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Maternal Smoking, Birth Weight, and Infant Health

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Abstract

Recent research into the implications of birth weight for infant health, and the implications of smoking during pregnancy for birth weight, may be plagued with omitted variable bias. In this study, two unique British longitudinal data sets on children and their mothers are used to address this issue. Cross sectional and panel estimates which exploit within-sibling differences in data suggest that improvements in birth weight will produce healthier children especially among women at risk of delivering low birth weight infants. Furthermore, the fixed estimates imply the benefits of smoking cessation among pregnant women are greatly exaggerated by the well-documented cross-sectional estimates. The results suggest that smoking during pregnancy reduces birth weight on average by 100 grams.

Keywords: birth weight, smoking, endogeneity bias.

JEL Classification: I1

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1. Introduction

A vast number of observational studies have identified birth weight as the most important determinant of neonatal mortality, as well as being a significant predictor of post-neonatal mortality and morbidity (Chernichovsky and Coate 1979; Mathews 2001; McCormick 1985; Nigel 1995; Rees et al. 1996). Research has also shown that birth weight is an important predictor in the analyses of a range of long-term outcomes including educational attainment, cardiovascular disease, and labor market earnings (Baker 1995; Case et al. 2005; Currie and Hyson 1999; Currie and Moretti 2007). In the large number of studies conducted by economists and other social scientists considering the determinants of birth weight, cigarette smoking during pregnancy has stood out as the most important and preventable risk factor (Kramer, 1987). The policy implications from the results of this literature suggest that investments in reducing the incidence of low birth weight, especially the prevention of smoking during pregnancy, are likely to reap large payoffs in terms of improved infant health, growth and development.

The current literature into the implications of birth weight for infant health has for the most part neglected to address serious estimation questions about omitted relevant variables. For instance, it is unclear whether the early-life consequences found to be associated with birth weight are a genuine result of weight, or whether this association arises from underlying factors such as genetic disposition, pregnancy-related behaviors or socioeconomic factors. Therefore, the fact that heavier babies have better health does not mean that investments in increasing birth weight would effectively improve the overall health of the population. A small number of recent studies have investigated the impact of birth weight on short and long-term life outcomes using within-family and within-twin estimates to try to sort out the relative contributions between various factors. Almond et al. (2005) for the United States and Black et al. (2007) for Norway find that the effect of birth weight on infant mortality largely disappears once across-twin comparisons are made to condition out characteristics between respondents that are common among twins. In light of these results, it is particularly striking that Black et al. (2007) and Behrman and Rosenzweig (2004) find that OLS estimates greatly understate the true effects of birth weight when looking at long-run outcomes such as education, height and earnings. Despite the theoretical appeal of using twin comparisons to isolate causal effects, twin pregnancies are unique and often suffer from complications as well as generally falling in the lower tail of the birth weight distribution. This may lead to possible difficulties in quantifying the true effect of birth weight on infant health and also a loss in the generalization of results to the broader population.

Policy initiatives designed to prevent maternal smoking during pregnancy have also been motivated primarily by cross-sectional studies. The bulk of this evidence suggests that, on average, smoking during pregnancy reduces birth weight by approximately 200 grams (U.S. Department of Health and Human Services 1990). Proper interpretation of these estimates requires consideration of several other features specific to women who smoke during pregnancy. To more carefully estimate the effect of smoking on birth weight, a number of recent papers have relied on estimates based on non-twin sibling comparisons (Abrevaya 2006; Almond et al. 2005; Rosenzweig and Wolpin 1991; Walker et al. 2009). These studies generally imply substantially smaller effects of smoking on birth weight than OLS estimates would suggest.

This article contributes to the literature by exploiting sibling differences in data from two unique British cohort studies. These data sources are the only studies that permit both an investigation of the effects of birth weight on infant health and the effects of smoking on birth weight for the same samples. This article is particularly distinguished by advancing the recent literature on the short-term implications of birth weight by using a broader measure of infant health than has been previously studied. However, these data are not appropriate for the investigation of the long-run implications of birth weight because the children of these cohorts are generally too young to have reached a socioeconomic transition such as labor market entry. Nevertheless, to understand how birth weight affects long-run outcomes, it is important to examine the effect of birth weight earlier in the life cycle. Also, the cohort data sets present a unique opportunity to draw stronger causal statements than are usually possible with non-sibling populations and more general than those which can be made using twin populations. However, as siblings share about half their genetic material there may be genetic differences across siblings that are positively correlated with birth weight. This suggests that sibling fixed effects estimates of the effects of birth weight are likely to provide an upper bound of the effect of birth weight on initial infant health. This caution notwithstanding, by invoking a fixed-effects framework, the present analysis eliminates the confounding effects of many unobserved factors that exist among families. Finally, this study focuses on children born in Great Britain between 1973 and 1991; it is not clear whether findings for the United States and elsewhere are relevant to the British context where children have universally-provided health insurance.

The remainder of this paper is organized as follows. Section 2 briefly summarizes and discusses the existing literature on this topic. Section 3 presents on overview of the data which is followed by the empirical results presented in section 4. A brief summary and some concluding remarks appear in Section 5. Cross sectional and panel estimates suggest that improvements in birth weight will produce healthier children especially among women at risk of delivering low birth weight infants. The fixed estimates which exploit within-sibling differences in data imply the benefits of smoking cessation among pregnancy women are greatly exaggerated by the well-documented cross-sectional estimates. The results imply that smoking during pregnancy reduces birth weight on average by 100 grams. These findings are consistent with those of previous researchers for the United States (Abrevaya 2006; Almond et al. 2005; Rosenzweig and Wolpin 1991; Walker et al. 2009). These results are also consistent with recent research for Great Britain by Fertig (2009) that suggests that the observed association between smoking and birth weight could be overstated by as much as 50 percent.

2. Literature review

The emphasis of public policy on reducing the incidence of low birth weight rests crucially on the underlying assumption that low birth weight has a causal effect on infant health outcomes. However, a number of studies have seriously questioned the reliability of these studies which document a statistical association between birth weight and better infant health. Almond et al. (2001) document that the dramatic improvements in the relative health of black infants between 1965 and 1971 in the U.S. could not be accounted for by changes in the birth weight distribution of black infants relative to whites over the same period. Chay and Greenstone (2003) found that the positive effect on infant mortality of a reduction in total suspected particulates (which is widely thought to be the most dangerous form of air pollution) induced by the 1981-1982 recession in the United States did not correspond with improvements in birth weight. These examples raise the possibility that the strong correlation found in earlier studies between birth weight and infant health may partially reflect the influence of omitted variables.

While twin comparisons are relatively uncommon in research on infant health, a series of recent studies have used within-twin variation to identify the effects of birth weight on short-run and long-run outcomes (Almond et al. 2005; Behrman and Rosenzweig 2004; Black et al. 2007; Conley et al. 2003; Royer 2009). Almond et al. (2005) using U.S. data concluded that the effects of birth weight on short-run indicators of infant health, including mortality (defined as death under one year of age) and APGAR scores, are overstated by cross-sectional correlations . Using the same indicators of infant health, Black et al. (2007) using Norwegian data found little if any relationship between birth weight and infant health. More recently, Royer (2009) using Californian-born twins also found that the short-run effects of birth weight on infant development to be quite small. An earlier study by Conley et al. (2003) that breakdowns infant mortality into neonatal mortality (death under 28 days of age) and post-neonatal mortality (between 28 days and one year) found that low birth weight increases the risk of mortality in the post-neonatal period only. However, Black et al. (2007) present evidence of a significant impact of birth weight on later outcomes including height, IQ, education and wages, which are similar in magnitude to their cross-sectional equivalents. In an earlier study Behrman and Rosenzweig (2004) using data for the United States on monozygotic female twins found that the effect of increasing fetal growth (birth weight/gestational age) on schooling was understated by conventional cross-sectional relationships. Royer (2009) also found that birth weight does have a significant impact on long-run outcomes especially future pregnancy complications.

The conflicting evidence between the findings of short-run versus long-run studies have lead some authors to conjecture that the impact of birth weight on mortality and APGAR scores is misleading about the true effects of birth weight on general infant health. A number of studies have found some evidence to suggest that birth weight effects on mortality for twins may depend on other factors such as the amount of discordance between twins (Cheung et al. 1995; Hollier et al. 1999; Webb and Shaw 2001). Growth rate discordance is associated with preterm delivery (both spontaneous and induced) that can lead to congenital defects resulting from prematurity which are likely to affect infants similarly without distinguishing between differences in birth weight (Hollier et al. 1999). That is, the implications of birth weight differences in highly discordant twins may be confounded and overwhelmed by the implications of short gestational age or some other severe anomaly. Although the estimates of the effects of birth weight via twin differences is conceptually appealing, fixed effects models may have removed genetic factors that are responsible for reducing the implications of birth weight in twin studies.

Alternatively, it might be the case that the seemingly contradictory results between short-run and long-run outcomes reflect different mechanisms through which birth weight affects life-cycle outcomes. It is possible that postnatal investments are related to children's endowments in ways that may reinforce or offset the true biological effect of birth weight. Thus, it may not be the physiological effects of low birth weight that give rise to the observed deficiencies in educational and labor market outcomes later in life. Rather, it may be that parents invest less in low birth weight children than in otherwise similar offspring. This would exacerbate estimates of the effect of birth weight. Parents may also seek to dampen the negative effects of birth weight by allocating resources away from heavier children and towards lighter children. If parental investment is a negative function of birth weight differences, estimates of the effects of birth weight would be biased-downwards.

Most of the analyses investigating the relationship between cigarette smoking during pregnancy and birth weight have also employed conventional cross-sectional estimates. These studies repeatedly indicate that a mother's smoking during pregnancy is associated with an average reduction in the birth weight of her child by approximately 200 grams (MacArthur and Knox 1988; Messecar 2001; U.S. Department of Health and Human Services 1990; Wainwright 1983). The notion of an underlying causal mechanism, that is, biological processes, for the correlation between maternal smoking during pregnancy and low birth weight is well accepted (Lambers and Clark 1996; Lieberman et al. 1994; Nash and Persaud 1988; Spinillo et al. 1994c; USDHHS 1988; Zaren et al. 1997) . Yet, assigning a credible and accurate causal interpretation to simple associations between smoking and birth weight is also potentially confounded by a range of socioeconomic and genetic characteristics of families. For example, smoking during pregnancy is likely to be correlated with a range of other behavioral characteristics of the mother, such as inadequate nutrition, delayed prenatal care and alcohol consumption, which may also have a detrimental effect on birth weight. That these estimates are, therefore, good guides for the allocation of public resources has been seriously questioned.

A major methodological shortcoming in empirical research is that cigarette smoking cannot be assigned experimentally in randomized clinical trials that are commonly used in biomedical studies seeking to evaluate a causal mechanism. Medical researchers who have relied on this approach have tended to focus on experimental interventions designed to encourage pregnant women to stop smoking. The best known of these studies by Sexton and Hebel (1984) found that the mean birth weight of infants in the treatment group was 92 grams higher than in the control group without the intervention. Inferences drawn from these types of studies about the magnitude of the effect of smoking cessation during pregnancy on birth weight may be biased, as selection effects among women who respond to the treatment may partially obscure the effect of smoking.

Previous attempts by economists to mimic random assignment and identify the causal effect of smoking on birth weight have tended to rely on instrumental variables (IV) estimation (Evans and Lien 2001; Evans and Ringel 1999; Permet and Hebel 1989). These studies typically find that smoking during pregnancy results in a reduction in birth weight which is not statistically different from those produced by simple cross-sectional estimates. Moreover, studies which have relied on instrumental variables such as changes in taxes on cigarettes to identify the causal effect of smoking on birth weight only apply to the subgroup of the population who changed their smoking behavior during pregnancy as a result of tax changes and do not apply to the general population.

Panel data methods provide an alternative for researchers seeking to identify the causal effect of smoking on birth weight from women who change their smoking behavior from one pregnancy to the next. Recent evidence from studies which have used this approach suggests that the impact of maternal smoking on birth weight may be smaller in magnitude than indicated by standard estimates, suggesting a strong negative correlation between omitted variables and smoking indicators (Abrevaya 2006; Almond et al. 2005; Rosenzweig and Wolpin 1991; Walker et al. 2009). Rosenzweig and Wolpin (1991) using the National Longitudinal Survey of Youths found fixed effects estimates in the range of 83 to 160 grams. Abrevaya (2006) using matching algorithms to construct panel data, suggests that the causal impact of smoking on birth weight was within the range of 100 to 150 grams. Walker et al. (2009) using data on siblings for the entire population of births in Georgia between 1994 and 2002 find that fixed effects estimates range from 50 to 130 grams depending on smoking intensity; these estimates are substantially lower than their OLS equivalents which range from 140 to 255 grams.

3. Data

This study draws on highly comparable longitudinal information from two British cohort studies, names the National Child Development Study of 1958 (NCDS) and the British Cohort Study of 1970 (BCS). The use of the two data sets is to give a careful indication of the robustness of the results of this research. The NCDS has followed all children born in the week of March, 3 1958 from birth to age 42. The relevant follow-up surveys were conducted at ages 33 and 42. In similar fashion, the BCS has followed the lives of all individuals born in the week of April 5, 1970 from birth to age 34. The relevant follow-up interviews were conducted at ages 29 and 34. In these follow-ups, the respondents were asked a range of questions about all of their pregnancies and births, as well as their marital arrangements, educational attainment, health status and healthiness of their lifestyles. Table 1 presents means and standard deviations for key variables. The information is presented for the women who had at least two children by the time of the last survey and for whom there is complete information on all relevant variables. After deleting observations with missing values in key variables, 5,959 births to 2,457 mothers remain in the NCDS and 3,760 births remain in the BCS to 2,015 mothers for the main analysis.

In relation to their pregnancies, there are three main features of these surveys that are particularly relevant to the analysis of infant wellbeing. First, the cohort studies contain a binary indicator broadly summarizing an infant health at birth which simply asks if there was anything wrong with the baby at birth. This variable is arguably a wider indicator of the healthiness of a child at birth than the 5-minute APGAR scores used in earlier studies. Although mortality is the most frequently used measure of infant health in the literature in this area, the number of infant deaths recorded in the cohort studies is quite low, and thus, this line of inquiry is not pursued. Table 1 shows that approximately 11 percent of infants in these data are characterized as having some congenital anomaly.

The starting point of this study is to test the validity of using birth weight as a marker for infant health. In this respect, the second important strength of these data is that they contain excellent information on birth weight. The birth weight for each infant was originally coded in two variables: pounds and ounces. Ounces were recoded to pounds simply by dividing by 16 and added to the number of recorded pounds. Then the total child's weight in pounds was multiplied by 454.55 to convert to grams. Although the analysis of low birth weight (less than 2,500 grams) is interesting from a public health standpoint, a continuous measure of birth weight has obvious statistical advances over a dichotomous dependent variable in this type of study. The average birth weight in the samples is approximately 3,400 grams. The two cohort studies also contain the mother's own birth weight taken in 1958 for the older sample and in 1970 for the more recent sample. The tabulations reveal a sizeable increase in average birth weight across generations.

The further objective of this study is to examine the causal relationship between birth weight and cigarette smoking during pregnancy. In this regard, the third important aspect of these data are the questions relating to smoking in general and smoking during pregnancy in particular which are recorded specifically for each pregnancy. If an individual reported being a smoker before a particular pregnancy, she is then asked to indicate whether or not she quit during the pregnancy. In unreported analysis, no significant difference was observed between smokers who quit during pregnancy and those who never smoked. Thus, the smoking information is coded as a dichotomous variable where 1 indicates that the respondent smoked during a particular pregnancy and 0 otherwise. The tabulations presented in Table 1 show the 24 percent women smoke during pregnancy in both studies.

Also listed in table 1 are a number of other variables available in these data which have been identified in the medical literature as potentially important predictors of birth outcomes. These include a dichotomous variable to control for birth order because research has shown that the entire birth weight distribution of first borns is shifted to the left of that of other children (Miller 1994). While the number of firstborn children in both data sets is quite similar, a slightly higher number of firstborns comprise the more recent sample, as expected. Gender is included in estimation because female infants weigh less than male infants in general (Gross et al. 1997). At the same time, however, low birth weight females have been shown to suffer fewer of the health and developmental problems associated with low birth weight (Bennett 1997). In spite of the 12-year age gap between cohorts, the descriptive statistics reveal that average maternal age in both surveys is 27. This reflects a trend towards women delaying their childbearing until they are older in general. Three variables are used to measure the health and nutritional status of respondents. They are a binary variable representing the daily intake of fruit and vegetables to reflect nutritional status, a dichotomous variable measuring regular weekly exercise, and an indicator variable for long-standing illness representing maternal morbidity. Marital status or more broadly, parental cohabitated is included as a control variable. Any effect on infant health or birth weight might operate in the mother through psychological or socioeconomic mechanisms. For example, maternal psychological factors linked to cohabitation status include stress, anxiety, and unwanted pregnancy, which may have deleterious effects on fetal development.

To consider the effects of educational attainment, table 1A in the appendix provides a list and a brief description of all qualification variables used in this study. Qualifications are organized into this classification from the lowest to the highest primarily on the basis of the number of years of schooling usually required. The descriptive statistics in table 1 show that the more recent cohort has more education than the earlier cohort. From a theoretical perspective, education is primarily expected to influence infant development either through raising income or improving learning (Michael, 1973).

Alcohol consumption during pregnancy is not included in this analysis as it was not present in both surveys. Previous studies which have included alcohol consumption alongside cigarette smoking in birth weight equations have not found the former to be statistically significant (Rosenzweig and Wolpin 1991; Zuckerman et al. 1989). As it is well-known that alcohol has one of the most pernicious impacts on infant health, the lack of significance of an alcohol effect may be due to underreporting.

4. Results

This section opens by addressing the basic question of the impact of birth weight on the probability of early infant health problems. Prior studies suggest the existence of non-linear birth weight effects on various indictors of adult socioeconomic outcomes (Almond et al. 2005; Behrman and Rosenzweig 2005; Currie and Moretti, 2005; Rosenzweig and Schultz 1982). In the present paper, the birth weight distribution is represented by quintiles to allow for the possibility of non-linear effects in infant health. The results from a pooled logit are contained in table 2 for the NCDS and table 3 for the BCS. Coefficients have been converted to odds ratios by taking their exponents. The first column shows estimates without controls for other variables. A similar pattern is observed across the two data sources. Relative to the lowest quintile, the results indicate that the odds of experiencing a problem at birth are 50 to 60 percent lower for those in the second lowest quintile of the birth weight distribution. The effects of birth weight on infant health appear to attenuate passed this range of the birth weight distribution.

The general concern with the magnitude of these estimates is that it could be driven by a correlation with other characteristics of the mother which coincide with smoking during pregnancy. To address this concern, columns (2) and (3) include successive groups of variables that are known to be associated with both birth weight and infant developmental outcomes. These include birth order, infant gender, maternal height, maternal age, maternal birth weight, maternal nutrition, parity (birth order), birth interval, maternal general morbidity, and educational attainment. The intuition is that if birth weight is correlated with these variables, then the coefficients on birth weight quintiles will be smaller after controlling for these characteristics. Conditional on the importance of these factors, the coefficients and their standard errors are virtually identical throughout the birth weight distribution to those obtained when these variables were not included in estimation. The stability of estimates across columns lends some credibility to that idea that birth weight genuinely affects infant health independent of other indicators of the characteristics of the mother. Nevertheless, this form of analysis is always open to the criticism that there may be some other omitted factor that should have been included in the model such as unmeasured genetic or biological characteristics.

To absorb the effects of unobservable family characteristics, the estimates in column (4) present the odd ratios from a “fixed-effects” logit specification – a conditional logit. The reduction in sample size used to estimate the conditional logit was brought about because only families in which there are within sibling differences in the dichotomous health outcomes contribute to the likelihood function. This reduces sample size as observations from families in which all siblings have the same outcomes must be dropped. These estimates for the two data sources are quite similar and reveal the same pattern as those implied by the cross-sectional estimates. Relative to bottom quintile of the birth weight distribution, the estimates imply that being in the second quintile or higher reduce the odds of experiencing a problem at birth by between 50 and 75 percent. The fact that the correlation between birth weight and infant health persists even when unobserved fixed effects have been accounted for, suggests that birth weight in the cross section represents a true causal effect. The panel estimates reveal a significantly flattening out of this relation beyond the first quintile or above 3,000 grams. These threshold results are consistent with those reported by Rosenzweig and Schultz (1982) for infant mortality.

The control variables used in this analysis appear to exert little or no direct effect on infant health with the exception of gender and birth order. In neither survey does it appear that maternal birth weight, height or educational attainment is directly linked to infant health. The lack of observed effects among these control variables does not preclude the possibility that these characteristics play an important role in infant development indirectly through their effects on birth weight. Overall, the policy relevance of birth weight in order to alleviate inequalities in child health clearly stands out as an important indictor of variation in infant health.

Having identified the importance of birth weight as an indicator of early infant health, the next section of this analysis attempts to isolate variation in birth weight that is directly attributable to maternal smoking, which has been identified as the leading cause of low birth weight in the United States and the United Kingdom. The analysis begins by documenting the conventional cross-sectional relationship between infant birth weight and maternal smoking during pregnancy. The results are reported in table 4 for the NCDS and in table 5 for the BCS. The point estimates in column (1) without controls for other variables indicate a 227 gram and 162 gram deficit to mothers who smoke for the NCDS and BCS samples, respectively. The consensus from previous observational studies is that maternal smoking reduces birth weight in the range of 150 grams to 250 grams (Aronson et al. 1993). The difference in estimates between the two cohort studies may suggest that the variation in other determinants of birth weight (apart from smoking) has changed over time. Although it is difficult to point to one specific factor, improvements in education and health care may have played a role in counteracting the negative effects of smoking among the more recent cohort.

Of course, the coefficients on smoking estimated by OLS will only be unbiased if smoking is uncorrelated with the other determinants of birth weight. Unfortunately this is unlikely to be the case because women who smoke tend to have other characteristics that are also known to influence birth weight. Researchers in the medical sciences have repeatedly sought to reduce the extent of this potential bias by adding proxies for the unobserved heterogeneity which are similar to those used in the infant health equations. The implicit assumption is that smoking during pregnancy is "randomized" conditional on these observed characteristics. As specifications are extended to admit more controls in columns (2) and (3), there is a tendency towards a smaller, but still statistically significant, negative effect of smoking on birth weight. The deleterious effect of smoking on birth weight is 185 grams for the NCDS cohort and 125 grams for the BCS sample, conditional on the inclusion of all observed family background characteristics and child-specific variables. The appreciable drop in magnitude, particularly for the most recent cohort, as a result of including more controls raises the question of whether the coefficient on smoking would fall even more after conditioning on other characteristics of the mother and infant.

Before turning to the fixed effects results, is worth highlighting several additional insights which emerge from the cross-sectional results. Mothers with higher levels of education tend to have children with higher birth weights. These findings are consistent with previous evidence which suggests that parents' education, especially mothers' schooling, is an important correlate of infant health (Grossman 2006; McCrary and Royer 2006). The results show that maternal health is not statistically significant in birth weight equations, net of education and other background characteristics. The age of the mother at birth is also revealed to have no discernible effect on birth weight. Although research to date is mixed, evaluated risk of low birth in cross-sectional work usually only arise at the extreme ends of the age spectrum (Royer, 2004). Interestingly, the results indicate that taller women tend to have heavier children. A mother's height could affect intrauterine growth through either a genetic or environmental mechanism. Finally, the results demonstrate that there is a significant intergenerational correlation in the birth weight of mothers and children. These findings, however, must be interpreted with care because a mother's birth weight may affect her choices of inputs that affect the production of birth weight in her children.

Column (4) presents the fixed-effects results which factor out the effects of family-level unobservable variables that exist in common among siblings. Identification of the effect of smoking during pregnancy in this approach relies on mothers who change their smoking behavior between pregnancies. The panel estimates drawn from both cohort studies are remarkably close and imply that smoking during pregnancy results in an average reduction in birth weight of approximately 100 grams. These findings are consistent with the omitted variable story which suggests that smokers have a variety of other health habits that would bias the OLS estimate upwards. Though the magnitude of the panel effect is not trivial, these estimates point to a much more muted role of smoking in birth weight than simple estimates would imply.

Although the two cohort studies contains as complete a set of behaviors as can be found in any data set with comparable sample features, ideally one would like to control for all the other relevant time-varying factors that may be correlated with changes in smoking patterns between births. If there are important omitted variables which change with changes in smoking behavior across pregnancies, this would naturally lead to an estimate that is either smaller or larger than the true effect of smoking cessation during pregnancy. The direction of the bias will depend on the relationship between smoking participation and the unobserved characteristics.

However, the results for both cohorts are broadly in agreement with those obtained in recent comparable studies for the United States (Abrevaya 2006; Almond et al. 2005; Rosenzweig and Wolpin 1991; Walker et al. 2009).

5. Conclusions

The first objective of this paper is to extend recent work on the effects of birth weight on early infant health using two cohort studies for Great Britain. While there is broad agreement that low birth weight in particular is a marker for poor infant health, some analysts have questioned whether birth weight has a major underlying causal influence on infant health. It is possible that it is other factors that are correlated with birth weight which are driving the adverse outcomes associated with low birth weight infants. Previous research regarding this question has generally found that once family fixed effects are held constant, the effect of birth weight on measures of infant health are largely eliminated (Almond et al. 2005; Behrman and Rosenzweig 2004; Black et al. 2007; Conley et al. 2003; Royer 2009). Conley et al. (2003) suggest that there are a number of issues surrounding twin-based evidence that may confound efforts to accurately estimate the pure effects of birth weight on early health status and would most likely yield downward estimates of the underlying effect of birth weight. In the present paper based on pooled logit and “fixed effects” logit estimates relying on sibling comparisons, birth weight is revealed to be a strong predictor of early infant health. There is a remarkable similarity between the results of the two cohort samples. The effects of birth weight on infant health are relatively important until one reaches weights above 3,000 grams. These findings indicate that government health policies with the aim of increase birth weight among women at risk of delivering low birth weight babies are likely to be most effective in terms of improving early infant health. Overall, this evidence suggests that birth weight plays a powerful role in determining the overall health of children.

The second part of this paper attempts to isolate variation in birth weight that is the direct result of cigarette smoking during pregnancy which is considered the most important modifiable cause of low birth weight in developed countries. The true benefits of any public initiative focused on reducing cigarette smoking among pregnant women depend on the causal effect of smoking on birth weight. The problem is that mothers who smoke during pregnancy are also likely to adopt other unhealthy behaviours that could have a negative impact on birth weight. Using a cross-sectional approach similar to that taken by many previous studies, the OLS estimates generally imply that infants born of mothers who smoke during pregnancy on average weigh approximately 200 grams less than infants born to non-smokers. If smoking during pregnancy is negatively correlated with other omitted variables, this estimate is larger in magnitude than the causal effect since smoking is also proxying for unobservables that adversely affect birth weight. Consistent with this hypothesis the fixed-effects estimates of smoking turn out to be much smaller in magnitude than the OLS estimates. The point estimates from both cohort studies are strikingly similar and suggest that maternal smoking reduces average birth weight by 100 grams. The results from these two data sources support the conclusions from similar panel studies for the United States which suggests that the adverse effect of smoking is probably far lower than traditional OLS estimates would suggest (Abrevaya 2006; Almond et al. 2005; Rosenzweig and Wolpin 1991; Walker et al. 2009). These results are also consistent with recent research by Fertig (2009) for Great Britain that suggests that there is rising adverse selection into smoking across cohorts which could explain as much as 50 percent of the observed association between smoking and birth outcomes. The implication is that policy makers may be overly optimistic about the ability of smoking campaigns that solely encourage cessation during pregnancy to improve the birth weight and health of children.

Appendix
Table 1A. A Description of Qualifications by NVQ or Equivalent Classification

NVQ or equivalent
Level 5/level 4
University or CNAA Higher Degree (eg MSc, PhD)
University or CNAA First Degree (eg BA. BSc)
University Diploma
Teaching qualifications
Nursing qualifications
Other higher qualifications
Level 3
More than 1 GCE at A level
Scottish Higher Grade Equivalent
Level 3 vocational qualifications
Level 2
1 GCE at A level
Scottish standard grades – grades 1-3
GCE O level – passes or grades A-C
GCSE grades A-C
CSE grade 1
Scottish O grade – passes or grades A-C
Level 2 vocational qualifications
Level 1
CSE grade 2-5
Other qualifications
Level 1 vocational qualifications
Level 0
No qualification

Qualifications are re-classified into five groups using the National Vocational Qualification (NVQ) or academic equivalent framework derived by the Centre for Longitudinal Studies at the Institute of Education. Qualifications are organized into this classification from the lowest to the highest on the basis of the number of years of schooling usually required as well as the contribution of qualifications to improvements in intelligence and productivity. The large number of categories of education reflects the complicated structure of education in the UK. Secondary education is composed of two main branches: academic and vocational. Within each branch there are multiple schooling streams which young students may take, depending on whether they plan attending university, vocational college, or entering work immediately. Categories from level 1 to level 3 are usually awarded by secondary schools. The qualifications awarded at NVQ level 1 and level 2 are typically worked towards between the ages of 14 and 16. These qualifications are often necessary to gain access to higher levels of education, in particular higher academic courses. Qualifications awarded at level 3 usually build on earlier levels and are usually studied for between the ages of 16 and 19. The next two categories of qualifications are offered by colleges of higher education, and naturally follow from the secondary education system with separate academic and vocational systems. Individuals can take them at any age though many will take them just after leaving secondary school. The NVQ level 4 category comprises advanced vocational qualifications such as nursing and academic qualifications such as a teacher's certificate. Qualifications awarded at NVQ level 5 include a university bachelor's degree or post-graduate qualification. Individuals potentially may have any number of qualifications. The measure of education used here is highest educational qualification obtained during full-time education.

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Table 1 Summary statistics

	NCDS		BCS	
	Mean	Std. Dev.	Mean	Std. Dev.
Birth weight (grams)	3,368	531	3,425	557
Infant health	0.106	0.308	0.119	0.324
Smoke during pregnancy	0.238	0.426	0.243	0.429
First born	0.412	0.492	0.454	0.498
Boy	0.514	0.500	0.512	0.500
Mother's age (years)	27.144	5.417	26.630	4.195
Long-standing illness	0.149	0.356	0.154	0.361
Partner	0.904	0.294	0.856	0.351
NVQ level 0 (No qualifications)	0.151	0.358	0.112	0.315
NVQ level 1	0.155	0.362	0.178	0.382
NVQ level 2	0.378	0.485	0.380	0.485
NVQ level 3	0.100	0.300	0.079	0.269
NVQ level 4/level 5	0.216	0.411	0.252	0.434
Mother's birth weight (grams)	3,268	510	3,260	500
Mother's height (cm)	162.846	6.464	164.419	6.560
Regular exercise	0.729	0.445	0.794	0.404
Fruit and vegetables (daily)	0.391	0.488	0.294	0.456
Passive smoke (household)	0.320	0.458	0.268	0.443
Observations children	5,959		3,760	

Table 2 The effect of birth weight on infant health using the NCDS

	(1) Logit	(2) Logit	(3) Logit	(4) Condit. logit
Infant's birth weight - default - quintile 1				
Birth weight - quintile 2	0.430	0.422	0.427	0.322
	[0.053]***	[0.053]***	[0.054]***	[0.066]***
Birth weight - quintile 3	0.417	0.415	0.423	0.363
	[0.052]***	[0.052]***	[0.054]***	[0.075]***
Birth weight - quintile 4	0.371	0.361	0.371	0.329
	[0.047]***	[0.046]***	[0.048]***	[0.074]***
Birth weight - quintile 5	0.350	0.331	0.341	0.283
	[0.047]***	[0.045]***	[0.048]***	[0.069]***
First-born		1.170	1.167	1.304
		[0.107]*	[0.109]*	[0.167]**
Boy		1.493	1.479	1.728
		[0.130]***	[0.129]***	[0.220]***
Mother's age (years)		1.010	1.007	1.021
		[0.008]	[0.009]	[0.020]
Long-standing illness			1.400	1.839
			[0.155]***	[0.784]
Partner			0.960	0.992
			[0.139]	[0.292]
Educational Qualifications - default no qualifications				
NVQ level 1			1.122	
			[0.174]	
NVQ level 2			1.088	
			[0.148]	
NVQ level 3			1.146	
			[0.211]	
NVQ level 4/level 5			1.134	
			[0.181]	
Mother's birth weight - default quintile 1				
Mother's birth weight - quintile 2			1.147	
			[0.143]	
Mother's birth weight - quintile 3			1.026	
			[0.138]	
Mother's birth weight - quintile 4			0.962	
			[0.135]	
Mother's birth weight - quintile 5			1.047	
			[0.149]	
Mother's height - default quintile 1				
Mother's height - quintile 2			1.009	
			[0.129]	
Mother's height - quintile 3			0.824	
			[0.103]	
Mother's height - quintile 4			0.867	
			[0.128]	
Mother's height - quintile 5			0.944	

Table 2 The effect of birth weight on infant health using the NCDS (Concluded)

	(1) Logit	(2) Logit	(3) Logit	(4) Condit. logit
			[0.139]	
Regular exercise			0.916	
			[0.089]	
Fruit and vegetables (daily)			0.937	
			[0.087]	
Passive smoke (household)			0.940	
			[0.092]	
Observations children	5,959	5,959	5,959	1,294
Observations families				494

Notes: The dependent variable takes value 1 if reported infant health problem at birth and value 0 otherwise. Coefficients have been converted to odds ratios. Estimation of the model presented in column (4) is based on Chamberlain's (1980) conditional fixed-effects logit. One asterisk represents significant at 10%; two asterisks denotes significant at 5%; and three asterisks signifies significant at 1%

Table 3 The effect of birth weight on infant health using the BCS

	(1) Logit	(2) Logit	(3) Logit	(4) Condit. logit
Infant's birth weight - default - quintile 1				
Birth weight - quintile 2	0.490	0.483	0.483	0.432
	[0.073]***	[0.073]***	[0.073]***	[0.109]***
Birth weight - quintile 3	0.489	0.473	0.476	0.490
	[0.072]***	[0.070]***	[0.071]***	[0.137]**
Birth weight - quintile 4	0.390	0.368	0.361	0.259
	[0.063]***	[0.060]***	[0.060]***	[0.076]***
Birth weight - quintile 5	0.513	0.482	0.468	0.273
	[0.078]***	[0.075]***	[0.075]***	[0.086]***
First-born		0.915	0.914	0.979
		[0.104]	[0.106]	[0.186]
Boy		1.595	1.607	1.803
		[0.166]***	[0.168]***	[0.278]***
Mother's age (years)		0.976	0.974	1.013
		[0.013]*	[0.015]*	[0.041]
Long-standing illness			1.130	2.219
			[0.156]	[1.809]
Partner			1.094	0.691
			[0.170]	[0.209]
Educational Qualifications - default no qualifications				
NVQ level 1			1.181	
			[0.235]	
NVQ level 2			1.257	
			[0.226]	
NVQ level 3			1.749	
			[0.404]**	
NVQ level 4/level 5			0.987	
			[0.202]	
Mother's birth weight - default quintile 1				
Mother's birth weight - quintile 2			1.158	
			[0.195]	
Mother's birth weight - quintile 3			1.046	
			[0.176]	
Mother's birth weight - quintile 4			1.084	
			[0.185]	
Mother's birth weight - quintile 5			1.291	
			[0.220]	
Mother's height - default quintile 1				
Mother's height - quintile 2			0.997	
			[0.140]	
Mother's height - quintile 3			0.743	
			[0.147]	
Mother's height - quintile 4			0.966	
			[0.149]	
Mother's height - quintile 5			0.829	
			[0.149]	

Table 3 The effect of birth weight on infant health using the BCS

	(1) Logit	(2) Logit	(3) Logit	(4) Condit. logit
Regular exercise			0.956	
			[0.118]	
Fruit and vegetables (daily)			0.987	
			[0.114]	
Passive smoke (household)			0.961	
			[0.114]	
Observations children	3760	3760	3760	824
Observations families				359

Notes: The dependent variable takes value 1 if reported infant health problem at birth and value 0 otherwise. Coefficients have been converted to odds ratios. Estimation of the model presented in column (4) is based on Chamberlain's (1980) conditional fixed-effects logit. One asterisk represents significant at 10%; two asterisks denotes significant at 5%; and three asterisks signifies significant at 1%

Table 4 The effect of cigarette smoking during pregnancy on birth weight using the NCDS

	(1) OLS	(2) OLS	(3) OLS	(4) Fixed Effects
Smoking during pregnancy	-227.227	-220.510	-185.511	-101.124
	[15.886]***	[16.180]***	[16.863]***	[34.723]***
First-born		-125.408	-138.381	-99.491
		[14.545]***	[14.330]***	[13.674]***
Boy		96.603	98.316	121.202
		[13.364]***	[13.011]***	[13.157]***
Mother's age (years)		3.193	0.094	9.072
		[1.357]**	[1.441]	[2.265]***
Long-standing illness			-19.043	36.223
			[18.429]	[50.589]
Partner			37.678	-56.594
			[22.860]*	[35.742]
Educational Qualifications - default no qualifications				
NVQ level 1			36.148	
			[23.837]	
NVQ level 2			54.005	
			[20.797]***	
NVQ level 3			51.391	
			[28.123]*	
NVQ level 4/level 5			43.852	
			[24.388]*	
Mother's birth weight - default quintile 1				
Mother's birth weight - quintile 2			65.803	
			[19.710]***	
Mother's birth weight - quintile 3			137.037	
			[20.534]***	
Mother's birth weight - quintile 4			177.562	
			[20.940]***	
Mother's birth weight - quintile 5			248.999	
			[21.054]***	
Mother's height - default quintile 1				
Mother's height - quintile 2			48.646	
			[20.387]**	
Mother's height - quintile 3			106.961	
			[19.192]***	
Mother's height - quintile 4			118.135	
			[22.419]***	
Mother's height - quintile 5			184.006	
			[22.404]***	
Regular exercise			-4.101	
			[15.197]	
Fruit and vegetables (daily)			35.517	
			[13.967]**	
Passive smoke (household)			2.726	
			[15.241]	

Table 4 The effect of cigarette smoking during pregnancy on birth weight using the NCDS (Concluded)

	(1) OLS	(2) OLS	(3) OLS	(4) Fixed Effects
Constant	3421.604	3335.426	3125.863	3169.890
	[7.749]***	[41.747]***	[48.960]***	[63.551]***
R-squared	0.030	0.060	0.110	0.070
Observations children	5,959	5,959	5,959	5,959
Observations families				2,457

Notes: Robust standard errors are presented in brackets. One asterisk represents significant at 10%; two asterisks denotes significant at 5%; and three asterisks signifies significant at 1%

Table 5 The effect of cigarette smoking during pregnancy on birth weight using the BCS

	(1) OLS	(2) OLS	(3) OLS	(4) Fixed Effects
Smoking during pregnancy	-162.280	-158.970	-121.471	-93.960
	[21.004]***	[21.086]***	[21.580]***	[41.689]**
First-born		-103.311	-123.019	-122.289
		[19.877]***	[19.666]***	[22.260]***
Boy		134.284	135.234	139.449
		[17.768]***	[17.340]***	[18.018]***
Mother's age (years)		6.425	2.018	2.291
		[2.390]***	[2.593]	[4.698]
Long-standing illness			-39.230	-78.079
			[24.255]	[75.291]
Partner			2.826	3.419
			[26.660]	[40.132]
Educational Qualifications - default no qualifications				
NVQ level 1			95.944	
			[33.799]***	
NVQ level 2			124.955	
			[30.593]***	
NVQ level 3			144.639	
			[41.755]***	
NVQ level 4/level 5			127.459	
			[33.885]***	
Mother's birth weight - default quintile 1				
Mother's birth weight - quintile 2			51.054	
			[28.843]*	
Mother's birth weight - quintile 3			102.685	
			[28.152]***	
Mother's birth weight - quintile 4			96.810	
			[28.515]***	
Mother's birth weight - quintile 5			249.265	
			[28.793]***	
Mother's height - default quintile 1				
Mother's height - quintile 2			22.194	
			[24.622]	
Mother's height - quintile 3			103.958	
			[31.654]***	
Mother's height - quintile 4			112.640	
			[26.669]***	
Mother's height - quintile 5			177.007	
			[29.754]***	
Regular exercise			59.361	
			[21.287]***	
Fruit and vegetables (daily)			-11.601	
			[19.401]	
Passive smoke (household)			-9.476	
			[20.664]	

Table 5. The effect of cigarette smoking during pregnancy on birth weight using the BCS (Concluded)

	(1) OLS	(2) OLS	(3) OLS	(4) Fixed Effects
Constant	3464.596	3270.884	3070.276	3380.255
	[10.350]***	[70.363]***	[76.310]***	[128.111]***
R-squared	0.020	0.040	0.100	0.070
Observations Children	3,760	3,760	3,760	3,760
Observations Families				1,708

Notes: Robust standard errors are presented in brackets. One asterisk represents significant at 10%; two asterisks denotes significant at 5%; and three asterisks signifies significant at 1%

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