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Maternal residential proximity to surface mining associated with preterm birth and low birth weight in Appalachian Kentucky

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MATERNAL RESIDENTIAL PROXIMITY TO SURFACE MINING ASSOCIATED WITH PRETERM BIRTH AND LOW BIRTH WEIGHT IN APPALACHIAN KENTUCKY

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Public Health in the
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at the University of Kentucky

By

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ABTRACT OF THESIS

MATERNAL RESIDENTIAL PROXIMITY TO SURFACE MINING ASSOCIATED WITH PRETERM BIRTH AND LOW BIRTH WEIGHT IN APPALACHIAN KENTUCKY

Objective: This study aims to examine the relationship between maternal residency in a county with surface coal production and preterm birth or low birth weight.

Methods: A cross sectional study was conducted using birth records (n=62,766) for 54 Appalachian counties and coal production in tons. Logistic regression and chi squared analysis was done to analyze the relationship between surface coal mining and preterm birth and low birth weight in two different birth groups.

Results: After controlling for covariates, statistically significant increases were seen in Birth Group 1 and Birth group 2. Birth Group 1 had statistically significant results for preterm birth ((1.19 CI 1.07-1.33) (1.24 CI 1.13-1.37)) and low birth weight ((1.26 CI 1.11-1.43) (1.21 CI 1.08-1.35)) for both "medium-high coal production" and "high coal production", respectively. Birth Group 2 had statistically significant results for preterm birth (1.14 CI 1.14-1.74) in the "medium-high coal production" and statistically significant results for low birth weight in the "medium-low coal production" (1.19 CI 1.05-1.35) and medium-high coal production" (1.31 CI 1.03-1.68) categories.

Conclusion: There was a statistically significant relationship seen between maternal residency in a county with surface coal production and the incidence of preterm birth and low birth weight in Appalachian Kentucky. This research can be used as a guide for future studies to help determine the relationship between proximity to surface mines and birth outcomes.

Key words: Appalachia, Surface Mining, Birth Outcomes, Preterm Birth, Low Birth Weight

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

Environmental exposures can cause a multitude of problems in the body especially for expectant mothers. Air pollution interferes with the many hormone driven areas in the body and can increase the risk of infection (Ritz, Yu, Chapa, & Fruin, 2000). This disturbance can trigger premature contractions and membrane rupture inducing labor earlier than expected (Ritz, Yu, Chapa, & Fruin, 2000). Exposure to particulate matter smaller than 10 micrograms, carbon monoxide, and ozone after conception and before birth has been shown to increase the risk of having a preterm baby (Ritz, Yu, Chapa, & Fruin, 2000**).** The odds of preterm birth were 20% higher for every increase of 50 microgram levels of PM10. Also, African American mothers who lacked prenatal care, smoked during pregnancy, and had a history of low-birth-weight births were at the highest risk for having a preterm birth (Ritz, Yu, Chapa, & Fruin, 2000). Exposure to 5.5 ppm or greater of carbon monoxide in the last trimester of pregnancy has been shown to increase the odds of delivering a low-birth-weight baby by 22% (Ritz & Yu, 1999).

Peak coal production was in Kentucky was 1990 when roughly 175 million tons were produced (Kentucky Energy and Environment Cabinet, 2017). By 2016, only 43 million tons of coal were produced throughout Kentucky (Kentucky Energy and Environment Cabinet, 2017). Although coal production has been decreasing, Kentucky was ranked as the fourth highest producer of coal in 2016 (Kentucky Energy and Environment Cabinet, 2017). Nearly half of the coal produced is used by the state of Kentucky for electricity needs and the rest is used by the southeast United States (Kentucky Energy and Environment Cabinet, 2017). The peak of employment in the mines was in the 1950's with 75,000 people employed in Kentucky (Kentucky Energy and Environment Cabinet, 2017). That number has decreased over the years, but Kentucky still has the second highest employment with 6,612 persons employed in coal mines. That equates to 0.4% of the workforce in Kentucky and roughly 2% of the eastern and western Kentucky population (Kentucky Energy and Environment Cabinet, 2017). Coal is a large economic investment in the state with $4.6 billion worth of coal sold in 2014 (Kentucky Energy and Environment Cabinet, 2017). This allowed the government to collect $191 million dollars in 2014 due to the severance tax which in turn gave coal producing counties $61 million back for infrastructure improvements (Kentucky Energy and Environment Cabinet, 2017).

To help reduce the environmental impact that coal has, many policies were created and passed throughout the 1970's and 1980's including the Clean Water Act (1972), Endangered Species Act (1973), Federal Coal Releasing Amendments Act (1977), Federal surface Mine Control and Reclamation Act (1977), Mine Safety and Health Act (1977), National Acid Precipitation Assessment Program (NAPAP) (1980), and the Clean Coal Technology Act (1986) (Kentucky Energy and Environment Cabinet, 2017).

During the peak of coal production, 131 million tons of coal were produced in eastern Kentucky in a single year (Kentucky Energy and Environment Cabinet, 2017). Since then, production has decreased by 87% to roughly 20 million tons per year in eastern Kentucky in 2016 (Kentucky Energy and Environment Cabinet, 2017).

Surface mining encompasses several mining techniques including mountaintop removal, contour, auger, and highwall mining (Environmental Protection Agency, 2016). Surface mining involves removing the top layers of mountains to expose the coal seams (Environmental Protection Agency, 2016) The extraction, transportation, and processing of coal can lead to heavy metals and chemicals (ammonium nitrate, sulfur, and silica) leaching downstream into water sources and soil causing inhalation of toxic metals (Environmental Protection Agency, 2016; Kentuckians for the Commonwealth, n.d.; Hendryx, Zullig, & Luo, 2020). This type of mining reduces the number of workers and increases production numbers.

One challenge associated with this technique is the excess of soil and rock, commonly called "spoil", that is needed to be disposed of in another location (Environmental Protection Agency, n.d.). Many adverse health effects have been documented in persons who live near surface mining including asthma, COPD, hypertension, lung cancer, kidney disease, respiratory disease, cardiovascular disease, poor mental health, and birth defects (Hendryx, 2013; Hendryx, O' Donnell, Horn, 2008; Hendryx, Zullig, & Leo, 2020). Some studies have been able to identify a relationship between coal mining and preterm birth and low birth weight in central Appalachia (Ahern, Mullett, Macka, & Hamilton, 2010; Buttling Et al., 2021)

Surface mining remains a common practice in the Appalachian region of Kentucky. The practice accounts for 24% (10.3 million tons) of the coal mined in the state of Kentucky and 43% of the coal mined in eastern Kentucky (Kentucky Energy and Environment Cabinet, 2017). Pike county has the highest production of coal from surface mining with 7.4 million tons of coal (Kentucky Energy and Environment Cabinet, 2017).

Surface soils sampled near surface mine sites exhibit higher concentrations of heavy metals and trace elements, such as arsenic (As), mercury (Hg), chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), cadmium (Cd), and lead (Pb) (Bu et al., 2020). Arsenic can leach into water and soil surrounding surface mines, causing complications for pregnancies with the baby's birth weight and length. Arsenic can cross the placenta and accumulates in the fetus (Bloom et al., 2016). A statistically significant association has been found between higher maternal arsenic exposure and lower birth weight and height in babies (Bloom et al., 2016).

A study of surface mining exposure in Central Appalachia found a slight increase in low birth weight in counties with surface mining compared to counties with no surface mining (Small et al., 2020). In moderate coal mining areas (13,510,500 tons or less) there was a 14% increase in the odds of low birth weight, and in high coal mining areas (13,510,500 tons or more) there was a 16% increase in odds of a low birth weight baby (Ahern, Mullett, Mackay, & Hamilton, 2010).

Roughly 8% (one in twelve) of all babies are born with low birth weight (LBW). Fetal growth restriction and preterm birth are the two main reasons for a low-birth-weight baby (March of Dimes, 2018). Risk factors that increase a woman's chance of delivering a baby with low birth weight include chronic health conditions, infections, exposure to air pollution or lead, socioeconomic status, smoking, drinking, age, and race (March of Dimes, 2018).

Preterm birth occurs in nearly one out of every ten live births in the United States (2019), contributing to 1 million deaths of preterm children under the age of 5 in 2015 (CDC, 2020; WHO 2018).

Many who survive are left with lifelong complications from early delivery including social and learning disabilities, Sudden Infant Death Syndrome (SIDS), and are more likely to have chronic diseases as an adult (heart, disease, diabetes, and hypertension) (UK Healthcare, n.d.). Access to and affordability of care are two reasons there is a higher death rate for preterm births in low-income communities (World Health Organization, 2018)**.** Nearly half of preterm babies in low-income areas die because of a lack of effective and affordable quality care (World Health Organization, 2018).

Risk factors that can influence a woman's probability of delivering a preterm baby include a previous premature baby, a twin pregnancy, uterus or cervix problems, family history, diabetes, high blood pressure, late or no prenatal care, smoking tobacco, drinking alcohol, low socioeconomic status, race, and exposure to air pollution and heavy metals (March of Dimes, 2019).

While the implications of air and water pollution for preterm birth and low birth weight have been studied, the effects of exposure to surface mining on preterm births and low birth weight have received less attention. This study aims to answer the research question: is there a relationship between surface mine exposure and preterm birth or low birth weight in Appalachian Kentucky**.** I hypothesize that preterm birth and low birth weight incidence will be higher in years with high coal production.

2. Methods

A cross sectional study was conducted to determine whether a relationship exists between maternal residence during pregnancy in one of five different surface mining production groups and preterm birth or low birth weight in newborns in Appalachian Kentucky.

2a. Coal production data

Surface coal production data was retrieved from the Kentucky Geological Survey (KGS) for years 2012-2017 for fifty-four Appalachian counties designated as Appalachian by the Appalachian Region Commission (ARC) (Kentucky Geological Survey, 2021; Appalachian Region Commission, 2020). Quartiles were created to reflect coal production over the entire five-year period, with non-coal producing counties acting as the reference. Quartiles of all surface coal production for years 2012-2017 were used to create the coal production categories in Table 1. Figure 1 and Figure 2 are visual representations of which counties were included in each exposure year for each birth group.

2b. Birth record data

Birth records were acquired from the Office of Vital Statistics for all live births occurring in Kentucky during 2013-2017 (n=273,697The address given at the time of birth was used to determine the county of residence.

A significant drop off in coal production starting in 2015 drove the creation of two different birth groups to compare results. Birth Group 1 comprised 2013-2014 birth years and Birth Group 2 comprised 2016-2017 birth years. Each participant was assigned an exposure year based on the child's date of birth. If the date of birth occurred on or before May 15th of a given year, the exposure was determined by surface coal production in the year prior. If the date of birth was after May 15th, exposure was determined by production during that same year. This was done to account for exposure leading up to and during pregnancy. For Birth Group 1, there would be coal exposures in 2012, 2013, and 2014, depending on the date of birth of the child. For Birth Group 2, there would be coal exposures in 2015, 2016, 2017, depending on the date of birth. A birth record was excluded if any of the following were true:

- Gestation less than 17 weeks or greater than 47 weeks
- Birth weight less than 227g or greater than 8,165g
- Maternal age at time of birth was greater than 55 years old
- Non-singleton birth
- Outside of the 54 Appalachian counties identified

Preterm birth was defined as gestation less than 37 weeks and low birth weight was defined as the child weighing less than 2,500g at delivery. Exclusions for gestation and birth weight were found from the Centers for Disease Control and Prevention (Martin et. al., 2015; CDC, 2012). After all exclusions, the data set had a total of 62,766 observations: 25,848 observation in Birth Group 1 and 24,357 observations in Birth Group 2.

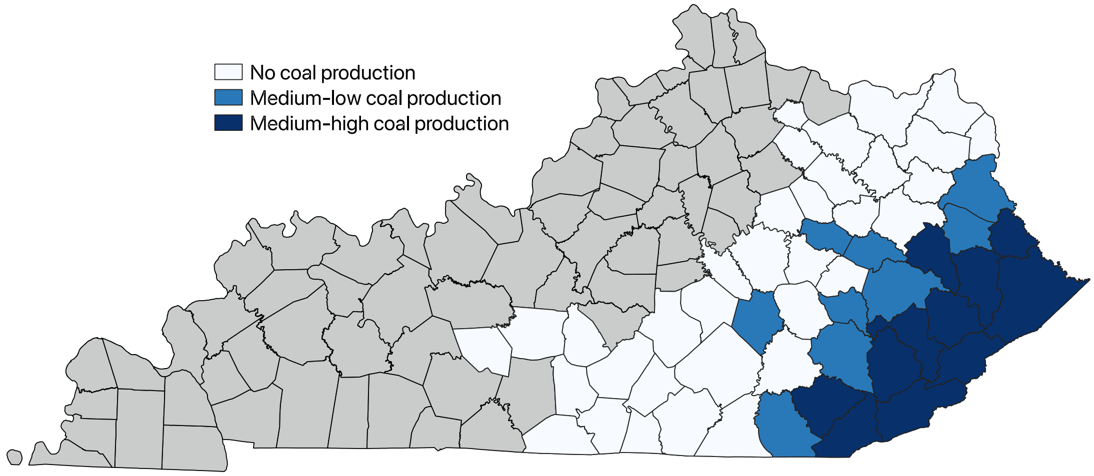
Table 1. Coal production groups with the corresponding number of counties for Birth Group 1 and 2

	Range **	Birth Group 1	Birth Group 2
No coal production	None	46 counties	37 counties
Low (Q1*)	1-258	none	13 counties
Medium-low (Q2*)	259-1,449	none	12 counties
Medium-high (Q3*)	1,450- 579,761	14 counties	2 counties
High (Q4*)	579,762-6,090,559	11 counties	none

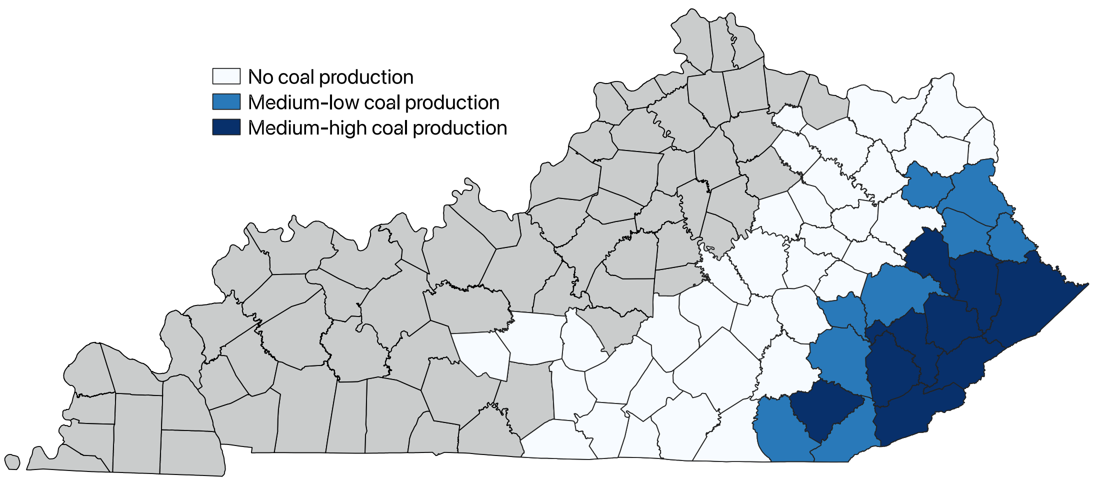
*Quartile
**Tons of coal production

Figure 1. Coal production groups by county for each exposure year in Birth Group 1

a. 2012



b. 2013



c. 2014

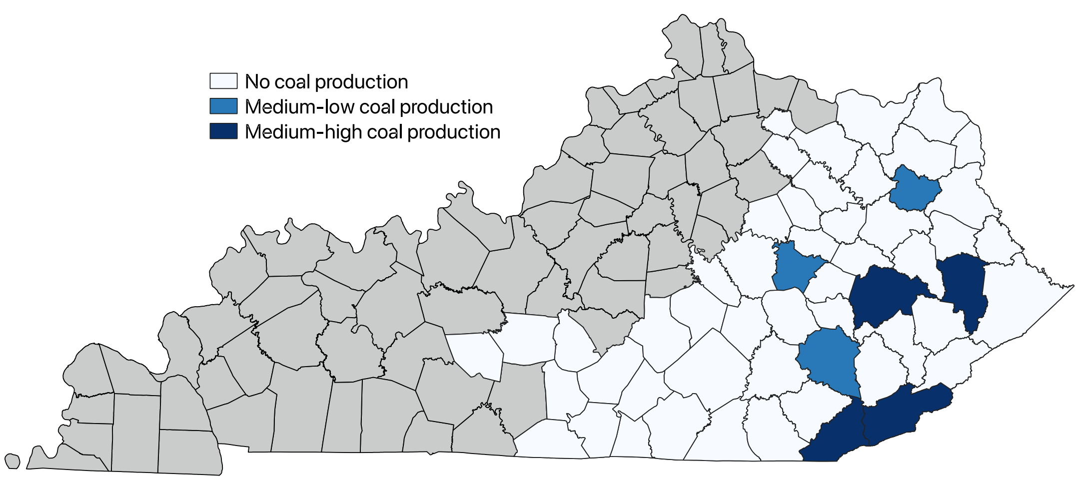
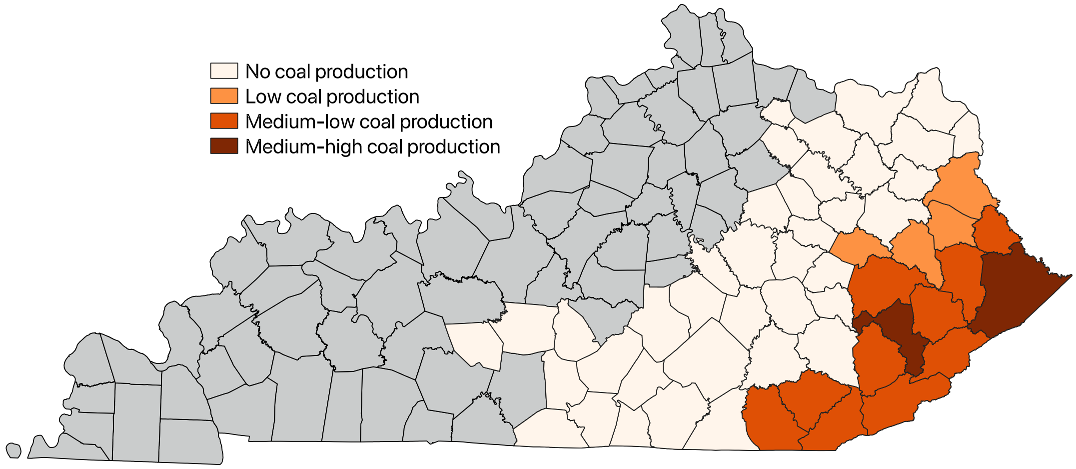
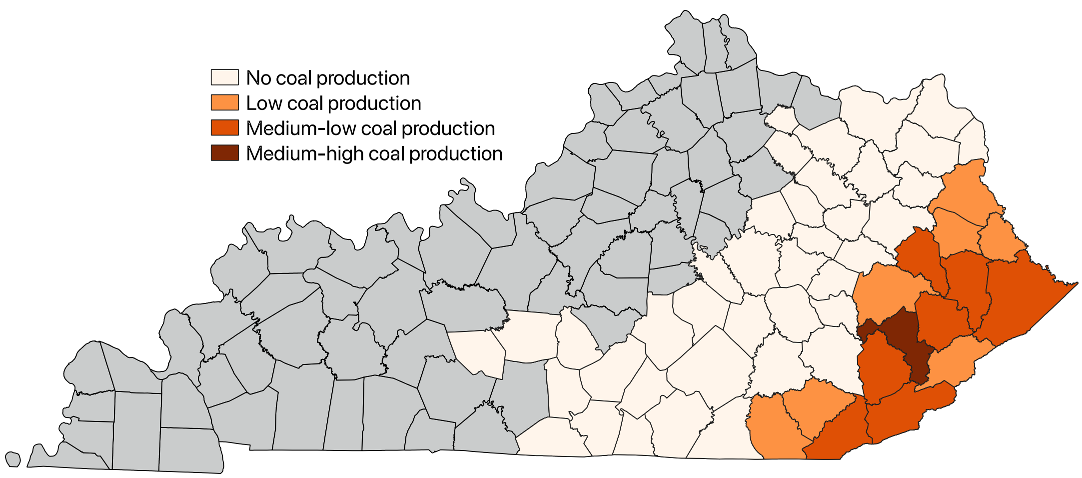


Figure 2. Coal production groups by county for each exposure year in Birth Group 2

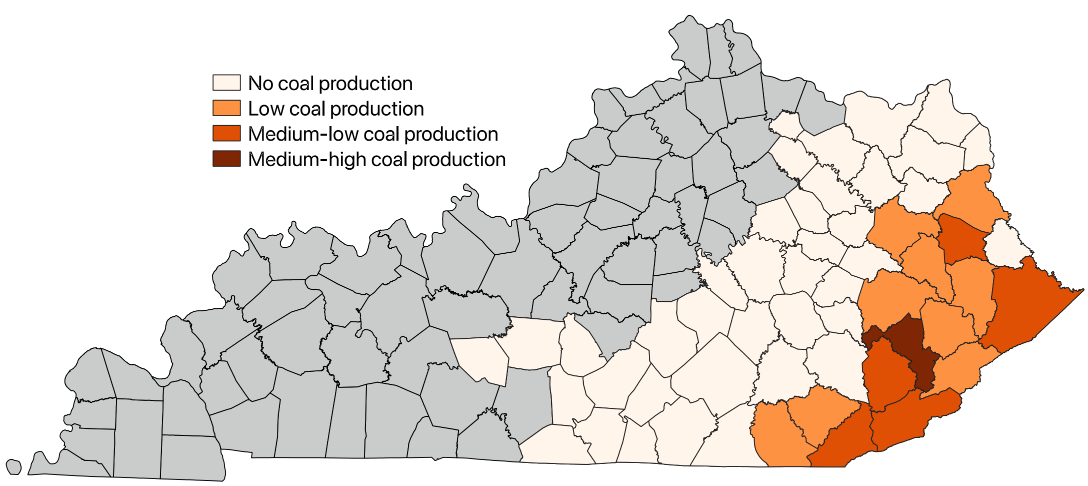
a. 2015



b. 2016



c. 2017



2c. Analysis

Unadjusted and adjusted odds ratios (OR) and confidence intervals (CI) were calculated for each applicable exposure group using logistic regression. Dichotomous birth weight and gestation variables were created if birth weight was above or below 2,500g, or gestation was above or below 37 weeks, respectively. Age of the mother at birth, education attainment, smoking, BMI and race were all included as covariates for the model to remove bias from the results.

3. Results

3a. Birth Group 1 demographic characteristics

A total of 25,848 birth records are included in the 2013-2014 birth years. Table 2a summarizes the maternal demographic characteristics by surface coal mine production. Mothers were predominately white (96.6%), between the ages of 20 to 34 (79.7%), and non-smokers (66.5%). Approximately 33.7% were high school graduates and 39.9% had a normal BMI.

3b. Birth Group 2 demographic characteristics

A total of 24,357 birth records are included in birth years 2016-2017. Table 2b depicts the maternal demographic characteristics by surface coal mine production. Similar to Birth Group 1, mothers were predominately white (95.9%), between the ages of 20 to 34 (80.5%), and non-smokers (71.4%). Approximately 34.6% and 36.6% were high school graduates and had a normal BMI, respectively.

Table 2a. Maternal demographic characteristics by county surface coal mine production for Birth Group 1(2013-2014)

	No Coal Production n (%)	Low* n (%)	Medium-low* n (%)	Medium-high n (%)	High n (%)	Total n (%)	p-value**
Age							
13-19	1,928 (60.3)	0 (0.0)	0 (0.0)	547 (17.1)	723 (22.6)	3,198 (12.4)	<0.001
20-34	13,232 (64.3)	0 (0.0)	0 (0.0)	3,161 (15.4)	4,195 (20.4)	20,588 (79.7)	
35+	1,356 (65.9)	0 (0.0)	0 (0.0)	330 (16.0)	372 (18.1)	2,058 (8.0)	
Education							
Less than HS	2,718 (57.7)	0 (0.0)	0 (0.0)	847 (18.0)	1,144 (24.3)	4,709 (18.5)	<0.001
High school	5,438 (63.3)	0 (0.0)	0 (0.0)	1,420 (16.5)	1,733 (20.2)	8,591 (33.7)	
Some college	4,079 (64.8)	0 (0.0)	0 (0.0)	933 (14.8)	1,287 (20.4)	6,299 (24.7)	
AS or BS	3,070 (68.0)	0 (0.0)	0 (0.0)	594 (13.1)	855 (18.9)	4,519 (17.7)	
Ma, PhD+	977 (71.5)	0 (0.0)	0 (0.0)	190 (13.9)	199 (14.6)	1,366 (5.4)	
Race							
White	15,832 (63.4)	0 (0.0)	0 (0.0)	3,938 (15.8)	5,190 (20.8)	24,960 (96.6)	<0.001
Black	186 (75.0)	0 (0.0)	0 (0.0)	24 (9.7)	38 (15.3)	248 (1.0)	
Other	500 (78.1)	0 (0.0)	0 (0.0)	77 (12.0)	63 (9.8)	640 (2.5)	
BMI***							
Underweight	920 (60.9)	0 (0.0)	0 (0.0)	262 (17.3)	330 (21.8)	1,512 (6.0)	<0.001
Normal	6,576 (65.2)	0 (0.0)	0 (0.0)	1,583 (15.7)	1,920 (19.1)	10,079 (39.9)	
Overweight	3,933 (64.0)	0 (0.0)	0 (0.0)	920 (15.0)	1,293 (21.0)	6,146 (24.3)	
Obese	4,522 (62.2)	0 (0.0	0 (0.0)	1,164 (15.9)	1,598 (21.9)	7,314 (28.9)	
Smoking							
Non-smoker	11,157 (64.9)	0 (0.0)	0 (0.0)	2,574 (15.0)	3,455 (20.1)	17,186 (66.5)	<0.001
Quit smoking	806 (72.7)	0 (0.0)	0 (0.0)	172 (15.5)	131 (11.8)	1,109 (4.3)	
Smoked during pregnancy	4263 (59.4)	0 (0.0)	0 (0.0)	1,251 (17.4)	1,659 (23.1)	7,173 (27.8)	

*No counties met eligibility requirements for the “low” and “medium-low” categories.
**Chi-squared test
***Body mass index

Table 2b. Maternal demographic characteristics by county surface coal mine production for Birth Group 2(2016-2017)

	No Coal Production n (%)	Low n (%)	Medium-low n (%)	Medium-high n (%)	High* n (%)	Total n (%)	p-value**
Age							
13-19	1,489 (58.4)	534 (21.0)	438 (17.2)	90 (3.5)	0 (0.0)	2,551 (10.5)	0.14
20-34	11,760 (60.0)	3,935 (20.1)	3,231 (16.5)	685 (3.5)	0 (0.0)	19,611 (80.5)	
35+	1,371 (62.5)	428 (19.5)	326 (14.9)	69 (3.1)	0 (0.0)	2,194 (9.0)	
Education							
Less than HS	2,218 (55.0)	889 (22.0)	792 (19.6)	137 (3.4)	0 (0.0)	4,036 (16.7)	<0.001
High school	5,010 (60.0)	1,799 (21.5)	1,292 (15.5)	254 (3.0)	0 (0.0)	8,355 (34.6)	
Some college	3,491 (60.9)	1,057 (18.4)	934 (16.3)	253 (4.4)	0 (0.0)	5,735 (23.8)	
AS or BS	2,858 (62.8)	826 (18.2)	722 (15.9)	143 (3.1)	0 (0.0)	4,549 (18.8)	
Ma, PhD+	930 (63.1)	282 (19.1)	214 (14.5)	49 (3.3)	0 (0.0)	1,475 (6.1)	
Race							
White	13,873 (59.4)	4,759 (20.4)	3,907 (16.7)	814 (3.5)	0 (0.0)	23,353 (95.9)	<0.001
Black	264 (78.3)	32 (9.5)	32 (9.5)	9 (2.7)	0 (0.0)	337 (1.4)	
Other	484 (72.6)	106 (15.9)	56 (8.4)	21 (3.2)	0 (0.0)	667 (2.7)	
BMI***							
Underweight	670 (57.9)	246 (21.3)	199 (17.2)	42 (3.6)	0 (0.0)	1,157 (4.9)	<0.001
Normal	5,349 (61.6)	1,710 (19.7)	1,384 (15.9)	248 (2.9)	0 (0.0)	8,691 (36.6)	
Overweight	3,518 (60.6)	1,169 (20.1)	911 (15.7)	207 (3.6)	0 (0.0)	5,805 (24.5)	
Obese	4,347 (57.3)	1,574 (20.7)	1,359 (17.9)	312 (4.1)	0 (0.0)	7,592 (32.0)	
Smoking							
Non-smoker	10,517 (60.4)	3,514 (20.2)	2,803 (16.1)	567 (3.3)	0 (0.0)	17,401 (71.4)	<0.001
Quit smoking	610 (75.4)	135 (16.7)	54 (6.7)	10 (1.2)	0 (0.0)	809 (3.3)	
Smoked during pregnancy	258 (74.9)	45 (13.6)	33 (10.0)	5 (1.5)	0 (0.0)	5,816 (23.9)	

*No counties met eligibility requirements for the “high coal production” category
**Chi-squared test
***Body mass index

3c. Birth Group 1 significance

Table 3 summarizes the incidence of preterm birth and low birth weight from the study for 2013-2014 birth years. Preterm birth accounted for an average of 10.5% (2,709) of the births ranging from a low of 9.8% (1,615) in the “no coal production” category to a high of 11.4% (461) in the “high coal production” category. Low birth weight is slightly less common with an average of 8.2% (2,107) across all production groups with the lowest being the “no coal production” category with 7.7% (1,260) and the highest being the “medium-high coal production” category with 9.5% (380) births being low birth weight

3d. Birth Group 2 significance

Preterm birth accounted for an average of 10.2% (2,482) of births ranging from a low of 9.9% (1,452) (“no coal produced”) to a high of 13.5% (114) (“medium-high coal production”). Low birth weight accounted for 8.0% (1,938) of the births analyzed with a low of 7.7% or 1,110 births in the “no coal production” category and a high of 10.0% or 84 births in the “medium-high coal production”. Comparing Birth Group 1 to Birth Group 2, one can see that overall rates of preterm birth and low birth weight slightly decrease in the later year.

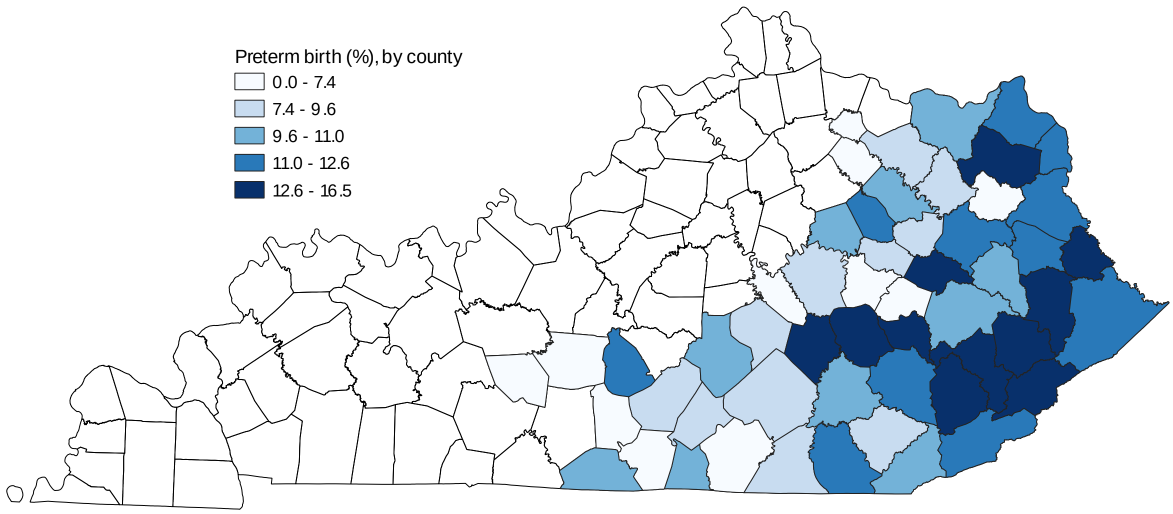
Table 3. Preterm birth and low birth weight by county surface mine production

	Birth Group 1		Birth Group 2	
	n (%)	p-value*	n (%)	p-value*
Preterm birth				
No coal production	1,615 (9.8)	<0.001	1,452 (9.9)	0.009
Low	0 (0.0)		497 (10.2)	
Medium-low	0 (0.0)		419 (10.5)	
Medium-high	461 (11.4)		114 (13.5)	
High	633 (12.0)		0 (0.0)	
Total	2,709 (10.5)		2,482 (10.2)	
Low birth weight				
No coal production	1,260 (7.7)	<0.001	1,110 (7.7)	0.009
Low	0 (0.0)		389 (8.0)	
Medium-low	0 (0.0)		355 (9.0)	
Medium-high	380 (9.5)		84 (10.0)	
High	467 (8.9)		0 (0.0)	
Total	2,107 (8.2)		1,938 (8.0)	

*chi-squared test

Figure 3. Preterm birth by county for Birth Group 1 and Birth Group 2

a. Birth Group 1



b. Birth Group 2

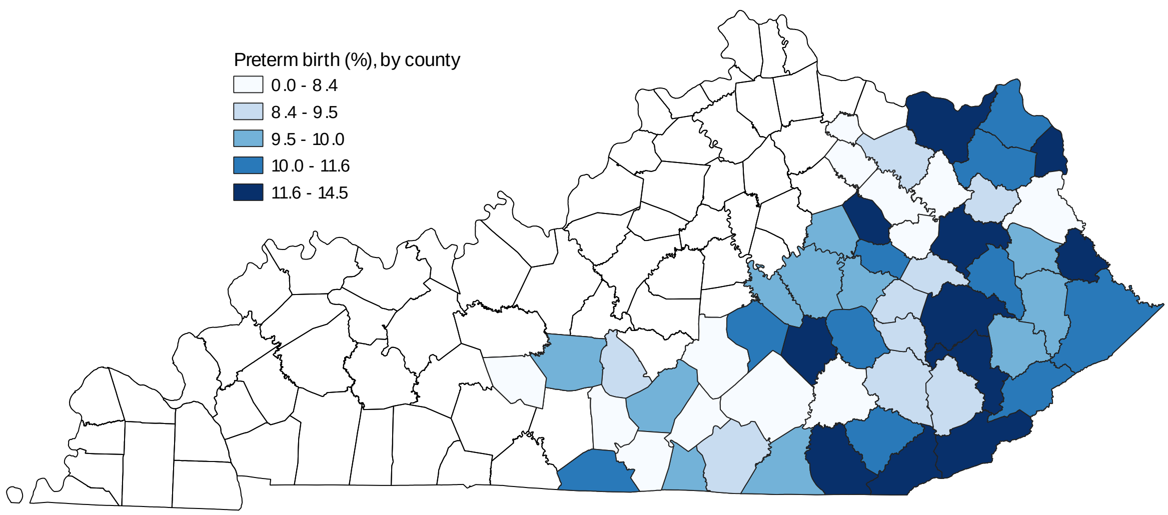
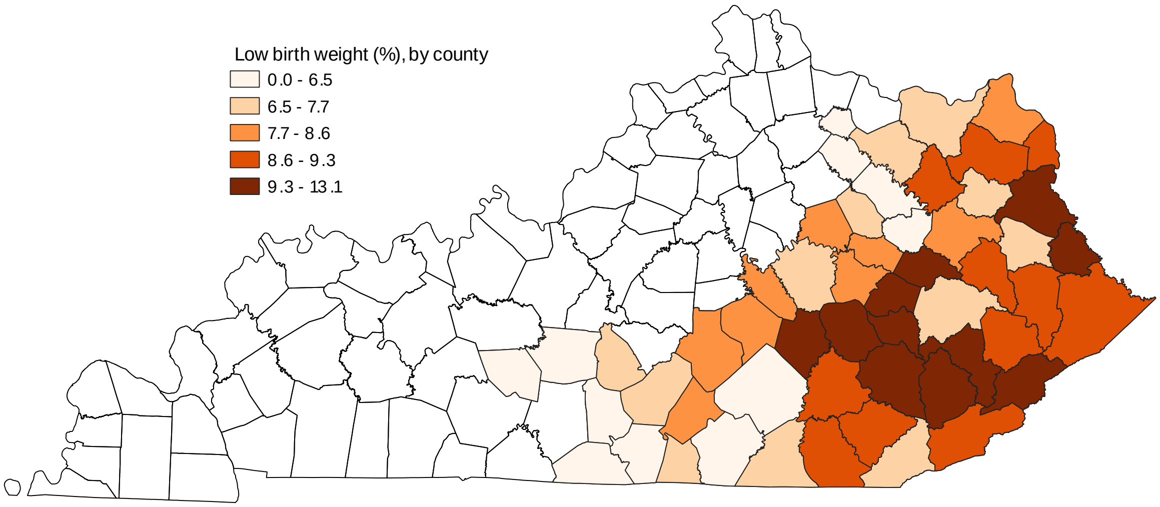


Figure 3a and Figure 3b illustrate the distribution of preterm birth aggregated by county in Appalachia for Birth Group 1 and Birth Group 2, respectively. The highest percentage of preterm birth in Birth Group 1 (Figure 3a) was 16.5% while in Birth Group 2 (Figure 3b) it was 14.5%. There is also a cluster of dark blue (12.6%-16.5%) in Figure 3a that disperses in Figure 3b.

Figure 4. Low birth weight by county for Birth Group 1 and Birth Group 2

a. Birth Group 1



b. Birth Group 2

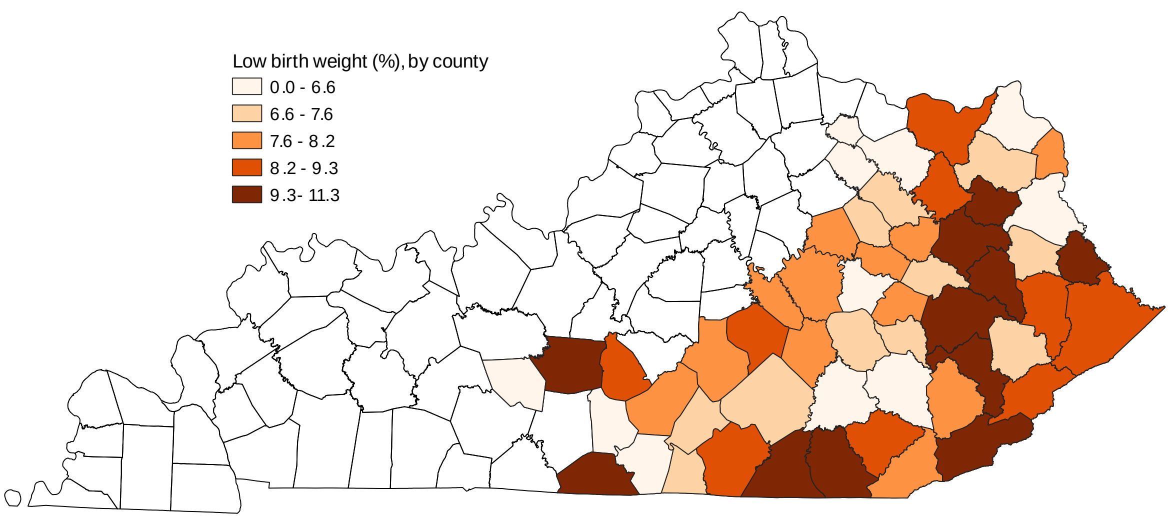


Figure 4a and Figure 4b display the distribution of low birth weight aggregated by county in Appalachia for Birth Group 1 and Birth Group 2, respectively. In Birth Group 1 (Figure 4a), the highest incidence of low birth weight was 13.1% and the highest in Birth Group 2 (Figure 4b) was 11.3%. There is a cluster in Figure 4a in a similar location to the cluster seen in Figure 3a (preterm birth). This cluster disperses slightly in Birth Group 2 (Figure 4b).

Table 4a and Table 4b show the odds ratios and 95% confidence intervals for the unadjusted and adjusted models. The independent variable is the surface mine production category, and the dependent variables are preterm birth and low birth weight for Birth Group 1 and Birth Group 2. The “no coal production” category is used as the referent group. The adjusted model uses maternal age, race, smoking status, BMI, and education as the covariates in the model.

3e. **Birth Group 1 significance**

Table 4a summarizes the odds ratios for preterm birth and low birth weight for the corresponding coal production categories. Both the unadjusted and adjusted odds ratios for low birth weight and preterm birth are significant for all exposure categories. The adjusted odds ratio for preterm birth was 1.19 (1.07-1.33) for the “medium-high coal production” category and 1.24 (1.13-1.37) for the “high coal production” category. The adjusted odds ratio for low birth weight was 1.26 (1.11- 1.43) for the “medium-high coal production” category and the odds ratio for the “high coal production” category is 1.21 (1.08-1.35).

Table 4a. Odds ratios based on coal production for Birth Group 1 (2013-2014)

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*
Preterm birth		
Medium-high	1.19 (1.07-1.33)	1.19 (1.07-1.33)
High	1.25 (1.14- 1.38)	1.24 (1.13-1.37)
Low birth weight		
Medium-high	1.26 (1.11-1.42)	1.26 (1.11-1.43)
High	1.17 (1.05-1.31)	1.21 (1.08-1.35)

*Adjusted for mother’s age, race, education, BMI, and smoking

3f. Birth Group 2 significance

Table 4b summarizes the odds ratios for preterm birth and low birth weight for the corresponding coal exposure categories for birth years 2016 to 2017. The statistically significant adjusted odds ratio for preterm birth was the “medium-high coal production” category being 1.41 (1.14-1.74). The statistically significant adjusted odds ratio for low birth weight in the “medium-low coal production” was 1.19 (1.05-1.35) and the “medium-high coal production” category was 1.31(1.03-1.68).

Table 4b. Odds ratios based on coal production for Birth Group 2 (2016-2017)

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*
Preterm birth		
Low	1.03 (0.92-1.14)	1.03 (0.92-1.15)
Medium-low	1.06 (0.95-1.19)	1.06 (0.94-1.19)
Medium-high	1.42 (1.15-1.74)	1.41 (1.14-1.74)
Low birth weight		
Low	1.05 (0.93-1.19)	1.07 (0.94-1.21)
Medium-low	1.19 (1.05-1.34)	1.19 (1.05-1.35)
Medium-high	1.34 (1.06-1.69)	1.31 (1.03-1.68)

*Adjusted for mother’s age, race, education, BMI and smoking

4. Discussion

The findings from the analysis demonstrate a statistically significant relationship between maternal residence in a county with surface coal mining and incidence of both preterm birth and low birth weight. In Birth Group 1, there were statistically significant 19% and 24% increases for preterm birth in the “medium-high coal production” and “high coal production” groups, respectively (Table 4a). There were statistically significant 26% and 17% increases for low birth weight in the “medium-high coal production” category and the “high coal production” groups, respectively. In Birth Group 2, there was a 41% statistically significant increase in preterm birth in the “medium-high coal production” group and there were statistically significant 19% and 31% increases in low birth weight in the “medium-low coal production” group and “medium-high coal production” group, respectively (Table 4b).

A study recently published, “Maternal Proximity to Central Appalachia surface mining and Birth outcomes” by Buttling et. al examined a similar relationship as this current study. Buttling et. al used birth records from Tennessee, Virginia, West Virginia, and Kentucky to determine if there was a relationship between maternal proximity to surface mines and preterm birth or low birth weight. This study used maternal zip code to assign surface mine exposure within a 5 km radius and used land area disturbed to determine the exposure categories. This study concluded that there was a relationship between surface mine exposure and preterm birth (1.04 (1.03-1.05)) and low birth weight (1.03(1.02-1.05)). The Buttling et. al study differs from this current one in the following areas: exposure categorization, the mode of determining maternal location, and the states included in the study.

One advantage of this current study is county of residence is used as a proxy for location instead of zip code. Using the zip code makes an assumption that the majority of time is spent at home. Using county location gives a better overall perspective of exposures seen not only at home, but also in the workplace. Another advantage of this study is two birth groups were created to examine the change over time for preterm birth and low birth weight rates. The median production of coal by surface mines in Birth Group 1 was 591,384 tons and 286 tons in Birth Year 2.

One limitation of this study is the birth data is self-reported. This could lead to underreporting social or behavioral factors like smoking and alcohol. Secondly, this data is manually transcribed to the birth certificate, so error is possible, especially for the continuous variables like mother’s age. Another limitation is that for many Appalachian rural counties, it can be quicker to travel to West Virginia or Tennessee to receive treatment for a high-risk pregnancy instead of driving into central Kentucky. This could deflate the rates of preterm births and low birth weight in this study because this study only includes Kentucky births. Lastly, biological samples were not obtained from the counties of interest, so assumptions were made that the coal production data retrieved from the Kentucky Geological Survey (KGS) is an accurate representation of exposure.

In Appalachian Kentucky, access to general and specialty practitioners is extremely lacking. Compared to the United States, Appalachia has 12% fewer primary care providers (PCP), 35% fewer mental health providers, and 28% fewer specialty providers (including reproductive health) each per 100,000 persons (Appalachian Regional Commission, 2019). Not only are there fewer practitioners per 100,000 people, but there is a higher percent of people who do not have access to reliable transportation (7.3%). (Appalachian Regional Commission, 2019). This can cause issues if one needs to drive to reach the nearest provider.

Using three-year averages of per capita market income, unemployment rates, and poverty rates, ARC creates an index classification for each county to determine the overall socioeconomic status (SES) for each central Appalachian county covered by ARC (ARC, 2020). Each county is classified into one of the following five categories: “distressed, at-risk, transitional, competitive, or attainment” (ARC, 2020). A distressed county refers to a county that is economically depressed and in the bottom 10% in the nation (ARC, 2020) In 2021, of the 78 counties deemed as distressed, 42 of those counties are in Kentucky (ARC, 2020). This indicates that surface mine proximity is not the only factor affecting birth outcomes in this area. A multi-sectoral approach is needed to have a lasting impact on preterm birth and low birth weight in Appalachia.

This study attempts to generate additional knowledge of the relationship between active surface mining exposure during pregnancy and the measurable effects on the baby. A definitive causal relationship cannot be made based on a handful of studies, but this creates a basis for areas that could use more funding and research. More research is needed to determine the duration of exposure needed to influence fetus development as this study did not look at long term coal exposure. This study and other similar ones can be used as reference when officials are trying to develop policies surrounding surface mining adverse health outcomes of the mother and baby.

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