Energy Production and Newborn Health: Lessons Learned in Assessment of the Effect of Mountain Top Mining

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ABSTRACT

Background

A research program was developed to investigate associations between residence in coal mining counties and two measures of newborn health – frequency of birth defects and prevalence of small-for-gestational age.

Materials and Methods

The risks of birth defects among infants born to residents of Mountain-Top mining (MTM) counties and of non-mining counties were compared using 1990-2009 life birth certificate data from West Virginia. Poisson regression analysis was used to examine the influence of hospital of birth on the prevalence rate ratios (PRR). Mantel-Haenzel analyses revealed hospital-specific rates.

The SGA prevalences for residents of mining counties and non-mining counties and for MTM-mining counties and Non-MTM mining counties were compared using 1990-2002 live birth certificate data from central Appalachian states (KY, TN, VA, and WV). Logistic regression analysis was used to examine the influence of co-variables, specifically tobacco use.

Results

Birth defect rates appeared to be more a characteristic of hospital of birth than of maternal county of residence. The prevalence rate ratio (PRR) comparing births from residents of MTM-counties and of non-mining counties was 1.43 (95% CI, 1.35-1.51; $p < 0.001$) unadjusted for hospital of birth and 1.08 (95% CI, 0.97-1.20; $p = 0.16$) when adjusted for hospital of birth.

Maternal tobacco use varied among the counties grouped by mining activity and was the major risk factor for SGA with an odds ratio of 2.5. Maternal tobacco use (30.9% in MTM-mining counties and 25.8% in non-MTM mining counties) accounted for the differences in their SGA prevalences [e.g., PRR = 0.999 (95% CI, 0.98-1.02; $p = 0.90$)]. The prevalence of maternal tobacco use (28.3% in mining counties and 19.2% in non-mining counties) accounted for three-quarters of the differences in their SGA prevalences leaving a residual unexplained PRR of 1.07.

Conclusion

The two studies indicated that birth defect and SGA rates were primarily a reflection of hospital of birth and of maternal tobacco use rather than of mining activity in the maternal county of residence.

INTRODUCTON

The impact of energy production on newborn health is of great public and public health concern. The focus, more particularly in recent years, has been on mountain-top mining activity. Birth defects are the newborn health outcome that the public has focused upon as an adverse effect of environmental exposures, including industrial exposures. Adequate intrauterine (or fetal) growth is the newborn health outcome that the public health and pediatric communities have been more focused on as the measure of newborn health for a community. The outcomes of concern when looking at adverse effects of environmental exposures on the health of newborns are issues of body form and body size. Is the frequency of birth defects or congenital anomalies appropriate or excessive? Is the rate of intrauterine growth appropriate, i.e., are the newborns of adequate or inadequate weight at their times of birth? Is the frequency of adverse outcomes differentially associated with potential exposures to mining activity? This is a review of the recent results from our research program that seeks to examine the degree to which coal mining activities may be an environmental health risk factor regarding the health of newborns in Appalachia.

BACKGROUND

In the mid to late 20th century, when survival rates of premature infants were low, the standard measures of adequate intrauterine life was the avoidance of prematurity (i.e., births prior to a gestational age of 37 weeks) and of low birth weight (i.e., less than 2,500 grams for a full-term birth). In the beginning of the 21st century, attention focused on small-for-gestational age (SGA) as a more useful summary measure. It gives greater recognition to the clear observation that the third trimester of pregnancy is the period of accelerated growth and that the expected “normal” weight is thus dependent on the gestational age of the newborn and not independent of gestational age. SGA is defined as a birth weight below the 10th percentile birth weight for an infant of a specific gestational age.

Potential data sources include live birth certificates, hospital records, and state registries. Live birth certificates have the advantages that they are public documents, are obtained on 100 % of live births, and have a standardized form that is identical across all states. The US live birth certificate was revised and standardized in 1989 and further revised in 2003. The 1989 revision was adopted by all states by 1990, and the 2003 revision was adopted by all states by 2015.

Individualized information on newborns that is found on the live birth certificate includes congenital anomalies (both specific birth defects and other congenital anomalies), birth weight, gestational age (completed weeks of pregnancy), and additional medical risk factors and behaviors such as smoking and alcohol use. Additional information includes place of maternal residence and place of infant's birth. The birth certificate data file, thus, has data potentially useful to assess newborn health of a community, both for birth defects and for SGA and depending upon the data quality and completeness.

Early studies based on birth certificate data have been undertaken by Ahern and her colleagues: Ahern et al (2011a) examining congenital anomalies in the four state central Appalachia area and Ahern et al. (2011b) examining low birth weight in West Virginia. We have sought to examine those associations and to seek the role of explanatory factors including biological, demographic, behavioral, and social factors in addition to industrial factors. The Ahern et al. (2011a) study of birth defects was a birth certificate study for live births in four Appalachian states (Kentucky, Tennessee, Virginia, and West Virginia) for the years 1996-2003. The data were analyzed on the basis of maternal county of residence, which they grouped into three mining groups – (1) Counties with no mining activity (Non-mining), (2) Counties with only underground coal mining activity and no surface mining [i.e., mountain-top mining (MTM)] (Non-MTM), and (3) Counties with both underground and surface mining activity (MTM). Ahern et al. (2011a) concluded that birth defect rates were higher in MTM mining areas.

The Ahern et al. (2011b) study of low birth weight (LBW) was a birth certificate study for live births in West Virginia for the years 2005-2007. Counties with mining activity were dichotomized into moderate and high mining depending on whether the coal mining production for 2005-2007 was greater or less than the median of 13,510,500 tons. The data were analyzed also on the basis of maternal county of residence which they grouped into three mining groups – (1) Counties with no mining activity (no coal mining), (2) Counties with moderate mining (moderate), and (3) Counties with high mining activity (high). Ahern et al. (2011b) concluded that living in mining areas in West Virginia increased the LBW rate by about 15% after adjustment for co-variables.

The previous birth certificate-based studies of newborn health have reported associations with mining activity in central Appalachian states or more specifically in West Virginia both for birth defects and for low birth weight (Ahern et al. 2011a; Ahern et al. 2011b). We have developed similar data sets, used their county classification scheme, and have sought to examine these issues in greater detail. We have expanded upon these studies to examine risk factors that may contribute to these associations.

METHODS AND MATERIALS

In our analyses, we used birth certificate data from the four-state area (Kentucky, Tennessee, Virginia, and West Virginia) from the state health departments. One study concerned birth defects/congenital anomalies in West Virginia and mountain-top mining (Lamm et al. 2015) and a second study concerned small-for-gestational age in the four state area and coal production (Afari-Dwamena et al. 2015).

Birth Defects/Congenital Anomalies, West Virginia, Mining Activity

The West Virginia birth defect study compared the risk of birth defects among infants born to residents in counties with mountain-top mining (MTM) activity to that of infants born to residents of non-mining

counties. Birth certificate data files were provided by the West Virginia Department of Health for the years 1990 to 2009. The West Virginia file was large (greater than 400,000 live births) and had the advantage that it included hospital of birth and transcriptions of the entries on congenital anomalies that had been hand-written. While births occurred at 319 locations, 44 hospitals accounted for 98% of the live births for residents of the MTM counties and for 95% of the live births for residents of the non-mining counties. Analyses were limited either to the 44 hospitals with greater than 1000 live births to West Virginia residents or to the 6 hospitals with at least 1000 live births from residents of counties with MTM activity and 1000 live births from residents of counties with no mining activity. The outcome measure was the occurrence of newborns with one or more birth defect or congenital anomaly reported on the birth certificate. Adjusted and stratified Prevalence Rate Ratios (PRR) of the group of hospitals was computed using Poisson regression and Mantel-Haenszel analyses with a two-tailed p-value < 0.05 as the standard for significance.

Small for Gestational Age, Four State, Mining Activity

The primary goals in the SGA analyses were to determine, first, whether the SGA prevalence was significantly different for residents of counties with mining activity compared to residents of counties without mining activity, and, if so, what proportion could be explained by known risk factors. Secondly,, our analysis was to determine whether SGA prevalence was significantly different for residents of mining counties with MTM mining activity compared to residents of mining counties without MTM mining activity, and, if so, what proportion could be explained by known risk factors. Data were extracted from live birth certificate files obtained with the approval of the respective state departments of health and from the National Center for Health Statistics from 1990-2002 for the four central Appalachian states of Kentucky, Tennessee, Virginia, and West Virginia. The four-state file had the advantage of great numbers (more than three million live births) and the disadvantage that location was limited to the county of birth and the county of maternal residence and did not include hospital of birth. Extracted data included information on both the infant and the parents. Infants were categorized as having SGA or not. SGA was defined as having a birth certificate recorded birth weight that was below the 10th percentile for the weights of singleton live births from gestational ages 22 to 44 weeks, using the Oken et al. (2003) standards. While Oken et al. (2003) had standards for live births of both non-Hispanic white women and of black women, this study was restricted to the analysis of the live births to non-Hispanic white women as non-Hispanic white women comprised 95% of the birth mother population in the mining counties.

Co-variables or risk factors for SGA extracted from the birth certificate for analysis were variables of time (year of birth and gestational age) and space (place of maternal residence (state), place of maternal birth (country)), maternal characteristics (marital status, race, Hispanic origin, age, and education), pregnancy care (prenatal adequacy), newborn characteristics (sex) and social exposures (tobacco). Attention was focused on maternal tobacco use as it has previously been shown to be a dominant risk for SGA (van den Berg 2013; Thompson 2001; McCowan 2009). Paternal characteristics were not included in the analysis as they were under assessed with about 20 to 70% missing data. Data on maternal alcohol use was available on the birth certificate but not extracted for our analysis as the reported prevalence of alcohol use (1.5%) indicated it was markedly under reported. Data on maternal medical risk factors (diabetes, hypertension, etc.) were also not extracted as the information had not been validated.

SGA prevalence rates were determined for live births from residents of mining counties and from residents of non-mining counties; from residents of MTM mining counties and from residents of non-MTM mining counties. Prevalence rate ratios were calculated. Similarly, maternal tobacco use prevalence rate ratios were assessed using the same comparisons. For each area comparison, logistic regression analyses were conducted to assess the contributions of maternal tobacco use and of the other co-variables on the SGA odds ratio (OR).

RESULTS

Birth Defects/Congenital Anomalies, West Virginia, Mining Activity

The proportion of infants with recorded birth defects or congenital anomalies has been compared for 1990-2002 live births to West Virginia women residents of MTM counties or of non-mining counties. A set of 44 hospitals accounted for 98% of infants born to residents of MTM mining counties and 95% of infants born to residents of non-mining counties [Table 1]. Congenital anomalies were reported for 2.1% of the live births to residents of the MTM counties and for 1.5% of the residents of the non-mining counties, for an unadjusted prevalence rate ratio (PRR) of 1.43 (95% CI, 1.36-1.52) that was statistically significant ($p < 0.001$).

As prevalence rates varied markedly among the various hospitals of birth (Mean 1.8%, Median 1.3%, Range 0.4%-11.6%), a Poisson regression analysis was conducted adjusting for hospital of birth. This Poisson regression analysis yielded a PRR of 1.08 (95% CI, 0.97-1.20; $p = 0.16$) that was not statistically significant ($p = 0.16$). Thus, adjustment by hospital of birth by itself accounted for 80% of the excess rate of congenital anomalies that had been observed in the unadjusted analysis [i.e., (0.08-0.43)/0.43 = - 0.81 or 81% reduction).

The purpose of the analysis was to seek explanations for the greater recorded congenital anomaly rates for residents of MTM mining counties than for residents of non-mining counties. The Poisson analysis demonstrated that the varying rates among hospitals explained much of the difference, i.e., an inter-hospital effect. We conducted a Mantel-Haenzel analysis, i.e., an intra-hospital analysis, which assessed whether, within each hospital, the congenital anomaly rates differed depending on the mother's county of residence and its mining activities. We identified the six hospitals that had sufficient live births to residents from each area (> 1000 from MTM counties and > 1000 from non-mining counties) to provide a stable prevalence rate for each area and then compared the prevalence rates within hospitals. The 6 hospitals accounted for 77% of the live births to residents of MTM mining counties (119,058/155,382 = 0.77, or 77%) and 30% of the live births to residents of non-mining counties (41,918/139,603 = 0.30, or 30%). The 6 hospitals also accounted for 84% of the live births with congenital anomalies to residents of MTM mining counties (2,768/3,297 = 0.84, or 84%) and 20% of the live births with congenital anomalies to residents of non-mining counties (408/2,077 = 0.20, or 20%) Four of the six hospitals had more live births from the MTM mining counties than from the non-mining counties with one hospital having 25 times more live births to residents of MTM mining counties than to residents of non-mining counties (31,039/1,137 = 27.3).

Overall, the prevalence of birth defects among the 6 hospitals was 2.3% for resident of MTM mining counties. The prevalence of birth defects among the 6 hospitals was 1.0% for residents of non-mining counties. The crude or unadjusted PRR for all 6 hospitals was 2.39 (95% CI, 2.15-2.65; p-value < 0.001) which was statistically significant. Individually, the PRR for the 6 hospitals ranged from 0.69 to 1.17 with hospital 4 being the only hospital to indicate statistical significance. Data distribution among hospital of

birth influenced the perceived increased risk of birth defects among residents in MTM mining counties in comparison to non-mining counties (Table 1).

Figure 1 shows, for all six hospitals combined and for each hospital separately, the prevalence rate of live births being recorded as having a congenital anomaly both for the live births from mothers resident in MTM mining counties and from mothers resident in non-mining counties. For all hospitals combined, the congenital anomaly prevalence rate for the MTM mining counties (Rate = 0.023) is more than twice that for non-mining counties (Rate = 0.010) with a crude or unadjusted PRR of 2.39 (95% CI, 2.15-2.65). In contrast, for each of the individual hospitals, the congenital anomaly prevalence rate for

Table 1. 1990-2002 Births, Birth Defects, Prevalence Rates and Prevalence Rate Ratios to WV Residents

1990-2009 Births, Birth Defects, Prevalence Rates and Prevalence Rate Ratios to WV Residents*												
Hospitals	MTM-mining Live Births	MTM-mining with Birth Defect	Prevalence in MTM-mining	Non-mining Live Births	Non-mining with Birth Defect	Prevalence in Non-Mining	PRR	95% CI	p-value	Hosp-Adj PRR	95% CI	p-value
All sites	155,382	3,297	0.021	139,603	2,077	0.015	**1.43**	**(1.36-1.52)**	**< 0.001**	[Non-convergent]		
44 Hosps+	152,540	3,235	0.021	132,732	1,972	0.015	**1.43**	**(1.35-1.51)**	**< 0.001**	**1.08** [a]	**(0.97-1.20)**	**0.16**
6 Hosps++	119,058	2,768	0.023	41,918	408	0.010	**2.39**	**(2.15-2.65)**	**< 0.001**	**1.01** [b]	**(0.89-1.14)**	**0.87**
Hosp 04	53,595	211	0.004	11,900	68	0.006	0.69	(0.52-0.90)	0.01			
Hosp 07	2,366	26	0.011	5,460	67	0.012	0.90	(0.57-1.41)	0.64			
Hosp 14	10,529	128	0.012	2,353	26	0.011	1.10	(0.72-1.67)	0.67			
Hosp 21	8,431	125	0.015	1,259	17	0.014	1.10	(0.66-1.82)	0.73			
Hosp 22	31,039	2,155	0.069	1,137	71	0.062	1.11	(0.88-1.40)	0.36			
Hosp 26	13,098	123	0.009	19,809	159	0.008	1.17	(0.93-1.48)	0.19			

* MTM-mining / Non-mining

\+ Hospitals with greater than 1,000 live births in MTM-mining and Non-mining counties, combined

++ Hospitals with greater than 1,000 live births in MTM-mining and Non-mining counties, separately

a Poisson Regression

b Mantel-Haenszel Analysis

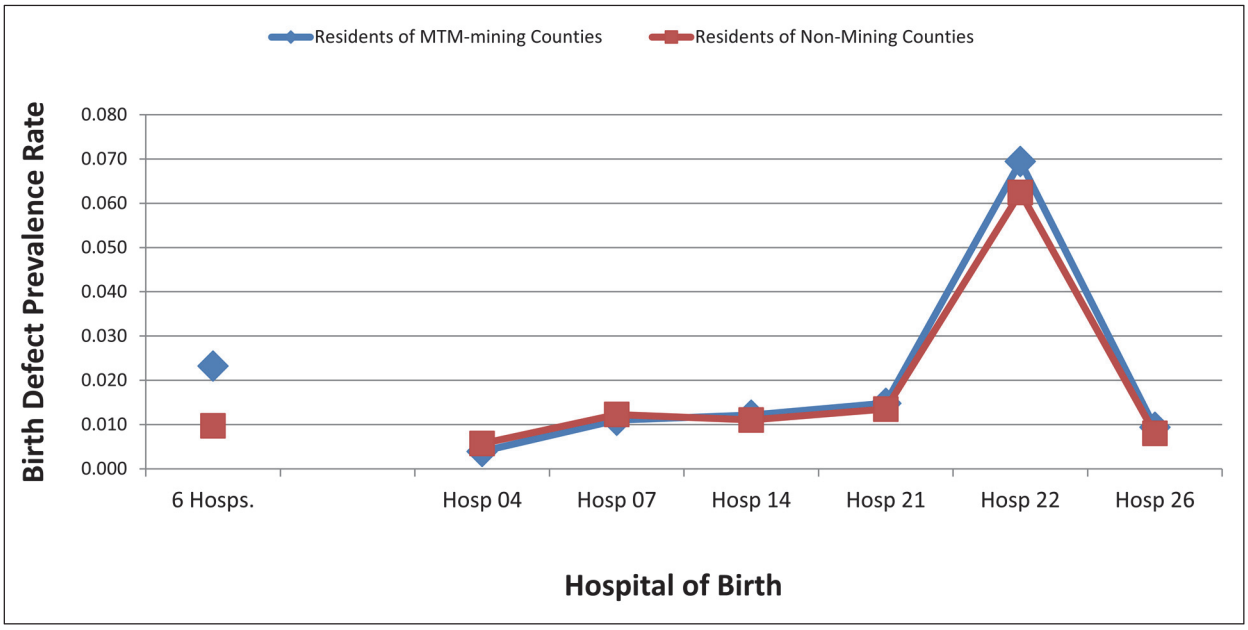

Figure 1. Comparison of Birth Defect Rates by Maternal Residence in Mountain- Top Mining and Non-mining Counties for Hospitals with >=1,000 Live Births in Each Group (WV, 1990-2009)

the MTM mining counties is very similar to that for non-mining counties. The prevalence rate ratios for the individual hospitals range from 0.69 to 1.17 with an average of 1.01. The hospital-adjusted PRR for the six hospitals combined is 1.01 (95% CI, 0.89-1.14), which is indistinguishable from no increased risk (p = 0.87).

Small for Gestational Age, Four State, Mining Activity

Our final analytic dataset consisted of information on 2,305,025 live births to non-Hispanic white mothers with known tobacco use histories who were residents of the four-state area (Kentucky, Tennessee, Virginia, and West Virginia) during 1990-2002.

The overall SGA prevalence rate was 11.4%, somewhat higher than the expected prevalence of 10%. The SGA prevalence differed among the counties grouped by mining activity. The SGA prevalence for residents of counties with mining activity (13.3%) was significantly higher than the rate for residents of counties with no mining activity (11.0%), yielding a prevalence rate ratio (PRR) of 1.21 (95% CI, 1.20-1.22). The SGA prevalence for residents of counties with MTM activity (13.7%) was significantly higher than the rate for residents in counties with Non-MTM activity (12.9%), yielding a prevalence rate ratio of 1.07 (95% CI, 1.05-1.09).

Similarly, the maternal tobacco use prevalence differed among the counties grouped by mining activity. While the overall prevalence was 20.8%, the maternal tobacco use prevalence for residents of counties with mining activity (28.3%) was significantly higher than the rate for residents of counties with no mining activity (19.2%), yielding a prevalence rate ratio (PRR) of 1.47 (95% CI, 1.46-1.48). The maternal tobacco use prevalence for residents of counties with MTM activity (30.9%) was significantly higher than the rate for residents in counties with non-MTM activity (25.8%), yielding a prevalence rate ratio (PRR) of 1.20 (95% CI, 1.19-1.21).

Since both SGA prevalence and maternal tobacco use prevalence showed similar patterns with respect to the counties grouped by mining activity, logistic regression analyses were conducted to assess the SGA prevalence rate ratios while adjusting for the maternal tobacco use. This was conducted both with and without the additional co-variables (Table 2).

Table 2. SGA Odds Ratios by Residential County Mining Activity Group – Unadjusted, Adjusted, and Tobacco inclusion

SGA Model	OR	95% CI	Z	p-value
Mining vs. Non-Mining Counties				
Unadjusted	1.25	(1.24-1.26)	44.75	0.000
With Tobacco	1.10	(1.09-1.11)	18.58	0.000
Adjusted*	1.09	(1.08-1.11)	13.71	0.000
With Tobacco	1.07	(1.05-1.08)	9.87	0.000
Mining with vs. without Mountain-Top Mining (MTM)				
Unadjusted	1.09	(1.07-1.10)	9.35	0.000
With Tobacco	1.02	(1.00-1.04)	2.46	0.014
Adjusted*	1.04	(1.02-1.07)	4.34	0.000
With Tobacco	0.999	(0.98-1.02)	-0.12	0.901

* Adjusted for child sex, prenatal care adequacy, maternal characteristics (married, age, education, foreign-born), state of residence, year of birth, and gestational age (weeks) in analysis for non-Hispanic white women.

The odds ratio for SGA prevalence of residents of counties with mining activity compared to those without mining activity was 1.25 (95% CI, 1.24-1.26), which with the inclusion of maternal tobacco use became 1.10 (95% CI, 1.09-1.11). Maternal tobacco use alone accounted for 60% of the risk difference [(0.10-0.25)/0.25 = -0.60, or -60%)]. The odds ratio adjusted for co-variables other than maternal tobacco use was 1.09 (95% CI, 1.08-1.11) and including maternal tobacco use was 1.07 (95% CI, 1.05-1.08). Thus, inclusion of co-variables along with maternal tobacco use accounted for 75% of the difference in SGA prevalences between residents of mining counties and residents of non-mining counties [(0.07-0.25)/0.25 = 0.75, or 75%)]. In the overall model, the maternal tobacco use odds ratio (OR = 2.46; z-score = 186.4) was far greater than that for mining counties (OR = 1.07; z-score = 9.87).

Similarly, the odds ratio for SGA prevalence of residents of counties with MTM-mining activity compared to those without MTM mining activity was 1.09 (95% CI, 1.07-1.10), which adjusted for maternal tobacco use became 1.02 (95% CI, 1.00-1.04). Maternal tobacco use alone accounted for 78% of the risk difference [(0.02-0.09)/0.09 = -0.78, or -78%)]. The odds ratio adjusted for co-variables other than maternal tobacco use was 1.049 (95% CI, 1.02-1.07) and including maternal tobacco use was 0.999 (95% CI, 0.985-1.02). Thus, inclusion of co-variables along with maternal tobacco use accounted for all of the difference in SGA prevalences between residents of mining counties with MTM activities and residents of mining counties without MTM activities, i.e., OR = ~ 1.00. In the overall model, the maternal tobacco use odds ratio (OR = 2.52; z-score = 88.2) was the strongest risk factor, while MTM-mining had no contribution (OR = 0.999; z-score = -0.12).

Previous analysis had shown that the effect of maternal tobacco use on SGA prevalence was gestational age dependent (Ferdosi, 2015). No effect was seen at less than 33 weeks of age ("extremely pre-term" through "very pre-term") and a monotonically increasing rate was seen that reached a doubling of the risk by week 37 ("moderate to late pre-term" to "full-term"). For women who did not use tobacco during pregnancy, the SGA prevalence rate was independent of the gestational age, being similar across the full gestational age range of 22-44 weeks. Figure 2 shows the gestational age-specific SGA prevalence rates for tobacco users and tobacco non-users for residents of non-mining counties, of non-MTM mining counties, and of MTM counties. The patterns for both tobacco users and tobacco non-users do not differ with respect to mining activities in the county of residence.

DISCUSSION

We have undertaken a program to assess the potential impact of mining activities, particularly mountain-top mining, on the health status of newborns in the central Appalachian states using data recorded on the live birth certificates (US revision 1989). Two aspects of health status of newborns that could be examined from birth certificate data were the presence of malformations and inadequacy of growth. Lamm et al. (2015) analyzed the frequencies of newborns having reported congenital anomalies among the newborns of women who resided in West Virginia (1990-2009). Results showed that the major determinant of newborns having been recorded as having a congenital anomaly was the hospital of birth rather than the maternal county of residence. Afari-Dwamena et al. (2015) analyzed the frequency of small-for-gestational age newborns among the newborns of women who resided in the four central Appalachian states of Kentucky, Tennessee, Virginia, and West Virginia (1990-2002). Results showed that the major determinant of newborns being small for gestational age (based on birth weight and gestational age) was whether the mother reported being a tobacco user rather than her county of residence.

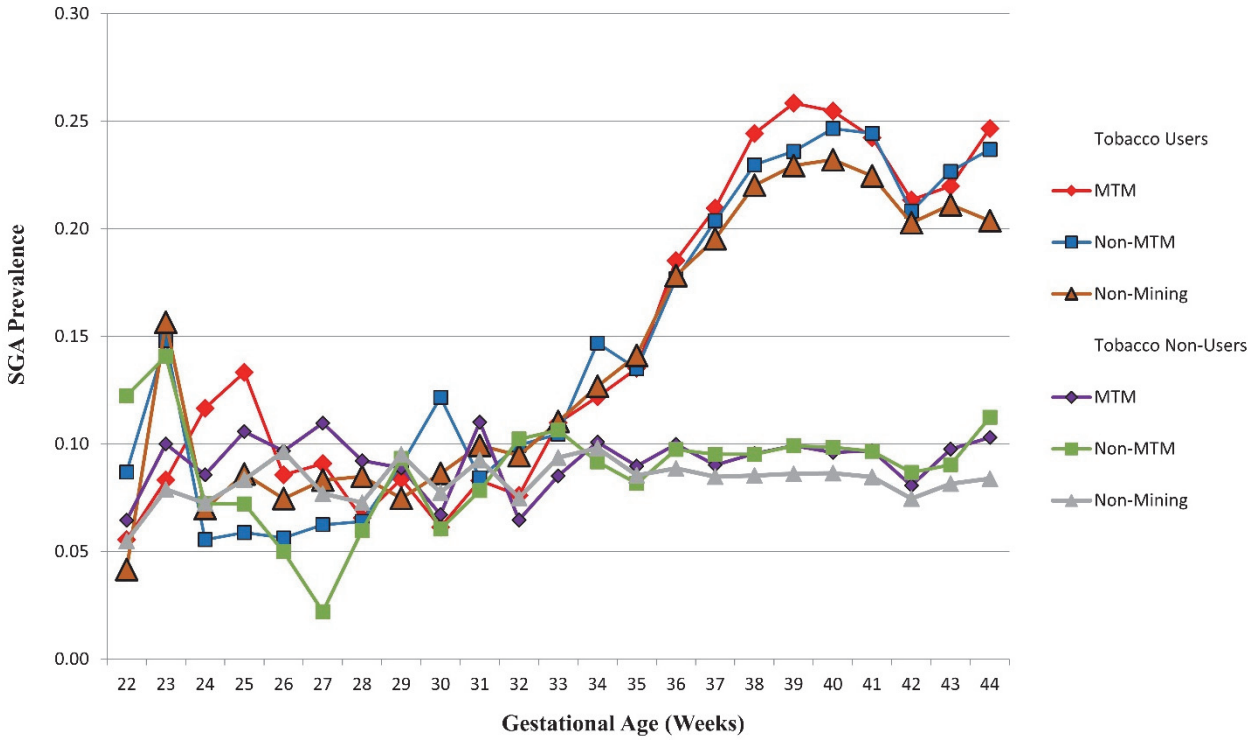

Figure 2. SGA Prevalence by Gestational Age, Tobacco Use, and Mining Activity (1990-2002)

Lamm et al. (2015) observed that although births to residents of West Virginia occurred in 319 locations, most occurred in a more limited set of 44 hospitals. Further, the frequencies with which reported congenital anomalies were reported varied thirty-fold among these hospitals. The prevalence rate ratio (MTM counties vs. non-mining counties) was 1.43 and statistically significant prior to adjustment for hospital of birth and was 1.08 and not statistically significant after adjustment for hospital of birth. Thus, hospital of birth contributed more than 80% [(0.08-0.43)/0.43 = 0.82, or 82%] of the observed excess risk. After adjustment for hospital of birth, there was no longer a significant difference in risk observed between mothers resident in MTM counties and mothers resident in non-mining WV counties. Further analysis confined to the hospitals with a large number of births both from mothers resident in MTM counties and from mothers resident in non-mining counties showed no difference in risk (PRR = 1.01; 95% CI, 0.89-1.14; p-value = 0.87).

It is not surprising that hospital of birth is a major determinant of the reporting of congenital anomalies. Boulet et al. (2011) reported, using an active surveillance program for birth defects [Metropolitan Atlanta Congenital Malformation Program [MACMP]), that "the underreporting of birth defects on birth certificates is influenced by socio-demographic and hospital characteristics". Li et al. (2013), examining these same West Virginia birth certificates, demonstrated that coding practices differed across hospitals independent of mining activity of maternal county of residence. Li et al. (2013) distinguished between birth defects specified on the life birth certificate, such as, anencephaly, spina bifida, and cleft lip/palate, and "other congenital anomalies" which are not specifically specified but indicate miscellaneous observations either for a specific organ system or not. They demonstrated that the greatest variability was in the "other congenital anomalies" rather than in the specified birth defects. The terms birth defect, congenital malformation, and congenital anomaly are generally used interchangeably in the literature, though Li et al. (2013) tended to use birth defect to refer to specifically

named malformations and congenital anomaly for unnamed or non-specific malformations (i.e., other). They also pointed out that many of the "other" congenital anomalies referred to post-natal circumstances rather than anomalies present at birth.

Afari-Dwamena et al. (2015) observed an increased prevalence of SGA among infants born to mothers who reside in mining counties in comparison to those who reside in non-mining counties and an increased prevalence among mothers who resided in MTM mining counties in comparison to those who reside in Non-MTM mining counties. We expanded the analysis to include SGA risk factors on the birth certificate that had been identified by previous SGA studies in order to explore the area differences. Among the risk factors included in our analysis, tobacco use had the highest odds ratio and by itself explained 60-75% of the excess risk. The effect of adjustment for tobacco use was, in magnitude, about equal to that for all other risk factors. The odds ratio for residents of mining counties in comparison to residents of non-mining counties dropped from 1.25 to 1.07 (95% Cl, 1.05-1.07). The resultant residual excess risk has not yet been explained though a number of known SGA risk factors have not been included in the analysis. For residents of MTM mining counties in comparison to non-MTM mining counties, the odds ratio dropped from 1.09 to 0.999 (95% Cl, 0.98-1.02). Examination of SGA prevalences by gestational age and tobacco use showed similar patterns for the three mining activity groups.

Our findings from Afari-Dwamena et al. (2015), in regards to the influence of maternal tobacco use on SGA, are consistent with those of a number of studies. Most studies have indicated a two-fold or greater risk for SGA among tobacco use for full term births (Horta, 1997; Chiolero, 2005; Raatikainen, 2007; Lang, 1996; Suzuki, 2008; Rodriques, 2007; Vardavas, 2010; Baba, 2013; Chan, 2001; Savitz, 2001; Gao, 2006; Mehaffey, 2010). Differences in tobacco dosage may explain the variation in SGA prevalence among these studies. Mehaffey et al. (2010) from Baffin Island had shown a risk of 2.5 for 10 (+) cigarettes per day but no increase for lower dosages. Kalinka (1996) in Poland had shown a risk of 5 only for the infants of mothers who had smoked more than 20 cigarettes per day.

Although the literature on the risk of SGA and preterm infants is scant, our analysis indicated a relative risk of 1.45 for premature infants with gestational ages of 22 to 36 weeks, a relative risk of 1.08 for infants with early prematurity and gestational ages of 22 to 32 weeks and a relative risk of 1.55 for infants with late prematurity and gestational ages of 33 to 36 weeks. These findings were similar to those found in the SGA literature (Polakowski, 2009; Baba, 2013; Taylor, 2013; Clausson, 1998). Assessing SGA prevalence among tobacco users by gestational week indicated no effect on gestational ages 22 to 33 weeks; a monotonically increasing effect for gestational ages 33 to 36 weeks and a steady two fold effect for 37+ weeks. The identification of this pattern was our primary contribution to the epidemiological literature.

Limitations

Important limitations to note for the birth defect study include the issues of reliability of birth certificate information including case ascertainment and accuracy. Li et al. (2013) had shown that neonatal conditions rather than congenital conditions accounted for a large proportion of "other" congenital anomalies. Our model focused on hospital as a potential systematic bias and did not include other potential risk factors, such as tobacco use, hypertension, and diabetes, or economic and cultural factors. Borak et al. (2012) had assessed the predictive value of coal mining for mortality rates across the Appalachian region and found that age-adjusted all-cause mortality was independently related to huge economic and cultural disadvantages and was not independently related to coal mining.

Important limitations to note for the SGA study include the lack of maternal tobacco history validation and of tobacco dosage information and the absence of certain known SGA risk factors in the analysis. Regarding smoking history, Nielsen et al. (2014) had found a sensitivity of 85 to 89% and a specificity of 99% for maternal smoking history from the Washington State birth certificate. Some individual risk factors (alcohol use, diabetes, hypertension, weight gain, cigarette dosage, and chronic kidney disease) of SGA found on the birth certificate were also not included in our analysis due to issues of quality and completeness of the data. Additional individual risk factors, such as maternal height and pre-pregnancy weight, were not included in the analysis as they are not found on the birth certificate. Community risk factors, such as poverty level, housing index, etc., that relate to county of residence could also be included in the analyses and may account for the residual difference in SGA prevalences between residents of mining and non-mining counties. Further, our analysis was also limited to non-Hispanic white mothers as the Oken et al. (2003) reference population was non-Hispanic white mothers and non-Hispanic white mothers accounted for 95% of the births in the mining counties. While there were few black mothers in the mining counties, the analysis could be extended to include them using the Oken et al. (2003) SGA values for black mothers. Analyses based on coal production might also be undertaken.

CONCLUSION

In summary, both of our studies demonstrated that residence in counties with mining activity did not primarily account for adverse infant health outcomes. In the case of our birth defects study, a major factor affecting the reported frequency of birth defects on the birth certificate was the hospital of birth and its recording practices. In the case of our SGA study, a major factor affecting the frequency of SGA was the history of maternal tobacco use.

It is important to assess newborn health for residents near industrial activities, including energy production. With respect to mountain-top mining activity, careful analysis of the birth certificate data has demonstrated that initial concerns could be explained by differences in hospital activities and in maternal activities. The two studies indicated that birth defect and SGA rates were a factor of unreliable congenital anomaly reporting and maternal tobacco use. As the energy industry enters new geographic areas, efforts should be undertaken to monitor the state of newborn health as part of industrial stewardship of other types of energy production. When assessing potential new risk factors for new born health, it is important to obtain information on the previously known risk factors in order to assess the magnitude of any residual unaccounted for risk.

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