Disparities in Maternal Health Behaviors during Pregnancy:

Estimating the Role of Income from a Natural Experiment*

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Women with higher socioeconomic status engage in healthier behaviors during pregnancy and, thereby, transmit their advantages to the next generation. These are correlations, however, and the true causal association between family income gains and maternal behaviors during pregnancy remains unclear. We take advantage of a natural experiment – the boom economy created by the extraction of natural gas from the Marcellus Shale geological formation – to study whether increased family income affects women's prenatal smoking, adequate weight gain, and prenatal care usage. Using predicted Marcellus Shale income as an instrument, we conduct difference-in-difference analyses to isolate the causal effect of income gains. Initial estimates suggest that the share of women smoking prenatally and the share receiving any prenatal care increase with increasing income. Further, the gains in prenatal care utilization are concentrated in areas with initially high poverty rates.

EXTENDED ABSTRACT

A key mechanism in the transmission of inequalities across generations is infant health (Aizer and Currie 2014; Haas 2006). Economically-disadvantaged mothers are more likely to have a pre-term and/or low birth weight birth and, in turn, pre-term and low birth weight babies are at greater risk of life-long complications (Blumenshine et al. 2010; Conley, Strully, and Bennett 2003). Regarding prematurity, pre-term births lead to significantly greater risk of life-long disability (Williamson et al. 2008), language problems (Spek, Franken, and Weisglas-Kuperus 2012), and lower academic achievement (Noble et al. 2012). Similarly, low birth weight is associated with poor childhood health and lower educational attainment (Behrman and Rosenzweig 2004; Conley and Bennett 2000).

Key mechanisms linking economic disadvantage and infant health are maternal health behaviors during pregnancy (Kramer et al. 2001), particularly smoking, adequate weight gain and prenatal care utilization. Cigarette smoking (Bharadwaj, Johnsen, and Løken 2014; Currie, Neidell, and Schmieder 2009) and inadequate weight gain (Stein, Ravelli, and Lumey 1995) during pregnancy inhibits intrauterine growth and increases the risk of low birth weight. Prenatal care is hypothesized to reduce the likelihood of preterm delivery, but the evidence is mixed (Alexander and Korenbrot 1995; Krans and Davis 2012). Yet greater supporting evidence is found when one measures the adequacy of prenatal care (versus measuring any prenatal care utlization; Krueger and Scholl 2000) or when one accounts for selection effects that downwardly bias the estimated association between prenatal care utilization and infant health (Loftus et al. 2015).

Further, prior research demonstrates that economically disadvantaged mothers are at greater risk of these poor behavior profiles than economically secure mothers. Low-SES mothers are more likely to smoke (Hamad and Rehkopf 2015; Kramer et al. 2001), less likely to gain the recommended weight during pregnancy (Aizer and Currie 2014; Ludwig and Currie 2010), and less likely to receive any prenatal care and more likely to have inadequate prenatal care (Krueger and Scholl 2000; J. P. Mayer 1997).

To understand the disparities in maternal health behaviors by income, the theoretical literature emphasizes the role of maternal psychosocial stress. First, increases in family income could lead to improvements in pregnant women's health via reductions in economic distress (Gennetian, Castells, and Morris 2010; Gershoff et al. 2007; McLoyd 1990) and, thereby, her exposure to acute and chronic household stressors. Having a low income could induce women to smoke or rely on other substances to self-medicate against their exposure to multiple stressors. Low income may also reduce their access to adequate nutrition, inhibiting recommended weight gain.

Despite the consistency of these socioeconomic disparities and the documented positive correlation between income and maternal health behaviors during pregnancy, it is unclear which stratified resources truly undergird these patterns. Some question whether these patterns primarily reflect differences in income. Some scholars suspect that instead maternal education drives these socioeconomic disparities given that education is usually established early in a woman's life course and is often a prerequisite to higher status occupations and incomes (Kramer et al. 2001). Education is the most frequently used indicator of socioeconomic status (SES) in studies of pregnancy behaviors and birth outcomes (Braveman et al. 2001). Yet

the strength of the association between SES and different pregnancy health behaviors varies by the behavior being measured. For prenatal smoking, women's education is a stronger indicator than poverty, crowding, or indicators of participation in means-tested programs; by contrast, for delayed or foregone prenatal care, poverty has the strongest association (Gazmararian, Adams, and Pamuk 1996; Hamad and Rehkopf 2015). Lastly, evidence of the "Hispanic paradox" or "epidemiological paradox," wherein low-income, Latina women who immigrated early in life are less likely to smoke during pregnancy than U.S.-born Latinas with greater incomes (Landale, Oropesa, and Gorman 1999), may undermine theoretical assertions that income fundamentally shapes maternal behaviors during pregnancy.

In this paper, we take advantage of a natural experiment – the extraction of natural gas in the Marcellus Shale geological formation – to study how increases in family income affect maternal health behaviors during pregnancy. Before recent technological advances, deep gas was not extractable and had no economic value; now, families who own mineral rights for land located above the Shale can receive payments upon signing a lease and royalties when gas is sold. There are two exogenous sources of variation in expected Marcellus Shale income: the quality of the shale and differences in state policy. First, within the Marcellus Shale some areas are more economically viable (in the "Core") because of the quality and characteristics of the rock and, thus, profitability of potential wells. Second, PA allows drilling, while New York (NY) does not. The combination of these factors determines which families living above the Marcellus Shale receive income. In some towns, the average family receives an additional $15,000 per year in income after drilling begins. Yet other families experience no income gains.

Drawing Causal Inferences

The challenge for drawing causal inferences from prior research is that family income is not randomly distributed; high-income women systematically differ from low-income women in ways that are not well captured in survey data. Family income is correlated with women's physical and mental health, skills, and behaviors (S. E. Mayer 1997). Family income is also correlated with personality traits. For example, mothers' conscientiousness (i.e., their prudence, dependability, organizational skills, and persistence; Friedman and Kern 2014) is difficult to measure, but positively correlated with family income and likely influences maternal behavior during her pregnancy. In addition, the intendedness of the birth is associated with women's socioeconomic status (Musick et al. 2009) and with differential pregnancy beliefs and behaviors, including prenatal care utilization (J. P. Mayer 1997). Yet intendedness is not collected on birth certificates and, thus, goes unmeasured in most large-scale analyses. The exclusion of these and other difficult-to-measure characteristics from multivariate models biases the estimated association between family income and maternal health behaviors (Kawachi, Adler, and Dow 2010; S. E. Mayer 1997). It most likely leads to upwardly-biased estimates of the true causal effect (MacKinnon, Krull, and Lockwood 2000).

Prior literature has sought to leverage a natural experiment design to better identify the causal effect of income for maternal behaviors during pregnancy. U.S.-based quasi-experimental studies utilize historical expansions of the Earned Income Tax Credit during the 1990s (EITC). Findings are mixed. On the one hand, several studies find exogenous increases in income significantly reduces reports of prenatal smoking (Hoynes, Miller, and Simon 2015; Strully, Rehkopf, and Xuan 2010) and increases prenatal care usage (Hoynes et al. 2015). On the

other hand, one study finds EITC income gains did not lead to changes in reports of prenatal smoking (Hamad and Rehkopf 2015). The generalizability of these prior results is limited, however, because the EITC is only available only to low-income families; moderate- and high-income mothers are excluded from these prior studies. Our study is able to examine the effect of increasing income for mothers from across the full income distribution.

It is worth noting, however, that the underlying causal effect of increasing income on smoking behavior and excess weight gain could be positive. If cigarettes and food are normal goods, then increasing income could increase consumption. Supporting this hypothesis, research examining whether changes in state cigarette excise taxes alter smoking among pregnant women by raising the costs of cigarettes (Ringel and Evans 2001) finds that, in absolute terms, a tax hike of $0.55 per pack would reduce maternal smoking by about 22%, while proportionately, a 10% increase in price would reduce smoking rates by 7% (Ringel and Evans 2001). Regarding weight-related responses, several studies of adults (Akee et al. 2013; Schmeiser 2009) and children (Jo 2018; Schmeiser 2012) find that exogenous increases in income lead to increases in obesity.

In summary, we build on prior studies to investigate the causal effect of increasing income on maternal pregnancy behaviors with the full population of Pennsylvania birth mothers before and after Marcellus Shale development. We then explore the total income effects and differences across districts by their initial poverty rates.

Our Research Design

We take advantage of a natural experiment occurring across Pennsylvania (PA) and New York (NY). Before 2005, families who purchased land did not consider Marcellus Shale gas or a

property's mineral rights in their purchase decision. Yet it is now profitable to extract natural gas trapped within microscopic pockets in the Marcellus Shale formation thousands of feet below the surface due to new drilling technology that combines hydraulic fracturing with horizontal drilling. The first productive Marcellus Shale well was drilled in southwestern PA in 2005, but the pace of drilling did not accelerate until 2008 when estimates were released that the Marcellus contains 50 trillion cubic feet of recoverable gas (Engelder and Lash 2008).

Families who own their property's mineral rights can sign a lease to allow gas companies to drill and extract the gas beneath their property, and so potentially receive large income gains. The lease establishes the royalty rate (i.e., the percentage of the profit the mineral rights owner receives upon the sale of the gas from their parcel). Reported royalty rates vary (primarily due to differences in when leases were signed), but the PA state-mandated minimum is 12.5% and average reported is 13.4% (Ward et al. 2011). The royalties families receive reflect the contracted royalty rate, the price of natural gas upon its sale, and the per acre volume of gas extracted (which reflects the Shale's quality beneath a parcel). Lease (i.e., bonus) payments are contracted to arrive either in one or multiple payments, while royalties are scheduled to arrive repeatedly. In 2010, natural gas companies reportedly paid $2.07 billion in Marcellus Shale lease and royalty payments to PA residents (Considine, Watson, and Blumsack 2011). Beyond royalty and leasing payments, the development of the Marcellus Shale created a boom economy and increased earnings in affected Pennsylvania communities (Kelsey et al. 2011).

Variation in the intensity of the economic stimulus and the amount of income families could receive in royalty payments from Marcellus Shale gas development primarily reflects the quality of the geological formation for natural gas extraction and production. Gas industry

experts determined the boundaries of the more and less economically-productive areas of the Marcellus Shale prior to its development based on the known depth, thickness, porosity, thermal maturity, and silica content of the rock (Dell, Lockshin, and Gruber 2008). These boundaries were determined without any consideration of the surface characteristics, including area's infrastructure, population, or local government. We refer to the more economically-viable area – our "treatment" – as the "Core" (i.e., the darkly-shaded area in Figure 1) and the less viable area – our comparison – as the "non-Core" (i.e., lightly-shaded area Figure 1). To assess the validity of this instrument for income, we leverage parallel data from New York (NY) given the policy differences across these two states. PA allows hydraulic fracturing, whereas NY has a statewide ban (Kaplan 2014). We leverage a pretest-posttest design that compares maternal pregnancy behaviors across Pennsylvania (PA) communities differentially affected by the boom created by the extraction of natural gas from the Marcellus Shale formation.

This natural experiment is quite compelling, but there are some limitations inherent in our design. First, the study site is necessarily restricted to the population living above the Marcellus Shale geological formation, yet northern and western Pennsylvania and upstate New York are not racially diverse and the results primarily reflect the experiences of non-Hispanic white women. Second, in a related point, much of the study site is rural. The largest cities above the Marcellus Shale are Pittsburgh and Scranton. Thus, the findings are most applicable to children in modest-sized cities and rural communities. Third, currently we must rely on birth certificate data aggregated Census data to examine this research question. The analyses are, thus, vulnerable to an ecological fallacy. Despite these limitations, we argue this is an

interesting and persuasive natural experiment to study the causal effects of increasing income on maternal behaviors during pregnancy.

Data and Methods

To leverage this natural experiment, we integrate numerous, comprehensive administrative datasets covering the PA and NY populations living above the Marcellus Shale with geological data, geographic information, and Census data. We use data aggregated to the school-district level instead of counties to have more refined, but socially meaningful geographic measures and a sufficient sample size to draw statistical inferences.[1] Because school district boundaries often straddle Core and non-Core Shale boundaries, we parse school-districts into Core and non-Core areas whenever possible, as noted below.

Maternal Pregnancy Behaviors

For PA, we acquired all individual birth certificate files for birth occurring in or after 2005 from the PA Department of Health. Using the longitudinal and latitudinal coordinates for the mother's residence, we identified her corresponding school district and aggregated individual birth certificate data into annual school district measures. To have more reliable estimates, we average across 2010 and 2011 PA district measures to create our "post" development dependent variable. The NY State Department of Health provided us with already aggregated measures for each NY school district in the following three-year time blocks: 2006-2008, 2009-2011, and 2012-2014, which roughly corresponds to pre-Marcellus development, the height of Marcellus development, and on-going but less rapid Marcellus Shale development, respectively. The data are compiled across years due to the following factors: (1)

[1] There are only 8 New York counties, but 86 school districts, with any territory above the Marcellus Shale Core.

many NY districts have relatively small populations with declining fertility, (2) the pregnancy behaviors we study are relatively rare, and (3) NY State Department of Health can legally only release district data when there are ten or more births with particular experiences (i.e., maternal smoking, absence of prenatal care). From the nationally-standardized birth certificate forms, we measure the following for each district: (1) share of births where the mother reported never smoking during her pregnancy and (2) share of births where the mother reported zero prenatal care visits. For this submission, we were not able to predict the share of mothers who gain adequate weight during their pregnancy.

State Income Tax Measures

Based on state income tax data, we measure the average household annual adjusted gross income (i.e., income minus specific deductions), further adjusted to 1999 dollars using the CPI-U-RS (Stewart and Reed 2000). We refer to this as "total income." For PA, changes in total income due to Marcellus Shale development should reflect the net effect of shifts in royalty and leasing income and shifts in parents' labor force participation. PA provides the amount of income earned via "royalties, rents, patents, and copyrights" (which we refer to as "royalty income"), earnings, and property sales. PA tax data for 2006-2012 are available online, while we obtained 2005-2011 NY data via personal contact with a representative at the NY Department of Taxation and Finance.

Marcellus Shale Geology and Development Measures

We digitized a 2005 gas industry map of the geological and predicted economic limits of the Marcellus Shale and overlaid it with school district boundaries (See Figure 1). The white areas do not lie above the Marcellus Shale formation, while the dark grey areas indicate the

Core and the lighter grey areas indicate the non-Core of the Marcellus Shale formation. We measure the proportion of the school district's land area that lies in the Core and non-Core areas of the Marcellus Shale formation. We flag whether the district is in Pennsylvania or New York.

Analytic Sample

We begin with 501 PA and 718 NY public school districts with valid 2000 Census information. We drop two PA school districts that merged together in 2009, as well as the resulting new school district. We then omit 2 additional PA districts with insufficient birth certificate data. We drop 137 NY school districts that lack income tax data and/or that had their birth certificate data suppressed due to small frequencies for either outcome. Most of the NY districts without income tax data are those containing a single, specialized charter school. The final sample contains 496 PA and 581 NY school districts.

Analytic Approach

We use a two-sample instrumental variable approach and a difference-in-difference framework, leveraging differential income change across Core and non-Core Pennsylvania school districts pre (2006) and post (2010-2011) Marcellus Shale development, to determine the effect of income on maternal pregnancy behaviors. Our instrument for family income is the percentage of the district's area in the Core of the Marcellus Shale formation controlling for the lagged value of family income in the district prior to Marcellus Shale development. Our system of equations can be represented as follows:

$$(1) \qquad IncomePost_d = \beta_0 + \beta_1 \%Core_d + \beta_2 IncomePre_d + \beta_3 C_d + \varepsilon_d$$

(2) $$MaternalBehavPost_d = \beta_0 + \beta_1 \widehat{IncomePost}_d + \beta_2 MaternalBehavPre_d + \beta_3 C_d + \varepsilon_d$$

where *d* references school districts, *%Core* refers the proportion of the district's land in the Core of the Marcellus Shale, *IncomePre* refers to total income before Shale development, *IncomePost* refers to total income after Shale development, and *C* refers to a vector of control variables. Equation (1) uses a difference-in-difference model predicting post-development total income per capita in school district *d* based on Marcellus Shale quality (*%Core*), while controlling for various district traits (*C*) and total income (*IncomePre*) measured before Shale development. The predicted post-development total income per capita, $\widehat{IncomePost}_d$, estimated in Equation (1), becomes the key predictor for the post-development prevalence of maternal health behaviors ($MaternalBehavPost_d$) in school district *d* in Equation (2), controlling for the pre-development prevalence of maternal health behaviors ($MaternalBehavPre_d$).

After estimating these initial equations, we conduct a series of tests. First, we run a series of "placebo tests" to examine whether there were any differences over time in income or outcomes between Core and non-Core areas in New York, where gas extraction is not allowed. Second, we explore whether the effect of income varies by the average socioeconomic status of district families prior to shale development.

Results

As shown in Table 1, Pennsylvania (N = 496) and New York (N = 581) school districts are relatively similar, though the share of women who never smoked during pregnancy and who did not receive any prenatal care is slightly higher in NY (82% and 1.5%, respectively) than in PA (78% and 0.8%). NY and PA school districts have similar rates of home ownership, poverty and

unemployment, but a greater proportion of PA's population self-identifies as "white." Important for our analyses, NY districts have greater total incomes in both 2006 and 2010-2011 and a smaller proportion of their area in the Core Shale.

For the PA school districts, we also compare "high Core" districts (i.e., those with at least 50 percent of their land area in the Marcellus Shale Core; N = 188) and "high non-Core" districts (i.e., those with at least 50 percent of their land area in the non-Core; N = 100). The prevalence of prenatal smoking and prenatal care utilization is similar across high Core and high non-Core areas across years. By 2010-2011, PA high Core districts had significantly greater total incomes ($72,328 vs. $57,308) and royalty incomes ($1,556 vs. $997) than high non-Core areas. Pennsylvania high Core and high non-Core districts are demographically similar, with statistically equivalent rates of home-ownership, unemployment, and poverty, as well as statistically similar proportions of individuals racially identifying as "white."

First Stage: Predicting Income Based on Marcellus Shale Traits

Table 2 shows the first stage results predicting PA districts' average royalty income and total income for 2010-2011 based on the proportion of the district's land area that lies above the shale's Core. Each cell is a separate two-stage least squares regression and controls for the district's initial income values in 2006. The first row displays results for all PA districts. Turning attention to the results for royalty income in column 1, we see that for every percentage point increase in district's area that lies in the Core, PA districts have an additional $6.23 in royalty income (two-tailed test, $p<.001$), or a $623 difference in average annual household royalty income for a district that lies entirely in the Core versus one that lies entirely outside it. To approximate the fact that PA residents must own mineral rights to receive royalty income from

Shale development, the model presented in Column 2 interacts the percentage of the district's land area above the Core of the Shale with the percentage of the district's households who owned their homes in 2000. If our identification strategy works, then we expect the interaction to be statistically significant, and the main effect of the extent to which the district lies above the Core Shale when none of the housing is owner-occupied to be non-significant. This is indeed what we find ($p<.05$). Lastly, we distinguish between the Core and non-Core areas of the Shale, while including interactions for the percentage of the housing that is owner-occupied, as shown in Column 3. If our identification strategy is correct, the interaction between the percentage of area above the Core and the percent of housing that is owner-occupied should be statistically significant (as before), but the interaction involving the percentage of the area above the non-Core Shale should be non-significant with a coefficient of smaller magnitude than the interaction involving the area above the Core. Our identification strategy again finds support; the interaction involving districts' area above the Core and the percent owner-occupied housing is statistically significant (two-tailed test, $p<.01$) and positive, while the interaction involving districts' area above the non-Core and housing tenure is not statistically significant.

This same sequence of models is repeated in Columns 4, 5 and 6 to predict total income for Pennsylvania districts. The precision of the key coefficients (outlined) in these models increases, consistent with less noise in the measurement of total income than of royalty income, while the magnitude of the significant coefficients are generally smaller. For example, in Column 4, we see that a percentage point increase in the district's area above the Core Shale translates into an increase of $5.04 in total income, or a $504 difference in average annual

household income for a district that lies entirely above the Core versus one that lies entirely outside it. The reduction in point estimate is as expected given that some families likely reduced other income-producing activities, such as their labor force participation, as their royalty income increased. The difference in magnitude is not statistically significant, however.

Lastly, we perform a falsification test of our identification strategy by examining these associations for New York districts. These results are shown in Columns 7, 8 and 9. Given "fracking" is banned in NY, Shale characteristics (and their interaction with housing tenure) should not predict total income. Indeed, the percentage of the district's area above the Core Shale does not independently predict variation in total income in NY, nor does the interaction with housing tenure. Together, the first stage results provide very strong evidence that the amount of the district's land area in the Marcellus Shale Core, conditional on initial income, is a very strong instrument for income post-Shale development.

Second Stage: Predicting Maternal Pregnancy Behaviors

Using the predicted total income for each school district based on the models shown in column 1 in Table 2, Table 3 presents the results for the second stage of our analysis for Pennsylvania, where each cell reflects a separate two-stage least squares regression. We predict the prevalence of not smoking during pregnancy in Models 1 – 4 and prenatal care utilization in Models 5 – 8. For each pregnancy behavior, we increasingly add control variables; we first control for the birth mothers' ages and education (Models 2 and 6), then the demographic characteristics of the district's residents prior to shale development (Models 3 and 7), and finally for economic characteristics of the districts prior to shale development (Models 4 and 8).

Model 1 shows that smoking any cigarettes during pregnancy actually increases with income. A $1,000 increase in predicted average income is associated with a significant .003 percentage point decline in never smoking, or a 0.4% percent decline from the base rate of 78%. Estimated effects remain statistically significant, but shift with the inclusion of various controls. Yet once all control variables are included, the estimated effect of exogenous increases income are quite similar to the baseline estimate.

In contrast, prenatal care utilization increases with increasing income. As shown in Model 5, a $1,000 increase in predicted average income is associated with a significant .05 percentage point decline in no prenatal care utilization or a 6.25% percent decrease from the base rate of 0.8%. With the inclusion of control variables, the estimated effect remains statistically significant, but generally declines. Once all control variables are included in Model 8, the estimated effect of exogenous increase of $1000 is associated with a 0.4 percentage point decline in the share of women with no prenatal care utilization.

As a falsification check, we estimate a reduced form model in NY where we predict the proportion who did not smoke during pregnancy in 2009-2011 based on the percent of the district area in the Core Shale and the proportion who did not smoke in 2006-2008. In accordance with our expectations, there is no significant relationship between location vis a vis the Shale and smoking during pregnancy in NY. (Results not shown). There were insufficient cases (n = 24) to estimate similar models for prenatal care utilization.

Differential Effects of Income by Initial Socioeconomic Status

Given prior research that examined the effects of increasing income among EITC-eligible women, we tested whether our findings differ across districts based on their initial rates of

poverty in 2000. To do so, we classified PA districts as initially (1) low poverty districts if their family poverty rates were in the bottom quartile of the distribution in 2000 or (2) high poverty districts if their family poverty rates were in the top quartile. Akin to Models 3 and 7 in Table 3, these analyses include controls for districts' 2000 demographic profiles.

Our first step is to ensure that the percentage of the district's land in the Core shale predicts significant increases in the district's total income for both low poverty and high poverty districts. These first-stage results, shown in the top rows of Table 4, find widespread effects of the shale boom, though the effects appear are larger in areas with initially low poverty.

The second-stage results in Table 4, indicate that the original estimated causal effect of increasing income on prenatal smoking is not statistically significant in initially high- or low-poverty districts. We suspect this is a function of power limitations and the small magnitude of the original estimated effect. For changes in prenatal care utilization, we observe that the take-up of prenatal care is concentrated among women in initially disadvantaged districts and absent in initially economically advantaged districts.

Steps Planned Prior to the PAA 2019 Conference

We plan to complete the following steps prior to the 2019 annual meetings of the Population Association of America. First, we plan to model adequate weight gain. Second, we will create more detailed measures of prenatal smoking and prenatal care utilization relative to specific trimesters. Third, we will include control variables for Marcellus Shale development itself to recognize that shale development may affect prenatal behaviors through channels other than income. Specifically, to capture the potential risk that Marcellus Shale development increases mothers' stress exposure, we will control for differences in traffic volume across

districts given increased truck traffic frequently emerges in residents' narratives about the stressors of shale development (Brasier et al. 2011; Stedman et al. 2012). Fourth, for increased validity and to ensure appropriate comparisons, we will restrict analyses to only districts in the Marcellus Shale (n = 320 in PA and n = 235 NY). Fifth, we will estimate a series of falsification checks. Despite the strength of our instrument, our second-stage estimates could be biased if Marcellus Shale development is correlated with mother's pregnancy behaviors through a pathway other than increasing family income. For example, there may be selective in- or out-migration from the Core, either as families move away after significant income gains or as children of drilling rig workers move into the area. In addition, we can test the extent to which the district's area above the Core predicts changes in women's and/or mothers' labor supply. Finally, we are currently seeking approval from the PA Department of Health to directly analyze the individual birth certificate data to better control for the individual characteristics of birth mothers.

Conclusion

Prior interdisciplinary research demonstrates positive correlations between a women's socioeconomic status and health-promoting pregnancy behaviors. Yet the extent to which family income undergirds these associations and whether these associations are causal remains unclear because family income is endogenous to a host of difficult-to-measure maternal characteristics. Further, the available quasi-experimental research in the U.S. is limited to studying the effects of income gains for low-income women. Our analyses are able to explore these potential causal effects across the full income distribution. The lingering question of causality hinders our scientific understanding and identification of effects of social policy

interventions aimed at improving women's pregnancy behaviors and, thereby, infant health. Our research will contribute to science assessing the causal relationship between increases in family income and maternal health behaviors during pregnancy – a critical linchpin in the processes of generating intergenerational health inequalities.

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Figure 1. Overlay of Industry Map of Marcellus Shale in Pennsylvania and New York (2005) with School District Boundaries and Research Design

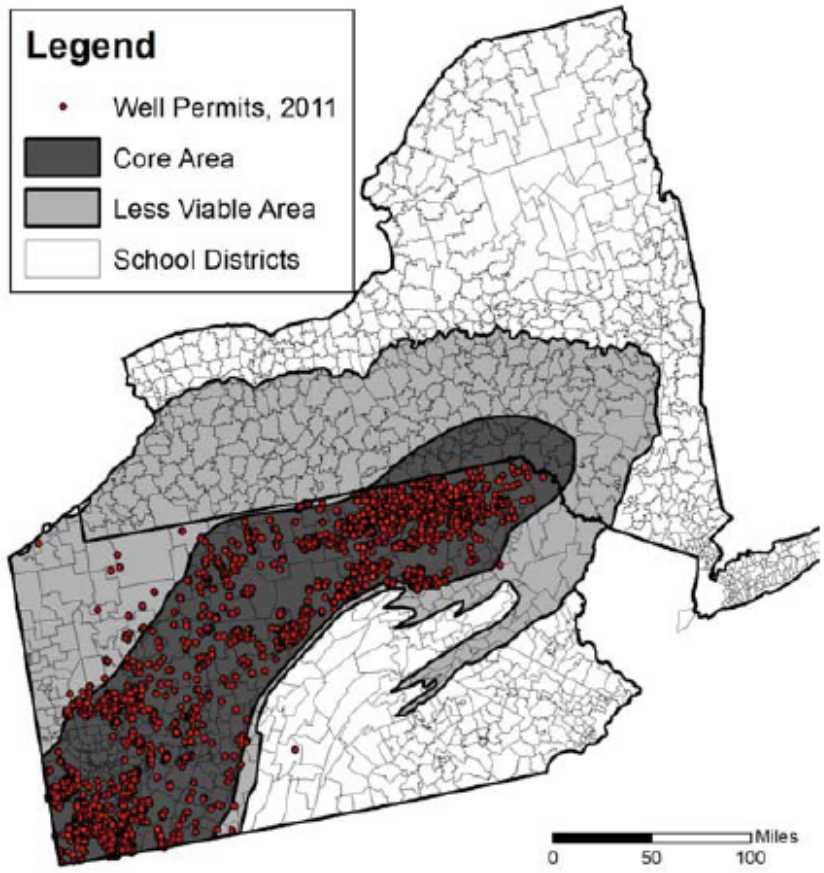

Table 1. Descriptive Statistics by State and PA Districts largely in the Core and non-Core Marcellus Shale

	Pennsylvania Districts						Falsification: New York Districts (N = 581)	
	All (N = 496)		50+% above Core Shale (N = 188)		50+% above Non-Core Shale (N = 100)			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Never smoked in pregnancy, 2010-11	0.782	0.085	0.754	0.085	0.740	0.072	0.816	0.096
No prenatal care, 2010-11	0.008	0.009	0.007	0.007	0.010	0.015	0.015	0.011
Royalty Income per household (inflation-adjusted)								
2006 (in $1000s)	0.675	0.601	0.678	0.542	0.567	0.344	-- [a]	
2010-2011 (in $1000s)	1.148	1.193	1.556	1.652	0.997	0.912	-- [a]	
Total Income per household (inflation-adjusted)								
2006 (in $1000s)	66.18	37.80	58.639	31.434	48.670	15.112	93.97	90.08
2010-2011 (in $1000s)	80.99	48.02	72.328	43.770	57.308	17.486	104.95	88.51
Pct. Land Above Core Shale	0.380	0.470	0.023	0.078	0.903	0.148	0.035	0.174
Pct. Labor Above Non-Core Shale	0.202	0.366	0.974	0.083	0.058	0.128	0.254	0.417
Controls, measured in 2000								
Pct. owner-occupied housing	0.761	0.090	0.762	0.090	0.774	0.085	0.752	0.111
Pct. "white"	0.941	0.090	0.953	0.081	0.957	0.060	0.912	0.115
Unemployment rate	0.052	0.023	0.059	0.023	0.057	0.018	0.054	0.027
Poverty rate	0.094	0.050	0.110	0.050	0.107	0.040	0.091	0.052
Maternal characteristics, 2005								
Educational attainment								
High school degree / GED	0.258	0.089	0.244	0.098	0.261	0.087	0.111	0.053
Some college	0.251	0.058	0.277	0.063	0.244	0.055	0.138	0.041
B.A. or higher	0.291	0.175	0.340	0.167	0.277	0.175	0.186	0.101
Age								
15-19	0.088	0.054	0.074	0.047	0.092	0.056	0.076	0.046
20-29	0.478	0.106	0.475	0.112	0.479	0.105	0.444	0.132
30-39	0.368	0.130	0.391	0.130	0.361	0.130	0.409	0.144
40+	0.027	0.016	0.028	0.015	0.027	0.018	0.040	0.020

a: New York does not have have school district data on royalty income.

Abbreviations: "SD" : Standard deviation; "Pct." : percentage of; "GED" : General Education Development

Table 2. First stage: Effect of Core Shale Presence on Average 2010-11 Household Income and Royalty Income (in 1999$)

	Pennsylvania						New York		
	DV: Royalty income			DV: Total income			DV: Total income		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Core shale: % of land area	.0623 ***	-.1407	-.1844 *	.0504 ***	-.0721 *	-.0672	-.0217	.0413	.0486
	(.0119)	(.0970)	(.1024)	(.0049)	(.0399)	(.0418)	(.0266)	(.1859)	(.1863)
% Owner-occupied		7.9918	.3308		4.8324	4.0460		9.1562 *	10.9730 *
		(7.7020)	(9.1670)		(3.1884)	(3.7849)		(4.3980)	(4.8646)
Core shale * % Owner-occupied		.2657 *	.3363 **		.1597 **	.1632 **		-.0849	-.0985
		(.1265)	(.1342)		(.0520)	(.0547)		(.2447)	(.2454)
Non-Core shale: % of land area			-.1428			.0508			.0524
			(.1400)			(.0571)			(.0934)
Non-Core shale * % Owner-occupied			.2224			-.0355			-.0843
			(.1809)			(.0738)			(.1220)
N		498			498			581	

All regressions control for lagged 2006 value of the dependent variable. Standard errors in parentheses; estimate of interest outlined.

Significance tests: *: p<.05; **: p< .01; *** p<.001

Table 3: Effect of Increasing Income on the Prevalence of Maternal Smoking and Prenatal Care Utilization

	Among All Births							
	No Smoking				No Prenatal Care			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
First stage								
Total income predicted by Core shale	.0468 ***	.0377 ***	.0397 ***	.0417 ***	.0504 ***	.0362 ***	.0383 ***	.0419 ***
	(.0081)	(.0092)	(.0095)	(.0105)	(.0081)	(.0088)	(.0094)	(.0104)
Second stage								
% Reporting Pregnancy Behavior	-.0031 **	-.0067 ***	-.0043 **	-.0028 *	-.0015 ***	-.0018 **	-.0005	-.0009 *
	(.0011)	(.0008)	(.0015)	(.0013)	(.0004)	(.0006)	(.0003)	(.0004)
with Mother controls	--	x	x	x	--	x	x	x
with District Demographic controls	--	--	x	x	--	--	x	x
with District Local Economy controls	--	--	--	x	--	--	--	x
N	494				494			

Each cell represents the estimate on a separate regression. Standard errors in parentheses.

Significance tests: *: p<.05; **: p< .01; *** p<.001

Demographic control variable are measured in 2000 (before Shale development) and include:
percent white; percent of public school parents with BA or higher, with some college, and with high school degree only.

Local economy controls are measured in 2000 (before Shale development) and include:Percent poor, percent unemployed, and median household income

Table 4: Effect of Increasing Income on Maternal Pregnancy Behaviors by Initial Family Poverty Rates

	No Smoking		No Prenatal Care	
	Low Family Poverty[a]	High Family Poverty[b]	Low Family Poverty[a]	High Family Poverty[b]
First stage				
Total income predicted by Core shale	.0893 **	.0369 ***	.0893 **	.0331 **
	(.0258)	(.0103)	(.0258)	(.0107)
Second stage				
% Reporting Pregnancy Behavior	.0033	-.0040	.0000	-.0034 *
	(.0089)	(.0028)	(.0001)	(.0016)
N	133	124	133	124

Each cell represents the estimate on a separate regression. Standard errors in parentheses.

Significance tests: *: p<.05; **: p< .01; *** p<.001

Demographic control variable are measured in 2000 (before Shale development) and include: Percent of families with minor children; percent white; percent of public school parents with BA or higher, with some college, and with high school degree only.

a: Defined as districts in the bottom quartile for family poverty

b: Defined as districts in the top quartile for family poverty