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Low Birth Weight, Maternal Age, and County Economic Status in the Appalachian Region

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Master of Public Health

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Abstract

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By Elizabeth Harlan

Introduction: The effects of area deprivation on perinatal outcomes in the Appalachian region have not been well studied. This analysis assessed the relationship between county economic status and low birth weight (LBW), hypothesizing that there would be a pattern of accelerated aging contrasting low economic status and high economic status counties, which would be supportive of the weathering hypothesis.
Methods: Appalachian Regional Commission county economic status labels were applied to the National Vital Statistics System natality file for births in the Appalachian region between 2006 and 2011. The outcome of interest was births weighing <2,500 grams, and predictors included maternal age, race, parity, adequacy of prenatal care use, education, and smoking. General estimating equations models were used to account for repeated county measures. The estimated age-specific risks of LBW were depicted graphically to better understand the relationship with county status.
Results: Women in low income counties were younger, had lower educational attainment, and a greater proportion smoked than women in high income counties. The relationship between county economic status and low birth weight varied by race and ethnicity. When controlling for smoking, women in low income counties had decreased odds of low birth weight compared to women in high income counties, OR 0.71 (95% CI 0.53-0.94). Among women living in low economic status counties had the lowest risk of LBW at age 28, while women living in high income counties had the lowest risk of LBW at age 32.
Discussion & Conclusions: Smoking is an important predictor of low birth weight among Appalachian women in low economic status counties, where smoking was more common than in high economic status counties. The age-specific risks of LBW are suggestive of a pattern of accelerated aging in women from low economic status counties as compared to women in high economic status counties. Accelerated aging leads to an increased risk of low birth weight as women age, and may be associated with limited educational or career opportunities. The results of this analysis support the weathering hypothesis as a function of county economic status in the Appalachian region.

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Introduction

Globally, perinatal outcomes are considered important indicators of population health. The proportion of infants in the United States who are born low birth weight and preterm has increased in recent years, making these issues important areas of study in community health.(1) The causes of adverse perinatal outcomes are complex and multifactorial. They result from both preconception health factors, such as smoking and obesity, as well as from psychosocial exposures such, as low social support or unstable communities. Perinatal outcomes have frequently been associated with income, education, and access to health care in a growing literature on the effects of psychosocial stress and neighborhood environment.(2-5) Maternal health and perinatal outcome are influenced by experiences of stress that occur over the life course, including early life and events during pregnancy.(6, 7)

The weathering hypothesis, as described by Geronimus, focuses on the racial disparity in perinatal outcomes and early mortality between black and white populations in the United States and describes the impacts of life-course deprivation and stress on health.(8-11) Most studies of deprivation have been conducted using data from urban regions with high concentrations of poverty, but studies have demonstrated that women from rural regions experience similar stress-related perinatal outcomes.(12) Low income communities frequently face barriers to health care, including lack of insurance and neighborhood effects that promote poor health.(7, 10, 13)

Much of the research on health inequalities in urban areas has focused on racial and ethnic disparities in conjunction with economic inequalities, which highlights the marginalization of minority populations.(3, 4, 14) There is also evidence of rural racial and ethnic health disparities, though they are not as well described because rural populations are less studied and

tend to be more racially homogenous.(13, 15) Fewer studies of rural areas have assessed the relationship between maternal socioeconomic status, community economic heath, and perinatal outcomes.

Populations in rural regions face unique challenges of limited access to services, few educational and career opportunities, and isolation. These challenges may be compounded by the stress and financial strain of pregnancy. Women from rural areas experience both physical and social challenges in access to care, though health behaviors perpetuated by low health knowledge and community services and support may be more important in determining perinatal outcomes.(16-18) Traditional attitudes towards women in the home, workplace, and education may promote early childbearing and maintain low educational attainment or employment in rural areas.(19-21) The joint effects of high poverty and low educational attainment contribute to the continuing high rate of births to adolescents in rural areas in spite of significant successes in reducing the overall adolescent birth rate in the United States.(22, 23) Rural teen mothers may be at increased risk of poor perinatal outcomes when compared to urban peers due to low social support and inadequate access to services.(24, 25)

The prevalence of alcohol and non-prescription opiate abuse in Appalachia, as well as rising heroin and methamphetamine abuse, and frequency of drug overdoses may also create low social support and increase community or family stress.(26) Furthermore, populations in areas with mineral extraction are exposed to environmental toxins that correlate with increased rates of low birth weight and early mortality.(27-29) In the largely rural Appalachian community poverty, increasing substance abuse, and environmental degradation combined with underdevelopment and rugged terrain have detrimental impacts on health.

The Appalachian region, described here using the area defined by the Appalachian Regional Commission (ARC), has historically had high poverty populations and low economic opportunity. According to the ARC the Appalachian region includes portions of Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania,

South Carolina, Tennessee, Virginia, and West Virginia.(30) Appalachia is not a homogenous region and varies by dominant industry, degree of rurality, and social composition. Health disparities have been described between Appalachian and non-Appalachian areas of states containing one or more Appalachian counties.(16, 26, 27, 31) Appalachian residents have higher rates of risk behaviors than their non-Appalachian in-state counterparts, including smoking, high caloric intake, sedentary lifestyle, and earlier initiation of sexual activity.(32)

The Appalachian Regional Commission (ARC) annually ranks all Appalachian counties on economic health using the three year average unemployment rate, per capita market income, and poverty rate as compared to national averages. The results are used to create a 5 level indicator of economic status, ranked Distressed, At-Risk, Transitional, Competitive, and Attainment.(33) In a study that made comparisons between Appalachian and non-Appalachian women as well as within the Region, Appalachian women living in Distressed and At-Risk counties had poorer preconception health than those in better off counties. Overall, Appalachian women had poorer preconception health than those in non-Appalachian counties.(31) Given the well-documented relationship between maternal health and perinatal outcomes(34-36), the preconception health status of Appalachian women is expected to have a negative impact on perinatal outcomes.

The purpose of this research is to assess births in the Appalachian region between 2006 and 2011 for evidence of heterogenous presentations of accelerated aging, as indicated by the age-specific risk of low birth weight by county economic status. The primary objective of this study is to assess the interaction of age and ARC ranked county economic status as predictors of risk of LBW. The secondary objectives of this analysis are to assess the age distribution of births across levels of county economic status and between Appalachian and non-Appalachian counties. This analysis will provide evidence to support maternal health interventions in the Appalachian region and promote further research into maternal health in rural areas. This study is the first attempt to assess accelerated aging by socioeconomic status in a primarily rural region.

Review of the Literature

Accelerated Aging

Accelerated aging describes trends in risk for and the development of disease. This may vary due to social disparities in stress exposure. For this study, assessing trends in LBW by age across strata of county economic status will describe the points of least and most risk for each group county economic status and suggest population health trends. The embodiment, or the physical impact of psychosocial stressors that occur throughout the life course are labeled accelerated aging. Allostatic processes include the physiologic response to stress and the regulation of that response through positive and negative feedback loops. Over time and through repeated stress exposures an 'allostatic load' builds up in the body, leading to chronic health conditions such as cardiovascular disease and diabetes. (37) Increased allostatic load is hypothesized to cause accelerated aging, which leads to early onset of chronic disease and early mortality.

Studies investigating population patterns of accelerated aging can indicate the point at which the lowest or highest risk of perinatal outcomes occur, and may also support evidence of variations in fertility timing. Births are expected to occur at a point in a woman's life when her health is at or near a peak, and births that occur too early or too late may have poorer outcomes.(38) For example, black women under the age of 20 have significantly lower infant mortality than black women aged 20 and older, while the opposite is true in most white populations. It is possible, in black populations, that the risks of early childbearing are lower than the risks of later childbearing when there has been greater exposure to stressors and a greater chance of chronic health conditions or early mortality. (39) It is also possible that the populations are inherently different and self-select into early childbearing or later childbearing based on a

variety of social factors. Allostatic load may influence the timing of childbearing either through a variety of social pressures or through limiting the fertility of older women in these populations.

Social factors, such as community make-up, educational status, poverty, and other patterns may also play significant roles in patterns of accelerated aging. These elements are collected under the title of the weathering hypothesis. Research by Geronimus has linked chronic disease and disability among older generations to early childbearing within African-American communities.(38) Alternative explanations of accelerated aging demonstrated by perinatal outcomes include cohort effects, changing medical practice over time, and regional variations.(40-43) Studies assessing the effects of age, maternal cohort, and birth time period have found slight or nonexistent cohort effects but strong time-period effects.(40, 42) This suggests that accelerated aging as measured by perinatal outcomes, such as infant death or preterm birth, may be influenced by changing medical practice. Epigenetic factors transmitted within families have also been suspected as leading accelerated aging, but, generally, psychosocial, environmental, and poverty-related factors are more important in describing family or population variation in perinatal outcomes.(44, 45) Measurement of accelerated aging provides important information about population health and the impacts of stress, poverty, and community well-being on health trends.

The Weathering Hypothesis

This study will be a test of the weathering hypothesis as it will demonstrate the ways in which "a woman's health reflects the cumulative impact of her experiences from conception to her current age."(39) The weathering hypothesis asserts that experiences of stress, discrimination, and limited opportunity over the life course will cumulatively accelerate aging, in other words, leading to weathering. The weathering hypothesis has been used to describe the incidence of low

birth weight (<2,500 grams) and preterm birth (<37 weeks gestation), both of which have age-related patterns, across neighborhoods, socioeconomic strata, and, most commonly, race.(5, 46-48) Geronimus has proposed that living in a high poverty area and experiencing chronic psychosocial stressors leads to increasingly poor health outcomes as individuals age.(14)

The weathering hypothesis was first proposed for the study of health disparities between racial and ethnic groups, with particular attention to perinatal outcomes. The weathering hypothesis has typically been applied to studies of racial and ethnic differences in pregnancy outcomes or health conditions by age to assess the impacts of institutional, structural, or systematic discrimination on health.(39) Studies of weathering have typically been conducted among urban populations though national studies have also found weathering effects. (14, 40, 48, 49) Region, including urban and rural identification, has been insufficiently studied as a factor in perinatal outcomes but data suggests that regional variation may play an important role in predicting preterm birth through access to care or environmental exposures.(13, 27, 43) Regional variation in population health may be due to geographical distributions of factors that promote or negatively impact health, such as environmental pollutants or drug trafficking within a community. Weathering is one hypothesis explaining observed patterns of accelerated aging with particular focus on racial/ethnic and economic disparities in health.

Health in Appalachia

There are historical, entrenched disparities in health, employment, and education between rural, urban, and suburban regions of the United States with suburban regions typically faring the best. Health risks vary by region, with urban areas having the highest homicide rates while rural areas have higher rates of death from motor vehicle crashes.(50) Health behaviors like smoking, high fat diet, and sedentary lifestyle persist in rural regions in spite of downward trends in urban

areas. This is due in part to the older average age of rural populations and low access to media and health literature.(51, 52) Adolescent pregnancy has remained high in rural areas in spite of a national decreasing trend, with a rate of 43 births per 1,000 in rural teen girls between the ages of 15 and 19, and a rate of 33 per 1,000 in teen girls in the rest of the country.(23) Access to specialty care and mental health services are limited, particularly in rugged areas with small, isolated communities.(16-18, 26, 53) Adolescents, in particular, face unique challenges in accessing care, including fears about confidentiality and privacy.(16) These challenges in access to care and changes of behavior are also influenced by poverty and low access to educational or career opportunities.(54) Many of the challenges faced by the diverse population of Appalachia are similar to those experienced by other rural populations, though direct comparisons in the literature are rare.

Those living in Appalachia commonly experience low insurance coverage and poor access to healthcare, which results in a variety of health disparities between Appalachian and non-Appalachian regions, and across socioeconomic strata within the region.(16) For those under age 75 living in the Appalachian region premature mortality was estimated to be 19% higher than in the rest of the United States.(16) Substance abuse, particularly of alcohol, tobacco, opiates, and synthetic drugs, is higher in Appalachia than in the rest of the United States, and are highest in areas that are categorized as economically Distressed by the ARC or that have coal mining as a primary industry.(26) Drug and alcohol use, tobacco use, and a high calorie diet paired with a sedentary lifestyle have serious implications for physical and mental health as well as perinatal outcomes.(32, 55) Data on maternal smoking before, during, and after pregnancy from 2000-2010 indicates that the prevalence of smoking increased for all 3 measures in West Virginia and Mississippi while it decreased for all three measures in New York and remained mostly unchanged in all other Appalachian states.(56) A recent study of Appalachian women's preconception health indicators found that they had low education, poor healthcare coverage and use, high smoking and alcohol consumption, poor diet and exercise habits, and high rates of

chronic diseases compared to non-Appalachian women. Women in counties classified as economically Distressed had poorer preconception health indicators than Appalachian women in Attainment counties.(31) A study of Appalachian women in Tennessee found that inadequate prenatal care, symptoms of depression, and attitude towards the current pregnancy predicted preterm birth before 37 weeks gestation.(12) These studies, though typically not conducted during the perinatal period, suggest overall poor health among adults in the Appalachian region and potential accelerated aging due to environmental, psychosocial, and physical stressors. Currently there is not a significant body of work assessing maternal health in Appalachian women, and very few studies have analyzed women's health across the whole region.

The distribution of county economic status types varies across the Appalachian region, and some types are concentrated in certain states or parts of the region. Most Appalachian states include at least one Competitive or Attainment county except for Ohio, Kentucky, Tennessee, and North and South Carolina (See Figure 1). The most Northern areas-- New York, Pennsylvania, Maryland, and Northern Ohio-- contain mainly Transitional and Competitive counties. Distressed counties are concentrated in central Appalachia—West Virginia, Ohio, Kentucky, Tennessee—with a few in the Southern states like North Carolina, South Carolina, Alabama, and another large concentration in Mississippi.(33) At-Risk and Distressed counties are typically more rural than Competitive and Attainment counties, which are more urban or suburban. Distressed and At-Risk counties are typically more racially and ethnically homogenous, with one study reporting white female populations reaching 86% in Distressed counties and 93% in At- Risk, but only 74% in Attainment counties. The same study found that annual income was significantly lower in Distressed counties than among Attainment counties: 21% of women in Distressed counties had an annual income below $15,000 and 18% had an annual income at or above $50,000. In Attainment counties only eight percent of women had an annual income below $15,000 while 45% had an annual income at or above $50,000. Women in Distressed counties are younger than women in other counties; 26% were between the ages of 18 and 25 while only 21% of women in

Attainment counties were below the age of 25. Women in At-Risk counties are, on average, older than women in other types of counties, with 46% between the ages of 35 and 44, while only approximately 40% of women in Distressed, Transitional, and Competitive counties were age 35-44.(31)

Relevance of Births to Adolescents

The National Campaign to Prevent Teen and Unplanned Pregnancy found that the rural teen birth rate is much higher than in urban areas, 43 births per 1,000 girls age 15 to 19 as compared to 33 births per 1,000 in more highly populated areas. The rural-urban difference is much greater in older teens, ages 18 to 19, with 75 births per 1,000 teen girls in rural areas and 58 births per 1,000 in large, central metropolitan areas, though these statistics are tempered by the much larger adolescent population in urban areas.(23) In a 2012 analysis of teen births the National Center for Health Statistics found that three Appalachian states had birth rates for girls age 15 to 19 that were lower than the national average, and seven states had teen birth rates well above the national average of 35 per 1,000. Of the 14 states across the nation with birth rates above 40 per 1,000 teen girls age 15 to 19, half were in the Appalachian region. Mississippi had one of the five highest teen birth rates. West Virginia was one of only three states did not see a significant decline in teen births between 2007 and 2010.(22) These differences highlight issues with poor transportation access, informational infrastructures, availability of reproductive services, and patient-provider confidentiality that are challenges for rural teens and adults.(25)

Births to adolescents are an important component of the current body of literature on weathering as the hypothesis explains some of the disparity in perinatal outcomes among black and white adults and adolescents. Accelerated aging, particularly through the lens of the weathering hypothesis, may explain why black adolescents typically have better birth outcomes

than their adult counterparts, while white adolescents typically have worse perinatal outcomes than their adult counterparts.(5, 8, 48) Populations that experience high deprivation or many threats to health may shift the timing of fertility to an earlier age to compensate for the negative impact of accelerated aging on adult births.(38) Furthermore, the social or familial pressures that contribute to socially sanctioned pregnancy timing are products of the economic and health experiences of that community. Early pregnancy in Appalachia may serve to reproduce gender roles, determining access to work and educational opportunities for young women and contributing to low educational attainment and earning potential. Furthermore, these gender roles may influence use of prenatal care services, patterns of illegal drug and alcohol use, and the financial stability of families.(19) In this way, evidence of earlier childbearing and lower risk perinatal outcomes during adolescence or the early twenties as compared to later in life may be an effect of accelerated aging in the Appalachian population. These differences in risk occur because of accelerated aging, not because of protective factors. Weathering may explain this population trend differences in comparisons of low income and high income Appalachian communities.

Low Birth Weight as an Indicator of Maternal Health

Low birth weight infants are known to experience a variety of health risks both immediately after birth and later in life. A variety of maternal exposures are associated with low birth weight. Birth weight frequently occurs in conjunction with preterm birth but it does not suffer from the measurement challenges of gestational age, which may be incorrect due to inaccurate recollection of last menstrual period or incorrect developmental estimates.(1) In a study of German estimates of births that were small for gestational age or large for gestational age using gestation and birth weight charts 5% of neonates were misclassified because age was measured by completed weeks of gestation.(57) A study also assessing misclassification of small

for gestational age births found that, after correcting gestational age assessments by an average of 1.5 weeks, small for gestational age cases increased by 12% and preterm delivery decreased by 8%.(58) The etiology of is not as clear though there are many promising theories about the roles of inflammation, stress, and hormone pathways in contributing to preterm birth. Infection, inflammation, and stress have also been studied as potential important factors contributing to population disparities in preterm birth. (59) These perinatal outcomes are significantly associated with socioeconomic factors, maternal smoking, and stress.. Smoking is also significantly associated with low birth weight but interacts with socioeconomic status, a more consistent predictor of poor perinatal outcomes in developed nations.(60, 61)

Several studies have assessed accelerated aging and low birth weight, typically through comparisons of race and socioeconomic status. These studies are usually conducted within one community or one state.(2, 5, 6, 8, 18, 46, 62) Rates of low birth weight have been demonstrated to vary significantly across the United States, with clustering of high rates in Southern, Midwestern, and plains states as well as in parts of the Southwest. Northeastern, West Coast, and both Northern and Southern central states have lower than average rates. (43) A broader regional view may bring into perspective some of the intra-state and interstate heterogeneity of birth weight. A review of the literature on perinatal outcomes and infant mortality rates across Western Europe and the United States also found heterogeneity in all outcomes between these nations, though the United States had the highest rates for all outcomes of interest. The authors noted within country variations in outcomes described in the literature suggest that the variation seen regionally in the United States has correlates, though perhaps not as dramatic, within other developed nations.(61)

Gaps in the Literature

The literature on weathering that compares black and white American women is extensive and well developed. Stress and health outcomes have been assessed in other racial and ethnic groups, though not as extensively as among African-Americans.(63, 64) Additionally, only one test of weathering has been conducted among Hispanics.(46) The focus on racial disparities has provided valuable evidence of entrenched racial disparities in perinatal outcomes while also highlighting the impact of poverty through the analysis of income, job type, education, and reliance on government assistance for housing, food, and insurance. Poverty is a root cause of these disparities. Historically low income and low opportunity populations have reduced access to opportunities and worse health across the life course and, outside of improving economic status, nothing will change that.(65, 66)

Describing population trends in low birth weight across the whole Appalachian region will build on recent work by Short, et al, [30] and Jesse, et al [11] analyzing preconception health and perinatal outcomes, among others.(67) Furthermore, the Appalachian Regional Commission has identified "clear geographic disparities in premature disease mortality" (68), however, the reports have focused on premature all-cause, heart disease, cancer, and stroke mortality. In addition to elaborating the relationship between socioeconomic status and health in the Appalachian Region, testing the weathering hypothesis in a unique rural population will provide evidence on the translation of a concept based on racial health disparities to one based on socioeconomic health disparities. By analyzing accelerated aging this study will highlight the effects of socially and individually mediated exposures and health behaviors on the well-being of a rarely studied population.

Methods

Study Population

The population of interest includes women aged 15 to 45 who have had live birth between the years 2006 and 2011 and who were residents of an Appalachian county when the birth occurred. The Appalachian region includes part or all of 12 states: Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and West Virginia.

Data Sources and Predictors of Interest

Low birth weight, the outcome of interest, was analyzed across county economic status, a five-level schema measure calculated using a measurement schema comparison of three county economic indicators to the national average. The three indicators include the three-year average unemployment rate, per-capita market income, and poverty rate. The five levels of county economic status are Attainment, Competitive, Transitional, At-Risk, and Distressed. Attainment counties are within the top 10% of the economy, while Competitive counties are between the top 25% and top 10%. Transitional counties comprise the middle 50%, At-Risk counties are between the lowest 25% and lowest 10%, and Distressed counties comprise the bottom 10%.(69)

Predictors drawn from the National Vital Statistics System (NVSS) 2006 to 2011 natality file include state and county of residence at birth, state and county of birth occurrence, population size of county of residence, maternal age, gestational age, birth weight, maternal education,

month of prenatal care start, number of prenatal care visits, parity, smoking status before and during pregnancy, plurality, and maternal race/ethnicity.

Data Preparation

A total of 7,903,086 births occurred in states that were part of the Appalachian region, but only 1,440,753 were retained for analysis. Births were eliminated from the sample due to missing information about county of residence (30 births), occurring in non-Appalachian counties (6,332,708 births), plurality (48,203 births), missing or implausible birth weight, including those weighing less than 500 grams (3,925 births), and for missing maternal education information (77,467 births). All births from Alabama, Mississippi, Virginia, and West Virginia were missing maternal education information for the year 2011 due to federal data collection practices. Ninety-six percent of the sample was retained for analysis. Of these births only 1,518,250 occurred in Appalachian counties, and 94.9% of those births were retained for analysis. A portion of the analysis focused exclusively on white women in the Appalachian region (1,131,228 births).

Two versions of the U.S. Standard Certificate of Live Births, referred to here as the birth certificate, were available during the time period of interest: the 1989 version and the 2003 revision of the birth certificate. A total of 35.3% of all births in states containing Appalachian counties, and 33.9% of births in Appalachian counties, were recorded on the 1989 version of the birth certificate. Four states used only the 1989 version of the birth certificate during the study period: Alabama, Mississippi, Virginia, and West Virginia. Three states transitioned from the 1989 birth certificate to the 2003 revision during the study period, Georgia, Kentucky, and North Carolina. Other states used the 2003 version of the birth certificate throughout the whole study period.

Several variables of interest were not equivalent between the 1989 and 2003 birth certificate revisions and required recoding and combination. Variables of interest were assessed for plausibility and frequency of missing data and several issues arose. Categories of race and ethnicity from the 2003 version were collapsed to fit the more limited levels used by some states on the 1989 version. The 1989 version did not allow for the "bridged multiple race" option, and did not differentiate between single race and multi-racial individuals. The grouped years of education, recorded on the 1989 birth certificate, were used to categorize the different levels of education on the 2003 revision birth certificate. The month of prenatal care start variable was recoded to create an equivalent variable between the two birth certificate versions and afterwards prenatal care start and the number of visits variables were used to create an adequacy of prenatal care use (APNCU) variable using Kotelchucks' proposed calculation. The APNCU was calculated using the month of prenatal care start, number of visits, gestational age, and birth weight to classify prenatal care use into five levels—missing, inadequate, intermediate, adequate, and adequate plus.(70)

Low birth weight was recoded into a dichotomous variables for clarity. Smoking was also recoded to a dichotomous variable, ever smoker or never smoker during pregnancy, from the different assessments of smoking used on the revised and unrevised birth certificates. The certificates both collect data on the number of cigarettes smoked per day in the unrevised version and per trimester in the revised version, as well as any tobacco use. Other required variables were equivalent between the two versions of the birth certificate.

County economic status data was drawn from Appalachian Regional Commission reports from the years between 2006 and 2011. To create the county status identifiers, state identifiers and county federal information processing standards (FIPS) codes were matched. By matching state and county codes between the two data sets county economic status levels could be applied to the birth counties by year.

Data Analysis

The data was prepared, managed, and analyzed using Statistical Analysis Software (Carey, NC). Descriptive statistics, including percent of births and means were calculated by county status, race, education level, maternal age, low birth weight, preterm birth, adequacy of prenatal care use, parity, marital status. Chi Square tests were used to assess the significance of differences in demographic characteristics of the population of interest.

A General Estimating Equations (GEE) model was used to conduct multivariable logistic regression while controlling for the correlation caused by grouping individuals by county. The main predictor of interest was the ARC ranked county economic status, with Attainment as the reference category, and the outcome of interest was low birth weight. Four types of GEE models were run for the whole Appalachian population and for white, black, Asian, and Hispanics separately. These included a model containing only main effects, Model 1, a model containing the main effects and parity, marital status, and APNCU, Model 2, a model that adds smoking, Model 3, and one containing all predictors, Model 4. These models were analyzed for comparisons of low birth weight and age trends by race, though only births to white women were used for further analysis due to time constraints. Births to white women are presented with the addition of a single predictor to the main effects and with the addition of two predictors to the main effects model. Models controlling for only main effects, main effects and another predictor, and main effects and two predictors were assessed for all variables of interest to determine which attenuate and which exacerbate the relationship between county status and low birth weight.

Two types of figures were created to visually describe the data: model-predicted, age-specific risk of low birth weight describing the changing risk of low birth weight across the reproductive years and a set of kernel density plots describing the distribution of births by maternal age. These figures are complementary ; they present both trends in fertility timing and

trends in risk of low birth weight among Appalachian women. Figures are presented for both overall births to white women and for only first births to white women, or births to nulliparous women. To simplify visualization of the data, and because of similar trends, Distressed and At-Risk counties were combined in to one category, Low Socioeconomic Status (SES), Transitional counties were renames as Mid SES, and Competitive and Attainment counties were combined into a High SES group.

Results

Descriptive Statistics

The majority of births, 63.9% (n=969,706) occurred in Transitional counties while the fewest births occurred in counties labeled Distressed, 2.5% (n=38,411) (See **Error! Reference source not found.**). Attainment and competitive counties had the greatest percentages of low birth weight births, 7.1% and 8.2%, respectively. Attainment counties had the oldest mean maternal age, 28.0 (sd=6.0), and the highest mean birth weight, 3,291 grams (sd=580). In contrast, Distressed counties had both the youngest maternal age, 24.7 (sd=5.5) and the lowest mean birth weight, 3,240 grams (sd=516). Transitional counties had the second highest birth weight, 3286 grams (sd=546).

In Distressed counties 37.0% of births were to women between the ages of 20 and 24, while in Attainment counties only 22.5% of births were to women in this age range (See **Error! Reference source not found.**). In Attainment counties a larger percentage of births were to Hispanic women, 23.0%, than to non-Hispanic black women, 17.3%. The least racially diverse counties were those in the Distressed category, where 86.5% of births were to non-Hispanic white women and only 8.3% were to non-Hispanic black women. Six point nine percent of births in the Appalachian region were low birth weight. Transitional counties had the greatest percentage of low birth weight births, 8.2%, while the lowest percentage was in At-Risk counties, 6.4%. Preterm birth followed a similar pattern to low birth weight.

Only 27.5% of births in the Appalachian region occurred to women with a college degree, while 30.7% were high school graduates. Competitive counties had the highest percentage of births to women with a college degree or a higher level of education, 37.5%, while only 13.0% of births in Distressed counties were to women with a college degree or a higher level

of education. Women in Competitive counties had the highest percentage of Adequate prenatal care use, 26.0%. Women in Attainment counties had the largest percentage of missing information, 24.6%, while women in At-Risk counties had the lowest percentage of missing prenatal care information, 2.2%. Overall, in Appalachian counties 21.2% of women reported ever smoking during pregnancy. Within the Appalachian region there was variance in the percentage of women who reported ever smoking during pregnancy between county economic status levels, ranging from 10.9% in Attainment counties to 34.4% in Distressed counties.

Among white women in the Appalachian region there were few evident differences from the overall population (See Table 3). Age distributions did not change markedly, though differences between low income and high income counties increased slightly in the white population. The overall prevalence of marriage increased, from 59.5% in the total population to 64.4 in the white population. Women in Attainment counties had a marked increase in college degrees compared to women in Distressed counties, 43.0% versus 13.6%. Smoking increased in all counties in white women compared to the overall population. In Attainment counties 13.9% of women in the white population smoked while only 10.9% of the overall Appalachian population smoked. In Distressed counties, white women smoked more than the overall population as well, 38.5% versus 34.4%.

Models

In models estimating the odds of low birth weight by county strata for all Appalachian counties, with Attainment counties as the referent, women in Transitional, At-Risk, and Distressed counties had decreased odds of low birth weight (See Table 4). In the main effects model, Model 1, and the Model 2, none of the results were significant for the overall population. In Model 3, which added smoking, the odds of low birth weight were 26% lower (95% CI 0.56-

0.98) in Distressed counties as compared to Attainment, and in At-Risk counties the odds of low birth weight were 31% lower (95% CI 0.56-0.85). Women in transitional counties also demonstrated decreased odds of low birth weight compared to women in attainment counties, OR 0.77 (95% CI 0.62—0.95). Model 4, which added education, demonstrates a similar but more pronounced trend in decreased odds of low birth weight among low income counties.

The results of the models varied across racial and ethnic groups, with white, Asian, and Hispanic women demonstrating changing odds of low birth weights as variables were added to the model while the odds for black women remained non-significant in all models. White women demonstrated a similar trend in Model 3 and Model 4 of decreased risk of low birth weight among Transitional, At-Risk, and Distressed counties and non-significant results among Competitive counties. The ORs among the three lower risk counties were closer together than they were in the overall model. There appears to be no relationship between county economic status and odds of low birth weight among black women in the Appalachian region. The results from all models for black women were non-significant. Asian women in Distressed counties experienced the greatest risk of low birth weight when compared to women in Attainment counties with an OR of 2.46 (95% CI 2.33—2.60). Asian women demonstrated a stronger trend of decreased odds of low birth weight with decreasing county economic status than any other racial or ethnic group, with the estimate for women in Distressed counties being 0.42 (95% CI 0.20-0.88) in Model 4. Asian women in At-Risk counties had significantly lower odds of low birth weight compared to women in Attainment counties in every model, while the results for women in Distressed counties only became significant after smoking was added in Model 3. Hispanic women in Distressed and A-Risk counties had decreased odds of low birth weight in every model, except for Model 3, where women in At-Risk counties had a non-significant result, OR 0.54 (95% CI 0.66-1.04).

To further explore the impacts of predictors like educational attainment, the adequacy of prenatal care use, parity, marital status, and smoking on the odds of low birth weight by county

economic status, the model of only white women was modified by adding single variable and two variable combinations (See Table 5). Controlling for smoking was the only change that led to significantly reduced odds of low birth weight in Distressed and At-Risk counties compared to Attainment counties. All other single or bivariate combinations were non-significant, except for marital status and education, which resulted in an OR of 0.76 (95% CI 0.59—0.98) for women living in At-Risk counties. Women living in At-Risk counties typically had the lowest odds of low birth weight, though women in Distressed counties were close behind. Women in Transitional counties also demonstrated a significant decrease in odds of low birth weight compared to women in Attainment counties when smoking was added to the model. The model with the greatest magnitude of association between low birth weight and county status contained smoking and education and resulted in an OR of 0.65 (95% CI 0.50—0.85) for Distressed counties, and an OR of 0.64 (95% CI 0.53-0.78) in At-Risk Counties, and an OR of 0.72 (95% CI 0.60—0.87) in Transitional counties. Models containing education approached significance in the single variable model, as well as in the model containing parity, though only in the models also containing marital status and smoking were results actually statistically significant.

Age-specific Risk of Low Birth Weight

Trends in the risk of low birth weight by maternal age vary between county economic status levels. Due to the similarity of the two lowest groups and the two highest groups, and to simplify visualization of the data, county economic status has been plotted in three levels rather than five. The Low SES group corresponds to women from Distressed and At-Risk counties, while the High SES group corresponds to women from Competitive and Attainment counties. The Mid SES group is equivalent women in Transitional counties.

When the model-predicted, age-specific risk of low birth weight for all white women in the Low SES group had the lowest risk of before the age of 28, after which their risk of low birth weight increases (See Figure 2). Women from Mid SES counties had the lowest model-predicted risk of low birth weight at age 30, as well as the lowest nadir of all the groups. Women from High SES counties had the lowest risk of low birth weight at age 32, and at younger ages they had a much higher risk of low birth weight than either of the other two groups.

The kernel density plots describe the density of births in a particular population across the age span of women in the Appalachian region. Contrasting the risks of low birth weight described in Figure 1 to the kernel density plot (See Figure 3), the bulk of the births in each category occurred at an age close to the lowest point of risk on the risk curves. Births to women in Low SES counties peaked at age 20 and had a long right tail. Women in Mid SES counties fall between women in High and Low SES counties, with the weight of their data sitting at age 28. Finally, women in High SES counties had a first group of births at age 20 followed by a second, much larger group at age 30, closer to where the nadir is on the graph.

When limited to first births, the age-specific risk of low birth weight increase for all economic strata, with even the lowest point of risk rising to above 6.0% (See Figure 4). Women in the Low SES group had the lowest overall risk of low birth weight at age 24, but by at age 35 their plot crosses over the others and they had the highest risk of low birth weight. Women in the Mid SES group experience their lowest risk of low birth weight at age 26, and women in the High SES group have the oldest age at the nadir, 29.

The second kernel density plot, which describes the distribution of first births in the three SES categories (See Figure 5), demonstrates a similar, but more extreme, patterns than the first density plot, presented in Figure 2. The bulk of births occurred at approximately age 20, though the High SES population demonstrates a distinct, bimodal pattern with a second, larger peak of births at age 30. Almost the entire weight of births in the Low SES county population at age 20, and the right tail is shorter than in Figure 2. The peak of the Mid SES plot sits at approximately

age 20, though it is flatter than the peak for the Low SES group. A second group of births in the Mid SES population is evident at approximately age 30.

When smoking is added to the main effects model, the predicted age-specific risks of low birth weight become more distinct and there are fewer overlaps or crossovers (See Figure 6). Overall, the risks have dropped compared to those presented in Figures 2 and 4, and all the nadirs sit below 6.0%. Risk of low birth weight by age for the Low SES population drops below that of either other population, and the age of lowest risk rises to nearly 27. The High SES group remains above the Mid SES group until after age 40, at which point the risk in the Mid SES group rises and crosses the High SES plot.

The predicted age-specific risk of low birth weight, using Model 2, which controls for parity, marital status, and APNCU, the age of lowest risk for the Low SES population drops to 15, while the age at the nadirs for other groups remain consistent with the risks presented in previous figures (See Figure 7). The risk of low birth weight among Low SES women rises in a nearly flat line from 1.3% to 1.9%. The nearly flat line of the Low SES risk plot is distinct to Model 2. The risks are also much lower, in general, than demonstrated in other graphs. In Figure 7 the nadir of the High SES population is 1.6%, while in in Figure 2 the nadir sits at 5.9%.

When using Model 3 the predicted age-specific risk of low birth weight across county economic strata the plotted risks are distinct and there is evidence of a more rapid increase in risk with increasing age (See Figure 8). Overall, the risks do not increase compared to those described in Figure 6, but the plotted risks do not overlaps, though the Mid and Low SES groups come close. Between Figure 7 and Figure 8, the age at the nadir of the Low SES plot increases from age 15 to age 20, which is consistent with other figures. The age at the nadirs for the Mid SES and High SES groups drop to 24 and 27, respectively. Overall, in Figure 8, the overall ages of lowest risk are younger than in other figures and the plotted age-specific risks are also the lowest.

Discussion

Demographics

The demographics of women in the Appalachian region vary significantly across county economic status. Women who had a live birth in lower income counties— Distressed, At-Risk, and Transitional counties—were younger and less racially diverse than women in higher income counties—Attainment and Competitive counties. Similarly, the majority of women in low income counties had attended at least some high school, but did not have further education. In high income counties, the majority of women had attended or graduated from college. Taken together, these facts suggest that mothers in lower income Appalachian counties have fewer career or educational opportunities than women in higher income counties.

In all counties, first births were in the minority. In Distressed counties, 60.5% of women were multiparous, while other counties had slightly more nulliparous women. Distressed counties also had the youngest population of mothers, suggesting that many of these women had their first birth at a young age, which reflected in the leftward shift of the age-specific risks in **Error! Reference source not found.** and**Error! Reference source not found.**. Women in Distressed counties also had the greatest proportion of "Adequate" prenatal care, followed by Competitive counties, while women in Attainment, Transitional, and At-Risk counties had higher frequencies of "Inadequate" prenatal care. This may be a result of missing or inaccurate information in other areas where women may have more options for prenatal care. Limited availability of health services in low-income counties, and perhaps reliance on public insurance programs, may improve record keeping at prenatal visits.

Smoking demonstrated a trend of increasing prevalence with decreasing county economic status. Women in Attainment counties had the lowest prevalence of smoking, 10.9%, while women in Distressed counties demonstrated the highest prevalence of smoking, 34.4%. This level of smoking is consistent with the findings of a study on preconception health in the Appalachian region, which found similar trends in smoking across county economic strata.(31) A previous study also found that smoking was strongly associated with low birth weight in a sample of rural, low income women seeking prenatal care in Tennessee.(18) In the sample containing only white women, smoking increased for all populations when compared to the overall sample, indicating that rural white women are a target population of interest for smoking cessation interventions. Smoking is a modifiable behavior, opening an avenue to improve health overall health and reduce low birth weight in these communities. In the low income counties with high rates of smoking, few women in the final sample were missing data on smoking while in Attainment counties 35% of women who had a live birth were missing information on smoking, which brings into question the impact of smoking on the relationship between county economic status and low birth weight.

As white women comprised the vast majority of the Appalachian population, it is no surprise that there were few changes in descriptive statistics when they were selected out for analysis. Some aspects increased, including marital status and educational attainment, but disparities remained between the low and high county economic status strata. The proportion of births that were low birth weight did not change, but preterm births did decreased slightly in the sample of white women. The reduction in preterm births may be due to removing populations with high rates of preterm birth, but the lack of change in low birth weight suggests that, in the Appalachian region, race may not be as influential as other factors. This is evidenced again by the results of the models presented in Table 4.

Models

The results from the models assessing the relationship between county economic status and low birth weight as modified by low birth weight, race, marital status, education, parity, the adequacy of prenatal care use, and smoking do not support the hypothesis that the odds of low birth weight are higher in counties with lower economic status. However, by stratifying the models by race and ethnicity both general trends and population-specific trends in the relationship between county status and low birth weight become apparent (See

).

Models containing the whole Appalachian population demonstrated decreased odds of low birth weight in the three lowest income county strata, and a non-significant OR in the Competitive strata when compared to Attainment counties. This trend is only evident after smoking is controlled for in Models 3 and 4. A large increase in the odds occurred for most populations in Model 3, when smoking was added to the variables assessed in Model 2. In general, Model 4 presented the lowest odds of low birth weight, suggesting that a combination of factors mediate the relationship between county economic status and low birth weight. It appears

that education is an important factor in determining the odds of low birth weight for a particular population, but perhaps it is not the best descriptor of individual economic status.

Among white women both Model 1 and Model 2, women in Distressed, At-Risk, Transitional, and Competitive counties had odds of low birth weight that are not significantly different from the odds among women in Attainment counties. In Model 3 both At-Risk and Transitional counties demonstrate a statistically significant relationship with low birth weight. Again, the combination of smoking and education in the model results in a greater magnitude effect of county status on low birth weight than other models, suggesting that neither smoking nor education alone may accurately represent differences between the county strata populations. There are potential unmeasured factors represented, partially, by smoking and education that influence the odds of low birth weight and, if included, may result in a better representation of the relationship between county status and low birth weight.

Models describing the odds of low birth weight as a function of county economic status among black women were entirely non-significant, though they do demonstrate a trend of decreasing point estimates as more variables are added to the models. Black women in the Appalachian region were largely concentrated in Attainment, Competitive, and Transitional counties, but these county labels may not accurately reflect the economic health of the counties or communities where black women reside within Appalachia. Though there are significant health disparities between racial and ethnic groups within the Appalachian region, county economic status does not appear to reflect the health of black populations.(15) More specific area or individual measures may be necessary to assess the influences of county economic status on low birth weight in black Appalachian populations.

Asian women make up a small percentage of the overall Appalachian population, 1.6% overall, but they demonstrated strong trends in the odds of low birth weight by county economic status, and consistently significant ORs in At-Risk counties. This suggests that Asian women may be a particularly vulnerable population in Attainment counties, and that Asian women in

Distressed and At-Risk counties may have distinct life-course health experiences compared to their peers in higher income counties. Unlike white women, Asian women in Transitional counties had consistently non-significant odds of low birth weight. Asians were the only population to demonstrate a consistent increased odds of low birth weight among Competitive counties. Asian populations, and especially rural Asian populations in the United States, are not well represented in the literature but may experience health risks differently than other racial or ethnic groups in Appalachia.

Among Hispanic women the relationship between county economic status followed similar trends to those among white and, especially Asian women. Hispanic women in Distressed and At-Risk counties demonstrated consistently reduced odds of low birth weight when compared to their peers in higher income counties. Similar to Asian women, Hispanic women in Transitional counties did not experience a statistically significant reduction in the odds of low birth weight as more variables were added to the model. Hispanic and Asian women had much lower frequencies of smoking than white women, but adding smoking to the model still had a noticeable impact on low birth weight for both populations. This supports the idea that smoking may represent more than just cigarette consumption and may be closely related to an important but unmeasured factor. Similar to other non-white populations Hispanics were clustered in more urban county types, Competitive and Attainment. Hispanic women were the second largest population in Attainment counties, 27.6%.

Among white women, the addition of single and bivariate combinations to the main effects model (Model 1) demonstrates the importance of smoking and education in influencing the relationship between age, county economic status, and low birth weight (See

Table 5). In general models containing education or smoking demonstrated the strongest associations between low birth weight and county economic status. The measurement of APNCU was non-significant among women in Distressed counties in all models except those containing smoking or education, suggesting that this variable attenuates the relationship between county economic status and low birth weight. It is also possible that APNCU is not effectively measured using data from this collection of birth certificates or that it does not accurately represent the actual prenatal care habits of Appalachian women.

Age-Specific Risk of Low Birth Weight

There are evident variations in the relationship between county status and low birth weight in the figures describing model-predicted age-specific risk in all births to white Appalachian women (See **Error! Reference source not found.**). The variations in risk of low birth weight represented in the model-predicted age-specific risks suggests that age and timing of births influence perinatal outcomes, with women in the Low SES strata having reduced risk at younger ages than women in either the Mid SES group or the High SES group. Women in the High SES group had a reduced risk of low birth weight at an older age than women in the other categories. In the context of the distribution of births described in the kernel density plot in Figure 3 the ages at the nadirs of the model-predicted age-specific risks fit with ages when the greatest

number of births are occurring. Women from the Low SES group whose birth falls in the right tail may experience an increased risk of low birth weight, particularly if it is their first birth, as suggested by Figure 4. Women from the High SES group who give birth at approximately age 20 may also experience a significant increase in risk because this age is a point of high risk for these women. If women from High SES counties have their first birth before age 25 then they may also experience a large increase in risk of low birth weight, as described by Figure 4. The bimodal distribution of High SES women in the density plot of first births suggests that a portion of women who gave birth in High SES counties are not homogenous and, therefore, the risk plot may not actually represent the whole population.

The kernel density plots, in conjunction with the predicted age-specific risk of low birth weight, provide some answers to the secondary question of how fertility timing differs among Appalachian populations (See **Error! Reference source not found.**). The kernel density plot including all births to white women there is a rapid rise in births among women in the Low SES group, peaking between age 18 and age 20, and a long right tail. The Mid SES group experiences a similar, but less dramatic increase and births that plateau between age 20 and age 30. The apex of the Mid SES group sits between the peaks of the High and Low SES groups, though the increased variation in the Mid SES group suggests that this population is not as homogenous as the High or Low SES groups are. The High SES group experiences two increases in births, one occurring at age 20 and a second at age 30. The High SES group may be comprised of two distinct populations, one similar to the Low SES group where childbearing begins at approximately age 20, and one who delays childbearing until age 30. The variation in these plots suggest that even within the county status groups there is significant variation in fertility timing, and that more exact area and individual based measures of socioeconomic status and incomes are needed.

All three county groups experience a peak in first births at approximately age 20, but the Mid SES and High SES counties have a bimodal distribution and contain a second population that

has their first birth at an older age (See **Error! Reference source not found.**). The most dramatic of the first peaks is within the Low SES group, where the average age at first birth is 22. By age 30 first births in this population have dropped off to nearly 0 and trail off from there. This dramatic left shift demonstrates extremely early fertility timing, with many first births occurring before age 20. Potentially high teen birth rates may indicate an adaptive socio-cultural trend in early childbearing as has been suggested in other low income populations.(71) This trend may be protective against low birth weight because encourages births at the point of lowest risk and before the higher rates of disease and disability appear, which may occur earlier in these populations than in populations with delayed births. Both the Mid SES group and, to a greater extent, the High SES group experience a two peak trend in first births. Again, this indicates that there may be two or more distinct populations in these county groups who have two distinct trends in fertility timing. The Mid SES group, among whom the age at first birth is 24.01, has a similar peak to the Low SES group followed by another increase between the ages of 25 and 30. The High SES group experiences the most distinct two-peak pattern suggesting a form of internal stratification.

The model-predicted, age-specific risk of low birth weight varies by other factors, as well. Controlling for parity, marital status, and APNCU shifts the risk nadirs right, while controlling for only smoking shifts the nadirs left. The right shift may be due to the stability and health that may come with marriage or a second, as opposed to first, birth. The rightward shift of the nadir that occurs with smoking in the model may be due to the increasing prevalence of smoking as age increases. The varying population risks of low birth weight reinforce the heterogeneity of the Appalachian population, both by county economic status and other factors. Adding smoking into the model presented in Figure 6 makes the risk of low birth weight among the Low SES population more convex and more similar in appearance to that of other populations. Age-specific risks predicted by models containing smoking are the most suggestive of accelerated aging as demonstrated by the spread of the nadirs. The early age of lowest risk

among women who had a live birth in Low SES counties fits the weathering hypothesis as it appears that women in these counties experience accelerated aging in comparison to those in higher income counties. The change in the relationship between county status and low birth weight when smoking is added to the model indicates that smoking modifies the relationship, perhaps as a mediator of county economic status or as a confounder. Alternatively, smoking status may be representative of other health behaviors that influence perinatal outcomes. Women may experience accelerated aging in High SES counties, or even Mid SES counties, particularly in the segments of these populations have earlier fertility timing. Identifying these women in future studies will require both individual and community level data to accurately depict their situation.

Variations in fertility timing appeared to be influenced by county status or a related factor. It is also possible that populations are unequally distributed into counties of different economic status levels, leading to a larger grouping of women with early fertility timing in Distressed and At-Risk counties than in Transitional, Competitive, or Attainment counties. Counties with a low mean age at first birth also had low overall educational attainment, which may be linked to early births. Delaying births in these counties may actually increase the incidence of low birth weight because women in these counties experience a low risk of low birth weight at a similar age to their peak period of fertility. Further investigation into the childbearing trends among Appalachian women is needed to corroborate the results of this study.

Strengths and Weaknesses

This study is one of a very few studies to look at perinatal outcomes across the Appalachian region, and one of the first studies to assess the relationship between county status, age, and low birth weight in this population. By assessing patterns of age-related risk of low birth

weight and fertility timing patterns across the Appalachian region this study demonstrates the impacts of county economic status, an ecological variable, on maternal and infant health. Ecological variables apply the characteristics of a region to the individuals living in that area, whether or not they are an accurate representation of those individuals. By using multiple years of data, the impacts of annual variations in economic status are washed out and the effects of long-term county status are revealed. By dividing women by racial and ethnic categories, this study eliminates confounding by race and allows for a understanding of the impacts of county economic status on perinatal outcomes among a specific, low-income, white population. This is not to disregard the significant and important impacts of community economic status on women from other racial and ethnic groups, who also experienced significant, differently patterned variations in the odds of low birth weight across county economic status. The distinct patterns reinforce the importance of stratifying by county economic status, but also call for further individualized investigation.

Many studies focus on racial or ethnic health disparities, or health disparities among populations where race/ethnicity and economic status are closely aligned. Selecting out a white population with entrenched, historical poverty and economic disparities eliminated confounding by race and focused the analysis on regional economic health as a driving factor behind low birth weight. Accelerated aging has been thoroughly assessed as an aspect of racial health disparities, but economic status has not been as thoroughly analyzed. Finally, by describing variations in fertility timing and smoking behaviors this study demonstrates two points of leverage for implementing public health interventions within Appalachia, delaying pregnancy and reducing smoking. Smoking is much higher in the white population than in the overall population, as is the disparity in age at birth between the low income and high income counties. Further analysis of racial and ethnic differences in the relationship county economic status and low birth weight are needed to fully understand these relationships.

This study uses an ecological variable, county economic status, as a primary predictor. The county economic status measure does not account for all regional or individual variations in economic status, but does provide general insight into patterns of low birth weight in relation to economic strata of the Appalachian region. As is highlighted by models assessing the relationship between low birth weight and county economic status among black women, county economic status is not equally applicable to all racial and ethnic groups and a more refined, area-specific measure of economic status would be needed to analyze some relationships. Rural areas are distinctly challenging in that population size varies across counties it may be difficult to apply a smaller area measure of economic status to populations that dispersed. Another weakness of this study comes in the lack of individual-level measures of economic status. Though education has been demonstrated to be a strong predictor of low birth weight, the effects of educational attainment on perinatal outcomes may vary within different communities and populations.(2, 41) Furthermore, there may be limitations within birth certificate data due to missing information, particularly in prenatal care, smoking, and race, as well as missing education data for several states during 2011.

Conclusions

This study demonstrates the significant effects of county economic status on maternal health and perinatal outcomes in the Appalachian region. The odds of low birth weight varied across economic status as well as within racial and ethnic groups. When stratified by race and ethnicity, there were distinct variations in the relationship between county economic status and low birth weight. When the relationship between county economic status was analyzed including single and bivariate pairs of predictors among white women it became evident that smoking was an important mediator of the relationship. As smoking and other variables were included in the model, a pattern of accelerated aging appeared in which women living in low income counties experienced the lowest risk of low birth weight at age 20, while higher income women experienced the lowest risk of low birth weight at age 30. The results of this analysis are supportive of a weathering pattern among Appalachian women living in low income counties.

Fertility timing varied significantly by county economic status, which suggests that social, cultural, and resource-availability factors may be influencing adolescent birth rates and fertility timing. Women in Distressed counties typically gave birth before age 25, while women in high income counties gave birth after age 25. Fertility timing is evidently either influencing or influenced by county economic status or related variables. Improving economic health in Distressed, At-Risk, and Transitional communities may help to delay childbearing in high risk populations. As such, it is evident that addressing adolescent pregnancy is essential to improving perinatal outcomes and improving career and educational opportunities for women in the rural communities. Future research should focus more specifically on the relationship between county economic status, individual income, age, smoking, and perinatal outcomes in Appalachia.

Tables

Table 1. Distribution of Births, Maternal Age, and Birth Weight by County Status

	Total	Low Birth Weight	Mean Maternal Age, Years	Mean Birth Weight, Grams
	Percent	Percent	Mean (SD)	Mean (SD)
N	**1440753**	**99412**		
Attainment	7.3	7.1	28.0 (6.0)	3291 (579)
Competitive	19.0	8.2	27.4 (6.0)	3270 (597)
Transitional	63.9	6.5	26.2 (5.8)	3286 (546)
At-Risk	7.2	6.4	24.9 (5.6)	3256 (516)
Distressed	2.5	6.8	24.7 (5.5)	3240 (516)

County	Attainment	Competitive	Transitional	A-Risk	Distressed	Total

N	**99340**	**274587**	**926309**	**103177**	**37340**	**1440753**
Total %	**6.9**	**19.1**	**64.3**	**7.2**	**2.6**	
LBW %	**7.1**	**8.2**	**6.5**	**6.4**	**6.8**	**6.9**
Age						
Under Age 20	8.4	9.8	12.6	16.8	17.8	12.2
Age 20-24	22.5	24.1	30.3	36.2	37.0	29.1
Age 25-29	28.8	29.1	28.9	26.6	25.8	28.7
Age 30-34	24.8	23.6	18.6	13.7	13.1	19.5
Age 35-39	12.7	11.0	8.0	5.6	5.0	8.7
Age 40 and Over	2.8	2.3	1.7	1.1	1.2	1.8
Race or Ethnicity						
White	54.6	74.5	81.4	86.4	86.5	78.7
Black	17.3	14.1	8.9	9.3	8.3	10.5
Asian	4.9	2.3	1.3	0.6	0.6	1.6
Hispanic	23.0	9.0	8.2	3.7	1.7	12.9
Gestational Age at Birth						
Term	92.7	91.7	93.7	94.0	92.9	93.2
Preterm	7.3	8.3	6.3	6.0	7.1	6.8
Marital Status						
Married	66.5	61.9	58.8	54.3	56.2	59.5
Unmarried	33.5	38.1	41.2	45.7	43.8	40.5
Education						
No High School	6.1	3.4	5.1	4.4	7.0	4.9
Some High School	11.6	13.2	16.5	21.2	27.2	16.2
High School Graduate	27.0	25.7	31.7	37.3	34.5	30.7
Some College	20.5	20.1	20.9	21.0	18.3	20.7
College Graduate	34.8	37.5	25.7	16.1	13.0	27.5
Parity						
Previous Birth	59.5	57.3	58.5	58.5	60.4	58.4
No Previous Births	40.5	42.7	41.5	41.5	39.6	41.6
Adequacy of Prenatal Care Use						
Missing	24.6	4.0	5.4	2.2	2.9	6.1
Inadequate	46.5	35.7	44.4	50.9	37.3	43.2
Intermediate	3.0	4.9	5.6	5.4	8.4	5.4
Adequate	14.8	26.0	21.9	18.3	21.4	22.0
Adequate Plus	11.0	29.4	22.7	23.1	29.9	23.4
Smoking Status						
Non-smoker	89.1	84.2	77.9	70.2	65.6	78.8
Smoker	10.9	15.8	22.1	29.8	34.4	21.2

Table 2. Demographics of Births in Appalachian States by County Economic Status

Table 3. Demographics of Births in Appalachian States by County Economic Status, White Women

County	**Attainment**	**Competitive**	**Transitional**	**A-Risk**	**Distressed**	**Total**

N	**54020**	**203836**	**752027**	**89086**	**32259**	**1131228**
Total %	**4.8**	**18.0**	**66.5**	**7.9**	**2.9**	
LBW %	**6.3**	**7.3**	**5.9**	**5.9**	**6.5**	**6.2**
Age						
Under Age 20	6.7	7.9	11.7	16.3	17.8	11.3
Age 20-24	20.7	21.9	29.8	36.2	37.4	28.7
Age 25-29	30.1	30.1	29.4	27.0	25.7	29.3
Age 30-34	26.2	25.6	19.2	13.9	13.0	20.1
Age 35-39	13.4	12.0	8.2	5.6	5.0	8.8
Age 40 and Over	2.8	2.5	1.7	1.1	1.2	1.8
Gestational Age at Birth						
Term	93.3	92.6	94.3	94.5	93.5	93.9
Preterm	6.7	7.5	5.8	5.5	6.5	6.1
Marital Status						
Married	77.0	70.3	62.9	57.9	58.5	64.4
Unmarried	23.0	29.7	37.1	42.1	41.5	35.6
Education						
No High School	1.0	0.8	2.9	3.4	5.1	2.5
Some High School	8.2	10.2	14.8	20.5	26.9	14.5
High School Graduate	26.0	24.8	32.3	38.0	35.6	31.2
Some College	21.8	20.6	21.6	20.9	18.7	21.3
College Graduate	43.0	43.6	28.4	17.2	13.6	30.5
Parity						
Previous Birth	57.1	56.0	57.6	58.1	59.7	57.4
No Previous Births	42.9	44.0	42.4	41.9	40.3	42.6
Adequacy of Prenatal Care Use						
Missing	18.2	3.7	4.9	2.4	3.1	5.1
Inadequate	49.4	30.8	41.5	46.9	31.1	40.1
Intermediate	3.2	5.4	5.9	5.8	9.3	5.8
Adequate	17.2	28.4	23.6	20.0	23.2	23.8
Adequate Plus	12.1	31.8	24.1	24.9	33.3	25.3
Smoking Status						
Non-smoker	86.1	82.1	75.4	67.2	61.5	76.0
Smoker	13.9	17.9	24.6	32.8	38.5	24.0

	Model 1*	**Model 2****	**Model 3*****	**Model 4†**

	County Type	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Overall	Distressed	0.89 (0.66-1.19)	0.94 (0.71-1.26)	0.74 (0.56-0.98)	0.71 (0.53-0.94)
	At-Risk	0.83 (0.65-1.05)	0.84 (0.67-1.07)	0.69 (0.56-0.85)	0.67 (0.53-0.84)
	Transitional	0.88 (0.70-1.09)	0.90 (0.72-1.13)	0.77 (0.62-0.95)	0.76 (0.61-0.96)
	Competitive	1.15 (0.93-1.42)	1.18 (0.96-1.46)	1.06 (0.88-1.27)	1.06 (0.87-1.29)
	Attainment	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
White	Distressed	0.94 (0.68-1.29)	0.98 (0.69-1.39)	0.75 (0.56-1.00)	0.70 (0.52-0.94)
	At-Risk	0.86 (0.67-1.10)	0.87 (0.6-1.15)	0.70 (0.57-0.86)	0.67 (0.54-0.84)
	Transitional	0.89 (0.71-1.13)	0.91 (0.69-1.18)	0.77 (0.63-0.95)	0.75 (0.61-0.84)
	Competitive	1.16 (0.90-1.49)	1.19 (0.92-1.55)	1.06 (0.87-1.28)	1.05 (0.87-1.28)
	Attainment	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Black	Distressed	1.11 (0.84-1.47)	1.05 (0.82-1.34)	0.97 (0.80-1.19)	0.93 (0.76-1.14)
	At-Risk	1.02 (0.76-1.37)	0.96 (0.73-1.26)	0.89 (0.70-1.12)	0.86 (0.68-1.09)
	Transitional	1.15 (0.86-1.55)	1.13 (0.87-1.48)	1.05 (0.84-1.31)	1.02 (0.82-1.29)
	Competitive	1.24 (0.95-1.63)	1.25 (1.00-1.56)	1.13 (0.96-1.35)	1.13 (0.95-1.33)
	Attainment	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Asian	Distressed	0.46 (0.21-1.00)	0.47 (0.22-1.00)	0.42 (0.20-0.89)	0.42 (0.20-0.88)
	At-Risk	0.59 (0.39-0.88)	0.59 (0.38 0.90)	0.54 (0.35-0.82)	0.54 (0.35-0.83)
	Transitional	0.87 (0.76-1.01)	0.90 (0.76-1.07)	0.83 (0.68-1.00)	0.83(0.67-1.02)
	Competitive	0.99 (0.79-1.24)	1.04 (0.85-1.28)	0.94 (0.77-1.16)	0.96 (0.77-1.21)
	Attainment	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Hispanic	Distressed	0.59 (0.38-0.90)	0.67 (0.46-0.98)	0.61 (0.42-0.90)	0.60 (0.40-0.89)
	At-Risk	0.60 (0.44-0.80)	0.61 (0.44-0.84)	0.54 (0.66-1.04)	0.53 (0.37-0.75)
	Transitional	0.89 (0.79-1.01)	0.91 (0.80-1.04)	0.83 (0.66-1.04)	0.83 (0.66-1.04)
	Competitive	1.18 (0.98-1.43)	1.19 (1.00-1.43)	1.11 (0.87-1.40)	1.10 (0.87-1.40)
	Attainment	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)

[*]Model containing main effects only (county status, age squared age)
[**]Model containing main effects and parity, marital status, and prenatal care use
[***] Model containing main effects and parity, marital status, prenatal care use, and smoking
[†] Model containing main effects and parity, marital status, prenatal care use, smoking, and education

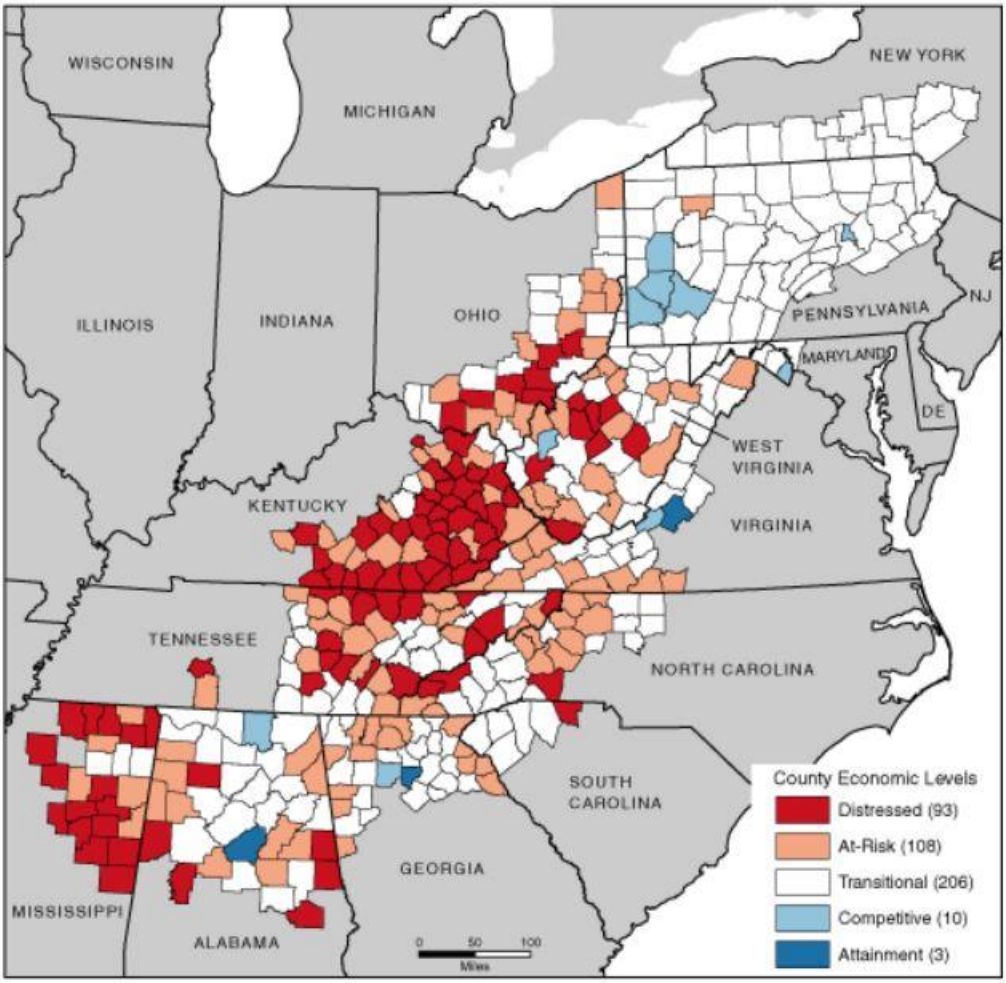
Table 4. Models Estimating the Odds of Low Birth Weight By County Economic Status, Stratified by Race and Ethnicity

Table 5. Odds of Low Birth Weight by County Economic Status Among White Women, Single and Two Variable Combinations

Second Variable	First Variable	Education OR (95% CI)	APNCU OR (95% CI)	Parity OR (95% CI)	Marital Status OR (95% CI)	Smoking OR (95% CI)
Education	Distressed	0.81 (0.58-1.12)	0.86 (0.60-1.23)	0.82 (0.60-1.13)	0.80 (0.58-1.11)	0.65 (0.50-0.85)
	At-Risk	0.77 (0.59-1.00)	0.81 (0.60-1.09)	0.78 (0.61-1.00)	0.76 (0.59-0.98)	0.64 (0.53-0.78)
	Transitional	0.84 (0.65-1.07)	0.89 (0.66-1.19)	0.84 (0.66-1.06)	0.82 (0.64-1.05)	0.72 (0.60-0.87)
	Competitive	1.16 (0.91-1.48)	1.23 (0.94-1.60)	1.15 (0.91-1.45)	1.14 (0.89-1.45)	1.03 (0.87-1.21)
	Attainment	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
APNCU	Distressed		1.00 (0.70-1.43)	1.01 (0.71-1.43)	0.97 (0.68-1.39)	0.72 (0.54-0.97)
	At-Risk		0.90 (0.67-1.21)	0.91 (0.68-1.20)	0.87 (0.65-1.16)	0.69 (0.55-0.85)
	Transitional		0.95 (0.71-1.26)	0.94 (0.72-1.23)	0.91 (0.69-1.21)	0.77 (0.63-0.95)
	Competitive		1.25 (0.95-1.64)	1.23 (0.94-1.59)	1.21 (0.92-1.59)	1.07 (0.88-1.29)
	Attainment		1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Parity	Distressed			0.95 (0.69-1.30)	0.92 (0.67-1.27)	0.72 (0.55-0.94)
	At-Risk			0.87 (0.68-1.11)	0.84 (0.66-1.07)	0.69 (0.57-0.84)
	Transitional			0.89 (0.71-1.12)	0.86 (0.68-1.08)	0.75 (0.63-0.91)
	Competitive			1.14 (0.90-1.46)	1.11 (0.87-1.42)	1.02 (0.87-1.19)
	Attainment			1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Marital Status	Distressed				0.91 (0.66-1.26)	0.69 (0.53-0.91)
	At-Risk				0.83 (0.65-1.07)	0.67 (0.55-0.81)
	Transitional				0.86 (0.68-1.09)	0.73 (0.61-0.88)
	Competitive				1.13 (0.88-1.45)	1.01 (0.86-1.18)
	Attainment				1.00 (1.00-1.00)	1.00 (1.00-1.00)
Smoking	Distressed					0.69 (0.53-0.91)
	At-Risk					0.67 (0.55-0.81)
	Transitional					0.74 (0.62-0.89)
	Competitive					1.02 (0.87-1.20)
	Attainment					1.00 (1.00-1.00)
First Variable P-Value		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Figures

Figure 1. County Economic Status in Appalachia, FY 2014



Created by the Appalachian Regional Commission, March 2013
Data Sources:
Unemployment data: U.S. Bureau of Labor Statistics, LAUS, 2009–2011
Income data: U.S. Bureau of Economic Analysis, REIS, 2010
Poverty data: U.S. Census Bureau, American Community Survey, 2007–2011

Effective October 1, 2013
through September 30, 2014

Figure 2. Model-predicted Age-specific Risk of Low Birth Weight Across Three-Level County SES Strata, White Women

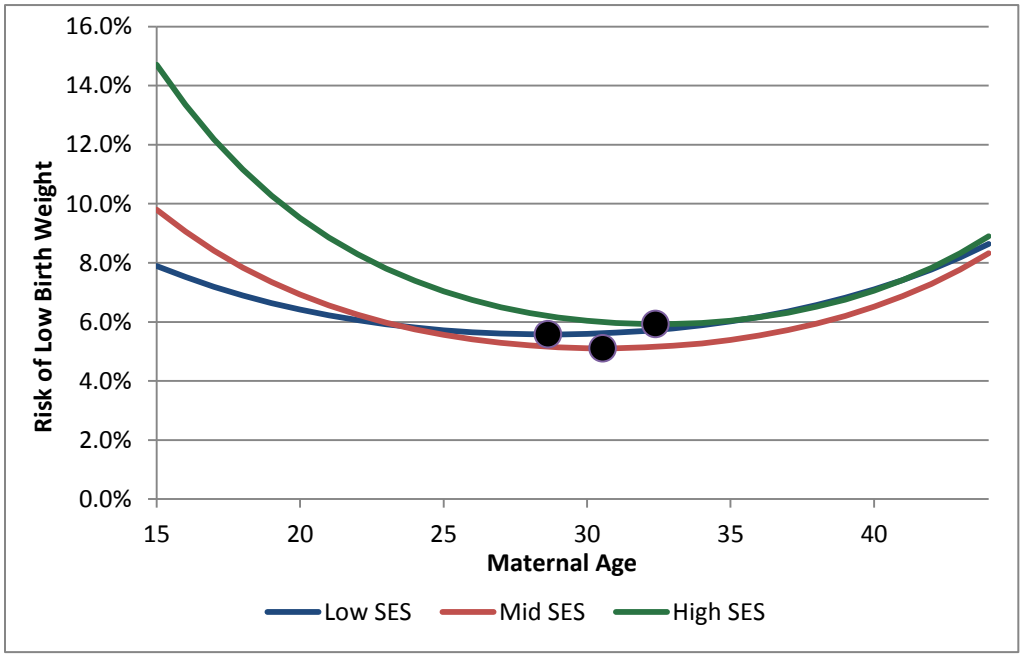


Figure 3. Kernel Density Plot of Maternal Age by Three-Level County SES Strata

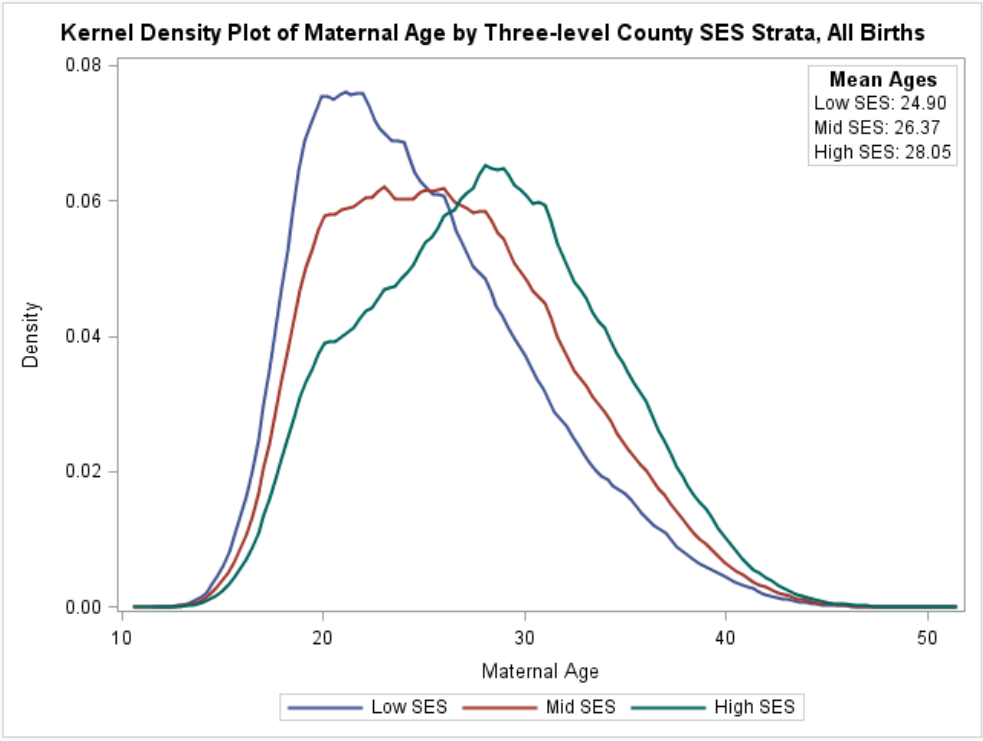


Figure 4. Model-predicted Age-specific Risk of Low Birth Weight Across Three-level County SES Strata, First Births Among White Women

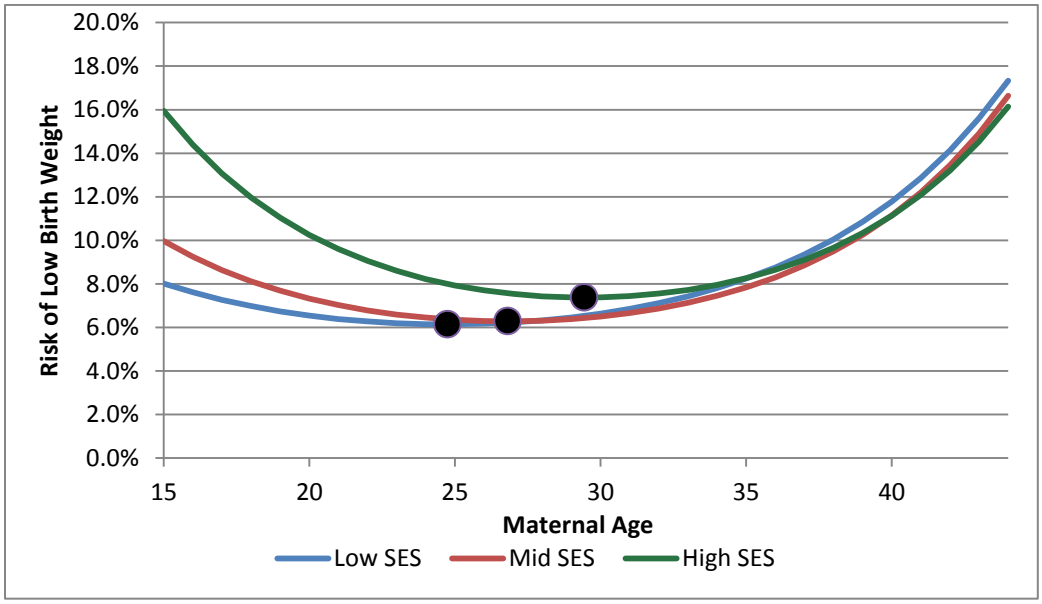


Figure 5. Kernel Density Plot of Maternal Age by Three-level County SES Strata Among White Women, First Births

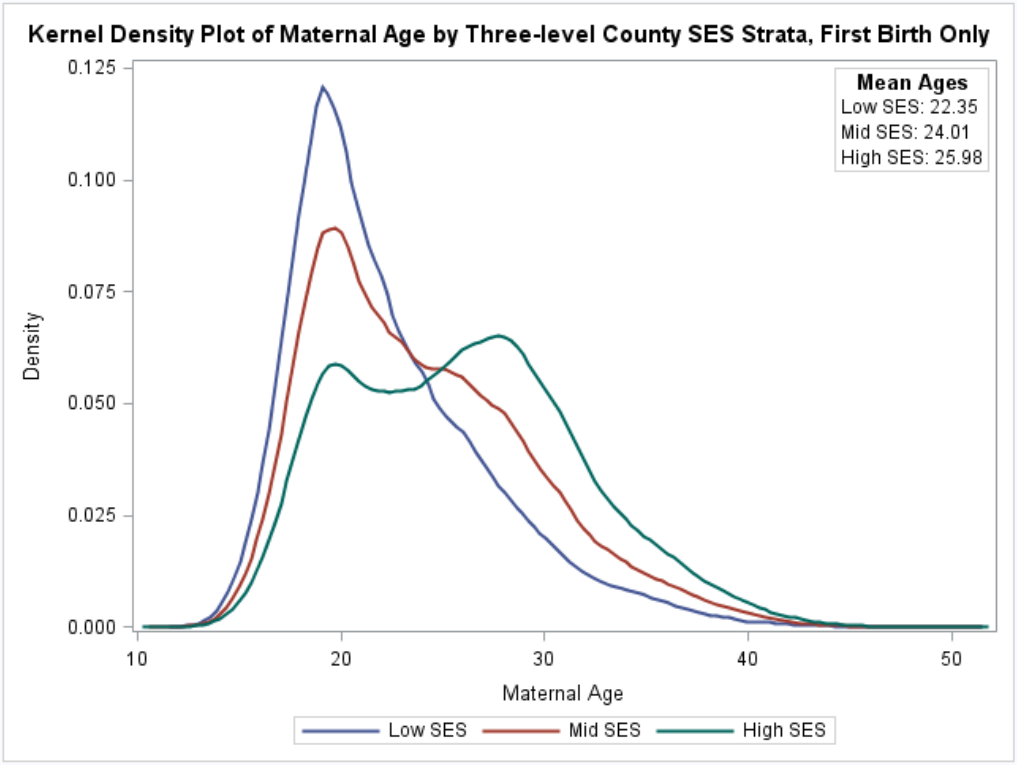


Figure 6. Risk of Low Birth Weight by Maternal Age When Controlling for Smoking, White Women

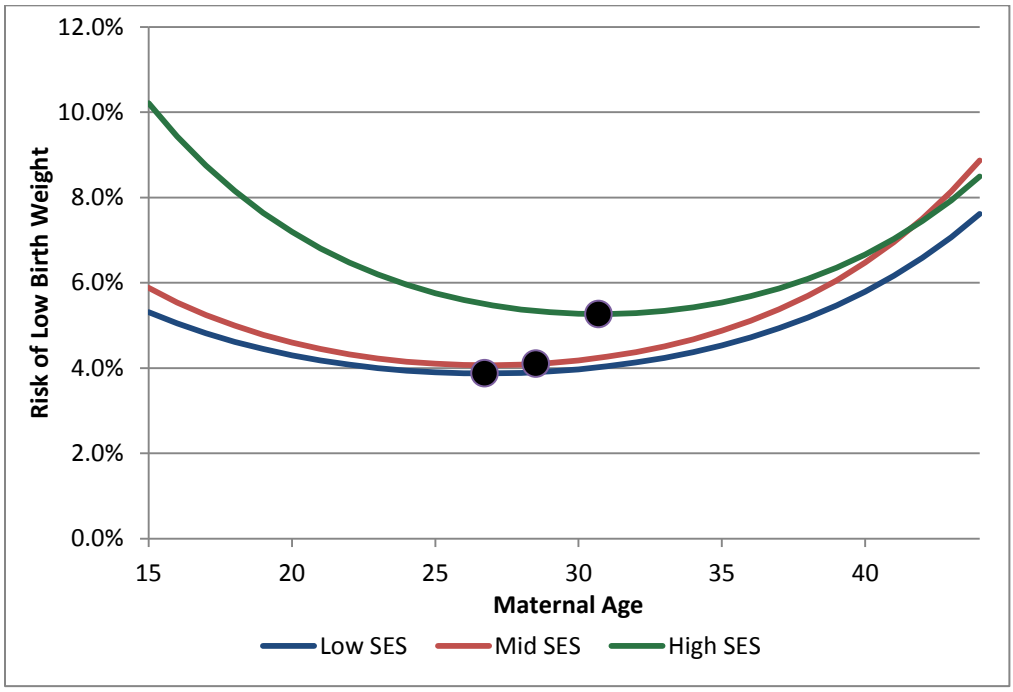


Figure 7. Model-predicted Age-specific Risk of Low Birth Weight Across Three-level County Strata Controlling for Parity, Marital Status, and APNCU, White Women

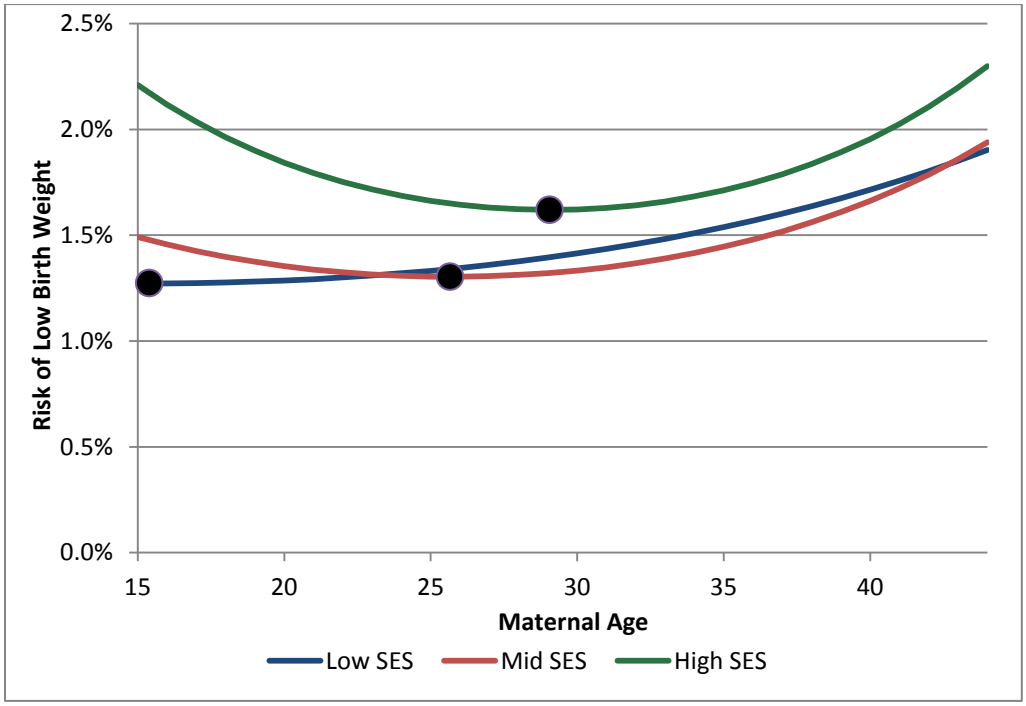
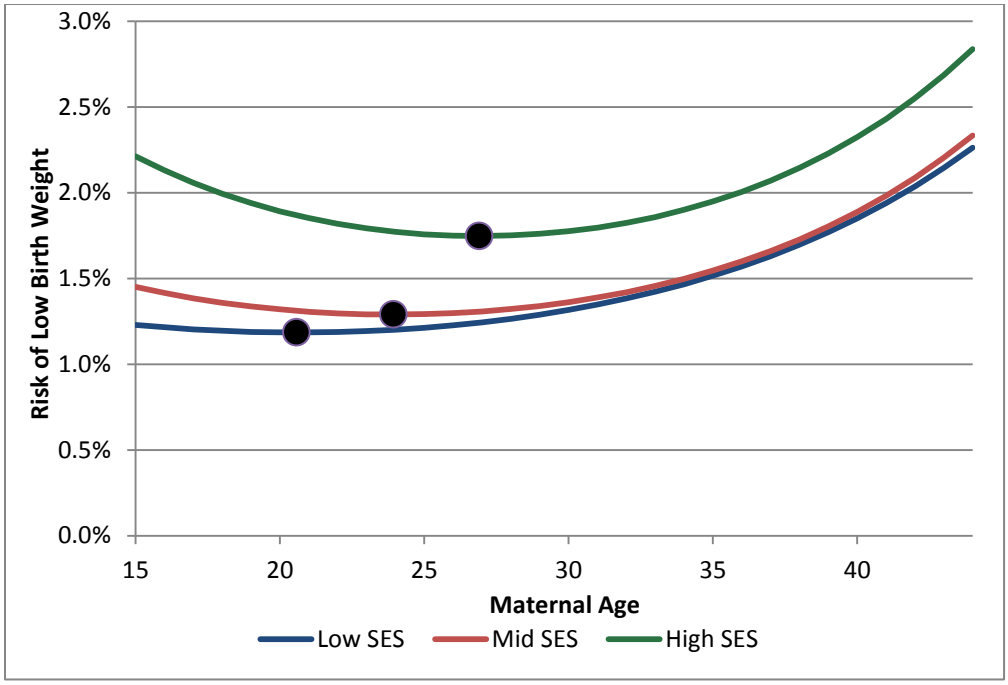


Figure 8. Model-predicted Age-specific Risk of Low Birth Weight Across Three-level County Strata When Controlling for Parity, Marital Status, APNCU, and Smoking, White Women



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