Educational Gradients in Cardiovascular Health: Cohort Change and Race/Ethnic Disparities

We use pooled data from nine waves (1971-2010) of the National Health and Nutrition Examination Survey (N=49,278) to document how educational gradients in cardiovascular health by race and ethnicity have changed across cohorts. Using logistic regression models with period fixed effects we find evidence of a convergence across cohorts between Mexican-Americans and whites for hypertension, and Mexican-Americans and blacks for obesity, LDL cholesterol, and smoking behavior. Educational gradients, the gap between those with a high school degree and those with a college degree, consistently narrow across cohorts for hypertension and widen across cohorts for smoking behavior across all subgroups; cholesterol and obesity show cohort-specific changes in the gradients but no trend towards narrowing inequality.

The extent to which education determines life chances is thought to reflect societal inequality. Extant inequality has been studied extensively with regard to health and mortality (Goldman, 2001; House et al. 1994; Marmot and Wilkinson, 1999; Montez et al. 2009; Montez, Hummer & Hayward, 2012). Further, research has also investigated whether the educational gradient in health varies across race and ethnic subgroups (Acevedo-Garcia, Soobader, & Berkman 2007; Chen, Martin, & Matthews 2006; Goldman et al. 2006; Kimbro et al. 2008). To date, scholars have largely relied on period or age-based change to infer whether inequality is persistent or has changed over time. To understand the intersection of social change and education on health, we argue for examining change across cohorts while taking into account age and period influences. This research fills this gap by asking whether educational gradients by race/ethnicity in cardiovascular health have widened across cohorts. We broadly define cardiovascular outcomes, including more traditional measures of hypertension and high cholesterol as well as related risk factors such as smoking and obesity.

Examining the relationship between education and cardiovascular outcomes is important for a number of reasons. Not only is poor cardiovascular health associated with reduced life expectancy (Fried et al. 1998; Roger, Go, & Lloyd-Jones 2011), but the prevalence of these outcomes continues to change over time highlighting the importance of investigating social determinants. For example, hypertension prevalence among U.S. adults declined substantially during the 1980s, increased from the mid to late 1990s through the early 2000s, possibly stagnating thereafter (Arnett et al. 2002; Cutler et al. 2008; Egan, Zhao, & Axon 2010; Hertz et al. 2005; Martin, Schoeni, & Andreski 2010). Obesity has also increased dramatically in recent decades (Flegal et al. 2002), with some evidence that these increases are starting to level off (Flegal et al. 2012). Trends for cholesterol showed improvements in health; recent declines in cholesterol (Crimmins et al. 2005; Kim et al. 2005; Martin, Schoeni, & Andreski 2010) follow a declining prevalence that dates to the 1960s (National Center for Health Statistics, 2002). Further, racial and ethnic disparities in these outcomes are well known, as are their associated complications and heightened mortality risk (Clark & Emerole 1995; Flack, Ferdinand & Nasser 2003Roger, Go & Lloyd-Jones 2011). Disparities are not, however, uniform across outcomes; while blacks are the most disadvantaged with respect to some health outcomes (e.g. blood pressure, BMI (Crimmins et al. 2005; Ogden, 2009; Ogden et al. 2007); they tend to have lower cholesterol levels than whites or Mexican Americans (Roger, Go, Lloyd-Jones 2012). Blacks face the highest levels of blood pressure risk relative to whites and Hispanics but research indicates little to no difference between the latter groups (Crimmins et al. 2007; Egan, Zhao & Axon, 2010). In addition to higher levels of blood pressure-related risk, Blacks also tend to fare worst with respect to BMI (Ogden, 2009; Ogden et al. 2007), followed by Hispanics and whites.

The social gradient in health has been well documented. Poor cardiovscular outcomes specifically show an inverse relationship with education (e.g. Karlamangla et al. 2005; Thurston et al. 2005). Looking at a broad range of health outcomes, research has found more steep educational gradients among whites and blacks than Hispanics (Acevedo-Garcia, Soobader, &

Berkman 2007; Chen, Martin, & Matthews 2006; Goldman et al. 2006; Kimbro et al. 2008). These scholars further disentangled Hispanic gradients and find that the relationship between education and health is weaker among foreign-born than native-born Hispanics (also see Zsembik & Fennell 2005). In terms of change over temporal dimensions, most evidence suggests that education differences in mortality and health have changed over time (e.g. Pappas et al. 1993) and are stronger at younger ages (Beckett, 2000; Crimmins & Saito, 1999; House et al. 1990; Preston & Taubman 1994). Though the role of cohort effects has been highlighted in studies of mortality, less study has focused on how educational gradients in other health outcomes vary by cohort. For example, Crimmins and Saito (1999) find that disability differentials by education have widened across cohorts for whites and black men, for black women such differentials exist only at younger ages; others have likewise found that educational gradients in mortality have also widened across cohorts (e.g. Lauderdale, 2001; Preston and Elo, 1995). Although not all causes of mortality may follow this pattern, we expect to see evidence of widening educational gradients in cardiovascular health given that previous evidence suggests that educational gradients in mortality are responsive to changes in heart disease mortality (Feldman et al., 1989).

Although examining educational gradients across periods or by age sheds light on health inequities, a cohort perspective sheds light on the role of social change and suggests the health burden that future generations will face. Individuals born during similar periods and entering into pre-existing social systems can be conceived of as a birth cohort. Birth cohorts represent variation between time periods among individuals who are born in similar years and experience similar formative environments (Yang & Land 2008). Some research indicates that the hypertension prevalence increased across older cohorts of black and white women, but not among younger cohorts nor among men (Geronimus et al. 2007). Research on obesity has also documented strong cohort effects for black women; blacks and whites born before 1955 experienced declines in obesity, however, cohorts of black women as well as men born afterwards experienced sharp increases in obesity (Reither, Hauser, & Yang 2009). However, there is a dearth of research on whether the relationship between education and these health outcomes varies across cohorts. There is also reason to expect that the educational gradient will not only vary by cohort but also by race/ethnicity. We can also think of groups as being born into a race-ethnic-specific opportunity structure that varies in terms of potential social mobility. This opportunity structure is a function of disparities in the pool of race-ethnic-specific resources available to a child as he or she ages as well as the level of prejudice and discrimination facing their group. For example, the opportunity to fully participate in the education system or to be exposed to employed co-ethnics have both differentially shifted across time for race and ethnic groups (Chandra 2000; Walters 2001; Welch 1990). Varying cohort-level macro-economic conditions, historical shifts in opportunity and the structure of daily family and economic life that are decidedly race and ethnicity-specific, and a growing literature documenting health consequences of cohort economic conditions argues for increased attention on the cohort into which an individual is born.

Data and Methods

Our integrated NHANES (IHANES) dataset consists of demographic variables, age, period, cohort, and many other important biomarker variables including body mass index, pulse rate, blood pressure, serum cholesterol, serum triglycerides, cholesterol-to-HDL ratio, blood glucose, and serum albumin. These variables were harmonized across nine waves of NHANES (1971-2010) data collections which allow consistent coding for each variable. The use of multiple waves of the NHANES data sets will also allow for a rich analysis of health disparities in the United States. We restrict our sample to those aged 25 and older and exclude pregnant women and those missing on cardiovascular health outcomes; our analytic sample varies across outcomes and includes 49,278 for hypertension, 49,731 for obesity, 50,134 for smoking and 15,203 for ldl cholesterol.

Measures

Our cardiovascular health outcomes include: hypertension, obesity, ever smoker and ldl cholesterol. We use traditional high risk cut points to define our clinical cardiovascular outcomes. Obesity is measured by a BMI of ≥30 kg/m; ldl serum cholesterol is considered high if it is ≥160; hypertension is defined as systolic pressure equals or greater than 140 mm Hg or diastolic blood pressure equals or greater than 90 mm Hg. The collection of blood measures differed by each wave. For NHANES 1, respondents' blood measurements were only taken in a sitting position whereas blood measures for NHANES 2 were taken at both sitting and recumbent positions. We chose to use the sitting position measure for NH2 in order to be consistent with NH1. Three sets of blood measurements were taken for NH3 respondents; however, we used the average of the three measurements that were calculated by NHANES. For NH4 and NH5, we also used the average of the four available blood pressure readings provided by NHANES. For NH6 and forward, NHANES no longer provide the average of the 4 available blood pressure measurement; thus, we calculated the average of the 4 measurements for each respondent. LDL serum cholesterol is only available from NH2 forward; in NH2 we derive the LDL measure using information on total cholesterol, HDL cholesterol and triglycerides (University of Michigan Health System, 2013). For the smoking outcome, we estimated a model in which being a current or former smoker was considered at-risk compared to being a never smoker. We also estimated models considering only current smokers at-risk (not shown); the patterns were similar however sample sizes were too small to estimate models for the earliest cohort band due to high rates of smoking cessation among the oldest cohorts.

Our sample is restricted to white, black and Mexican-American respondents. We also include a control for foreign birth. We use a continuous measure of age as well as an age squared term. To retain consistency across waves; we top-coded age in all waves to seventy-five. While an age variable is readily available in all waves of the NHANES data, period (survey year) and cohort (birth year) are de-identified in order to protect the anonymity of respondents; thus, we only know that the phase, but not the exact year the respondent was interviewed/examined. For this reason, we create low (assumes interviewed in earlier year) and high (assumes later year) period and cohort measures. The concordance rate between high and low period/cohort is over 90% for all waves except NH3 (only 57.7%) due to the wide range of survey years. Given the high degree of concordance in all but Wave 3, our prior working papers have found that health disparities are not sensitive to choice of cohort or period definition, even including Wave 3. We select the low definition and include period as a series of dummies in our model and stratify our analysis by cohort (before 1920, 1920 to 1939, 1940 to 1959, 1960 and after).

We also include a number of indicators of socioeconomic status and demographic controls. Of primary focus, we measure education as a series of dichotomous indicators, capturing less than a high school degree, high school degree, some college and college degree or higher. The structure of data collection prohibits us from considering continuous or other nonlinear variants of education. Although highest year of school completed is available for NHANES I through III, thereafter educational attainment is only available in categories. A series of dichotomous indicators capture marital status, including: married (omitted), never-married and other (widowed, separated, or divorced). A continuous measure of household size was also included; on average family size is approximately 3 individuals. We also include a measure of income to poverty ratio. We capture variation in employment with indicators of the respondent being employed (omitted category), unemployed/not in the labor force and retired.

In addition to socioeconomic control variables, we also included a number of health behavior variables in our model. Three indicators for smoking status (non-smoker-omitted category, previous smoker, and current smoker) were included for the obesity, cholesterol and hypertension models. For the hypertension models, we also include a dichotomous indicator for whether the respondent is currently taking the anti-hypertension medication. We also added three dietary (mineral) intake variables (sodium, potassium, and calcium) that were previously found to be associated with hypertension. The NHANES collected the 24-hour recall of respondents' diet (food and beverages) one day prior to the data collection and the estimated intake for each nutrient was also calculated. The amount of sodium (mg), potassium (mg), and calcium (mg) intake was entered as three continuous variables in our model. From NHANES 2003-2004 onward, two 24-hour recalls were available, however, we only use day 1 recall for our analysis to maintain consistency. Although we are aware that several other nutrients (e.g. magnesium, fiber, and fruit and vegetable consumption) and health behaviors (e.g. alcohol consumption and physical activity) reported in the literature are significantly associated with hypertension, these measures were not collected consistently across the eight NHANES waves. With the exception of when obesity is the outcome, we also include a measure of BMI for all outcomes as it is an important predictor of cardiovascular outcomes such as high blood pressure/ hypertension (Cutler et al. 2008; Krauss et al. 1998). We include indicators of missingness for marital status, poverty status, and employment status, imputing the mode or mean value for those with missing values.

Analytic Plan

We first estimate logistic regression models for each dichotomous outcome which include age, gender, race/ethnicity, foreign birth, education indicators and period fixed effects. The second model includes marital status, household size, poverty status and employment. Third, we include smoking controls, BMI, minerals, and an indicator of blood pressure medication, when applicable. Fourth, we estimate a model which interacts race/ethnicity with education to estimate the race/ethnicity-specific educational gradients.

Results

[Table 1 and Figure 1 About Here]

Figure 1 displays the simple descriptive difference in the percent of those with a high school degree with the poor health outcome from those with a college degree; more positive percentages indicate a steeper educational gradient with stars indicating significant differences. Gradients are steepest for ever smoking, and somewhat similar, and less steep for the other outcomes. The difference in hypertension by education is greater among whites than blacks and Mexican-Americans; for LDL cholesterol whites and blacks exhibit similar gradients. Whites and blacks also show steeper gradients for ever smoking. For the pooled sample, there is no apparent educational gradient in obesity among blacks and Mexican-Americans, nor ldl cholesterol among Mexican-Americans.

[Figure 2 and 3 About Here]

We graph the results of our final logistic regressions stratified by cohort; these models address whether race-ethnic specific gradients vary across cohorts. Figure 2 illustrates the predicted probability of hypertension by education, race, ethnicity and cohort; Figure 3 graphs the difference in predicted probability between high school graduates and college graduates. We use caution interpreting these gradients for blacks and Mexican-Americans given smaller sample sizes of college graduates in cohorts born before 1920. Figure 2 illustrates that the predicted probability of hypertension has declined across cohorts; though the decline is weaker, this pattern also holds for LDL cholesterol (Figure 6). For the 1920-1939 cohorts, the educational gradient is similar among Mexican-Americans and blacks through some college; college graduate Mexican-Americans look more similar, with a lower predicted probability of hypertension, to whites. For cohorts after 1940, Mexican-Americans fare better and more similar to whites across education levels. Figure 3 illustrates the gradients for hypertension, with the exception of cohorts before 1920, gradients in hypertension are initially largest among Mexican-Americans, followed by blacks and whites. These gradients all narrow across cohorts, with the most recent cohorts (1960-1986) showing similar gradients across all race-ethnic groups.

[Figure 4 and 5 About Here]

Counter to trends in hypertension and LDL cholesterol, the predicted probability of obesity slightly increases across cohorts. For the 1920-1939 cohorts, whites and Mexican-

Americans with high school degrees or less have lower predicted probabilities than blacks. Mexican-Americans with at least some college fall between whites and blacks. For more recent cohorts, this converge encompasses all education levels, with Mexican-Americans exhibiting similar (higher) probabilities as blacks. Figure 5 shows a slight widening of the gradient among whites between the 1920-1939 cohorts and the 1940-1959 cohorts, but it stagnates thereafter. There is a slight narrowing of the gradient among blacks between the 1940-1959 cohorts and the most recent ones; Mexican-Americans do not show a consistent pattern of gradient change, however the gradient for the most recent cohort is large and similar in magnitude to whites.

[Figure 6 and 7 About Here]

LDL cholesterol shows a slight declining trend across cohorts; further, Mexican-Americans again show a convergence towards the trends of blacks, however, trends in cholesterol are generally similar across all groups. Figure 7 illustrates that the gradient appears to narrow among between the 1920-1939 cohorts and 1940-1959 cohorts before widening again for recent cohorts of blacks and Mexican-Americans. The opposite is true among whites in that the 1940-1960 cohorts have a steeper gradient than cohorts before or after. Finally, our results suggest similar predicted probabilities of smoking until the post-1959 cohorts when the probability is substantially lower among blacks and Mexican-Americans than for prior cohorts. Mexican-Americans exhibit lower probabilities than blacks and whites for all but the most recent cohorts when they are more similar to blacks for lower levels of education and intermediate between blacks and whites for higher levels of education. The educational gradient in smoking consistently increases across cohorts for all groups and is steepest for whites, followed by blacks and Mexican-Americans.

[Figure 8 and 9 About Here]

Our preliminary results will be confirmed with more stringent significance tests between groups as well as considering heterogeneity by nativity within groups.

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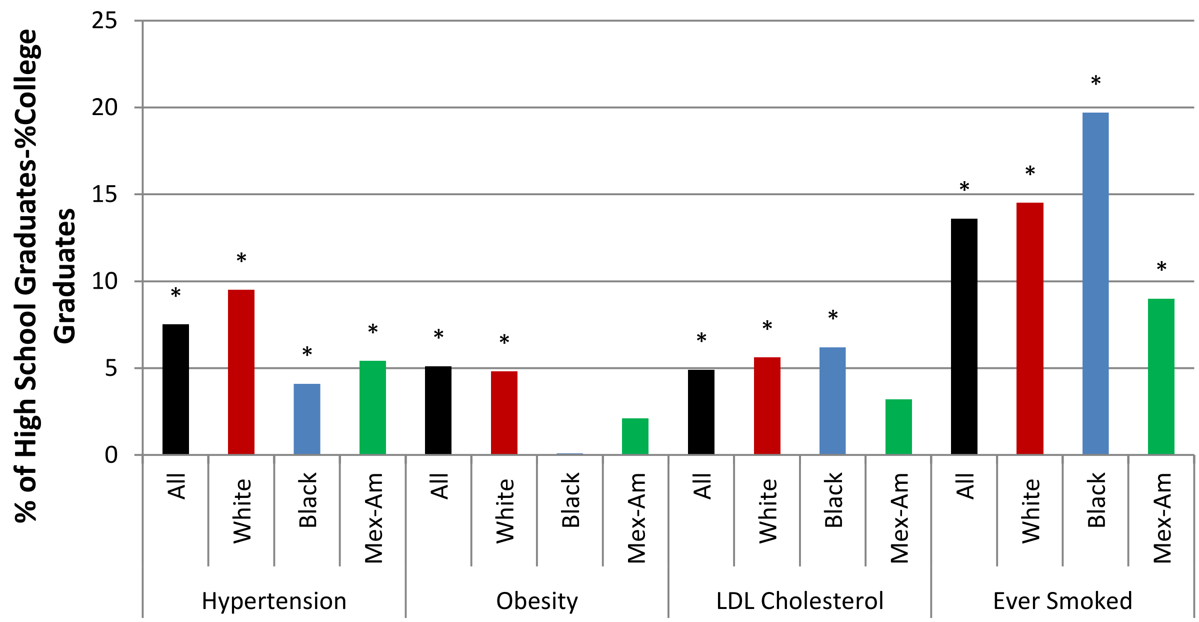
Table 1. Descriptive Statistics for IHANES, 1971-2010

Variable	All Mean/%	White Mean/%	Black Mean/%	Mexican-American Mean/%
Outcomes				
Hypertension	29.4	30.5	32.5	22.0
Obese (BMI≥30 kg/m)	28.2	23.7	36.6	33.2
High Serum LDL Cholesterol (≥160)	15.2	15.8	15.7	13.4
Ever Smoker	53.5	56.9	50.9	44.9
Controls				
Age	50.9	52.8	48.8	47.6
Female	51.0	51.0	52.5	49.4
Foreign Born	15.2	5.9	7.6	55.0
Less than High School Degree	36.6	27.8	39.7	62.6
High School Degree	28.3	31.4	27.9	18.3
Some College Education	19.2	20.3	21.0	13.3
College Degree	15.9	20.5	11.4	5.8
Missing Education Information	0.5	0.4	0.7	3.8
Married	63.6	69.3	44.5	66.8
Divorced, Separated, Widowed	21.9	20.2	30.5	17.7
Nevermarried	14.5	10.5	25.0	15.5
Missing Marital Status	0.9	0.7	1.1	1.2
Household Size	3.1	2.7	3.2	4.0
Poverty Status	2.54	2.87	2.16	1.91
Poverty Status Missing	6.9	5.3	8.4	10.6
Employed	56.3	55.3	57.2	58.6
Unemployed/NILF	22.4	20.1	26.0	25.8
Retired	21.3	24.6	16.8	15.6
Employment Status Missing	0.2	0.2	0.3	0.1
Takes Blood Pressure Medication	20.1	19.3	26.9	14.7
Body Mass Index	27.6	26.9	28.9	28.6
Missing BMI	0.8	0.6	0.8	0.8
Current Smoker	27.1	27.4	32.0	20.4
Previous Smoker	26.4	29.6	19.0	24.5
Never a Smoker	46.5	43.0	49.0	55.1
Sodium	3082.8	3096.0	3047.6	3080.27
Potassium	2575.0	2670.6	2230.6	2660.0
Calcium	784.3	826.3	642.3	810.7
N	49278	29878	10493	8907

Figure 1. Educational Gradients by Cardiovascular Outcome and Race-Ethnicity



*Indicates a significant difference by education in the % with stated outcome, *p<0.05*

Figure 2. Hypertension Trends, by Education Level, Cohort and Race-Ethnicity

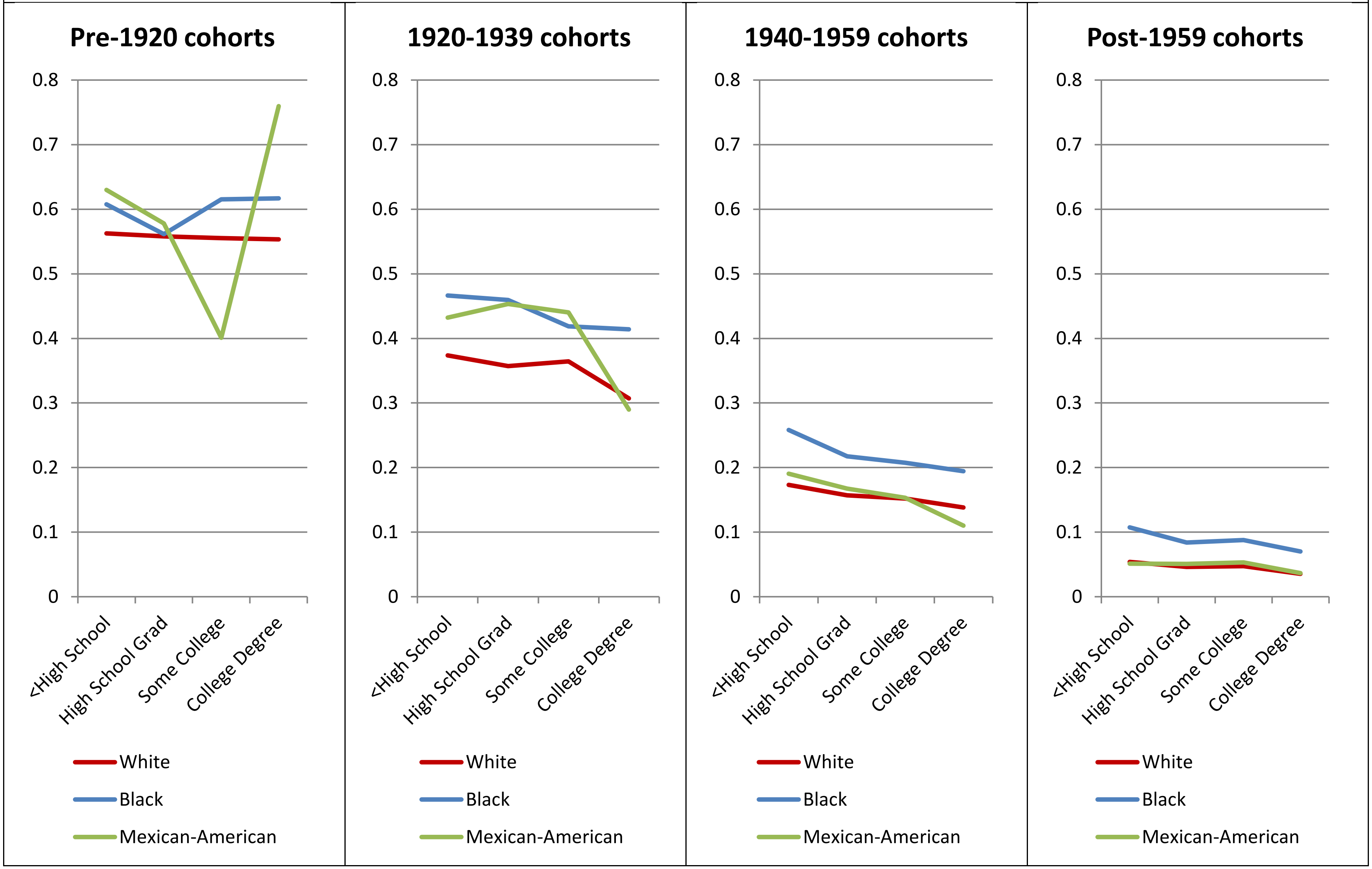
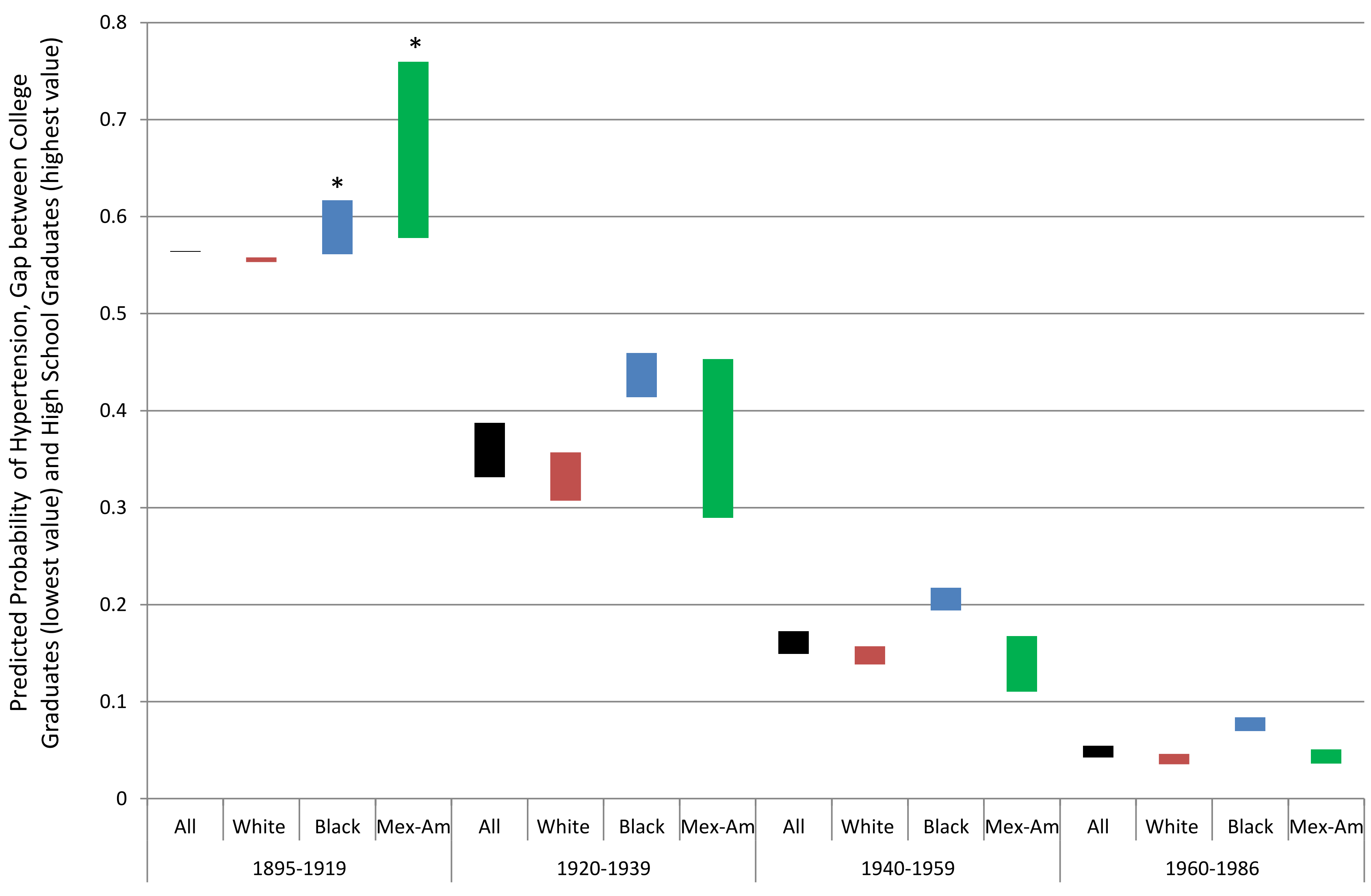


Figure 3. Educational Gradients for Hypertension, by Cohort and Race-Ethnicity



*Indicates that college graduates have a higher predicted probability of hypertension than high school graduates

Figure 4. Obesity Trends, by Education Level, Cohort and Race-Ethnicity

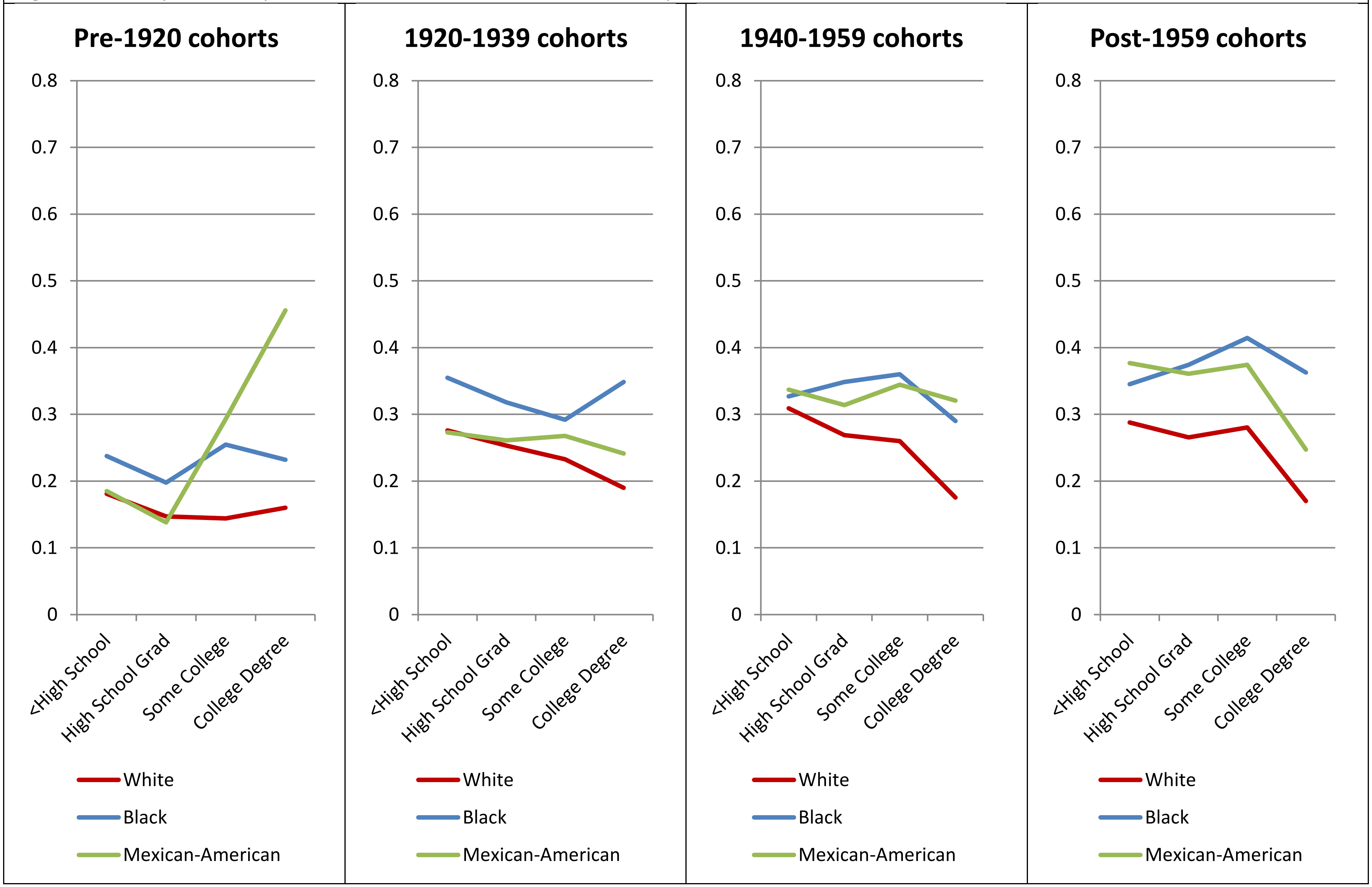
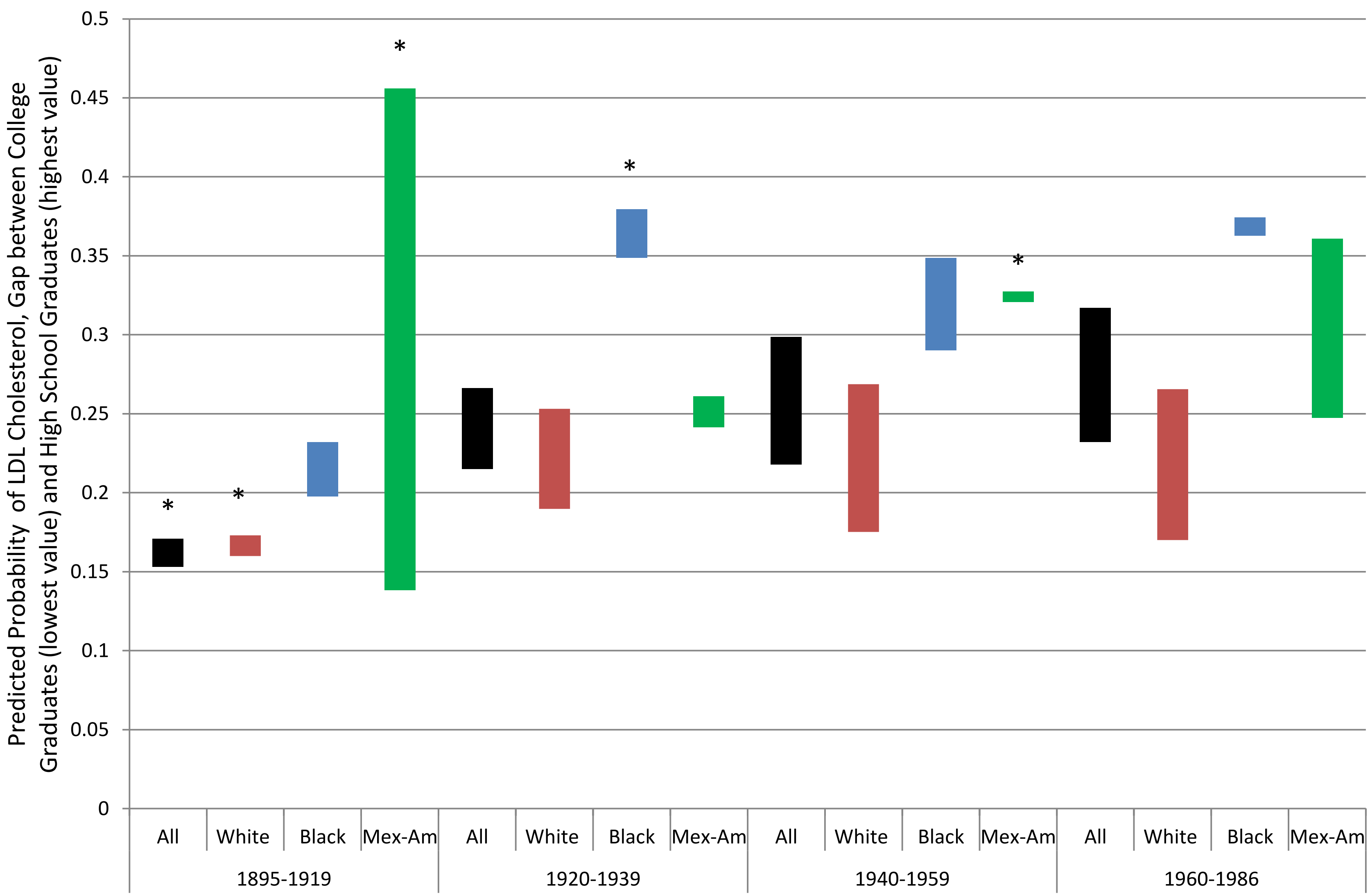


Figure 5. Educational Gradients for Obesity, by Cohort and Race-Ethnicity



*Indicates that college graduates have a higher predicted probability of obesity than high school graduates

Figure 6. Educational Gradients for LDL Cholesterol, by Cohort and Race-Ethnicity

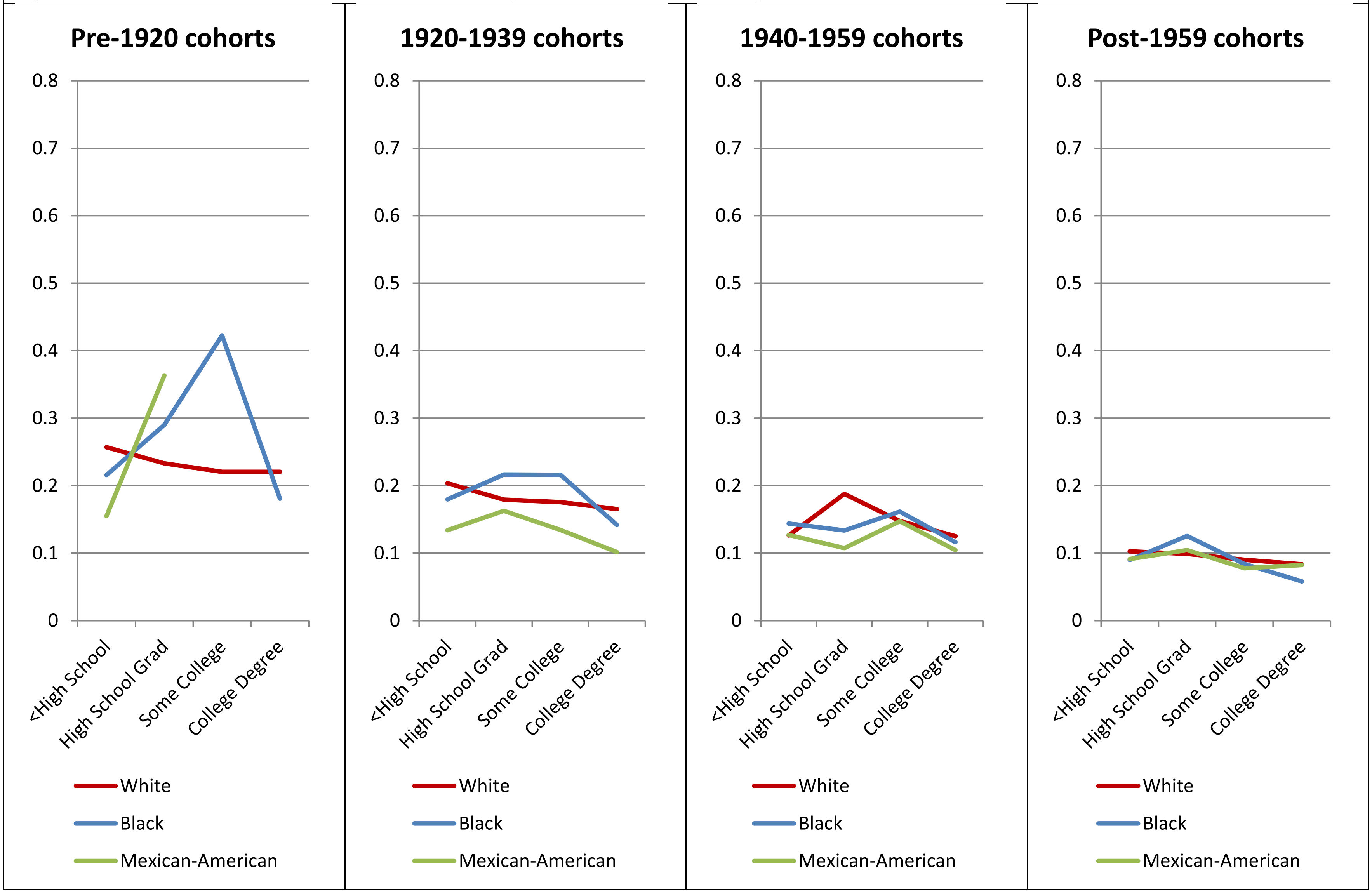
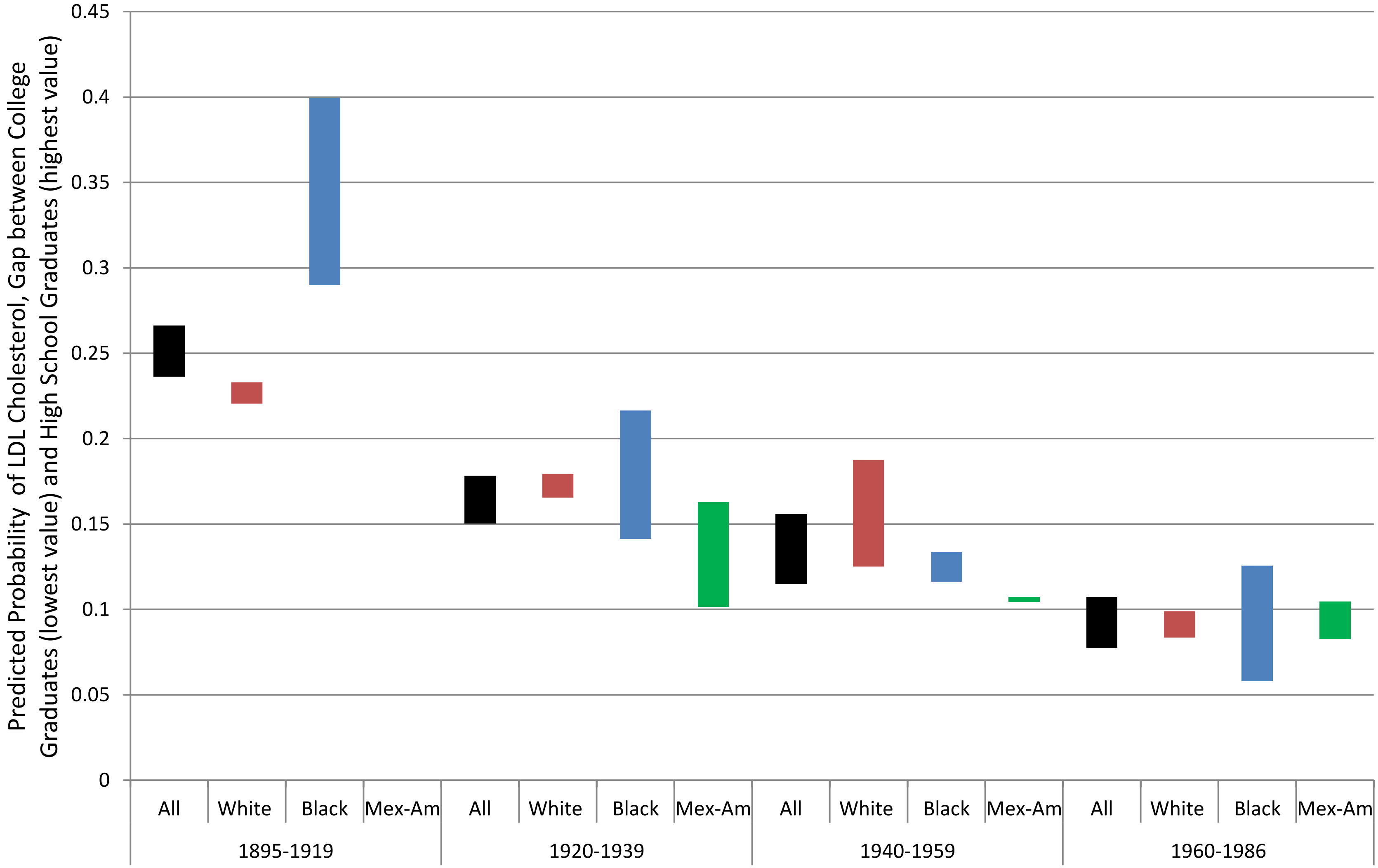


Figure 7. Educational Gradients for LDL Cholesterol, by Cohort and Race-Ethnicity



*Indicates that college graduates have a higher predicted probability of LDL Cholesterol than high school graduates

Figure 8. Educational Gradients for Ever Smoked, by Cohort and Race-Ethnicity

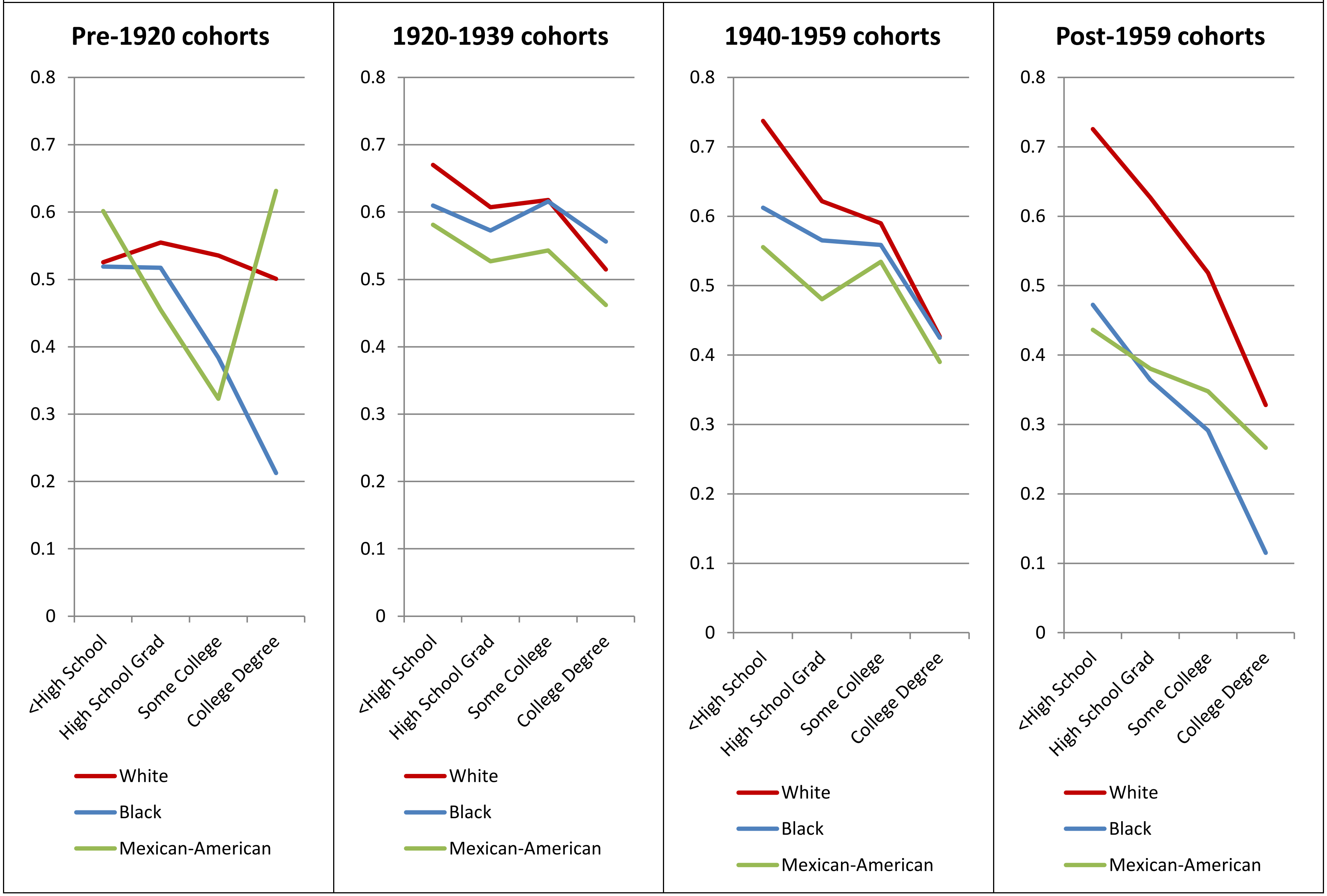
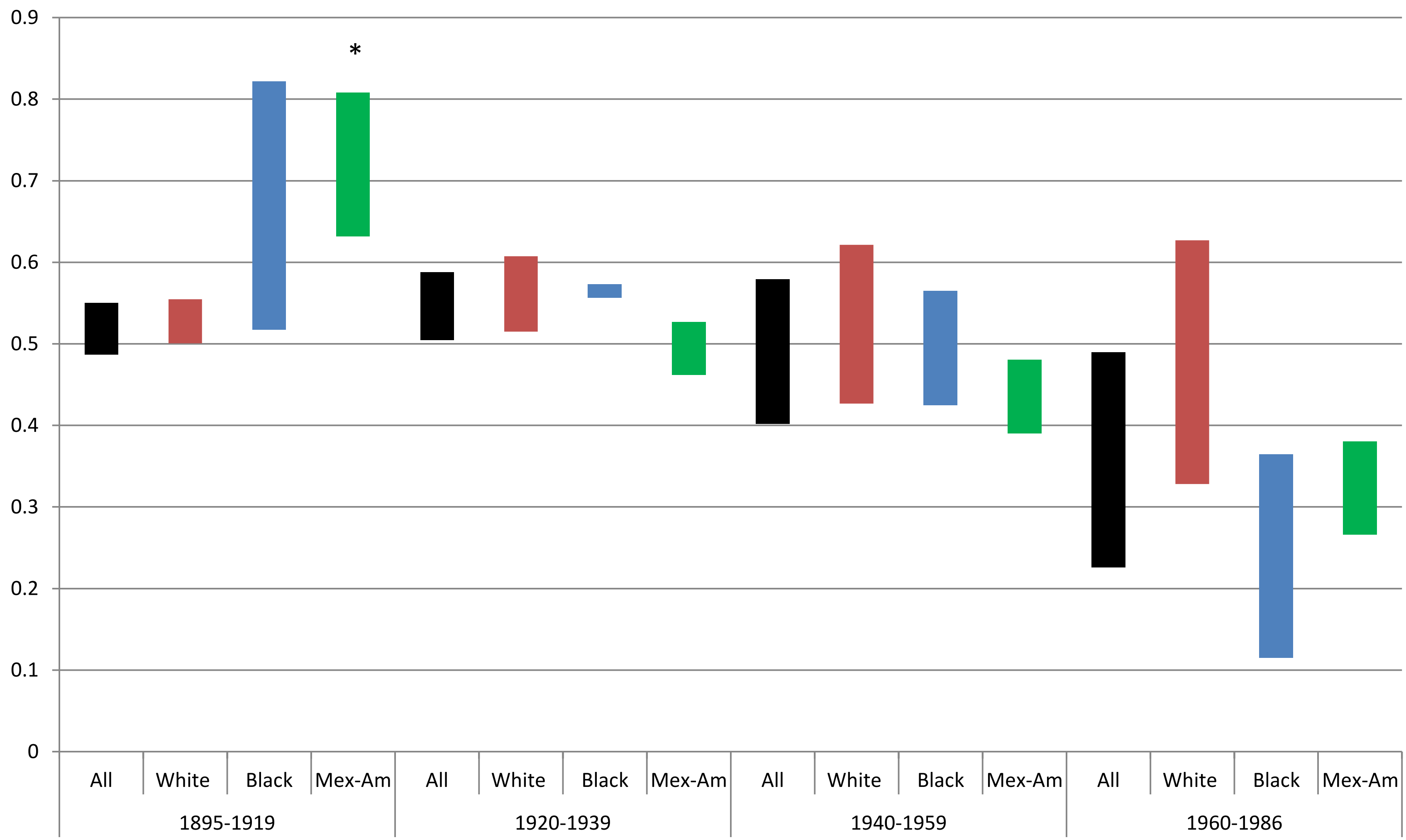


Figure 9. Educational Gradients for Ever Smoked, by Cohort and Race-Ethnicity



*Indicates that college graduates have a higher predicted probability of ever smoking than high school graduates