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Small-for-Gestational Age Prevalence Risk Factors in Central Appalachian States with Mountain-top Mining.

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SMALL-FOR-GESTATIONAL AGE PREVALENCE RISK FACTORS IN CENTRAL APPALACHIAN STATES WITH MOUNTAIN-TOP MINING

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Abstract

Objectives: To identify risk factors for small-for-gestational age (SGA) for counties in central Appalachian states (Kentucky (KY), Tennessee (TN), Virginia (VA), and West Virginia (WV)) with varied coal mining activities. **Material and Methods:** Live birth certificate files (1990–2002) were used for obtaining SGA prevalence rates for mothers based on the coal mining activities of their counties of residence, mountain-top mining (MTM) activities, underground mining activities but no mountain-top mining activity (non-MTM), or having no mining activities (non-mining). Co-variable information, including maternal tobacco use, was also obtained from the live birth certificate. Adjusted odds ratios were obtained using multivariable logistic regression comparing SGA prevalence rates for counties with coal mining activities to those

without coal mining activities and comparing SGA prevalence rates for counties with coal mining activities for those with and without mountain-top mining activities. Comparisons were also made among those who had reported tobacco use and those who had not. **Results:** Both tobacco use prevalence and SGA prevalence were significantly greater for mining counties than for non-mining counties and for MTM counties than for non-MTM counties. Adjustment for tobacco use alone explained 50% of the increased SGA risk for mining counties and 75% of the risk for MTM counties, including demographic pre-natal care co-variables that explained 75% of the increased SGA risk for mining counties and 100% of the risk for MTM. The increased risk of SGA was limited to the third trimester births among tobacco users and independent of the mining activities of their counties of residence. **Conclusions:** This study demonstrates that the increased prevalence of SGA among residents of counties with mining activity was primarily explained by the differences in maternal tobacco use prevalence, an effect that itself was gestational-age dependent. Self-reported tobacco use marked the population at the increased risk for SGA in central Appalachian states. Int J Occup Med Environ Health 2018;31(1):11–23

INTRODUCTION

Adverse community health metrics have been the characteristics of life in Appalachia for as long as records have been maintained. The Appalachia Regional Commission was established in 1965 to focus resources on elevating the health status of residents in Appalachia to that of the rest of the United States. Nonetheless, the health status of residents of Appalachia is still diminished. This study focuses on neonatal or infant health in the 4 central Appalachian states of Kentucky (KY), Tennessee (TN), Virginia (VA), and West Virginia (WV). Infant mortality data shows that the infant mortality for each of these 4 states is above the national mean and median [1].

Within the last decade, health studies have emerged to have examined the association of adverse community health metrics with residence in Appalachian counties and the presence or nature of coal mining activity [2–4]. These 4 states account for one-third of the U.S. coal production [5]. Although most Appalachian health studies have focused on adult health [6–9], a few have examined the health of newborns [9,10]. Ahern et al. [9] reported on birth defect rates with respect to mining activities, and Ahern et al. [10] reported on low birth weight prevalence with respect to mining activities.

Adequacy of fetal growth is a common public health concern, and the prevalence of small-for-gestational age (SGA) infants is a standard and primary growth measure of newborn health in a population. It is preferred over low birth weight (LBW), as LBW is confounded by prematurity and SGA is not [11]. Small-for-gestational age is thus a direct measure of intrauterine growth retardation (IUGR), the outcome of concern, and is relevant across the full gestational age range of live births.

From the mid to the late 20th century, when survival rates of premature infants were low, the standard measures of adequate intrauterine life were the avoidance of prematurity (i.e., births prior to a gestational age of 37 weeks) and the avoidance of low birth weight (i.e., < 2500 g 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. Small-for-gestational age is defined as a birth weight below the 10th percentile birth weight for an infant of a specific gestational age (in weeks). Small-for-gestational age gives recognition to the 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 rather than independent of gestational age. Small-for-gestational age has been chosen as the outcome variable of interest as it allows for the examination of the prevalence of IUGR, which is the outcome of concern, independent of gestational age.

A recent analysis of SGA prevalence in the 4-state Appalachian area (KY, TN, VA, and WV) showed the analysis,

that did not include mining activity, that the SGA prevalence was most markedly influenced by tobacco use (odds ratio (OR) = 2.5) and that the effect changed markedly across the gestational age range of 22–44 weeks [12]. We now examine the 1990–2002 SGA prevalence in the 4-state area specifically with respect to the mining activity in the county of maternal residence taking into consideration both the issues of tobacco use and of gestational age.

MATERIAL AND METHODS
Study population
Data for the study population came from the 1990–2002 live birth certificate files for the 4 central Appalachian states (Kentucky, Tennessee, Virginia, and West Virginia) and were obtained from the National Center for Health Statistics with the approval of the 4 state departments of health. All data was from the 1989 revision of the U.S. live birth certificate; none of the data was from the 2003 revision. Data files included information on both newborns and parents with geographic location de-identified to state and county of maternal residence at the time of the infant's birth. Analyses were limited to singleton live births. The counties in the 4 study states had been categorized in Ahern et al. [9] as either having no mining activity (non-mining), having only underground mining activity and no surface or mountain-top mining activity (non-MTM), or having, in addition to underground mining activity, mountain-top mining activity (MTM). This classification of the counties was used in our analyses. The classification was similar to that based on the county-specific coal production data from the Energy Information Agency of the U.S. Department of Energy [5].

Outcome measure
Small-for-gestational-age (SGA) is a relative measure of fetal growth that relates the birth weight distribution to the gestational age, specifically a birth weight less than the 10th percentile of the birth weights recorded for

that gestational age in weeks [13,14]. The determination of SGA is based on the recorded birth weight and the recorded gestational age and then compared to the cutoff value of the reference population. Each reference gives a set of cutoff values by each week of gestational life, sometimes separately by race, sometimes separately for gender [13,14].

The analyses presented here use the 10th percentile cutoff values for non-Hispanic white mothers, reported by Oken et al. (2003) [15]. The reference population was derived from the 1999–2000 U.S. birth certificate data from the National Center for Health Statistics Natality Data Sets (National Vital Statistics System Birth Data), thus using the same form as that of our study population [16]. There is little cross-over between the study and reference population as the white singleton birth population of the reference population (US, 1999–2000) comprises less than 0.5% of the study population (4 states, 1990–2002). Each 1990–2002 singleton live birth with gestational age 22–44 weeks for the 4 states was categorized as SGA or not, based on the cutoff values for non-Hispanic white mothers, reported by Oken et al. [15].

Our analysis was limited to the non-Hispanic white population as that was the population definition of Oken et al. [15]. Non-Hispanic white women comprised 98% of the maternal population in the mining counties and 94% of the maternal population in the non-mining counties. We had used the cutoff values for white (non-Hispanic) mothers, reported by Oken et al., that have been adjusted to child's gender [15].

Co-variables or risk factors
The birth certificate contains data on a limited number of potential co-variables. Co-variables extracted from the birth certificate form included variables of time (year of birth and gestational age) and space (place of maternal residence (state) and place of maternal birth (country)), maternal characteristics (marital status, age, race,

Hispanic origin, and education), paternal characteristics (age, race, and education), pregnancy care (prenatal care adequacy, number of pre-natal visits, month when prenatal visits began), newborn characteristics (sex) and lifestyle factors (self-reported tobacco and alcohol use). All co-variables that entered the analysis had been recorded for at least 98% of the live births.

Place of maternal birth entered the analytic data set as a dichotomous variable (foreign or domestic), as did marital status (unmarried or married), tobacco use (yes or no), child sex (male or female), Hispanic ethnicity of mother (yes or no), maternal education (> 12 years of schooling or not), and pre-natal care adequacy (PCA) (adequate or not). Prenatal adequacy is a constructed co-variable that includes both trimester when prenatal visits were initiated and the number of prenatal visits, using a nomogram of the Institute of Medicine-modified Kessner criterion [17], and were recorded in the birth certificate data set. Maternal age entered as a categorical variable with strata of < 18 years old, 18–35 years old, and > 35 years old at the time of delivery. The state of maternal residence was limited to the 4 states in the study (KY, TN, VA, and WV). While maternal race was entered in the analytic data set as white, black, or another, the analysis was limited to the non-Hispanic white. Birth year (1990–2002) entered as a continuous variable, and gestational age in weeks (22–44 weeks) entered as a categorical variable.

Paternal characteristics were not included in the analysis as the documentation was incomplete (20–70% missing data), as was the average number of cigarettes (17% missing data). Similarly, alcohol use was not included as it was markedly underreported – 1.5% prevalence compared to national rates of 16.3% [18]. Data on medical risk factors, e.g., diabetes, hypertension, and renal disease, was not extracted as it, unlike tobacco use, had not been validated from the birth certificate [19]. Thus, all analytic co-variables included in the analysis had individual data reported on at least 98% of the subjects.

Data analysis

Live births (4 states, 1990–2002) were aggregated to the county of maternal residency and then by mining activity for that county, i.e., counties with no mining activity, counties with only underground coal mining activity, and counties with mountain-top mining activity. Small-for-gestational-age prevalence rates and prevalence rate ratios were calculated using Epi-Info7 [20] with a two-tailed p-value < 0.05 as the level of significance. Analyses compared rates for residents of mining counties with those for residents of non-mining counties. Analyses also compared rates for residents of mining counties with MTM activity with those for residents of mining counties without MTM activity. Similar analyses were conducted for prevalence of self-reported maternal tobacco use.

Logistic regression analytic models were developed using Stata SE-13 [21] with SGA as the dependent variable, mining activity group as the primary independent variable of interest, maternal tobacco use as the secondary independent variable of interest, and co-variables of maternal and infant risk factors as additional independent variables of interest. Logistic regression analyses yielded unadjusted (crude odds ratio – cOR), tobacco-adjusted, co-variable-adjusted, and fully (tobacco and co-variables) adjusted odds ratios (aOR). Effects on the odds ratio of the addition of tobacco use and/or the co-variables to the models were demonstrated. Z-scores of independent variables were compared.

In order to assess whether the effect of tobacco use on SGA varied across the mining groups, gestational-age specific SGA prevalence rates for tobacco using and non-tobacco using residents of each mining group were calculated and graphically compared.

RESULTS

The 4 state (KY, TN, VA, WV) live birth certificate (1990–2002) data file contained 3 206 343 live births, out of which 3 067 914 (95.7%) met the Oken et al. crite-

ria [15]. As the study population was the non-Hispanic white mothers, the major exclusion was for 762 889 mothers (632 265 non-white and 130 624 Hispanic-white), out of whom only 4% lived in the mining counties. Singleton live births totaled 2 305 025 (1 185 159 males and 1 119 866 females) to non-Hispanic white mothers with known tobacco use histories served as our study population.

SGA prevalence by mining group activity

The overall SGA prevalence (%) in the four-state data set was 11.4%; slightly higher than the 10% expected from the national data. The SGA prevalence was not uniform across the residential county mining activity groups (Table 1). Residents of counties with mining activity had a higher SGA prevalence (13.3%) than did residents of counties with no mining activity (11%). Residents of counties with MTM activity had a higher SGA prevalence (13.7%) than did residents of non-MTM counties, i.e., with only underground mining activity (12.9%).

The prevalence rate ratio (PRR = 1.21, 95% confidence interval (CI): 1.20–1.22) for counties with coal mining activity compared to residents of counties with no mining activity showed a 21% higher SGA prevalence. The prevalence rate ratio (PRR = 1.07, 95% CI: 1.05–1.09) for counties with MTM coal mining activity compared to residents of non-MTM counties showed a 7% higher SGA prevalence.

Tobacco use by mining group activity

Maternal tobacco use prevalence overall in the 4-state data sets was 20.8%, but it ranged by mining group activity from 19.2% to 30.9% (Table 2). The maternal tobacco use prevalence was 19.2% in the non-mining counties and 28.3% in the mining counties (PRR = 1.47, 95% CI: 1.46–1.48), showing a nearly 50% higher prevalence in the mining counties than in the non-mining counties.

Among the counties with mining activity, the maternal tobacco use prevalence was 25.8% in the counties with only non-MTM activity and 30.9% in the counties with MTM activity (PRR = 1.20, 95% CI: 1.19–1.21), showing a 20% higher prevalence in counties with mining counties with MTM activity than in mining counties without MTM activity. The rate of tobacco use in counties with MTM coal mining (30.9%) was higher than that of mining counties without MTM (25.8%), which was higher than that in counties with no mining activity (19.2%).

Logistic regression model

The logistic regression analysis was undertaken to examine the influence of the covariates on the estimation of the associations between SGA frequency and residency in the mining groups. Co-variables were extracted from the birth certificate form. Analyses were conducted both including and excluding tobacco use as a co-variable.

Table 1. Small-for-gestational age (SGA) prevalence by residential county mining activity, central Appalachian states, 1990–2002

Activity	Live births [n]	SGA		PRR (95% CI)
		n	%	
Non-mining	1 914 231	210 125	11.0	–
Mining	390 794	51 939	13.3	1.21 (1.20–1.22)
non-MTM	201 391	25 906	12.9	–
MTM	189 403	26 033	13.7	1.07 (1.05–1.09)
Total	2 305 025	262 064	11.4	–

MTM – mountain-top mining.
PRR – prevalence rate ratio; CI – confidence interval.

Table 2. Maternal tobacco use prevalence by residential county mining activity, central Appalachian states, 1990–2002

Activity	Live births [n]	Maternal tobacco use		PRR (95% CI)
		n	%	
Non-Mining	1 914 231	368 047	19.2	–
Mining	390 794	110 514	28.3	1.47 (1.46–1.48)
non-MTM	201 391	51 918	25.8	–
MTM	189 403	58 596	30.9	1.20 (1.19–1.21)
Total	2 305 025	262 064	11.4	–

Abbreviations as in Table 1.

Table 3. Small-for-gestational age (SGA) odds ratios by residential county mining activity group – unadjusted, adjusted, and tobacco inclusion, central Appalachian states, 1990–2002

Model	OR	95% CI	Z	p
Mining vs. non-mining counties				
unadjusted	1.240	1.23–1.26	41.45	0.000
including tobacco	1.120	1.10–1.13	18.58	0.000
adjusted*	1.090	1.08–1.10	13.57	0.000
including tobacco	1.060	1.05–1.08	9.78	0.000
Mining with vs. non-MTM				
unadjusted	1.080	1.06–1.10	8.11	0.000
including tobacco	1.020	0.99–1.04	1.94	0.052
adjusted*	1.040	1.02–1.07	4.37	0.000
including tobacco	0.999	0.98–1.02	–0.07	0.941

MTM – mountain-top mining.
OR – odds ratio; CI – confidence interval.
* Singleton births 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 logistic regression analysis was conducted to determine the SGA odds ratio for residents of counties with mining activity (mining) as compared to that of residents of counties without mining activity (non-mining) (Table 3). The unadjusted crude odds ratio was 1.24 (95% CI: 1.23–1.26). Adjustment only for tobacco use reduced the odds ratio to 1.12 (95% CI: 1.10–1.13), accounting for the reduction of 50% ((1.12–1.24)/(1.24–1.00) = –50%). Adjustment for all other co-variables except for tobacco use reduced the odds ratio to 1.09 (95% CI: 1.08–1.10), accounting for the gross reduction of 64%.

The full model including both tobacco use and the other co-variables yielded the odds ratio of 1.06 (95% CI: 1.05–1.08), accounting for the total reduction of 75%. Tobacco use accounted by itself for 50% of the excess odds ratio for mining counties and for 75% of the excess odds ratio with the other co-variables.

In the full model, the tobacco use odds ratio (OR = 2.46, z-score = 186.6) was far greater than that for mining

counties (OR = 1.06, z-score = 9.78). Other major risk factors were male child (OR = 1.65, z-score = 115.4), maternal education ≤ 12 years OR = 1.31, z-score = 53.63), not married (OR = 1.28, z-score = 47.9), and adequacy of prenatal care (OR = 1.20, z-score = 35.39) (not shown).

A similar logistic regression analysis was conducted to determine the SGA odds ratio for residents of mining counties with mountain-top mining activity (MTM) as compared to residents of mining counties without mountain-top mining activity (non-MTM) (Table 3). The unadjusted crude odds ratio was 1.08 (95% CI: 1.06–1.10) and with adjustment for tobacco use alone was reduced to an odds ratio of 1.02 (95% CI: 1.00–1.04), accounting for the reduction of 75%. Adjustment for all other co-variables, except for tobacco use, reduced the odds ratio to 1.04 (95% CI: 1.02–1.07), accounting for the gross reduction of 50%. The full model including both tobacco use and the other co-variables yielded the odds ratio of 0.999 (95% CI: 0.98–1.02), accounting fully for the excess odds ratio. By itself, tobacco use accounted for 75% of the excess odds ratio for mining counties with MTM activities and for 100% with the other co-variables.

In the full model, the tobacco use odds ratio (OR = 2.52, z-score = 88.82) was the strongest risk factor, while MTM mining had no contribution (OR = 0.999, z-score = –0.07). Other major risk factors were male child (OR = 1.63, z-score = 49.59), maternal education ≤ 12 years (OR = 1.30, z-score = 20.99), not married (OR = 1.22, z-score = 18.29), and adequacy of prenatal care (OR = 1.21, z-score = 16.92) (not shown).

The analyses above indicate that maternal tobacco use is the major explanatory risk factor for SGA in these Appalachian states and that it explains most of the differences in SGA prevalence by mining activity and type of mining activity (MTM). No evidence of significant collinearity was found with a mean variance inflation factors (VIF) of 1.13 and a range of 1.00–1.35.

SGA prevalence by maternal tobacco use, residential county mining activity group, and gestational age

The effect of tobacco use on the prevalence of SGA has been shown to be gestational-age-dependent, with a monotonic rise between weeks 33–37 and a more than doubling of the prevalence at weeks 37–44. We have examined the gestational-age effect of tobacco use on SGA prevalence to determine whether the pattern varies across the mining groups. The Figure 1 demonstrates that the gestational-age specific pattern for SGA prevalence stratified by tobacco use is essentially the same for each of the 3 groups of counties. In each case, the SGA prevalence rose from about 0.085, or 8.5% for weeks 22 to 32 and then rose monotonically by week 37 to about a doubling or tripling to 0.20–0.26, or 20–26%. The increased risks of SGA were limited to those who had reported tobacco use, and was so for each of the 3 groups of counties.

The Figure 2 shows the differences in SGA prevalence between tobacco users and tobacco non-users by gesta-
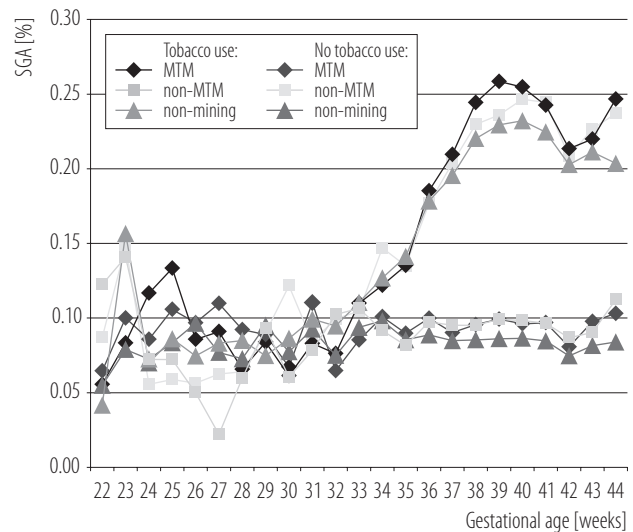
MTM – mountain-top mining.

Fig. 1. Small-for-gestational age (SGA) prevalence by gestational age, tobacco use, and mining activity, central Appalachian states, 1990–2002
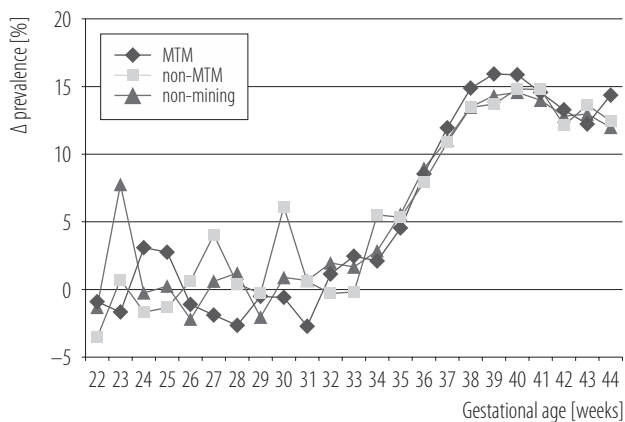
MTM – mountain-top mining.

Fig. 2. Difference (Δ) in small-for-gestational age (SGA) prevalence for tobacco users and non-users by gestational age and mining activity, central Appalachian states, 1990–2002

tional age at birth and by mining activity in the maternal county of residence, i.e., the tobacco-related increased risk of SGA. The gestational age pattern for the increased risk of SGA with tobacco use is similar for all 3 groups of counties, grouped by mining activity.

The overall SGA prevalence rates varied among the counties when grouped by mining activity with tobacco use being the major explanatory factor. Similarly, when SGA prevalence rates were examined by gestational age and tobacco use concurrently, the SGA prevalence rates by mining group were found to exhibit the same pattern with the tobacco effect by gestational age being the same.

DISCUSSION

The primary hypothesis investigated by this paper has been whether, in the four-state Appalachian area, the SGA prevalence is increased among infants born to women who have lived in the mining counties as compared to those who have lived in the non-mining counties, and whether prevalence rates are higher in mining counties with MTM as compared to mining counties without MTM. The data analysis has demonstrated, indeed, that the SGA prevalence rate is higher in either case.

The second task has been to determine to what degree these area differences could be explained by known risk factors and to what degree these differences are unexplained. Risk factor information was obtained from the birth certificate. The variable with the highest odds ratio was tobacco use. Its inclusion alone accounted for about 50–75% of the excess risk and in magnitude it was about equal to or greater than for all other risk factors.

The odds ratio for residents of mining counties as compared to residents of non-mining counties when adjusted for co-variables including tobacco use was reduced from 1.25 to 1.07 (95% CI: 1.05–1.07) and for residents of mining counties with MTM activity as compared to those of mining counties without MTM activity was reduced from 1.09 to 0.999 (95% CI: 0.98–1.02) for residents mining counties with MTM activity as compared to those of mining counties without MTM activity. The significant differences in SGA prevalence by gestational age that were seen with tobacco use were the same in all 3 county groups and thus appeared to be uninfluenced by the presence of the mining activity in the counties.

The variables found on the birth certificate data set, particularly tobacco use, were sufficient to explain all of the differences in SGA prevalence for mining counties with and without MTM mining activity and three-quarters of the difference among mining counties and non-mining counties. It may be that further inclusion of known risk factors for SGA, such as maternal height and weight [22] or socioeconomic disadvantage [23], might explain much of the remaining differences.

We have used Oken et al. [15] rather than Olsen et al. [24] for the SGA cut-points. The Oken data has been developed from the same form (1989 U.S. live birth certificate) as has been our data – from more than 6.6 million live births, separated by race. They are recommended for vital statistics purposes by the Association of Maternal and Child Health Programs [25]. In contrast, the Olsen data, based on nearly 400 000 hospital records of newborns

discharged live from one large multi-hospital medical group (Pediatrix), had instead been designed for use in the neonatal intensive care unit (NICU) setting.

Our findings regarding tobacco use and SGA are consistent with a rather extensive literature that has generally shown a two-fold or greater risk of SGA with tobacco use for full-term births, and often a dose-response. Risks of 2–3 fold have been reported from Brazil [26], Switzerland [27], Finland [28], Boston [29], Japan [30], Portugal [31], Crete [32], and Sweden [33], and for Aboriginal Australia [34], African-Americans in North Carolina [35], Pacific Islanders [36], Canadian Inuit [37] and adolescents in New Jersey [38]. These compare with prevalence rate ratios of 2.60 for full-term births and 2.48 for all births in our data set (not shown).

Differences among these populations may reflect differences in dosage. Clausson et al. [39] in Sweden had shown a risk of 2.6 for ≥ 10 cigarettes per day but of only 1.8 for smoking rates of 1–9 cigarettes per day. Mehaffey et al. [37] from the Baffin Island had shown a risk of 2.5 for ≥ 10 cigarettes per day but no increase for lower dosages. Kalinka and Hanke [40] in Poland had shown a risk of 5 only for the infants of mothers who had smoked more than 20 cigarettes per day. Both McCowan et al. [22] and Vardavas et al. [32] had shown that the adverse effect of smoking on small for gestational age prevalence was not observed for those who had stopped smoking prior to the 15th week of gestation.

The literature on the risk for SGA from maternal tobacco use among premature births is quite scant. Reported risks through the gestational age of 36 weeks include 1.5 (28–36 weeks), 1.85 (up to 36 weeks), and 2.23 (22–36 weeks) [33,41,42]. Our findings do not differ from those in the literature. Our data analysis (not shown) has found prevalence risk ratios of 1.07 for the gestational age of 22–32 weeks and of 1.70 for the gestational age of 33–36 weeks for an overall risk of 1.57 for premature births. Similar to our findings, Clausson et al. [39] also

reported no increased risk of SGA from tobacco use for severely pre-mature births (up to week 32) and adjusted odds ratios of 1.7–1.9 for moderately premature births (gestational age: 33–36 weeks).

Our study confirms the literature observation first clearly demonstrated nearly 20 years ago in Sweden [39] – smoking has no apparent effect on the prevalence of SGA prior to week 33 and a high risk for term babies (OR up to 2.6 for > 10 cigarettes/day) and gestational age ≥ 37 weeks, plus a lower rate for those with moderate prematurity (33–36 weeks).

Our analyses provide for the first time a quite granular look by respective weeks of gestational age and show no effect for tobacco use on SGA for the gestational age of 22–32 weeks births, a monotonically increase for the gestational age of 33–36 weeks births, and a steady 2–3 fold effect for ≥ 37 weeks births, i.e., term births. This has been our primary contribution to the SGA epidemiological literature. In this paper, we find that the patterns are the same for the sets of counties aggregated by mining activity.

Strengths and limitations

Positive attributes of this study include that it is based on a full live birth cohort for a defined geographical region (four states of central Appalachia) and time period (1990–2002) with all data collected on the same standardized U.S. birth certificate. The gestational-week-specific SGA cut-off values had been developed from a reference population (U.S. 1999–2002) that had used the same form [15]. The methods for measuring both birth weight and gestational age are standardized and have not altered during the period of the study. The analyses, while limited to singleton births with the gestational ages of 22–44 weeks for non-Hispanic white women, are based on over 2.3 million live births.

Limitations of this study include that the maternal tobacco use history was obtained by report or interview at

the time of birth only. While maternal smoking histories on birth certificates were validated elsewhere [19], not here. Nielsen et al. had shown – for maternal smoking history on the Washington State birth certificate – a sensitivity of 85–89% and a specificity of 99% based on urinary cotinine measures [19].

Self-reporting could serve as a surrogate for a set of lifestyle factors that may also correlate with SGA, such as heavy alcohol drinking [43,44] and the use of marijuana [45], cocaine [46], and opiates [47]. Out of these, opiate use is a particular problem in Appalachia [48].

Subsequent analyses might include alcohol use, the number of cigarettes per week, weight gain, diabetes, hypertension, and chronic kidney disease, items on the birth certificate but have not been included in these analyses, and county-specific socioeconomic co-variables such as income, poverty, and rural, which are not on the birth certificate were not included either.

As neither pre-pregnancy weight nor maternal height was included as a field on the birth certificate, it was not feasible to distinguish the constitutionally small-for-gestational age babies (i.e., small babies of small mothers) from the other SGA babies.

Exposure is limited to the county of residence as states would not release data at finer granularity for issues of privacy. Furthermore, routes of exposure, i.e., ingestion of water or soil or ingestion of air, are undefined and would be speculative with no proposed specific exposure agents and no specific exposure data.

CONCLUSIONS

In summary, this study demonstrates that the increased prevalence of SGA among residents of counties with mining activity has been greatly explained by the differences in maternal tobacco use prevalence, an effect that itself has been gestational-age dependent. No effect of maternal tobacco use on SGA prevalence has been seen prior to the gestational age of 33 weeks, from whence it rises monotonically to a 2–3-fold factor for full-term newborns. Seventy-five percent of the differences in SGA prevalence among counties with mining activity and those with no mining activity has been explained by tobacco use and demographic variables. One-hundred percent of the differences in SGA prevalence among mining counties with MTM mining activity and those without MTM mining activity have been explained by tobacco use and demographic variables.

The SGA prevalence rates by gestational age have not varied by mining activity group for both tobacco users and tobacco non-users. Tobacco use, not mining activity, has been the predominant variable explaining the differences in SGA prevalence in the study area.

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