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Teen Smoking and Birth Outcomes

Mary Beth Walker
Georgia State University, mbwalker@gsu.edu

Erdal Tekin
Georgia State University, tekin@gsu.edu

Sally Wallace
Georgia State University, swallace@gsu.edu

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Mary Beth Walker
Georgia State University

Erdal Tekin
Georgia State University

Sally Wallace
Georgia State University

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Mary Beth Walker (corresponding author)
Georgia State University
Andrew Young School of Policy Studies
P.O. Box 3992
Georgia State University
Atlanta, GA 30302-3992
Phone: (404) 413-0254
Email: mbwalker@gsu.edu

Erdal Tekin
Georgia State University
Andrew Young School of Policy Studies
P.O. Box 3992
Georgia State University
Atlanta, GA 30302-3992
Phone: (404) 413-0163
Email: tekin@gsu.edu

Sally Wallace
Georgia State University
Andrew Young School of Policy Studies
P.O. Box 3992
Georgia State University
Atlanta, GA 30302-3992
Phone: (404) 413-0250
Email: swallace@gsu.edu

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Abstract

Teen mothers in the United States (U.S.) are more likely to give birth to low birth weight babies. Substantial evidence indicates that smoking is a risk factor correlated with low birth weight. Low birth weight is a costly outcome for parents, children, and society at large. This paper examines the causal link between teen smoking behavior and low birth weight. We use a variety of empirical techniques including fixed effects and a matching estimator to identify the impact of smoking on babies of teen and non-teen mothers. Both ordinary least squares (OLS) and matching estimators yield large impacts of smoking on birth weight for teens and adults. However, to the extent that unobservables are fixed over time, they can be controlled using fixed effects. These estimates indicate that the impact of smoking on birth weight is diminished, and there are small differences in the impact of smoking on birth weight between teens and non-teens.

1. Introduction

The Centers for Disease Control and Prevention (CDC) reports that the incidence of low birth weight births (infants weighing less than 2,500 grams at birth) is on the rise, and that very young mothers (those 15 and under) are 2 to 3 times more likely to have a low birth weight baby than their counterparts aged 24-34. The incidence of low birth weight for all teens is 23 percent higher than for the population as a whole (CDC 2006a). A recent study by Chen et al. (2007) concludes that low birth weight and other adverse birth outcomes observed in teen pregnancies cannot be fully attributed to known risk factors such as low socioeconomic status and inadequate prenatal care.

Low birth weight is correlated with a number of adverse outcomes for children including future health problems and poorer educational outcomes. Low birth weight infants account for large public health expenditures —studies show that more than one third of the total dollar amount spent in the United States (U.S.) on health care during the first year of life can be attributed to low birth weight even though low birth weight infants account for less than 10 percent of all births in the U.S. (Lewitt et al. 1995).[1]

The presence of a link between birth weight and smoking has long been accepted. In 2001, the Surgeon General stated that "Infants born to women who smoke during pregnancy have a lower average birth weight and are more likely to be small for gestational age than infants born to women who do not smoke. Low birth weight is associated with increased risk for neonatal, perinatal, and infant morbidity and mortality. The longer the mother smokes during pregnancy, the greater the effect on the infant's birth weight" (CDC 2001). Multiple studies have shown that tobacco use during pregnancy is correlated with lower birth weights, see, for example, Evans and Ringel (1999), Abrevaya (2006), and Abrevaya and Dahl (2007). Shiono and Behrman (1995) report that smoking during pregnancy accounts for 20 percent of low birth weight births, making it the single most important modifiable risk factor for low birth weight in developed countries (Kramer 1987).

We also observe that the incidence of teen smoking is relatively high--in 2004, 21.7 percent of all high school students reported smoking cigarettes while the incidence of cigarette smoking among non-teens was 20.9 percent.[2] Data from Georgia (1994-2002) indicate that approximately 22.1 percent of nonblack teen mothers report that they smoked during their pregnancies whereas only 11.7 percent of nonblack older mothers report smoking (see Table 1).

Could the observed differences in birth weights for babies born to teen mothers and babies born to non teens be attributable, at least in part, to differences in the effects of smoking on infant health for these two groups? The issue is complicated by several factors. First, there are the physiological effects of nicotine on the fetus; medical research indicates that nicotine itself is a neuroteratogen, affecting nervous system development (see Roy et al. 1998; Slotkin 1998; Law et al. 2003). Smoking also interferes with the function of the placenta, which may lead to malnutrition (Law et al. 2003). Then, too, teen mothers will not have sustained the same physical damage from smoking as adult women, simply because the teens have not had the same length of exposure to tobacco. These causal effects do not suggest any reason to suspect substantial differences in the impacts on babies born to smoking teens or smoking adults.

However, smoking during pregnancy not only has a direct physical effect on the health of the fetus, but it also serves as a possible signal for other unhealthy behaviors that are not usually measured in our data sets. Although not all studies use methods to account for the possible correlation of maternal tobacco use with these other unobservable influences, in recent work, researchers do recognize the endogeneity of tobacco use in birth outcome models, see Almond et al. (2005) or Abrevaya (2006), for example. Simply stated, the hypothesis is that women who choose to smoke during pregnancy, despite the considerable evidence that relates smoking to poor birth outcomes, could be likely to engage in other risky behaviors. Use of tobacco could provide a signal of the mother's attitude or concern for a healthy birth and these unobservable factors could also affect the pregnancy outcome.

Perhaps some fraction of the difference in birth outcomes for teens and non-teens results from systematic differences in either the extent of these unobserved behaviors or the correlation of these behaviors with tobacco use. Thus, obtaining empirical evidence of the causal effect of maternal tobacco use on birth weight for both teen mothers and older mothers could provide some useful information on the signal provided by tobacco use such as the teen mother's attitude or concern for a healthy baby relative to a non-teen mom. In this paper, we provide estimates of the impact of maternal tobacco use on birth outcomes for teen mothers and older mothers, using a unique data set of the entire population of births in the state of Georgia over the period 1994 to 2002. We use three different estimation methods that rely on different assumptions regarding the unobserved components of maternal behavior, in the hope of obtaining estimates of the causal effect of smoking on birth weights. The results of the alternative estimators suggest that both ordinary least squares (OLS) and matching estimators which rely on observable characteristics to estimate the causal link between birth weight and smoking may overstate the impact of smoking on birth weight. The fixed effects estimates, which control for unobservables, suggest that there are some differences of the impact of smoking on birth weight for teen and non-teen mothers, but that the effect is substantially smaller than found in the other estimations.

Evidence that the impact of smoking on birth weight for teens and non-teens differs can inform future research into both teen smoking and teen pregnancy, as well as the policies and programs aimed at the teen population. Currently, many of the anti-smoking campaigns and programs are focused on teenagers. For example, the national campaign, “Healthy People 2010” lists tobacco use as one of its 10 high-priority public health issues, targeting a 50 percent reduction in tobacco use for teens. Evidence to justify and reinforce these efforts could be useful in the general policy debate regarding tobacco use.

The remainder of this paper is organized as follows. Section II reviews the literature. Section III discusses the empirical strategy. Section IV introduces the data used in the analyses. Section V presents the results and section VI concludes the paper.

2. Previous Literature

Across the U.S., teen births are on the decline. The southern states continue to have the highest teen birth rates in the nation. In 1990, the national teen birth rate (births per 1,000 females ages 15-17) was 37 and in Georgia it was 50. In 2004, these figures were 22.1 and 29.3 respectively (CDC 2006a). More detailed data on births in Georgia reflect some startling statistics regarding teen pregnancies. If we consider all births to mothers below the age of 19, 4 percent of those births are to mothers younger than age 15 (at time of delivery) and 26 percent to mothers ages 15-16. In 2002, 9.0 percent of live infant births were of low birth weight, an increase from 8.5 percent in 1998. Of teen births in 2000, 82 percent were covered by Medicaid.[3]

The previous literature most relevant to our work are the recent studies that recognize the endogeneity of tobacco use in birth outcome models and use various techniques to account for this estimation problem. In a randomized experiment, Permutt and Hebel (1989) considered the impact of ‘stop smoking’ counseling on birth weights for a group of smoking mothers. The control group for comparison was a group of smoking mothers who did not receive counseling. The authors found a negative effect of smoking on birth weight of about 400 grams, using a sample of 935 mothers. This is quite a large effect given that the normal birth weight is 3,500 grams. This study is unique in its natural experiment approach, but the causal effect of smoking is estimated imprecisely due to a small sample size.

Abrevaya (2006) estimates the causal effect of smoking during pregnancy on birth weight and gestation length in weeks using panel data techniques. This study is an interesting departure from the rest of the literature as it employs a panel data analysis using a sample of mothers with multiple births during the sample period. Since there are no individual identifiers in the data set that would allow the author to uniquely identify a mother (e.g. social security number), he employs a matching strategy to determine which individual mothers experienced multiple births during the time period considered. The results from the fixed-effects models indicate that the effect of smoking on birth outcomes is smaller than those obtained from the OLS models, suggesting a strong negative correlation between the omitted variables and the smoking indicators. Our study is similar to this one in that one of our identification strategies relies on the variation in the smoking behavior of mothers who give multiple births during the period analyzed. Because our data are drawn from administrative records, we identify each mother perfectly. We are also able to control for a much larger set of variables.

Almond et al. (2005) is another recent study on the effects of maternal smoking during pregnancy on health outcomes of singleton births controlling for a wide set of background characteristics. The authors compare the hospital costs, health outcomes, and infant mortality rates between heavier and lighter infants from all twin pairs born in the U.S. In order to identify the causal effect of smoking on birth weight, they use a propensity score matching estimator. The authors' analysis of the effect of smoking on birth weight uses data from Pennsylvania between 1989 and 1991, although the authors indicate that they found similar results for Florida, Georgia, Illinois, Michigan, North Carolina, and Ohio. However, this study does not distinguish between teen mothers and non-teen mothers. They find that the impact of smoking on birth weight is about -200 grams.

Evans and Ringel (1999) examine the effect of cigarette taxes on birth outcomes using data from the 1989-1992 Natality Detail Files. The results suggest that excise cigarette taxes are associated with a decrease in smoking participation among pregnant women and with an increase in birth weight. The smoking participation price elasticity is estimated to be -0.5. The authors use a dataset of over 10 million births, much larger than other studies. They employ an instrumental variables method to identify the causal effect of smoking on birth weight. Specifically, they use the changes in state cigarette taxes to identify the causal effect of smoking on birth weight. A potential problem with this estimation strategy is that the time period, 1989-1992, was not a period when changes in cigarette taxes were frequent. Their results indicate that smoking causes a decrease in birth weight by 350-600 grams. However, their results from the instrumental variables method are not statistically different from those from the OLS estimation, perhaps due to low variation in their instrument.

Abrevaya and Dahl (2007) estimate the effect of birth 'inputs' including smoking on birth weight. The authors use samples of natality data for the states of Washington and Arizona. In both states, births were maternally linked based on available information (for Washington: mother's name, mother's date of birth, mother's race, and mother's state of birth and for Arizona: mother and father's date of birth, mother's race, and mother's state of birth). The subsample chosen for estimation is the first and second births to white mothers. Their results are qualitatively similar to ours, though their estimation strategy is different. Their work uses quantile estimators to address the impacts of birth inputs over the entire distribution of birth weight. They incorporate individual effects that are somewhat different from the usual fixed effects, due to the fact that quantiles are not linear operators. The authors find that smoking reduces birth weight throughout the birth weight distribution by between 26.2 and 82.5 grams in the panel estimation. They also estimate a cross-section model and find much larger impacts of smoking, which they attribute to a failure to control for unobserved characteristics. Our results show similar negative effects of smoking on the conditional mean birth weight, but the magnitudes are not directly comparable, due to the different estimators and the fact that we incorporate measures of smoking intensity and distinguish between adult and teen mothers.

Our analysis focuses on Georgia and uses recent data that include the entire population of births over a longer period than used in most previous studies. The resulting sample is much larger than those of many other studies in this literature. We focus on the difference between teen and non-teen mothers and also focus on differences in outcomes by race. We pay careful attention to identifying the causal effect of teen smoking on birth weight by employing a variety of estimators that make different assumptions. Our identification strategy for the fixed effects estimator relies on a sample of mothers with multiple births during the period considered and we report OLS, matching, and fixed effects results.

3. Empirical Strategy

Our goal is to estimate the effect of smoking during pregnancy on birth outcomes and to assess whether this effect differs between teen mothers and adult mothers. Suppose that the true data generating process can be written as:

$$outcome_{it} = \alpha_1 S_{it} + x_{it}\beta + \alpha_2 z_{it} + \varepsilon_{it}. \qquad (1)$$

where $outcome_{it}$ is the outcome for the baby for mother i for birth t (first, second, etc.). The vector x_{it} contains all the mother, father, and location level characteristics that affect birth weight. The variable z_{it} measures other risky behaviors of the mother that affect the birth outcome of the infant, but are unobservable. S_{it} is an indicator of whether the mother smoked during the pregnancy. The random variable ε_{it} represents random shocks to birth weight. The parameters to be estimated are given by α_1 and β.

Because the z_{it} variable is not observable, its effects are reflected in the error term and the model that is actually estimated can be written:

$$outcome_{it} = \alpha S_{it} + x_{it}\beta + u_{it} \qquad (2)$$

where u_{it} now absorbs the unobservable variable. It can easily be shown that the OLS estimator for α can be written: $\tilde{a} = \hat{a}_1 + \hat{a}_2\tilde{\delta}$

where $\hat{\alpha}_1$ and $\hat{\alpha}_2$ represent the OLS estimators from equation (1) and $\tilde{\delta}$ represents the slope estimator from a regression of z_{it} on S_{it} and x_{it}.[4] Because we anticipate that both $\hat{\alpha}_1$ and $\hat{\alpha}_2$ will be negative and that S_{it} and z_{it} are positively correlated, on average, the estimates of α_1 that we obtain will usually be larger (in the negative direction) that they should be.[5] The greater the discrepancy between $\tilde{\alpha}_1$ and $\hat{\alpha}_1$, the larger the impact of z_{it} on $outcome_{it}$ and/or the closer the correlation between smoking and the unobservable z_{it}.

The first set of estimates we obtain for equation (2) are OLS estimates; this estimator is consistent under the conditions that either z_{it} has no effect on $outcome_{it}$ or the sample covariances between z_{it} and both S_{it} and x_{it} are zero.

A second possible estimation strategy is to assume that the selection into tobacco use by pregnant women is determined by observable variables. That is, if the relevant characteristics that determine smoking behavior are observable, we can use this information to control for the endogeneity of tobacco use. We use these observable characteristics to sort our data into "matched" samples of smoking and non-smoking women. We can then compute the impact of tobacco use on birth weight as the average difference in birth weights of infants in the matched samples of smokers and non-smokers. Unlike regression techniques, matching estimators do not impose any functional form restrictions nor do they assume a homogenous treatment effect across populations (Zhao 2005). The assumption of 'selection on observables' is quite strong, however; it implies that the density of infant health outcomes is independent of smoking behavior, once observable variables have been conditioned on. More formally, with birth weight, *bw*, as the outcome under consideration, these assumptions are written as follows, where "1" means a smoker and "0" a non-smoker:

$$pdf\,(bw_1 \mid x, S) = pdf\,(bw_1 \mid x)$$
$$pdf\,(bw_0 \mid x, S) = pdf\,(bw_0 \mid x).$$

Although these assumptions cannot be tested directly, some indirect evidence can be obtained through estimating the treatment effect on a subsample that cannot have been affected by the treatment; we compute these tests and discuss the results below.[6]

The third estimation strategy relaxes the assumption that conditioning on observable characteristics that determine tobacco use makes infant health outcomes independent of smoking behavior. We turn to a fixed effects specification that requires a sample of mothers who gave birth multiple times during our data period. In order to implement this estimator, we specify:

$$outcome_{it} = \alpha S_{it} + x_{it}\beta + \mu_i + \varepsilon_{it}, \tag{3}$$

where μ_i is an individual effect associated with the ith mother. Because mothers' social security numbers were available, we can uniquely identify mothers with multiple births over the period of our sample. Thus any time invariant observed or unobserved influence on infant health outcomes will be controlled for by the fixed effect, only factors that change over time will be included in the vector of control variables. Some of these will include marital status of the mother, mother's age, mother's education, infant's sex, possibly the place of birth, the number of prenatal care visits, mother's weight gained during pregnancy, and Medicaid status.

Identification of the treatment effect in this approach relies upon mothers who change their smoking behavior between births. Our data cover a relatively long period of time so that a substantial number of teenager and adult women do change their smoking behavior as noted in Table 2. This estimator is attractive as it eliminates any mother specific time-invariant unobserved heterogeneity. However, if there are time-varying unobserved characteristics of the mother that are correlated with her smoking behavior, this approach would still yield biased estimates. Abrevaya (2006) considers the bias that could result from time-varying unobserved characteristics. He analyzes the simple correlation of changes in observed behavior with changes in smoking behavior. He finds that reduced smoking is associated with increased prenatal care and speculates that reduced smoking would also be correlated with reduced alcohol consumption and poor nutrition. From this analysis he concludes that the direction of bias of the potential time-varying characteristics is negative.

4. Data

Our data come from Georgia's Department of Human Resources birth records.[7] Georgia is an interesting state to analyze due to the state's above average incidence of teen births (noted above) and above average teen smoking behavior during our sample period. In 2002, the incidence of tobacco use in Georgia was 22.8 percent for the adult population and 23.7 percent for the high school aged population. The U.S. averages for that period were 22.5 percent and 22.9 percent for these groups, respectively.[8]

The data include detailed information on the birth of a child, the health status of the mother and child, and basic demographic information including the race and ethnicity of the mother, and age of the mother. Our data cover 1994-2002, which provides a substantial number of births. This is also a period long enough to observe enough numbers of multiple births for our fixed effects model. We have a total of 941,746 observations (births) in the entire file and 138,500 incidents of teen births, where teen births are live births to girls aged 19 and younger at the time of birth. The number of teen births per year fell over the sample period, ranging from a minimum of 13,544 births in 2002 to a maximum of 16,353 births in 1995.

We subdivided the data a number of ways. First, we separated African-American women from others. In keeping with much of the health literature, we estimate separate models for blacks and non-blacks. In the non-black sample, the only substantial ethnic subgroup is Hispanic women. In the subsamples that include mothers who have experienced two or more live births within the sample period, the teen data set includes teens who gave birth at least twice *as teenagers* (aged 19 or younger). Similarly, the subsample of non-teen multiple births includes women 20 or older who have experienced two or more live births. Among non-black teens, the maximum number of live births to a single mother during the sample period was 4; for non-black non-teen women, the maximum was 7. For black teens and women, the maximum number of live births was 5 and 8, respectively.

We consider two infant health outcome measures. The first is the actual birth weight of the child, measured in grams, for full-term births and the second is the gestation-adjusted birth weights as computed by Oken et al. (2003). The gestation-adjusted birth weight is measured in percentile rankings so that infants that are relatively heavy for the gestational age are assigned a high percentile ranking whereas small infants are assigned lower percentile rankings. When actual birth weights are used as the outcome measure, we limit the sample to only full term births, meaning those with weeks of gestation recorded as more than 37. This avoids the comparison of unusually small full-term infants with those that are pre-term.

Table 1 documents smoking behavior reported in the vital statistics records for all women in our data, and also reports low birth weight incidence along with average birth weight and gestation. Table 2 summarizes smoking patterns for mothers with multiple births. Overall, teen mothers are somewhat more likely to use tobacco during pregnancy, but there appear to be fewer teens who report heavy smoking over all the years of our data. Teen mothers are less likely to quit smoking between the first and second pregnancy--2.7 percent quit of teen mothers quit versus 5.9 percent of non-teen mothers. Teen mothers do have lighter babies and this effect is most pronounced for the black subsample.

There are interesting differences among the mothers in terms of the time profile of their smoking behavior. We break the data into groups by teens and non-teens, first births and subsequent births, and by smoking behavior. Smoking behavior is classified into four mutually exclusive categories. They are "never smoked," "always smoked," "quit smoking after the first birth," and "started smoking after the first birth." In Table 3, we show the average birth weight and gestation length for these groups for teens and non-teen mothers. As displayed in the table, the highest birth weights for teens and non-teens generally occurs when there is no tobacco use just prior to the birth ("never," "started after first birth," and "quit after first birth"). Teens who never smoked have first babies that are about 93 percent of the birth weight of non-smoking, non-teen moms (3,110/3,334). Smoking behavior brings the teen and non-teen moms slightly closer together in terms of the birth weight ratio for first and subsequent births. When teen mothers quit smoking, we see an increase in the birth weight of their subsequent babies, while there is little change for non-teen moms in this category (actually, a slight decrease in birth weight for non-teen moms). For teen moms who begin smoking after the first birth, we notice a *decrease* in birth weight between the first and subsequent births of 34.9 grams (3,121.6-3,156.5) compared to a non-smoking teen mom who sees, on average, an increase between first and second births of 49 grams (3,159-3,110).

A full list of variable names and definitions, plus summary statistics for both teen and non-teen mothers, is provided in Table 4. As displayed in Table 4, teen mothers are more likely to be black and are more likely to be using Medicaid. They are much less likely to be married or report a father. Furthermore, they have fewer prenatal care visits than non-teen mothers but they also are less likely to be smokers.

5. Results

The results we focus on are based on the models using full term births.[9] Results of the gestation-adjusted birth weight estimation are available from the authors.[10] In the estimation, prenatal care is measured with two variables; the number of visits and the number of visits squared. A dummy variable to indicate whether the infant represents the mother's first live birth is included. Mother's age and mother's education are entered as continuous variables.

We experimented with using demographic information on the father, based on the idea that the father's characteristics might proxy for otherwise unmeasured socio-demographic characteristics of the mother and the mother's environment. For a substantial portion of the sample, however, the father characteristics were missing. When included in the models, these variables had virtually no impact on the outcome measures. Finally, we constructed a binary variable that is equal to one when all demographic information on the father is missing; again, we hypothesize that this provides a signal on the socio-economic characteristics of the mother.

A variety of other control variables were included, but they had little impact on the estimation results in a variety of specifications.[11] Dummy variables were included for year and county of birth (these coefficients are suppressed in the tables).

We have chosen not to test whether the effect of smoking differs between teens and non-teens by pooling the data and using dummy variables for teenage mothers in equation (1), this method would impose the restriction that all other variables have identical effects for the two groups.[12] We prefer to allow for the possibility that there are substantive differences between these two groups in the way birth outcomes are determined for the reasons discussed earlier. Therefore, we will estimate equation (1) separately for teen and non-teen mothers.

The consistency of the OLS estimator depends on the assumption that smoking is uncorrelated with the unobservable factors reflected in the errors. The results are presented in Tables 5 (adults) and 6 (teens). The OLS results suggest some sizeable impacts of smoking on birth weight, but the impact is somewhat larger for non-teen women--which is not what we expected. Among all of the subgroups and categories of smoking, the impact of smoking on birth weight ranges from 109 to 275 grams (the omitted category of smoking is “no smoking”). At all three levels of smoking intensity, the point estimates for adult women exceed those for teens, and the point estimate for adults is nearly double the impact for teens in the highest smoking category. Thus, based on these estimates, maternal smoking has more deleterious effects on non-teens than on teens.

The second estimator involves sorting both teen and non-teen samples into matched groups of smokers and nonsmokers based on a number of observable variables, using the matching estimator suggested by Abadie and Imbens (2002). As described above, this estimator relies on the assumption of selection on observables. Although this assumption cannot be directly tested, Imbens (2004) suggests that some information can be gained by estimating the treatment effect on an outcome that could not have been affected by the treatment. If this treatment effect is found to be not significantly different from zero, it lends some plausibility to the unconfoundedness assumption and hence the consistency of the matching estimator.

A form of this test was implemented by estimating the effect of smoking behavior on birth weight, using samples of first births to women (either adults or teens and stratified by race) where the treatment group consisted of women who did not smoke during the first pregnancy, but smoked during subsequent pregnancies. The control group consisted of women who did not smoke during either the first or subsequent pregnancies.[13] Results from these tests indicate that the null hypothesis of unconfoundedness is not rejected for the sample of black teen mothers only. Nonetheless, matching estimator results are reported for all subsamples in order to compare to our other empirical results.

The covariates used for matching include length of gestation, number of prenatal visits, mother's age, mother's education, mother's weight gain categories, marital status, and first birth and year dummies. The estimator uses the four 'closest' matches to the treated individuals, where closeness is defined by the vector norm given by $(x'Vx)^{1/2}$, with x representing the vector of covariates and V defined as the diagonal matrix of the inverse variance matrix of x. We also used the bias adjustment suggested in Abadie and Imbens (2002) due to the large number of covariates.

The treatment effect on the treated is computed by averaging the difference between the birth weight of children of smokers and non-smokers within the matched groups. Note that these model results are based only on the mother's use of tobacco, rather than the intensity of tobacco use, as in the other models. These results, given in Table 7, suggest that smoking has a detrimental effect on birth weight, but that the effect is larger for non-teen women than for teens. The effect for non-black teens is estimated as -164 grams and the effect for non-black non-teens is -211 grams, both effects have very small standard errors. For blacks, the teen estimate is -106 grams and for non-teens it is -176 grams. It is interesting to note that these results are similar to an average of the coefficients for the three smoking intensity categories used in the OLS model.

The results from the fixed effects model that uses the sample of mothers with multiple births and full term babies are presented in Table 8 (non-teens) and 9 (teens). The substantial changes in the measured impact of smoking support the notion that smoking is an indicator of other unhealthy behaviors which are not measured in the OLS or matching estimation strategies.

The difference in the impact of smoking on birth weight between adults and teen moms is subtle. At the lowest level of smoking (l0 cigarettes per day or less), children of smoking, non-black teen moms are 9.7 grams lighter than children of smoking, non-black adults. This difference decreases to 3.7 grams for non-blacks smoking more than 10 to 20 cigarettes per day. For black women and teens, the differences in the effects of smoking on birth weight are larger. At the lowest level of smoking, black teen mothers give birth to babies that are 42.9 grams lighter than black adult women in the same smoking category. In the highest smoking category (more than 20 cigarettes per day), the difference is quite large - black teen mothers give birth to infants that are nearly 300 grams lighter than black adults. There are very few black teen mothers who report heavy smoking, however, so that although the large effect is striking, we cannot expect that it is representative of this population.

Are the differences in the impact of smoking on birth weight between teens and adults important? Clearly the differential impact of smoking on birth weight for teens and adults is not sufficient to explain the gap in average birth weights for teens and adults. Non-black teens give birth to infants who are, on average, 128 grams lighter than infants born to adult non-black women.[14] The different sizes of the causal effects of smoking accounts for between 7 and 18 percent of that 128 gram gap. For black teens and adults, the average birth weight gap is smaller, about 113 grams. For these women, the differential impact of smoking is somewhat larger; the difference accounts for 44 percent of the difference in average birth weights.

Overall, the differences between the teen and non-teen mothers are relatively small for most of our subsamples. Recall that because teen smokers, by virtue of their youth, will have smoked fewer years, on average, than adult smokers, they will have sustained less physical damage from smoking than long term smokers. This yields some ground to argue that the effects on infants born to teen mothers should be smaller. Our finding of a negative impact of smoking on teen and non-teen's babies, and a slightly stronger impact for teens, once the impact of unobservable factors is accounted for, is very interesting.[15]

6. Conclusions

In this paper, we have used three different estimation strategies to analyze the impact of smoking on birth weight of teen and non-teen mothers. Our results suggest that the unobservables that influence behavior and correlate with tobacco use during pregnancy play a large part in the previously reported impacts of smoking on birth weight. When we control for unobservables (model 3, fixed effects), we find that smoking is still an important factor in infant health, but the marginal impact of smoking is much smaller than typically estimated. Both our OLS estimates (model 1) and our estimates from our matched sample (model 2) result in larger coefficients for smoking.

The differences in the estimated impact of smoking on birth weight for teens and non teens are somewhat surprising. We actually anticipated that while the causal effects of smoking would be similar for teens and adults, the signal provided by tobacco use--that is, the correlation of tobacco use with other unhealthy behaviors--would be stronger for teens than non teens. We had expected that the signaling model would help explain more of the well documented result that teens to give birth to relatively lower birth weight children. Instead, our results indicate that the signal effect provided by tobacco use is stronger for adults than for teens whereas the causal effects are somewhat stronger for teens. The differences in the causal effects, however, are modest. For non-blacks, 7 percent of the difference in average birth weights of infants born to teens and non-teens can be explained by smoking behavior for those in the low smoking category. For blacks, about 40 percent of the difference can be explained by low levels of smoking.

From a policy perspective, successful smoking cessation campaigns (all else constant) should have similar impacts on the health of children of teen and non-teen mothers. The difficulty, of course, is that similar cessation programs will probably not have the same level of success on smoking cessation for teens and non-teens. The choice of appropriate policy is confounded by the lack of empirical results that explain the differences in teen and non-teen birth weight. As discussed by Chen et al. (2007) and as found here, it is very difficult to make headway into an explanation of the differences in birth weight between teens and non-teens. Further research is needed regarding the impact of unobservable variables such as teen attitudes toward pregnancy and associated behaviors (physiological, social, and emotional). Survey data may be an interesting supplement to currently available administrative data in this regard.

References

Abadie, Alberto and Guido Imbens. 2002. Simple and bias-corrected matching estimators for average treatment effects. NBER Technical Working Papers No. 0283.

Abrevaya, Jason. 2006. Estimating the effect of smoking on birth outcomes using a matched panel data approach. *Journal of Applied Econometrics* 21(4):489-519.

Abrevaya, Jason and Christian M. Dahl. 2007. The effects of birth inputs on birthweight: Evidence from quantile estimation on panel data. Forthcoming in *Journal of Business and Economic Statistics*.

Almond, Douglas, Kenneth Y. Chay, and David S. Lee. 2005. The costs of low birth weight. *Quarterly Journal of Economics* 120(3):1031-83.

Centers for Disease Control and Prevention (CDC). 2001. Women and smoking: A report of the surgeon general, 2001. Tobacco Information and Prevention Source, from: http://www.cdc.gov/tobacco/sgr/sgr_forwomen/ataglance.htm.

Centers for Disease Control and Prevention (CDC). 2003. Tobacco use among middle and high school students, United States, 2002. *Morbidity and Mortality Weekly Report* 52(45):1096-98.

Centers for Disease Control and Prevention (CDC). 2005. Tobacco use, access, and exposure to tobacco in media among middle and high school students. *Morbidity and Mortality Weekly Report* 54(12):297-301.

Centers for Disease Control and Prevention (CDC). 2006a. Births: Final data for 2004. *National Vital Statistics Reports* 55(1).

Centers for Disease Control and Prevention (CDC). 2006b. Errata: Tobacco use, access, and exposure to tobacco in media among middle and high school students. *Morbidity and Mortality Weekly Report* 55(17):490.

Chen, Xi-Kuan, with Shi Wu Wen, Nathalie Fleming, Kitaw Demissie, George G. Rhoads, and Mark Walker. 2007. "Teenage pregnancy and adverse birth outcomes: A large population based retrospective cohort study. *International Journal of Epidemiology* 10:368-73.

Evans, William N., and Jeanne S. Ringel. 1999. Can higher cigarette taxes improve birth outcomes. *Journal of Public Economics* 72(1):135-54.

Imbens, Guido W. 2004. Nonparametric estimation of average treatment effects under exogeneity: A review. *Review of Economics and Statistics* 86:4-29.

Kramer, Mark S. 1987. Determinants of low birth weight: Methodological assessment and meta-analysis. *Bulletin of the World Health Organization* 65:663-737.

Law, Karen, Laura R. Stroud, Linda L. LaGasse, Raymond Niaura, Jing Liu, and Barry M. Lester. 2003. Smoking during pregnancy and newborn neurobehavior. *Pediatrics* 111(6):1318-23.

Law, C. M. 2002. Significance of birth weight for the future. *Archives of Disease in Childhood Fetal and Neonatal Edition* 86:F7-F8.

Lewitt, E. M., L. S. Baker, H. Corman, and P. H. Shiono. 1995. The direct costs of low birth weight. *The Future of Children* 5:35-51.

Oken, E., K. P. Kleinman, J. Rich-Edwards, and M. W. Gilman. 2003. A nearly continuous measure of birth weight for gestational age using a U.S. national reference. *BMC Pediatrics* 5:1-10.

Permutt, Thomas, and J. Richard Hebel. 1989. Simultaneous-equation estimation in a clinical trial of the effect of smoking on birth weight. *Biometrics* 45:619-22.

Roy, Tara Sankar, Frederic C. Seidler, and Theodore A. Slotkin. 1998. Prenatal nicotine exposure evokes alterations of cell structure in hippocampus and somatosensory cortex. *Journal of Pharmacology and Experimental Therapeutics* 300:124-32.

Slotkin, Theodore. 1998. Fetal nicotine or cocaine exposure: Which one is worse?" *Journal of Pharmacology and Experimental Therapeutics* 285:931-42.

Shiono,P. H., and R. E. Behrman. 1995. Low birth weight analysis and recommendations. *The Future of Children* 5:4-18.

Wei, Jung-Nan, Fung-Chang Sung, Chung-Yi Li,, Chia-Hsuin Chang, Ruey-Shiung Lin, Chau-Ching Lin, Chuan-Chi Chiang, and Lee-Ming Chuang. 2003**.** Low birth weight and high birth weight infants are both at an increased risk to have type 2 diabetes among schoolchildren in Taiwan. *Diabetes Care* 26:343-48.

Wooldridge, Jeffrey M. 2002. *Econometric analysis of cross section and panel data*. Cambridge, MA: The MIT Press.

Zhao, Zhong. 2005. Sensitivity of propensity score methods to the specifications. Institute for the Study of Labor Discussion Paper No. 1873.

Notes

[1] It is worth noting here that while low birth weight is clearly a health risk to the infant, high birth weight babies are also at risk (Wei et al. 2003; Law 2002). Previous research has not shown any connection between maternal smoking and abnormally high birth weights. Part of our empirical strategy controls for high birth weight births.

[2] CDC (2005, 2006b).

[3] Based on the authors' tabulations of Georgia Medicaid records and the Georgia Vital Statistics data file.

[4] See Wooldridge (2002, p. 62).

[5] Note that estimated values of δ would also depend on the other covariates in the model and their relationship to S_{it}.

[6] Further details on the estimator that we use and the specification tests can be found in Abadie and Imbens (2002) and Imbens (2004).

[7] Permission of the Department of Human Resources is necessary for use of the data.

[8] Centers for Disease Control and Prevention (2003).

[9] We do not estimate the effect of smoking on gestation and hence that channel of causation to birth weight remains unexplored in this paper.

[10] The gestation adjustment controls for the gender of the infant, with different percentiles for males and females.

[11] These variables include: presence of a father, mother's education, county of birth, and various medical conditions.

[12] We did estimate a model that used interaction terms between the teen dummy and the other variables to distinguish the coefficients for the two groups. The joint hypothesis that the coefficients were the same for the two groups was soundly rejected, even for subsets of coefficients that did not include the smoking variables.

[13] Clearly, this test procedure is not fully adequate as we cannot know whether women who did not smoke during first pregnancies had actually never smoked before or had smoked then stopped. Similarly, the women in the control group, who never reported smoking during pregnancy, could have been smokers at some previous period.

[14] This difference is based on calculations from the Georgia Vital Statistics data file, using full-term births only.

[15] The results using the gestation adjusted birth weights for the OLS, matching, and fixed effects models were very similar to those reported for the full term birth samples. These results are available upon request.

Table 1. Birth Outcomes and Smoking Behavior

	Black Adults	Non-Black Adults	Black Teens	Non-Black Teens
Low Birth weight incidence	10.29%	4.61%	12.15%	7.16%
Average Weight (grams)	3170.5	3423.1	3063.3	3278.1
Average gestation length (weeks)	38.43	38.95	38.40	38.95
Did not smoke during pregnancy	94.68	88.28	97.60	77.93
Smoked < 10 cigarettes daily (%)	4.53	7.35	2.22	16.35
Smoked 10 -20 cigarettes daily (%)	0.69	3.80	0.17	5.18
Smoked > 20 cigarettes daily (%)	0.09	0.57	0.02	0.55
Number of observations	257,664	520,306	69,989	66,847

Source: Tabulations from Vital Statistics data file.

Table 2. Smoking Patterns of Mothers with Multiple Births

Smoking Behavior Between Births	Teen Mothers (%)	Non-Teen Mothers (%)
Never smoked	78.87	86.12
Always smoked	7.33	5.20
Quit smoking between first and subsequent births	5.86	2.74
Started smoking between first and subsequent births	4.39	2.69

Source: Tabulations from Vital Statistics data file.

Note: Totals do not add to 100 percent due to missing values for smoking behavior.

Table 3. Birth Weight (grams) and Gestation Length (weeks) by Smoking Patterns

	Never Smoked		Always Smoked		Quit after First Birth		Started after First Birth	
Outcome	**First Birth**	**Subsequent Birth**	**First Birth**	**Subsequent Birth**	**First Birth**	**Subsequent Birth**	**First Birth**	**Subsequent Birth**
Teen Mothers								
Birth weight	3,110	3,159	3,071.6	3,111.5	3,103.6	3,184.9	3,156.5	3,121.6
Gestation	38.5	38.3	38.9	38.54	38.8	38.6	38.7	38.5
Adult Mothers								
Birth weight	3,334.27	3,409.2	3,128.1	3,112.6	3,246.8	3,200.6	3,197.6	3,207.1
Gestation	38.98	38.7	38.99	38.5	39.1	38.6	38.9	38.5

Source: Tabulations from vital statistics data.

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Table 4. Variable Definitions and Descriptive Statistics

Variable Name	Definition	Teen Mothers Black	Teen Mothers Non Black	Adult Mothers Black	Adult Mothers Non Black
Weight	= Birth weight in grams	3,063.3 (569.295)	3,278.1 (558.278)	3,170.9 (614.178)	3,423.1 (550.602)
Gestweight	= Gestation-adjusted birth weight, in percentile rankings	35.6 (28.59)	44.9 (28.42)	41.9 (28.38)	53.1 (28.68)
Gestweek	= Length of gestation in weeks	38.4 (2.687)	38.952 (2.322)	38.435 (2.627)	39.0 (2.014)
First birth	= 1 if birth represents first live birth to mother, 0 otherwise	0.737 (0.440)	0.808 (0.394)	0.314 (0.464)	0.393 (0.488)
Non-smoker [a]	= 1 if mother's tobacco use is zero, 0 otherwise	0.976 (0.153)	0.779 (0.414)	0.947 (0.224)	0.883 (0.322)
Smoker: 0 – 10 Cigarettes	= 1 if mother's tobacco use is between 0 and 10 cigarettes per day, 0 otherwise	0.022 (0.147)	0.163 (0.370)	0.045 (0.208)	0.073 (0.261)
Smoker: 10 – 20 Cigarettes	= 1 if mother's tobacco use is between 10 and 20 cigarettes per day, 0 otherwise	0.002 (0.041)	0.052 (0.222)	0.007 (0.083)	0.038 (0.191)
Smoker: > 20 Cigarettes	= 1 if mother's tobacco use is greater than 20 cigarettes per day, 0 otherwise	0.0002 (0.014)	0.006 (0.074)	0.0009 (0.031)	0.006 (0.076)

Male	= 1 if the infant is a male, 2 otherwise	1.492 (0.500)	1.488 (0.500)	1.494 (0.500)	1.488 (0.500)
Prenatal care	= Number of prenatal care visits	10.33 (3.928)	11.56 (4.002)	11.48 (4.018)	12.60 (3.788)
Mother's age	= Mother's age in years	17.51 (1.431)	17.81 (1.214)	26.86 (5.363)	28.35 (5.236)
Mother's education	= Mother's education in years	10.62 (1.430)	10.45 (1.523)	12.96 (1.966)	13.52 (2.433)
Mother's weight gain: missing	= 1 if mother's weight gain is missing, 0 otherwise	0.060 (0.238)	0.045 (0.206)	0.060 (0.238)	0.042 (0.200)
Mother's weight gain: < 10 pounds	= 1 if mother's weight gain is less than 10 lbs, 0 otherwise	0.075 (0.263)	0.037 (0.189)	0.093 (0.290)	0.048 (0.213)
Mother's weight gain: 10 - 35 pounds	= 1 if mother's weight gain is between 10 lbs and 35 lbs, 0 otherwise	0.610 (0.488)	0.544 (0.198)	0.592 (0.491)	0.620 (0.485)
Mother's weight gain: > 35 pounds [a]	= 1 if mother's weight gain is greater than 35 lbs, 0 otherwise	0.254 (0.436)	0.374 (0.484)	0.255 (0.436)	0.291 (0.454)
Marital status	= 1 if the mother is married, 0 otherwise	0.035 (0.185)	0.405 (0.491)	0.412 (0.492)	0.855 (0.352)
Father missing	= 1 if information on father is missing, 0 otherwise	0.533 (0.499)	0.249 (0.432)	0.286 (0.452)	0.061 (0.240)

Medicaid	= 1 if Medicaid paid for birth, 0 otherwise	0.689	0.617	0.439	0.210
		(0.463)	(0.486)	(0.496)	(0.407)
Number of observations		69,989	66,847	257,664	520,306

Note: Standard deviations are in parentheses.

Source: Vital statistics data from Georgia.

[a] Omitted category.

Table 5. OLS Results for Birth Weight - Adult Mothers

	Black		Non Black	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Male	-121.9***	1.20	-131.1***	1.34
Prenatal care	9.55***	0.75	13.89***	0.62
Prenatal care –squared	-0.143***	0.03	-0.305***	0.02
First birth	-82.16***	2.29	-98.18***	1.48
Mother's age	2.99***	0.22	0.903***	0.15
Mother's education	6.74***	0.61	8.77***	0.35
Marital status	35.93***	2.59	37.86***	2.43
Father missing	-10.15***	2.56	-12.69***	3.35
Medicaid	-9.38***	2.68	-26.63***	2.04
Mother's weight gain: missing	-126.3***	4.59	-127.99***	3.60
Mother's weight gain: < 10 pounds	-207.6***	4.03	-197.6***	3.48
Mother's weight gain: 10 – 35 pounds	-152.0***	2.35	-160.9***	1.52
Smoker: 0 – 10 Cigarettes	-171.7***	5.11	-199.1***	2.75
Smoker: 10 – 20 Cigarettes	-228.1***	12.79	-248.7***	3.73
Smoker: > 20 Cigarettes	-271.6***	35.99	-274.9***	9.21
Observations	198,398		437,076	

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. OLS Results for Birth Weight – Teen Mothers

	Black		Non Black	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Male	-116.1***	3.61	-114.7***	3.70
Prenatal care	2.11	1.56	12.31***	1.66
Prenatal care –squared	0.093	0.07	-0.223***	0.06
First birth	-64.14***	4.54	-63.69***	5.20
Mother's age	1.85	1.91	2.93	1.88
Mother's education	5.42***	1.85	14.00***	1.49
Marital status	42.18***	10.12	14.89***	4.33
Father missing	8.76**	3.78	-1.96	4.81
Medicaid	-0.061	6.01	-19.43***	5.22
Mother's weight gain: missing	-139.1***	8.26	-137.4***	9.48
Mother's weight gain: < 10 pounds	-253.5***	8.09	-208.9***	10.88
Mother's weight gain: 10 – 35 pounds	-174.6***	4.19	-148.0***	24.95
Smoker: 0 – 10 Cigarettes	-109.1***	12.62	-153.3***	5.20
Smoker: 10 – 20 Cigarettes	-155.8***	48.48	-200.9***	8.60
Smoker: > 20 Cigarettes	41.15	131.3	-148.0***	24.95
Observations	53,019		54,932	

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Matching Estimates of the Sample Average Treatment Effect for Birth Weight

	Teen Mothers			
	Black		Non Black	
Variable	Coefficient	Standard Error	Coefficient	Standard Error
The sample average treatment effect	-106.00***	13.37	-164.09***	5.10
Observations	53,019		54,932	

	Adult Mothers			
	Black		Non Black	
Variable	Coefficient	Standard Error	Coefficient	Standard Error
The sample average treatment effect	-176.44***	5.46	-211.21***	2.45
Observations	198,398		437,076	

*** indicates statistical significance at the 1% level.

Note: List of covariates controlled in the matching models is as follows: Birth weight, a binary indicator for the mother's tobacco use, first birthmother's education, prenatal care , gestation, father missing, mother's marital status, Medicaid, and year dummies.

Table 8. Fixed Effects Results for Birth Weight - Adult Mothers with Multiple Births

	Black		**Non Black**	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Male	-134.6***	3.42	-139.3***	2.14
Prenatal care	6.77***	1.39	9.62***	1.10
Prenatal care –squared	-0.094*	0.05	-0.181***	0.04
First birth	-55.85***	4.61	-77.72***	2.74
Mother's age	-0.943	2.75	-0.283	2.00
Mother's education	1.33	2.23	2.36	1.47
Marital status	8.24	6.63	24.89***	5.84
Father missing	3.83	5.14	-13.43**	6.82
Medicaid	-3.94	5.09	6.41	3.91
Mother's weight gain: missing	-60.94***	8.12	-67.73***	6.11
Mother's weight gain: < 10 pounds	-105.7***	7.69	-129.6***	6.43
Mother's weight gain: 10 – 35 pounds	-60.86***	4.63	-82.11***	2.89
Smoker: 0 – 10 Cigarettes	-50.31***	12.10	-53.17***	6.75
Smoker: 10 – 20 Cigarettes	-59.61**	26.58	-82.52***	9.02
Smoker: > 20 Cigarettes	-113.1	73.78	-50.71***	19.13
Observations	68,795		169,951	

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 9. Fixed Effects Results for Birth Weight - Teen Mothers with Multiple Births

	Black		Non Black	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Male	-131.8***	8.34	-127.8***	9.10
Prenatal care	5.38	3.74	11.65***	4.23
Prenatal care –squared	-0.031	0.17	-0.303*	0.16
First birth	-24.39**	12.26	-42.05***	14.92
Mother's age	11.73	10.23	27.02**	11.41
Mother's education	-9.09*	5.48	1.25	6.03
Marital status	44.32	29.11	-5.26	14.92
Father missing	11.09	9.79	-10.87	13.04
Medicaid	-9.65	14.49	-24.71*	14.13
Mother's weight gain: missing	-93.24***	29.31	-62.41***	23.98
Mother's weight gain: < 10 pounds	120.9	110.4	-115.3***	24.24
Mother's weight gain: 10 – 35 pounds	-412.4*	224.4	-81.42***	11.59
Smoker: 0 – 10 Cigarettes	-39.95**	19.39	-62.86***	16.29
Smoker: 10 – 20 Cigarettes	-94.70***	19.06	-86.26***	23.81
Smoker: > 20 Cigarettes	-74.50***	11.07	-72.82	58.88
Observations	11,901		9,957	

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.