all data collection waves (1986–2005), the majority of children contributed three observations or fewer; thus, it was not common for a child to contribute data to all three age ranges across different data waves. Additionally, within each age range, no child contributed more than one observation, which prohibits longitudinal within-person analyses (i.e., inclusion of random intercepts). Historical time was calculated as the month and year of assessment (e.g., September 1990). Although the CNLSY's design included biennial data collection, the assessment/interview dates for each wave ranged across as few as 6 months, and as many as 18 months, resulting in a wide range of assessment dates for each data collection wave. This allowed us to examine historical variation as close to "continuous" time as possible, with data available at over 50% of the months between the years 1986 to 2005; the longest length of time between available data (based on assessment date) was 7 months. Additionally, given the nature of the sample, it is noteworthy that early cohorts of the child sample were born disproportionately to young mothers, while the latest cohorts were born to mothers as old as 42.

Measures

Academic skills—Our key dependent variables were two dimensions of academic skills: reading and math achievement. Children's early academic skills were measured by the Peabody Individual Achievement Tests (PIAT Reading Recognition and Math; Dunn and Markwardt 1970). Interviewers verbally administered the PIAT to all children ages five or older. Children were first given an age-appropriate item, and then a basal score was established when a child answered five consecutive questions correctly. Once a basal was established, interviewers continued to ask the child questions until the child answered five out of seven consecutive items incorrectly. Subtracting the number of incorrect scores between the basal and the ceiling score from the ceiling score produced a raw test score. Descriptive statistics for reading and math achievement are summarized biennially for each of the six groups at each of the three age ranges in online supplemental materials, Tables 1-6.

Reading: The reading recognition test consisted of 84 items that measure word recognition and pronunciation ability. It tested children's skills at matching letters, naming names, and reading single words out loud. Dunn and Markwardt (1970) reported the 1-month temporal reliability of a national sample, and the test-retest correlations ranged from a low of .81 for kindergarteners to a high of .94 for third-grade students. Overall, the test had an average test-retest reliability of .89.

Math: The PIAT Math test consisted of 84 multiple-choice items designed to measure mathematic concepts taught in mainstream classrooms. The problems were designed so that children were required to apply math concepts to questions rather than conduct increasingly complicated computations. The test started with basic skills, such as number recognition and counting. It increased in difficulty to problems involving division, multiplication, and

fractions. The most difficult questions involved advanced concepts from algebra and geometry. Dunn and Markwardt (1970) reported that 1-month test-retest reliabilities from a national sample ranged from a low of .52 for kindergarteners to a high of .84 for high school seniors. On average, the test-retest reliability was .74. Following the most widely used approach for reporting achievement gaps (see Reardon and Robinson 2008), we report the PIAT estimates of achievement gaps in terms of scores that are standardized within each age-subject/year combination.

Race and ethnicity—Mothers reported children's race/ethnicity as Hispanic, Black non-Hispanic, or White non-Hispanic.

Family poverty status—Household poverty was determined from mothers' reports of family income in the year before the assessment. A dichotomous variable was created to indicate poverty as below 100% of the federal poverty line in the calendar year prior to the interview date.

Race/ethnicity by poverty status—The race/ethnic by poverty status groups were created by assigning each available observation to one of six groups (poor White, poor Black, poor Hispanic, non-poor White, non-poor Black, non-poor Hispanic) depending on children's race and whether the children's household was below the poverty threshold in the year prior to the interview.

Analysis

Analyses were conducted using time-varying effect modeling (TVEM), a type of semi-parametric spline regression that uses multiple observations to model a construct as a flexible function of time (Lanza et al. 2014; Tan et al. 2012). Standard longitudinal models either pool the effects of time into a single estimate, or must adhere to a particular parametric shape. TVEM assumes a smooth pattern of change, models the coefficient as a dynamic function of time, and does not require pre-specification of shape. For more information on both the statistical background and implementation of TVEM, see Shiyko et al. (2014).

In the present analyses, we modeled the historical trends in standardized math and reading ability for race/ethnicity by poverty groups at child ages 5–6, 9–10, and 13–14 using separate intercept-only TVEMs, expressed as: $\text{ACHIEVEMENT}_i = \beta_0(t) + \varepsilon_i$. Historical time was coded as the month and year of assessment (e.g., January 1990), which was turned into a numeric value by splitting the year into 12 equal intervals. For example, January 1990 would be coded as 1990 + 1/12 = 1990.08. All analyses were conducted in SAS 9.3 and TVEM was implemented using the SAS macros %normal TVEM and %logistic TVEM; these macros are available for download at methodology. psu.edu (Li et al. 2015). All TVEM models used the pspline estimation method. The implementation of TVEM also includes estimation of 95% confidence intervals, which allow for determination of significant differences in standardized scores across groups within and across time. The specific estimates from the smoothed fitted function are the least precise at either end of the age range because the sample size is smaller at these tail-ends of the birth distribution (i.e., data

at the high end represent young mothers while data at the bottom end represents older mothers). The confidence intervals are always wider at the tails of TVEM models, because TVEM uses all available data to estimate the fitted function, and with diminishing information at each end, the estimates become less reliable. Results are displayed graphically. Although intercepts and corresponding 95% confidence intervals are estimated separately, they are plotted together to aid in interpretation of significant differences.

Results

The results for reading achievement are displayed in Fig. 1, and for math achievement in Fig. 2. Each figure contains six panels, which display the standardized scores on reading or math for the six racial/ethnic by poverty groups: poor and non-poor White students, poor and non-poor Black students, and poor and non-poor Hispanic students. Each row of panels represents an age group. The White and Black students are graphed together, and the White and Hispanic students are graphed together. Significant differences between groups are interpreted from the 95% confidence intervals; when they do not cross, the groups significantly differ.

Reading Achievement

5–6-year olds—Figure 1a shows that the gap between poor and non-poor White 5–6-year old students' estimates of reading achievement appears to have narrowed over time due to increases in the relative ranking of poor White children's scores. Poor White 5–6-year olds' scores varied across the period, decreasing relative to the sample mean between 1986 and 1992, and then increasing from 1992 to 2001. Non-poor White children's relative rank remained fairly stable, while non-poor Black children's rank declined over the 20-year period. The poverty gap seemed to close for Black 5–6-year old students both because poor Black students' scores improved and because non-poor Black students' scores dropped relative to their peers leading to overlapping achievement estimates. Poor Black students' scores varied across the historical period, with a downward trend from 1989 to 1999, and an upward trend from 1999–2005. Figure 1b shows that until 1999, non-poor White 5–6-year olds outperformed poor Whites and both poor and non-poor Hispanic 5–6-year olds in reading achievement. The gap in estimates of reading achievement between 5–6-year old non-poor Whites, poor Whites, and non-poor Hispanics closed between 1999 and 2005, both because poor Whites and non-poor Hispanics' scores increased relative to the sample mean, looking more like their non-poor White peers, and because non-poor White students' relative rank did not increase. Poor Hispanic children consistently scored approximately .50 SD below the average across the 20-year period.

9–10-year olds—Figure 1c shows that non-poor White 9–10-year olds consistently outperformed all other groups, scoring an average of .30 SD above the standardized average across the time period. The poverty gap for White 9–10-year olds seemed to diminish between 1986 and 1992 as relative rankings converged, but widened again from 1993 to 2005. Poor and non-poor Black 9–10-year olds scores differed across the 20-year-period, and poor Blacks' scores dropping relative to their non-poor Black peers. Additionally, Black students' relative rank dropped in relation to their White peers, suggesting potential growth

in the Black-White reading achievement gap for 9–10 year olds across the 20-year period. Figure 1d shows that non-poor Hispanic 9–10-year olds' scores in relation to their peers reflected a curvilinear trend over time; their relative competencies in reading dropped from 1986 to 1991, and increased to the level of their non-poor White peers around 1998. Poor Hispanics' scores declined away from their peers over the time period, hovering near a .50 SD below the average across the time period. Thus, the poverty gap may explain the majority of the Hispanic-White 9–10-year old reading gap.

13–14-year olds—As shown in Fig. 1e non-poor Whites consistently outperformed all other groups, and this advantage remained steady across time. Poor Whites 13–14-year olds relative position improved over time, signaling a narrowing of the poverty gap for White 13–14-year olds. Non-poor Blacks 13–14-year olds' relative position declined slightly over time, and poor Blacks' scores declined more dramatically from 1989 to 2005; the difference in achievement between poor and non-poor Black 13–14-year olds appeared to grow from 1996 to 2005, and as of 2005, poor Blacks scores were nearly 1.00 SD below the average, while poor Whites scores hovered at the sample average. Figure 1f shows a different pattern for Hispanic 13–14-year olds, such that non-poor Hispanics' relative rank was much more variable over the time period, but suggested that they performed as well as non-poor Whites prior to 1989, and between 1994 and 2000, and as well as poor Whites between 1989 to 1994, and after 2000. Poor Hispanics' relative rank was no different from their non-poor peers until 1992; following 1992, scores diverged between poor and non-poor Hispanic 13–14-year olds until 2005. Thus, finding suggest a narrowing of rank differences of poor and non-poor White 13–14-year olds, and a widening of differences for poor and non-poor Hispanic 13–14-year olds.

Collectively, the findings show that across all age groups, the gap between non-poor White and Hispanic students narrowed or closed by 2005. However, across both historical time and as children progressed through school, the non-poor Black students' relative ranking dropped in relation to their non-poor White peers, as did poor Black students' rank compared with their poor White peers.

Math Achievement Gaps

5–6-year olds—Figure 2a depicts a drop in both poor and non-poor Black 5–6-year olds' relative rank in relation to their White peers. Non-poor White 5–6-year olds fairly consistently scored .30 SD above their peers across the 20-year span, and the difference between poor and non-poor White 5–6-year olds' relative ranks became negligible over time. The difference in math achievement estimates between poor and non-poor Black 5–6-year olds remained, and both groups of Black students dropped in their rank relative to their White peers. Figure 2b shows a different story for Hispanic children; scores differed between poor and non-poor Hispanic 5–6-year olds gap consistently throughout the 20-year-timeframe. Non-poor Hispanic 5–6-year olds consistently scored just below the average, and poor Hispanics scored between .5 and .9 SD below the sample average across time.

9–10-year olds—As shown in Fig. 2c, non-poor White 9–10-year olds consistently outperformed their poor and Black peers, while poor Whites' relative position dropped after

1995, suggesting potential growth in the poverty gap for White 9–10-year old students. We also documented a larger and widening difference in scores between poor and non-poor Black 9–10-year old students, such that non-poor Black 9–10-year olds relative rank dropped slightly over the period, while poor Black students' relative rank dropped dramatically. Figure 2d shows that non-poor Hispanic 9–10-year olds' scores hovered consistently around the sample average each year, with declines from 1986 to 1995, followed by a period of stagnation. Poor Hispanic 9–10-year olds' scores declined relative to their peers after 1992.

13–14-year olds—Figure 2e shows a striking race/ethnicity by poverty difference, such that non-poor White 13–14-year olds maintained the highest ranking in math over time, and poor Whites 13–14-year olds' ranking slightly increased over time. Black 13–14-year olds' scores decreased over time, and non-poor Black 13–14-year olds maintained a near .60 SD estimate advantage over their poor Black peers. Figure 2f shows the estimate differences between poor and non-poor Hispanic 13–14-year olds widened after 1993, at which time poor Hispanics' scores continued to decline and non-poor Hispanics' scores hovered around the average within age and year.

The findings for math are similar to those for reading, such that the gap between reading achievement of non-poor White and Hispanic students of all ages appears to have narrowed, while the gap between non-poor White and Black students at 5–6 years old and 13–14-year old appears to have widened. Additionally, the difference in ranking between poor White and Black students has not narrowed across historical time, particularly at the 9–10 and 13–14-year old age ranges, suggesting growing inequity as children progress through school. The gap between poor White and Hispanic students at ages 5–6 and 13–14 has remained sizeable; however, the gap for these populations at ages 9–10 appeared to have shrunk, as White students' ranking dropped and Hispanic students' ranking rose late in the historical period.

Discussion

The academic achievement gap has been the focus of education research and policy for decades, and while many scholars and politicians have focused on gaps by race, ethnicity, or family income, there have been few investigations of the intersection between these factors. The present study utilized time-varying effect models (TVEM) to examine historical changes over a 20-year period in math and reading achievement across groups of race/ethnicity by poverty for three different age groups of children (5–6, 9–10, and 13–14). Although descriptive in nature, our analysis responds to a recent call for detailed descriptive analyses of education-related data as a means of understanding the "landscape of needs and opportunities" (Loeb et al. 2017, p. 1) in our nation's education system, particularly with regard to disparities in academic achievement. Findings provided a new perspective on achievement gaps, showing that the poverty gap has changed across time differently for White, Black, and Hispanic students. Specifically, differences between poor and non-poor White students' scores did not grow across time at school entry or ages 13–14. In nearly all models, the differences between poor and non-poor Black and Hispanic students' scores remained sizeable across historical time and across developmental age.

Our findings suggest that examining gaps as interactions between race/ethnicity and poverty adds additional information relevant to the development of educational policies aimed at reducing achievement gaps. Specifically, we found that comparing poor White children with non-poor Black and Hispanic children illuminated the disparities undescribed by previous studies of income or poverty as a mediator of the Black-White and Hispanic-White academic achievement gaps. Furthermore, our study provides key information regarding historical variations in academic achievement scores at kindergarten for White, Black, and Hispanic students not found elsewhere in the literature. We note that while our study did not include nationally-representative data, the pattern of findings suggests that studies that do include representative data but examine only one dimension (poverty or race/ethnicity) may draw false conclusions regarding the United States' progress toward equity in education.

A Historical View on Education Inequality and Policy

By taking a historical approach and utilizing data from 20 consecutive cohorts of 5–6, 9–10, and 13–14 year olds, our study was poised to document any trends that would suggest the efficacy of national policy efforts aimed at closing academic achievement gaps. In addition, many policies enacted between 1986 and 2005, such as education accountability (NCLB), health care (CHIP), and welfare reform (PRWORA), had the potential to address factors related to school readiness and achievement, such as health, chronic absenteeism, family resources, children's access to learning materials and experiences, and others. We found no evidence to suggest national progress toward educational equity, despite the onset of several federal policies aimed specifically at addressing these gaps at a national level across the time period. This conclusion is strengthened by our use of an analytic approach (TVEM) that allowed us to model the achievement gaps as flexible functions of time, measured at monthly intervals across the 20-year period.

Previous research relying on distinct cohorts from the ECLS-K, or annual survey data from NAEP also supports our conclusion that across the twenty-year period, achievement gaps have not closed in a meaningful way for children. Comparisons to NAEP data, in particular, are useful given that they are nationally-representative of 9- and 13-year old children. In terms of the Black-White achievement gaps, we find similar fluctuations as those reported by Reardon and Robinson (2008), however, our findings illuminate the lingering disparities evident by gaps between poor White and non-poor Black kindergarteners and 13–14 year olds in math, and 9–10 and 13–14 year olds in reading. Additionally, our findings mirror those from NAEP's estimates of the Hispanic-White gap over a similar 20-year period; by examining the interaction, however, we find that poor Hispanic children still lag behind their poor White peers, particularly in math (Reardon et al. 2013).

The Intersection Between Race/Ethnicity and Economic Inequality

The interaction between race/ethnicity and poverty modeled in this study help elucidate important new areas of work in both research and policy aimed at ameliorating the achievement gap. We were able to address the question raised by Reardon (2016), namely whether achievement gaps have narrowed because Black, Hispanic, and/or poor children's scores have become more comparable to their White/non-poor peers, or if the opposite is true. Our historical analysis indicated no evidence that minority or economically

disadvantaged groups are consistently catching up to their White or non-poor peers. We did not perceive any narrowing of the Black-White gap, although some models showed that non-poor Blacks performed comparably to poor Whites, which may result in smaller gaps. The narrowing of Hispanic-White gaps was likely due to non-poor Hispanic students' increase and poor White students decrease in rank. Collectively, we found that by examining the intersection of race/ethnicity and poverty, we find gaps that are not explained by differential likelihood of exposure to poverty.

Additionally, the relevance of the intersection of race/ethnicity and poverty is illustrated by comparing our findings to those reported by Barton and Coley (2010), who utilized NAEP data to model the Black-White achievement gaps in math and reading at ages 9 and 13. Similar to their findings, we found that the Black-White score gaps in reading and math at ages 9–10 and 13–14 grew from 1990–2000; we found that this was likely driven by a decline in poor Black youths' ranking. We also find that the Black-White score gap in math and reading leveled out and appears to have perhaps shrunk after 2000; we only found this, though, for the 13–14 year olds and not 9–10 year olds. However, the gap reductions seem to be driven not by an increase in Black scores but rather by the overlap of poor White with non-poor Black scores. This again provides evidence of the importance of breaking out the score gap estimates by poverty in order to illuminate the nature of the Black-White achievement gap.

Importantly, across both historical time and developmental age, poor Black children's scores have become more disparate from their White peers. This finding is more pronounced when comparing non-poor Black children to poor White children, because it uncovers a blind spot in many Black-White achievement gap discussions; whereas most research concludes that income is a proxy for resources, and that lower income people have fewer resources, our findings align with Reardon's (2011) suggestion that resources are not evenly distributed across racial/ethnic groups (Duncan and Magnuson 2005). White families living below the federal poverty line have some advantages that are reflected in their children's higher academic achievement scores as young as at school entry, and persisting into high school (e.g., Burchinal et al. 2011). Additionally, our conceptualization of poverty may reflect very different cumulative socioeconomic circumstances. For instance, the reported length of time in poverty varied across the three racial/ethnic groups within our sample: Black and Hispanic children who were in poverty at ages 13–14 were in poverty at twice as many previous waves compared to White children. Thus, even our findings mask an important dimension of socioeconomic disparity.

Turning to the Hispanic-White gap, Fryer and Leavitt (2006) found that the Hispanic-White gap in kindergarten (using ECLS-K data) was nearly entirely explained by the poverty gap. However, we continue to find that poor White children perform better than poor Hispanic children. It is more difficult to situate the findings for Hispanics students given the demographic shifts that have occurred from 1986–2005, including shifts in language, country of origin, and generational status (Reardon and Galindo 2009). Our evidence showing that non-poor Hispanic children catch-up to their White peers in reading at all three ages could indicate a Hispanic poverty gap in English language acquisition; it could also

signal a difference in home reading materials, an issue that is found across racial/ethnic lines.

Policy Implications and Next Steps

We highlight three areas for policy attention. First, policies designed to target the Black-White or Hispanic-White achievement gap must include economic supports but should also consider that families in poverty are heterogeneous. Second, given growing residential segregation across both racial/ethnic and income lines (Bischoff and Reardon 2014; Reardon and Robinson 2008), there must be greater investment in quality instruction, high-quality teachers, curriculum, and adequate school resources across both of these dimensions, with particular attention paid to predominantly minority areas that are also economically disadvantaged. This is underscored by the fact that even as residential segregation shrank in the 1990s, Vigdor and Ludwig (2008) did not find such a decline in school segregation. Third, the focus should be on equity. That is, investments do not need to be evenly distributed, but do need to be concentrated where the resources of income, social status, and access to educational materials and experiences are limited. In our study, this was made clear by the evidence that across nearly every time point, particularly later in schooling, non-poor Blacks were faring worse than poor Whites.

Limitations

The study has a few limitations. One main limitation is that the data are not nationally representative of school children during the twenty-year study period. Thus, we cannot describe with certainty the size of the achievement gaps at a national level. For these reasons, we do not draw conclusions regarding the size of the gaps, rather we draw conclusions regarding the presence of gaps. The demographics of the children within the same racial/ethnic groups at the same ages also varied across historical time; for instance, the 5–6-year old group of children at the 2003 survey wave were born to mothers who were much older than the 5–6-year old group of children at the 1992 survey wave. Although scores were standardized within time and age to make point-in-time estimates relative to peers within that same year, the scores represent the shifting demographics of the children born to mothers who were between ages 14–22 in 1979. We find the threat of bias due to shifting demographics to be low given the concordance between our findings and those from NAEP, which reports nearly annual nationally-representative data. Although the CNLSY only had sufficient data for our analyses through 2005, the dataset still allowed us to create the first-ever continuous time models of achievement gaps over a 20-year period. The CNLSY was also limited in its categorization of race and ethnicity; future work on achievement gaps by race and ethnicity should use more accurate categorizations. Additionally, by looking only at the federal poverty line as an indicator of family income, we ignore the variability of families above the federal poverty line. To further explicate the achievement gap, work is needed to understand the interaction between race/ethnicity and income across the income spectrum. Examinations of the impact of policies should carefully measure the implementation of the policy for a given sample; in our study, we looked at a very broad level, but true policy analyses should consider regional implementation differences. Finally, TVEM is a descriptive analytic technique and thus does not support

causal conclusions; that said, this study responds to a recent call for more descriptive analytic studies of large datasets in ways that inform educational policy (Loeb et al. 2017).

Conclusion

Our study contributes to the literature in three important ways. First, using a large study of 20 cohorts of children ages 5–6, 9–10, and 13–14, we detected no systematic progress towards equity in achievement along either income/poverty or racial/ethnic lines. Second, we contributed specifically to the literature on gaps at kindergarten entry by modeling 20 years of historical variation in kindergarten-aged children's scores across racial/ethnic and poverty lines. Third, we highlighted the importance of modeling the interaction of race/ethnicity by poverty status for both academic and policy audiences. The interaction of the two factors is an added dimension that helps explicate the lack of effectiveness of many educational policies, indicating that more work needs to be done to promote educational equity, particularly for Black children.

The results of this study indicate that there remain significant race/ethnicity gaps in math and reading achievement, even when looking at racial/ethnic by poverty groupings, such that the gap between poor White students and their Black and Hispanic poor peers has widened with time. The source of these gaps remains unclear; potential sources include educational policies or policies regarding families in poverty, segregation and racism, unequal distribution of resources, and differences in home environments. As researchers and policymakers continue to probe the causes and trajectories of achievement gaps, we conclude that it is critical to consider the intersection of race and poverty.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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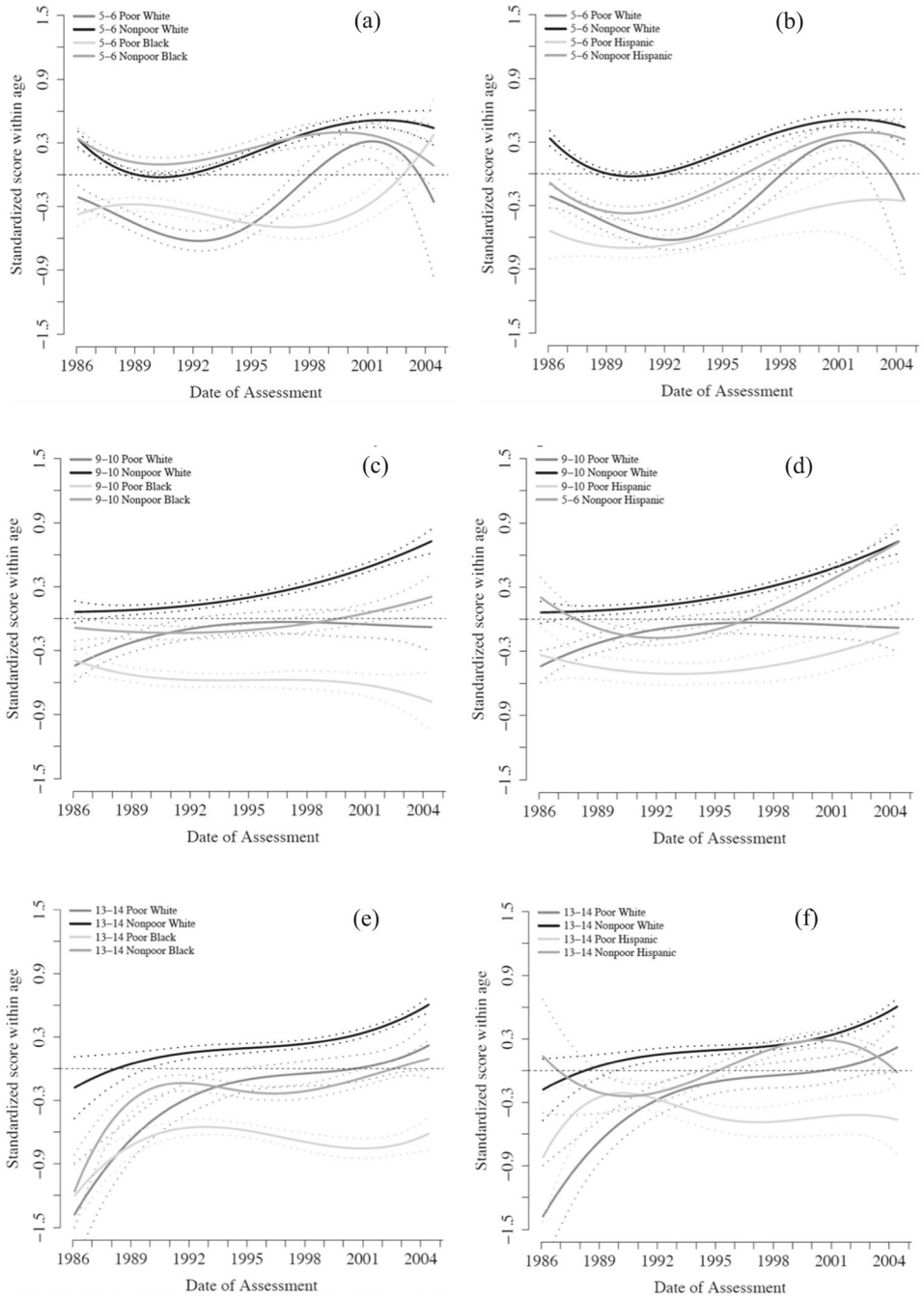

Fig. 1.

Historical variation in reading achievement for each race/ethnicity by poverty group at each age. **a, b** 5–6 year old reading achievement, **c, d** 9–10 year old reading achievement, **e, f** 13–14 year old reading achievement

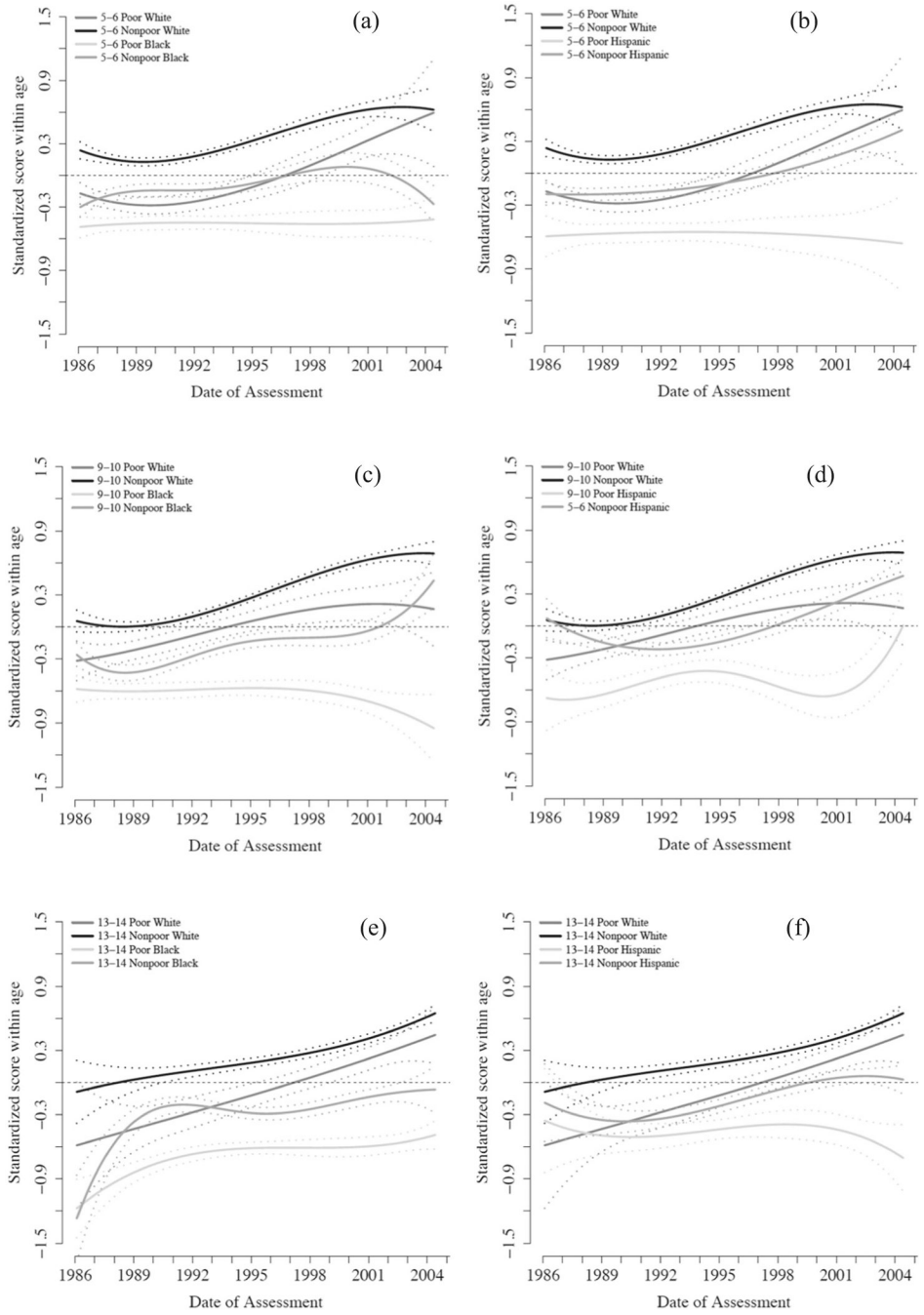

Fig. 2.

Historical variation in math achievement for each race/ethnicity by poverty group at each age range. **a, b** 5–6 year old math achievement, **c, d** 9–10 year old math achievement, **e, f** 13–14 year old math achievement