The Effect of Maternal Health Input Behaviors on the Incidence of Pediatric Asthma Diagnosis and Management

by
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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Economics.

Chapel Hill
2007

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ABSTRACT

TIFFANY L. GREEN: The Effect of Maternal Health Input Behaviors on the Incidence of Pediatric Asthma Diagnosis and Management.
(Under the direction of Donna B. Gilleskie.)

Asthma is the most commonly occurring chronic childhood disease in the United States and is the leading cause of hospitalization and missed school days. I examine whether socioeconomic disparities in asthma can be attributed to differences in low birthweight and maternal inputs, including smoking, breastfeeding and well-baby visits. I find that low birthweight is a major determinant of asthma at age three and that smoking is positively related to asthma attacks at age one. I find that when each of the inputs is modeled, low birthweight is the major determinant of an asthma diagnosis at age three and smoking is an important factor in asthma attacks at age two. Also, having had adequate well-baby visits at age one reduces the likelihood of an asthma-related hospital visit. Simulations of the effect of prenatal smoking on asthma suggest that the indirect effects of smoking are substantial and operate through low birthweight. Further policy simulations demonstrate the increasing the price of cigarettes is one potential mechanism for reducing prenatal smoking.

ACKNOWLEDGMENTS

Writing my dissertation has been a monumental undertaking that has seemed insurmountable. However, with an amazing support team, I have somehow managed to finally put this work to rest (for now)! Mom, you never questioned for one second whether or not I could finish this process. From the qualifiers to traveling across the globe, you always encouraged me to grow and learn as much as possible. Thanks Dad for not saying I told you so–I really took 'only doing an econ minor' to the extreme, didn't I? My other family members-thanks for having my back always. Great thanks to my advisor, Donna Gilleskie, for her countless edits and demands to produce a superior product. Sandy Darity, there's nothing I can say except that I can only try to live up to the faith you have always had in my potential. Thanks as well to the other committee members, E. Michael Foster, Sally Stearns and Helen Tauchen for your insightful and thoughtful questions and criticisms. As for other academic mentors, there are many. However, it was Rhonda Sharpe who helped a first year struggling graduate student to understand that there are only two life-altering tests–and neither of them include micro or macro theory. I can't say enough about the office staff in the economics department. From helping graduate students to navigate bureaucratic nightmares or making last minute copies of exams or simply lending a listening ear, each of you have been a valuable part of my graduate school experience. My friends have also been an incredible source of support. I will mention a few. Lara thank you pushing me and encouraging me especially when I was ready to quit. Hamilton-don't know what I would have done without you. Midwest, here we come! To Baba, who has pushed me to refine my ideas and be clear about my thoughts from day one (I'll get it right one day)! Thanks also to my salsa dancing crew for helping me keep sane and encouraging me keep my priorities in order. I would also be

remiss if I did not thank the people responsible for providing me with the data to push this project forward. Thanks to Tom Ricketts, Randy Randolph and the Cecil G. Sheps Center for Health Services Research for allowing me to use the Area Resource Files data. Thanks also to Irv Garfinkel for advocating for my use of the Fragile Familes restricted data and to Jean Knab for answering my seemingly endless queries. I also include the following, as requested by the Fragile Families team: "The Fragile Families and Child Wellbeing Study was supported by Grant Number R01HD36916 from the National Institute of Child Health and Human Development. The contents of the paper are solely the responsibility of the authors and do not necessarily represent the official views of the National Institute of Child Health and Human Development." Finally, thanks to the creators of the almighty search engine, Google–I'll never write another paper without it.

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Chapter 1

Introduction

Pediatric asthma, or asthma among those under 18, is the most commonly occurring chronic childhood disease. In 2003, nine million U.S. children under 18 were reported as having been diagnosed with asthma in their lifetimes. Almost four million children were reported as having experienced an asthma attack in the preceding month (Dey and Bloom, 2006). The economic costs associated with asthma are numerous. Asthma attacks result in more than 5 million hospitalizations, 14 million missed days of school and, more rarely, death. Medical expenditures on asthma totaled 3.2 billion per year (Selgrade et al., 2006; CDC, 2005; Akinbami and Schoendorf, 2002). Pediatric asthma is unevenly distributed with respect to gender and socioeconomic status, disproportionately affecting children who are male, poor, African-American and Latino (Dey and Bloom, 2006).

Parental decisions about smoking, medical care utilization and breastfeeding duration have all been implicated in the incidence of asthma and asthma attacks (Weitzman et al., 1990; Litonjua et al., 1998). However, much of this work on the relationship between parental behavior and asthma diagnosis fails to control for the endogeneity of observed inputs (or the unobserved heterogeneity that may affect both observed input behavior and health outcomes). That is, health behaviors (e.g., smoking) are treated as independent variables affecting health outcomes when they are likely correlated with unobservable individual (and family) characteristics in the error term. Failing to control for the endogeneity of important explanatory variables can lead to biased estimates of their effects. Adding to the economics and public health literatures, I explore the role of maternal input behaviors and initial child health as an

explanation of ethnic disparities in asthma outcomes. More specifically, I measure both the direct and indirect effects of low birthweight, smoking, breastfeeding duration and adequate number of well-baby visits on asthma diagnosis and morbidity. I find that when each of the inputs is modeled, low birthweight is the major determinant of an asthma diagnosis at age three and smoking is an important factor in asthma attacks at age two. Also, having had adequate well-baby visits at age one reduces the likelihood of an asthma-related hospital visit. Simulations of the effect of prenatal smoking on asthma suggest that the indirect effects of prenatal smoking are substantial and operate through low birthweight. Additional policy simulations demonstrate that increasing the price of cigarettes is one potential mechanism for reducing prenatal smoking.

The thesis proceeds as follows. Chapter 2 provides a comprehensive literature review on asthma, the economics of child health and the relationship between each of the maternal health inputs and asthma diagnosis and morbidity. Chapter 3 describes the empirical framework underlying the model and the estimation methods that are used. Chapter 4 discusses each of the data sources used and Chapter 5 provides a discussion of the results from the model estimation and simulation. Chapter 6 concludes the thesis with possible implications of findings and plans for future work.

Chapter 2

Background and Significance

The American Lung Association defines asthma as a 'reversible lung disease caused by the narrowing or blocking of the lung's airways' that can be triggered by various substances (ALA, 2005). An asthma attack is characterized by wheezing, shortness of breath, coughing, chest pain or tightness and can be life-threatening (Adams, 1995). Asthma triggers may include but are not limited to environmental irritants such as tobacco smoke and pollutants, household and industrial products, viruses, exercise and cold air (ALA, 2005). While the origins of asthma are not altogether clear, researchers have generally concluded that asthma has both genetic and environmental/behavioral causes (Litonjua et al., 1998).

As with other diseases, pediatric asthma (as well as asthma occurring in adults) is unevenly distributed with respect to gender, socioeconomic status and ethnicity. Boys are more likely to be diagnosed with asthma than girls (19 percent vs. 15 percent). There are also differences in pediatric asthma outcomes along socioeconomic lines. Those more likely to be diagnosed over a lifetime include poor children (15 percent vs. 12 percent for children from non-poor households) and children from single parent households (16 percent vs. 11 percent for children in two-parent households). Inner-city children (who are disproportionately non-white) have been shown in numerous studies to have higher rates of asthma morbidity (Meyer et al., 1998). Most studies conclude that this is a result of higher exposure to pollutants. Additionally, the stress/environmental link has been implicated in asthmatic symptoms. In a study of 951 inner-city children, Wright et al. (2004) find that exposure to violence is strongly correlated with caretaker reports of asthma symptoms, even after con-

trolling for income, education and other related factors. Among African-American children, asthma incidence, morbidity and mortality are higher compared to white children. For example, African-American children are more likely to report an asthma attack than white children (8 percent vs. 5 percent). Asthma incidence among latinos is lower, but there is considerable variation within latino subgroups. Mexican-American children have among the lowest incidence of lifetime asthma among all racial and ethnic groups, (10 percent) while Puerto-Rican children have the highest (over 25 percent)(Dey and Bloom, 2006; Flores et al., 2005).

2.1 Child Health Production Function

The economics of child health is grounded in the work of Becker and Grossman. Becker's seminal work on the allocation of time (Becker, 1965) used economic theories on human capital formation to place household production in a microeconomic framework. In Becker's view, the household seeks to maximize its utility through consumption of goods (e.g., children or child quality). These goods are produced with various inputs, including time.

Grossman's insights have arguably influenced all of the subsequent literature on health. Like Becker, Grossman applied the human capital theory to the demand for health and health care. He argued that the demand for health care is different than the demand for other goods because it was a derived demand. That is, medical care is not desirable for its own sake, but for its ability to produce or maintain health. Moreover, health could be viewed not just as a investment good, but a consumption good as well. That is, people like being healthy because it enhances their ability to enjoy other consumption goods *and* because it increases their stock of 'healthy days' available to earn more income.

The work of Rosenzweig and Schultz (1983) is considered one of the seminal papers on the economics of child health. Using data on birthweight and various behavioral determinants thought to influence birthweight, they estimate a child health production function. The pregnant mother derives utility from child health, inputs that affect child health (these do not affect utility except through the effect on child health), and non-health related goods. They

emphasize that much of the literature up to that point failed to account for the unobserved heterogeneity affecting both health care decisions and health, producing biased estimates of the effect of prenatal care on health. The authors estimate the (Cobb-Douglas) infant health production function by ordinary least squares (OLS), two-stage least squares (2SLS), and three-stage least squares (3SLS). The last two methods are in an effort to control for the correlation of error terms across the input demand equations. Contrary to previous literature, they find that while medical care delay during pregnancy does not have a significant effect on birth weight, OLS estimates appear to underestimate the significant negative effects of smoking on fetal growth (Rosenzweig and Schultz, 1983).

Grossman and Joyce (1990) build upon the work of Rosenzweig and Schultz (1983) by arguing that adverse selection in health care inputs is only one source of bias. In contrast to the earlier work, they argue that favorable selection may be even more problematic when interpreting estimation results. For example, women who elect to attend prenatal care early in their pregnancy may also engage in other healthy behaviors such as eating a more nutritious diet, exercising, and using fewer harmful drugs. Thus, the omission of these factors may overestimate the marginal effect of prenatal care on birthweight. The point is also made by the authors that pregnancy resolution (abortion decision) is not a random process. The authors find that there is significant unobserved heterogeneity between women who give birth and those who choose to terminate a pregnancy.

Using New York City data from live birth records, they estimate a system of three simultaneous structural equations for the probability that a birth occurs, the demand for prenatal care birth weight, and birthweight (health production). The authors concentrate on the role sample selection bias and prenatal care inputs play in the determination of birthweight. They find 'strong evidence of selectivity bias in the birthweight production function among blacks' and suggest that [for blacks] 'the probability of giving birth is positively correlated with the unobserved factors that decrease delay in the initiation of prenatal care and increase birthweight'. The authors find no evidence of such bias among white women. Grossman and Joyce (1990) find that among black women, all else held constant, those who aborted would have had lighter infants if they had chosen to give birth. 3SLS estimates show that the

deleterious effects of prenatal care delay increase threefold for blacks and sixfold for whites compared to models that do not account for the unobserved heterogeneity that influences both behavior and outcomes.

There is still more evidence of significant costs to ignoring unobserved heterogeneity. Rosenzweig and Wolpin (1988) use a longitudinal data set from Columbia on children and their families to estimate a dynamic model of infant health outcomes (birthweight) and later child-health outcomes (weight-for age). They find evidence that ignoring family-level health heterogeneity and parental behavioral adjustments to child-specific health shocks can yield biased estimates in a child health production function. For example, mothers are more likely to breastfeed healthier children – thus failing to control for unobserved heterogeneity will cause the benefits of breastfeeding to be overstated. The authors also find that child health significantly affects parental fertility behavior. That is, for parents who have a healthy child, there will be a smaller gap in age between the older child and an adjacent younger sibling.

Reichman et al. (2006) is one of the few economics papers to measure typically unobserved variables (TUVs) that are theoretically the sources of unobserved heterogeneity in the birthweight production function. These TUVs include child wantedness, taste for risky behavior and the maternal health endowment. They attempt to answer whether these variables are important and whether they bias the effects of other inputs (e.g., smoking and drug use). Using medical records on the mothers from the Fragile Families data, they find that TUVs are strongly related to health inputs and outcomes. For example, mothers who considered abortion were much less likely to have gone to prenatal care. Similarly, a mother's health conditions (like a previous lung condition) had a statistically significant effect on low birthweight. However, Reichman et al. (2006) find that excluding the TUVs from the child health production function does not substantially bias the results of prenatal inputs such as smoking. They find that measurement error is a much more serious problem in the estimation of the effects of maternal health inputs on birthweight. Mothers tend to systematically underreport prenatal drug use in particular, which appears to bias the effects of prenatal drug use downward.

Although the work of Reichman et al. (2006) captures important measures of unobserved

heterogeneity (and underscores the importance of measurement error), there are possibly other unobserved characteristics of the mothers (not captured by the Fragile Families Data) that can bias results and warrant attention attention (e.g., nutrition and exercise habits). Guilkey et al. (1989) use a rich longitudinal survey from the Philippines on infants and their mothers to examine the effects of prenatal inputs on pregnancy outcomes. Nutrition and exercise habits are typically unobserved pregnancy inputs and the authors find that both nutrition and work habits have significant effects on gestational age and birthweight.

Although Reichman et al. (2006) estimate reduced form models of the effects of TUVs and other 'exogeneous' inputs on maternal health inputs, they do not control for the endogeneity of these inputs (drug use, smoking, prenatal care) on birthweight. The authors make the (valid) claim that instrumental variables techniques are difficult to implement empirically and achieve valid results. However, failing to control for the endogeneity of the observed health inputs makes it difficult to determine whether or not the estimates of the coefficients is accurate.

Much of the current economics research in the area of child health tends to focus on the effects of socioeconomic status (SES) on child health and the effects of insurance (particularly public insurance programs such as Medicaid) on child health. Case et al. (2002) demonstrate the strong associations between children's health and long-run average income – a relationship that becomes stronger with age. Currie and Stabile (2003) show that health disparities on the basis of socioeconomic status widen with age due to the fact that low SES children tend to receive more health shocks over time. The authors also show that persistent health shocks tend to affect learning outcomes as well.

2.2 Diagnosis, Medical Care Use and Hospitalization

Pronounced differences occur in rates of medical care utilization across ethnic lines. In a study using data from the National Health Interview Survey (NHIS), Flores et al. (2005) report that non-white children are less likely to have visited a physician in the past year. Fifty-eight percent of White infants, 35 percent of African American infants, and 37 percent

of Hispanic infants have adequate well-baby care in the first year (Ronsaville and Hakim, 2000). Immigration status also tends to influence both the likelihood of having health insurance and receiving regular medical care. Latino children born to immigrant parents are less likely to be insured or have access to care compared to latino children of US-born parents (Granados et al., 2001). In particular, the passage of the Federal Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA) in 1996 greatly restricted the provision of many social services to undocumented immigrants (Kullgren, 2003). Kullgren (2003) notes that 'prohibiting the provision of discounted health care endangers access to services among undocumented immigrants' children, many of whom are born in the United States and are therefore eligible for publicly funded health care programs' (p. 1631). The author also references other studies that have suggested that fear of immigration authorities and/or beliefs that their children do not qualify for health services may discourage undocumented parents from seeking health care for their native-born children.

Freeman et al. (2003) show in a study of more than 4000 Passaic, New Jersey schoolchildren from 1998-2002 that children with health insurance were two to three times more likely to be diagnosed with asthma than those without, irrespective of country of origin. Children with insurance were also more likely to have their asthma managed by medications. Mexican-American children are the least likely to report an asthma diagnosis (11 percent without insurance, 6 percent with insurance, respectively). These children were also the most likely to be uninsured overall at the inception of the study (70 percent). However, during the study period, the passage of the NJ KidCare program extended healthcare coverage to a greater number of children. Coincidentally, there was a significant increase in reported familial asthma by Mexican parents over the four years of the study, while reports of familial asthma for other ethnic groups declined. The authors note that differences in reported asthma cases can be explained by differences in medical care access (Freeman et al., 2003). If, as theorized, low rates of medical care utilization (at least in the formal sector) are implicated in artificially low levels of asthma among Mexican-American children (for example), then we would expect to see higher rates than expected rates of emergency room visits for acute asthma episodes.

2.3 Parental Smoking

Environmental smoke is a prime source of indoor air pollution and has been shown to adversely affect lung function and development in children and also increase the likelihood of children developing pediatric asthma (Gergen et al., 1998). A wealth of studies support the association of parental smoking with childhood asthma and the exacerbation of asthmatic episodes. Weitzman et al. (1990), using data from the 1981 Health Interview Survey (NHIS), report that mothers who smoke at least 1/2 pack of cigarettes per day are more likely to give birth to children who develop asthma in the first year of life and are more likely to have children who take asthma medications. The authors also found a strong relationship between maternal smoking and hospitalizations. Surprisingly, this relationship was not statistically significant in the case of children already diagnosed with asthma. It should be noted that the number of children with asthma in the survey was fairly low and the authors were unable to disentangle the effects of prenatal and postnatal smoking. Maternal smoking behavior is also treated as exogenous, possibly understating (or overstating) the true effects of smoking on child health.

2.3.1 Prenatal Smoking

Several studies suggest that maternal smoking has more harmful effects on pediatric respiratory health than paternal smoking. On one hand, this could simply be a byproduct of increased exposure time. That is, most children simply spend more time with their mothers. However, there is a significant body of research examining additional effects of in utero tobacco exposure. It appears that prenatal smoking has additional harmful effects on children's pulmonary structure and function. Magnusson (1986) finds in a study of European infants that maternal smoking is associated with increased levels of immune response and heightened allergy sensitization (e.g., asthma and excema). Visscher et al. (2003) find that smoking during pregnancy is a strong predictor for low birthweight. However, this study fails to control for the endogeneity of smoking behavior as well as the other unobservable factors that may affect both smoking behavior and birthweight.

2.3.2 Ethnicity and Prenatal Smoking Behavior

Smoking among U.S. women has steadily declined over the past four decades with few exceptions. Prenatal smoking has been declining since 1989. Data from the 2003 National Vital Statistics shows that 10.7 percent of pregnant women smoked, down from 11.2 percent in 2002. Of the women who smoked during pregnancy, there are large differences in smoking behavior across socioeconomic groups. Women who are more educated have much lower rates of smoking than women who failed to graduate from high school (2 percent vs 25 percent). Even larger differences remain on the basis of race and ethnicity. Black women are much less likely to smoke than white women during pregnancy (8.3 percent vs. 14.3 percent) but more likely to smoke than Hispanic women. There is also considerable inter-group heterogeneity among Hispanics. While Puerto-Ricans have the highest rate of prenatal smoking (7.9 percent), Mexicans and Cubans have among the lowest (2.0 percent and 2.4 percent, respectively). Mothers of Central/South American descent have the lowest rates of smoking among Hispanics, with only 1.2 percent reporting having smoked during pregnancy.

2.4 Breastfeeding

The American Academy of Pediatricians recommend that infants be breastfed exclusively for the first six months of life and that mothers continue to breastfeed infants for at least the first year of life (Gartner et al., 2005). Breastfeeding has important infant health benefits including protection from illness (e.g., diarrhea) and growth enhancement (Adair et al., 1993). There has been a significant increase in breastfeeding initiation rates among groups at risk. Between the years 1990 and 2000, Black mothers' initiation rate increased from 23 percent to 51 percent while teenaged mothers' initiation rate went from 30 percent to 50 percent. However, only 17 percent of mothers breastfed exclusively for one year (Kimbro, 2006).

These low breastfeeding duration rates may be related to asthma. Evidence suggests that longer breastfeeding duration has a negative association with the incidence of asthma. Oddy et al. (2004) find in a longitudinal study of 2,195 Perth children from birth to age 6 that breastfeeding protected against the development of asthma. Oddy (2004) notes that breastfeeding

may reduce the likelihood of asthma development through negative effects on wheezing, lower respiratory illness (LRI) and atopy (allergy). Both LRI during first year of life and atopy are strongly associated with asthma development.

However, there appear to be positive associations between breastfeeding and exposure to environmental tobacco smoke (ETS). Mascola, et al. (1998) suggest in their study of 330 mother-infant pairs that the degree of exposure to ETS through breastfeeding is larger than previous research has supposed. They find that infants of mothers who smoke have significantly more exposure to tobacco smoke and its products than do infants of non-smokers. For example, the infants of smoking mothers who breastfed had significantly higher levels of urine cotinine (a tobacco byproduct) than the other infants in the study. Since ETS has been shown to increase the likelihood of asthma incidence (Etzel, 2003), programs that target postnatal smoking cessation are a potentially critical public health intervention. Mascola, et al.(1998) admit that their results are potentially problematic, given the small number of smoking mothers who breastfed their infants in the study is extremely small (n=13) and that unobserved individual-level characteristics may account for some of the results they obtained. Also, they note that 'cotinine is only a quantitative biomarker for smoking and that it is unlikely that cotinine or its parent compound, nicotine, is responsible for all of the adverse outcomes associated with smoking'. However, given that ETS has been shown to increase the likelihood of asthma incidence, the authors's results may indicate that postnatal smoking cessation is a potentially critical public health intervention.

Chapter 3

Empirical Framework

3.1 Child Health Production

The following section describes the decision making behavior of a mother and subsequent health outcomes for her child. More specifically, the model examines the relationship between maternal smoking, breastfeeding, child medical care and asthma as well as the relationship between maternal work and health inputs.

A pregnant woman makes several decisions that affect her utility as well as the health of her unborn child. These include prenatal medical care, P_0 , and cigarette consumption, S_0. During the prenatal period, the mother must consider the tradeoffs between her own well-being and that of her unborn child's. For example, a mother may enjoy smoking, but she knows that smoking has potentially damaging effects on the fetus. At the end of the first period, the woman gives birth.[1] After giving birth, parents choose the desired quantity of child health inputs each period. In addition to child medical care, D_t, and maternal smoking, S_t, the mother also chooses whether or not to breastfeed her infant, F_1. At the end of the first period (t=0), initial child health (health at birth) is measured by birthweight, W_0. Alternatively, child health can also be measured by low birthweight, defined as a birth weight lower than 2500 grams. In subsequent periods (t=1 and 2), child health is assessed by asthma incidence, A_t, number of asthma attacks, K_t, and the number of asthma-related

[1] As a simplification, I assume that the woman gives birth to a live infant. An argument could be made on theoretical grounds that the assumption of live birth introduces a degree of sample selection (Grossman and Joyce, 1990).

hospitalizations, H_t.

Prenatal Care

During the prenatal period (t=0), the mother chooses when to initiate prenatal care. She can choose to initiate prenatal care either during the first trimester or later in the pregnancy. Prenatal care is estimated using a probit specification. The probability of initiating care in the first trimester as opposed to later is:

$$P(P_0 = 1|X_0, N_0, Z_0^p) = \Phi(\beta_0 + \beta_1 X_0 + \beta_2 N_0 + \beta_3 Z_0^p) \tag{3.1}$$

where Φ defines the standard cumulative normal probability distribution. Whether the mother initiates care in the first trimester depends on various individual characteristics X_0 (e.g., age, education, marital status, number of children) and exogenous neighborhood or community (tract, city and state-level) variables, N_0. It also depends on Z_0^p, which contains county-level information on the number of obstetricians.[2]

Smoking

In both the prenatal and subsequent periods, the mother chooses whether or not to smoke cigarettes, S_t. Cigarette smoking is a binary outcome outcome and is estimated using the probit and the linear probability model techniques. More specifically, prenatal smoking is estimated as a probit. When low birthweight is treated as exogenous in later specifications, smoking at age one and at age three are estimated using the probit technique. However, when low birthweight is treated as endogenous, postnatal (t=1 and 2) cigarette smoking must be estimated as a linear probability model in order for the parameter estimates of the smoking

[2]In Z_t^l, l indicates which variable of the Z_t vector affects a particular dependent variable indicated by l.

equation to be consistent. For t=0, 1 and 2, the probability that a mother smokes is[3]:

$$P(S_t = 1|W_0, X_t, N_t, Z_t^s) = \gamma_0 + \gamma_1 W_0(t > 0) + \gamma_2 X_t + \gamma_3 N_t + \gamma_4 Z_t^s + \epsilon_0^s \tag{3.2}$$

In the smoking equation, a child's initial health, captured by low birthweight, is allowed to influence postnatal smoking decisions (t=1 and 2). X_t includes socioeconomic characteristics as before. Z_t^s contains information on state-level cigarette prices.

Birthweight

Birthweight, W_0, is a measure of initial child health. Birthweight is determined by maternal inputs (P_0 and S_0) and parental and child characteristics (X_0) such as gender and race/ethnicity. Birthweight is also influenced by neighborhood and city-level characteristics (N_0 and Z_0^w) such as season of birth. More specifically, for t=0, birthweight is[4]:

$$W_0 = \eta_0 + \eta_1 P_0 + \eta_2 S_0 + \eta_3 X_0 + \eta_4 N_0 + \eta_5 Z_0^w + \epsilon_0^w$$

After the mother gives birth and observes the birthweight outcome (W_0) parents choose the quantity of child health inputs each period in order to produce child health. These child health inputs include breastfeeding, well-baby visits and smoking.

Breastfeeding

Breastfeeding is believed to have a protective effect on child health. A mother chooses whether or not to breastfeed in the child's first year. F_1 is a binary outcome and is measured during the child's first year using the probit technique when low birthweight is treated as an exogenous variable and is estimated using the linear probability model when low birthweight is treated as endogenous. The decision to breastfeed is a function of birthweight, W_0 (a proxy for initial

[3]The probit specification is:

$$P(S_t = 1|W_0, X_t, N_t, Z_t^s) = \Phi(\gamma_0 + \gamma_1 W_0(t > 0) + \gamma_2 X_t + \gamma_3 N_t + \gamma_4 Z_t^s)$$

[4]An alternative measure of initial child health is an indicator for low birthweight. That is, I evaluate the probability that the infant weighs less than 2500 grams at birth. That is, $P(W_0 < 2500)$.

infant health), individual and family level factors, X_1, and community variables, N_1 and Z_1^f. Z_t^f includes variables about state-level laws regarding breastfeeding. For t=1, breastfeeding is[5]:

$$P(F_t = 1|W_0, X_1, N_1, Z_1^f) = \theta_0 + \theta_1 W_0 + \theta_2 X_1 + \theta_3 N_1 + \theta_4 Z_1^f + \epsilon_1^f \tag{3.3}$$

3.2 Well-Baby Visits

Medical care utilization is captured by an indicator of whether or not a child had an adequate number of well-baby visits, D_t. I define adequate visits as at least four visits in the first year of life, and four visits from ages two to three.[6] Well-baby visits depend on a child's initial health (low birthweight), socioeconomic characteristics, X_t, community variables N_t and Z_t^d (e.g., numbers of doctors in an area). That is, for t=1 and 2, adequate well-baby visits is represented by[7]:

$$P(D_t = 1|W_0, X_t, N_t, Z_t^d) = \lambda_0 + \lambda_1 W_0 + \lambda_2 X_t + \lambda_3 N_t + \lambda_4 Z_t^d + \epsilon_t^d \tag{3.4}$$

3.3 Asthma, Asthma Attacks and Asthma Hospitalizations

Child health outcomes are captured by asthma diagnosis, A_t, asthma attacks, K_t and asthma hospitalizations H_t. Each of these variables is a function of both maternal health behaviors and exogenous socieconomic variables. The maternal health behaviors thought to affect asthma outcomes are maternal smoking behavior, (S_t), birthweight, (W_0), well-baby visits,

[5]Breastfeeding is estimated using the probit technique when low birthweight is treated as endogenous:

$$P(F_t = 1|W_0, X_1, N_1, Z_1^f) = \Phi(\theta_0 + \theta_1 W_0 + \theta_2 X_1 + \theta_3 N_1 + \theta_4 Z_1^f)$$

[6]The American Academy of Pediatrics (www.aap.org) recommends 6 well-baby visits from birth to year 1 and 3 visits during years 2 to 3 (ages 2, 2 1/2 and 3) but the outcomes in the survey only include 0, 1-3, and 4+ visits. four more visits until age 3. I retain the specification of this variable for consistency purposes.

[7]As with each of the other postnatal health inputs (smoking and breastfeeding), adequate well-baby visits is estimated using the probit method when low birthweight is treated as exogenous. That is:

$$P(D_t = 1|W_0, X_t, N_t, Z_t^d) = \Phi(\lambda_0 + \lambda_1 W_0 + \lambda_2 X_t + \lambda_3 N_t + \lambda_4 Z_t^d)$$

(D_t) and breastfeeding, (F_1). Socioeconomic variables, X_t, that are related to asthma diagnosis and morbidity include factors such as ethnicity, child's age and parents' age. Also included are N_t ,which includes tract-level housing conditions, and Z_t^a, Z_t^k and Z_t^h, which include annual city-level measures of pollution. Both asthma attacks and asthma-related hospitalizations are also a function of asthma and asthma attacks in the previous period, A_t and K_t. In addition, asthma attacks, K_t and asthma hospitalizations, H_t are conditional on being diagnosed with asthma in either the preceding period or in the current period. A_t, K_t and H_t are dichotomous variables =1 if a child was diagnosed with asthma or had an asthma attack respectively, and =0 otherwise. Each outcome is measured using the linear probability model. For t=1 and 2, the probability of an asthma diagnosis, asthma attack, or asthma-related hospitalization is:

$$P(A_t = 1) = \chi_0 + \chi_1 W_0 + \chi_2 S_t + \chi_3 F_1 + \chi_4 D_t + \chi_5 X_t + \chi_6 N_t + \chi_7 Z_t^a + \epsilon_t^a \tag{3.5}$$

$$\begin{aligned} P(K_t = 1 | A_t = 1; A_{t-1} = 1) = \delta_0 + \delta_1 W_0 + \delta_2 S_t + \delta_3 F_1 + \delta_4 D_t \\ + \delta_5 X_t + \delta_6 N_t + \delta_7 Z_t^k + \epsilon_t^k \end{aligned} \tag{3.6}$$

$$\begin{aligned} P(H_t = 1 | A_t = 1; A_{t-1} = 1) = \psi_0 + \psi_1 W_0 + \psi_2 S_t + \psi_3 F_1 + \psi_4 D_t \\ + \psi_5 X_t + \psi_6 N_t + \psi_7 Z_t^h + \epsilon_t^h \end{aligned} \tag{3.7}$$

3.4 Estimation Methods

From previous discussion, it is clear that any estimation method used for the model must address the issue of endogeneity. Endogeneity is likely to influence many outcomes of interest. Failing to control for either may lead to biased estimates of the parameters of the model. There are many approaches to this problem. I estimate the system of equations using the probit and linear probability methods within an instrumental variables framework. For each of the asthma equations, I first estimate a two-stage model, with birthweight treated as exogenous and each of the health inputs (smoking, breastfeeding and well-baby visits) treated as endogenous. In this case, each of the health inputs are estimated using maximum likeli-

hood (probit) and their predicted values are used in the final asthma equation. The asthma equation must be estimated as a linear probability model to ensure that the coefficients on the explanatory variables are consistent (Wooldridge, 2002). The next step involves treating birthweight as endogenous, in which case each of the health inputs (each a function of birthweight) are also estimated linearly. Birthweight itself is also estimated as a linear probability model (in the case of low birthweight) or using ordinary least squares (birthweight continuous). Each of the prenatal inputs, smoking and prenatal care, is estimated using the probit technique. Using 2-stage and 3-stage instrumental variables methods requires that the standard errors be corrected using sampling with replacement (Wooldridge, 2002). I bootstrap the standard errors on each of the coefficients, using samples of 2,105 drawn with replacement from the full sample. In each of the models with endogenous regressors, all of the reported standard errors are bootstrapped.[8]

[8]See Hardin et al. (2003) for more details.

Chapter 4

Data

4.1 The Fragile Families and Child Wellbeing Study

The Fragile Families and Child Wellbeing study (FF), also called 'The Survey of New Parents', provides data on a cohort of 4,898 children (and their parents) from birth to age five. The survey oversamples unwed, low-income and black and Hispanic parents. These data are unique due to the relatively high response from unwed fathers. The information provided on the unwed fathers allows for the study of a wide variety of social and economic outcomes among families with unmarried parents such as the involvement of single fathers, how public policies (e.g., marriage) affect union formation and the consequences of stricter child support and welfare laws on parents and children.

The national study is a stratified random sample of large U.S. cities with a population of at least 200,000. Stratification was on the basis of variance in policy and labor market conditions. Cities were scored on the basis of labor market demand, strength of child support enforcement and welfare generosity.[1] Of the 77 original cities considered, the 'national sample' consists of 16 cities, including Indianapolis, IN; Austin, TX; Boston, MA; Santa Ana, CA; Richmond, VA; Corpus Christi, TX; Toledo, OH; New York, NY; Birmingham, AL; Pittsburgh, PA; Nashville, TN; Norfolk, VA; Jacksonville, FL; San Antonio, TX; Philadelphia, PA;

[1] Welfare generosity was measured by two indicators, the dollar value of a monthly welfare payment for a family of four and the dollar value of the median monthly rent in the city. Strength of child support was measured by the paternity establishment rate, the proportion of AFDC (Aid for Dependent Children cases with a child support award and the proportion of AFDC cases with an award. Labor market strength (demand) was determined using unemployment rates and rates of job and population growth.

and Chicago, IL. Four other cities were also included, Newark, NJ; Oakland, CA; Detroit, MI; and San Jose, CA. While the Fragile Families data are rich in measures pertaining to parenting behavior and child cognitive and behavioral outcomes, there are some limitations to the study. Since the study only samples urban respondents in large cities, it may be presumptuous to extend results to children in rural populations. The sample also oversamples minority, low income, unmarried parents, making any results subject to this caveat. Nevertheless, since poor health infant and child health outcomes are disproportionately experienced by the poor, this analysis will certainly have useful policy implications.

4.2 Sample Considerations

The original sample consists of a cohort of 4,898 children and their mothers and fathers. I excluded every observation in the sample without valid measures for birthweight of the child, prenatal care initiation and smoking behavior. For the second wave, I excluded all observations without valid values for the dependent variables, including the number of weeks the mother breastfed, smoking behavior, whether or not the child went to well baby care and whether or not the child had been diagnosed with asthma, had an asthma attack or was hospitalized for asthma-related complications. In the third wave, I excluded all observations with missing values for child's well-baby doctor visits, mother's smoking behavior and child's asthma status (diagnosis, attacks and hospitalizations). Using the above criteria, I retained all individuals who had valid values for each of the nine endogenous variables being estimated. My final sample consists of 2,105 individuals over three periods, resulting in 6,315 total observations.

Approximately three-quarters of the children in the sample are born to unmarried parents. Although the Fragile Families Research Team attempted to interview both mothers and fathers at the time of birth, some of the fathers could not be contacted. (Children were included if their mother was interviewed at the time of birth.) However, some fathers were eventually contacted for the one-year follow-up survey.

Table 4.1: Derivation of the Final Sample

	Missing Information	Number Individuals
1	Original Sample	4898
2	Low birthweight	75
3	Asthma, age one	564
4	Asthma, age three	914
5	Asthma attack, age three	1
6	Adequate well-baby visits, age one	895
7	Breastfed	11
8	Gender, mult. Birth	58
9	Prenatal Care	14
10	Smoking, age one	2
11	Smoking, age three	26
12	Other exogenous variables	233
13	Final Sample	2105

4.3 Health Inputs and Outcomes

Information on each of the prenatal inputs (month of prenatal care initiation and cigarette consumption) is found in the baseline survey of the Fragile Families data. Prenatal care initiation is measured by the month each mother first went to the doctor during her pregnancy. Cigarette consumption is a dichotomous variable indicating whether or not the mother smoked during her pregnancy. Birthweight is used as a measure of initial health. Questions about weight are asked during the baseline and first waves of Fragile Families. Weight is also measured by the interviewer if the primary parent participated in the In-Home Survey. While weight is a continuous measure of birthweight in grams, there is also an indicator variable for whether or not the child was a low birthweight baby. Low birthweight babies are defined as children born weighing less than 2500 grams. Low birthweight has been implicated in a host of pediatric health problems and infant mortality, so I include low birthweight as an alternative specification for weight (or initial health).

Parental health inputs after birth are captured in both follow-up surveys and include

the breastfeeding and smoking decisions and the number of well-baby visits. Child health outcomes at ages one and three include asthma diagnosis, asthma attacks and asthma-related hospitalizations. The breastfeeding decision is only measured during the second wave of the survey. Breastfeeding is a dichotomous indicator of whether or not the woman breastfed or not. It should be noted that the survey did not indicate whether or not the mother breastfed exclusively. The cigarette consumption variables are measured similarly during each wave of the survey.

Other child health inputs include medical care. The measure of medical care utilization is visits to the doctor for well-baby checkups. In both the second and third wave, parents were asked about the number of their child's well-baby visits. In the second wave, the variable created is a dichotomous indicator for whether the child had at least four or less than four visits during the first year. This is essentially an indicator of whether or not the infant had at least half of the recommended number of well-baby visits during the first year. Similarly, during the third wave, having had adequate well-baby visits is defined as having had four or more well-baby visits in previous year.

Child health outcomes in the second and third waves are represented by incidence of asthma diagnosis, asthma attack, asthma episodes and asthma-related hospitalizations. Asthma diagnosis is a dichotomous indicator for whether or not parents reported having been told by a doctor that their child had asthma. The asthma attack and asthma episode variables are indicators for whether or not the parent reported that their child had an asthma attack or asthma episode (e.g., wheezing). The asthma-related hospitalization variable is an indicator for whether or not a child with asthma had to be hospitalized due to complications from asthma.

4.4 Summary Statistics

4.4.1 Dependent Variables

Table 4.2 provides summary statistics of the maternal health behaviors and infant and child health outcomes for the estimation sample by race/ethnicity of the mother.

Table 4.2: Summary Statistics[a] for Health Inputs and Outcomes by Ethnicity[b]

Dependent Variable		All	White	Black	Latino	Other
Health Outcomes						
Birthweight	W_0	3.23	3.37	3.12	3.31	3.32
(kilograms)		(0.61)	(0.62)	(0.61)	(0.57)	(0.41)
Low Birthweight	$P(W_0 < 2.5)$	9.8	8.33	12.58	6.33	2.86
Asthma	$P(A_t = 1)$	16.67	9.03	20.37	17.24	12.86
Asthma Attack	$P(K_t = 1)$	57.12	50.55	59.91	55.03	44.44
Asthma Hospitalizations	$P(H_t = 1)$	47.58	30.77	52.12	45.56	44.44
Health Inputs						
Prenatal Care Initiation	P_0	2.46	2.24	2.54	2.52	2.42
		(1.58)	(1.42)	(1.66)	(1.53)	(1.59)
1st Trimester	$P(0 < P_0 \leq 3)$	82.00	89.09	80.02	79.39	78.59
2nd Trimester	$P(3 < P_0 \leq 6)$	15.25	8.73	16.71	18.32	18.57
3rd Trimester	$P(9 < P_0 \leq 9)$	2.76	2.18	3.27	2.24	2.86
Smoking	S_t					
S_0	$P(S_0 = 1)$	19.81	31.15	20.17	8.16	14.29
S_1	$P(S_1 = 1)$	27.93	37.70	26.99	20.00	27.14
S_2	$P(S_2 = 1)$	25.51	31.55	26.71	16.94	24.29
No. of Months Breastfed	F_1					
Not Breastfed	$P(F_1 = 0)$	45.51	32.54	56.87	37.35	27.14
Up to 1 month	$P(0 < F_1 \leq 1)$	12.11	14.41	9.70	15.31	8.57
1+ to 3 months	$P(1 < F_1 \leq 3)$	17.96	23.81	12.30	23.06	24.29
3+ to 6 months	$P(3 < F_1 \leq 6)$	14.06	15.28	13.26	13.27	22.86
6+ to 9 months	$P(6 < F_1 \leq 9)$	5.23	7.14	4.23	4.69	10.00
9+ months	$P(F_1 > 9)$	5.13	6.75	3.65	6.33	7.14
Well-Baby Visits	V_t					
V_1	$P(V_1 \geq 4)$	0.94	0.96	0.93	0.92	0.97
V_2	$P(V_2 \geq 4)$	0.18	0.11	0.21	0.21	0.11

[a] All numbers are percentages, except birthweight, W_0 and prenatal care, P_0, which are means.

[b] Standard errors are in parentheses.

4.4.2 Exogenous Explanatory Variables

Individual and Family Characteristics

Also important are individual characteristics such as race, ethnicity, educational attainment and age. Table 4.3 provides summary statistics for these exogenous family and individual characteristics.

Table 4.3: Summary Statistics for Parental and Child Characteristics

Variable	Mean	Std. Dev.
Child's age (in years)	1.39	1.22
Male child	0.53	0.50
Spring birth	0.35	0.48
Summer birth	0.19	0.39
Mother is white	0.24	0.43
Mother is black	0.49	0.50
Mother is latino	0.23	0.42
Mother is an immigrant	0.11	0.32
Years in U.S., if immigrant	2.54	4.57
Mother's age, in years	26.25	6.03
Father's age, in years	28.85	7.01
Married to biological father	0.27	0.45
Cohabitating	0.29	0.45
Biological father present in household	0.27	0.45
Biological father's age if married to mother	32.27	6.76
No. of adults in household	2.15	0.94
Grandmother present	0.19	0.39
No. of children in household	2.00	1.41
Pregnant	0.49	0.50
Income (in thousands)	19.14	20.52
Mother is high school grad	0.69	0.46
Mother attended some college	0.26	0.44
Mother has bachelor's degree	0.10	0.30
Medicaid	0.64	0.48
Mother religious	0.35	0.48
Sample size	6315	

4.5 Exogenous Neighborhood and State-Level Characteristics

Table 4.4 contains information on exogenous neighborhood, city and state-level variables. Tract-level characteristics include information such the racial composition of the neighborhoods, percentage of welfare recipients and poor housing conditions. More detailed information on city- and state-level characteristics follows.

Table 4.4: Summary Statistics for Neighborhood, City, State and Interview-Level Characteristics

Variable	Source of Variation	Mean	Std. Dev.
Percent hispanic	Tract	0.18	0.26
Percent black	Tract	0.41	0.38
Percent other ethnicity	Tract	0.01	0.01
Percent foreign-born	Tract	0.11	0.14
Percent with h.s. degree+	Tract	0.69	0.18
Percent unemployed	Tract	0.11	0.08
Percent vacant housing units	Tract	0.09	0.07
Percent on welfare	Tract	0.08	0.07
Tract variables, missing	Tract	0.02	0.13
Cigarette price (cents)	State	315.53	57.74
Anti-Smoking laws	City	0.16	0.37
Obstetricians per 100K	County	20.16	7.85
Pediatricians per 100k children	County	72.81	30.84
Price of Infant Formula	MSA	2.56	0.11
Public Breastfeeding Allowed	City/state	0.49	0.50
Ozone (ppm)	City	0.42	0.17
Particulate Matter , (ppm/100)	City	3.86	8.01
Carbon Monoxide (ppm)	City	0.59	0.15
1999 Interview	Individual	0.34	0.47
2000 Interview	Individual	0.33	0.47
2001 Interview	Individual	0.66	0.47
2002 Interview	Individual	0.34	0.47
2003 Interview	Individual	0.66	0.47
Sample size		6315	

4.5.1 Cigarette Prices

Previous research indicates that state-level cigarette excise taxes are negatively related to smoking before, during and after pregnancy (Colman et al., 2003).[2] One potential drawback to using state-level cigarette prices is that there may be notable differences in cigarette prices across localities due to differences in excise taxes. These price differentials create an incentive to 'border-cross' in order to purchase cigarettes at a lower price. To the extent that border-crossing is relevant in this sample, ignoring this issue will bias the price coefficients on cigarette cartons to zero (Chaloupka, 1991). Chaloupka circumvents this issue in his estimation of cigarette demand equations by using an equally weighted average of the 'border price' and the local price of cigarettes as his price for cigarettes. The 'border price' refers to the lowest price for a pack of cigarettes within 25 miles of the county of residence.

However, public data regarding cigarette prices by MSA are proprietary and currently unavailable for the relevant time periods in my data. I do include annual state-level data on cigarette prices and taxes compiled by the American Tobacco Institute. I also exploit the variation over time in city-level anti-smoking ordinances. To further aid in identification, I include several tract-level characteristics that may be associated with smoking, including the unemployment rate and the percentage of the population with a high-school degree. Tseng et al. (2001) hypothesize that area-level characteristics could operate as a source of stress to residents, thereby influencing smoking behavior. The authors find that among those who had ever smoked, continued smoking was associated with living in low-education areas, high unemployment areas, and high-crime areas.

4.5.2 Medical Care Supply Variables

The Area Resource Files (ARF) contain county-level information on variables such as the number of doctors, hospitals and Medicaid expenditures. I use the number of obstetricians/gynecologists in each city as well as the number of hospitals to provide exogenous variation affecting prenatal care demand. I also use the number of doctors/pediatricians to identify the equation describing well-baby visits.

[2]The authors report implied price elasticities ranging from -0.30 to -0.91.

4.5.3 Breastfeeding Policy Variables

Ideally, any model of the breastfeeding decision would contain information on formula prices. Consistent with economic theory and empirical research, one would expect the demand for breastfeeding to vary inversely with the price of formula (Blau et al., 1996). However, complete information on formula prices in the U.S. is proprietary and the cost of obtaining complete data is prohibitive. However, data on formula prices for the year 2000 is available in various USDA reports (Oliveira et al., 2004). I use formula price information in conjunction with indicators on breastfeeding legislation in order to identify the breastfeeding equation. Variations in breastfeeding laws over time can provide important information on barriers to breastfeeding. Approximately 39 states have enacted breastfeeding legislation. These laws generally are grouped into 7 major areas: public breastfeeding; jury duty; workplace accommodations; health, education and insurance measures; custody/visitation; and miscellaneous provisions (Vance, 2005). Public breastfeeding has been a major thrust of legislative efforts, given that only 16 states have statutes that explicitly exempt breastfeeding from public indecency statutes. I proxy for a state legal environment using an indicator of whether or not the mother lived in a state with a law protecting public breastfeeding. In the sample, approximately 845 mothers lived in areas with laws addressing public breastfeeding (Texas, Maryland, New Jersey, Pennsylvania[3], and New York.)

4.5.4 Pollution Variables

The effects of pollution on various infant and child health outcomes have been mixed. However, several studies have found fairly consistent effects for PM_{10} (particulate matter), Carbon monoxide (CO) and ozone, O_3 on infant health outcomes (Currie and Neidell, 2004). Asthma morbidity has also been shown to be related to pollution. Neidell (2004) identifies the effect of pollution using seasonal variations in pollution within zip codes. He finds that carbon monoxide (CO) has a statistically significant effect on asthma hospitalizations of children aged 1 to 18. That is, while exposure to ambient pollution may be exogenous, avoidance behavior

[3]While Pennsylvania does not have specific state legislation addressing breastfeeding, Philadelphia does have laws on the subject.

is not. Different parents may respond to pollution levels (via smog alerts) in varying ways, suggesting that some children even within the same area may not be exposed to identical levels of pollution. The author finds that avoidance behavior appears to play a significant role in reducing the effects of pollution on childhood asthma and that lower-income families have a lower tendency to undertake avoidance behavior. He also finds that the net effect of pollution tends to be larger for children of lower SES, suggesting that pollution may be one mechanism by which SES may affect health. The results obtained by Neidell (2004) and Currie and Neidell (2004) are supported by various medical and studies. Avol et al. (2001) find in a 10-year study of 110 children that changes in ambient pollution levels have measurable (negative) effects on long-term lung function and health outcomes. Mortimer et al. (2002) report that summer air-time pollution is 'associated with increased asthma morbidity and decreased pulmonary function among inner-city children with asthma in the United States'(p. 704). Neidell notes that while ambient pollution levels are exogenous at the individual level, exposure to pollution is endogenous with respect to the housing market and avoidance behavior (Neidell, 2004). However, I do not model behavior in response to pollution and I include the levels of ambient pollution as exogenous explanatory variables that partially explain health. While variations in pollution are hypothesized to affect health, they should not affect factors such as breastfeeding or medical care decisions.

There are, however, two major challenges posed by the data. The first issue is the length of time between waves of the Fragile Families survey. Participants are interviewed only at (or around) the birth of the child and then when the child is aged one and three years. Another issue is that the restricted version of the Fragile Families data that I am using provides only information about the respondents' respective cities of residence.[4] It is questionable whether or not measurement error in pollution at the city-level is problematic, although several studies using annual variations in pollution levels at the zip-code level have been able to link pollution and adverse health outcomes (Goss et al., 2004). However, since the effects of pollution on health are not a major focus of this analysis, I will use annual city-level pollution data provided by the United States Environmental Protection Agency.

[4]There are some census zip-code level variables provided, but the zip-code of each respondent is not.

4.6 Home Variables

As previously discussed, asthma attacks are often triggered by exposure to home environment factors such as pet dander, molds, cockroaches, broken windows and leaky roofs (Etzel, 2003), (Meyer et al., 1998). Although the Fragile Families In-Home Study contains measures of the home environment, this information is only provided when the child is aged three (N=2105). Table 4.5 provides summary statistics for several home environment variables.

Table 4.5: Summary Statistics for Home Environmental Variables

Variable	**Mean**	**Std. Dev.**
Broken Windows	0.03	0.17
Broken Windows, missing	0.05	0.22
Holes in wall	0.07	0.25
Holes in wall, missing	0.03	0.16
House Dirty or Cluttered	0.18	0.38
House Dirty or Cluttered, missing	0.02	0.13

Chapter 5

Results and Discussion

5.1 Estimation Results

In this section, I present estimates of the effects of maternal inputs and low birthweight on asthma diagnosis and asthma-related complications, including asthma attacks and asthma-related hospitalizations. I will compare the regression results from three different models: a model with no controls for endogeneity (Model 1), a model that controls for the endogeneity of each of the maternal inputs but treats low birthweight as exogenous (Model 2) and a model that treats all inputs, including low birthweight, as endogenous explanatory variables. Each of the inputs and the child health production function is estimated using probit and two- and three-stage instrumental estimation of the linear probability model. Afterwards, using the coefficient estimates generated by the model, I perform simulations designed to interpret the total effect of maternal smoking on child health outcomes. I use maternal smoking in the model simulations because it has the advantage of being measured in each of the three waves of the survey and is also thought to affect asthma incidence and morbidity through prenatal and postnatal pathways over time.

5.2 Asthma Diagnosis

5.2.1 Asthma Diagnosis at Age Three

I begin by analyzing the effects of maternal inputs on a child asthma diagnosis. At age three, 19.71 percent of the children in the sample were reported as having been diagnosed with asthma by a doctor. Since low birthweight is highly correlated with a pediatric asthma

diagnosis, I include an indicator of low birthweight in the model specification. From a child's perspective, low birthweight (a measure of initial health) is completely exogenous. However, from the mother's standpoint, low birthweight is a potentially endogenous variable, since maternal behaviors (e.g., prenatal smoking and prenatal care) may significantly affect birthweight. Moreover, any unobserved maternal characteristics that affect birthweight may also affect postnatal maternal behaviors. In Table 5.1, I compare results from a model where maternal inputs and birthweight are treated as exogenous (Model 1), all maternal inputs are treated as endogenous (Model 2), and all inputs, including birthweight, are treated as endogenous (Model 3). Focusing first on Model 1, I find that contemporaneous maternal smoking is unrelated to an asthma diagnosis at age three, while breastfeeding and well-baby visits have a positive association. The finding that breastfeeding, when treated as exogenous, is positively related to an asthma diagnosis conflicts with the findings of many studies (e.g., Oddy et al., 2004) but is in agreement with others who report that breastfeeding has either no association or a positive association with asthma (Sears et al., 2002). Adequate well-baby visits is also positively related to a diagnosis of asthma at age three. This can be interpreted in several ways. The first is that children of parents who are more compliant with well-child visits are more likely to be diagnosed because of frequent contact with a medical provider. The second related explanation appeals more to unobserved heterogeneity. If parents know that their child has a poor health endowment (e.g., low birthweight or family history of asthma or other related conditions), then they may be more likely to take their children to well-child visits.[1] This possibility suggests that the coefficient may be biased upward when endogeneity of maternal behaviors is not considered.

Model 2 demonstrates the changes in parameter estimates after controlling for the endogeneity of maternal inputs, while treating low birthweight as exogeneous. After controlling for endogeneity of maternal health decisions (smoking, breastfeeding and well-baby visits), I find that while low birthweight significantly explains asthma diagnosis (at the one percent level), the coefficients on breastfeeding and well-baby visits become statistically insignificant. These

[1]Unfortunately, the only measure of family asthma history in FF is whether or not the mother took medication for asthma. This question was not asked in every city, and only 19 mothers in the sample reported taking asthma medication.

results appear to support the notion that low birthweight is strongly related to subsequent maternal behavior (Rosenzweig and Wolpin, 1988). Model 3 investigates this idea further by treating low birthweight and all other inputs as endogenous. While the statistical significance of low birthweight drops to five percent, the other inputs remain statistically insignificant. However, the coefficient on low birthweight (0.506) has increased by a factor of 6. Why does low birthweight have such a strong influence on the likelihood of an asthma diagnosis at age three? Babies that are born full-term, but at low birthweight, may have a greater likelihood of exhibiting respiratory symptoms (Caudri, 2007). One study finds a higher prevalence of asthma diagnosis, smaller lungs and hyperreactive airways in low birthweight infants born at term, than in premature low birthweight infants (Wjst et al., 1998). Having information on weight-for-age at birth (gestational age) would make it possible to determine whether the effects of low birthweight are strongest for low birthweight children who are born prematurely or low birthweight children who are born at term, but underdeveloped. A disadvantage of the restricted FF data is that there is no measure of gestational age for the children in the sample.[2]

Curiously, the smoking variable is never statistically significant in any of the three models previously discussed. However, smoking does indeed affect the probability of an asthma diagnosis at year 3, through more indirect means. Table 5.4 shows the parameter estimates of a model explaining the effects of prenatal care and prenatal smoking on low birthweight (a dichotomous indicator) and birthweight (a continuous measure). While prenatal care is not statistically significant, prenatal smoking has a strong, positive and statistically significant effect on low birthweight (Table 5.4). The effects of prenatal smoking are examined in more detail in the simulations in section 5.9.

There is also a question of whether or not an asthma diagnosis is related to smoking behavior in the more distant past, namely, maternal smoking at age one. The results are presented in Appendix Table 1. The results are similar to those found in the previous specifications (Table 5.1), with few differences. The major distinction is that in Model 3, the

[2]According to the Fragile Families website, www.fragilefamilies.princeton.edu, the medical records data are slated to become available in Summer 2007. However, the medical records data are available for less than half the sample, N=1803.

statistical significance of low birthweight drops to the five percent level and the coefficient estimate is somewhat reduced (from 0.506 to 0.410). Also, well-baby visits become statistically significant at the ten percent level. It should be noted that in the previous set of models Table 5.1, the coefficient on well-baby visits falls just outside of the range of being statistically significant at the ten percent level. Therefore, I do not not attach a great amount of significance to this slightly altered result.

5.2.2 Asthma Diagnosis at Age Three, Alternative Definition

There are approximately 56 mothers who reported that their child had been diagnosed with asthma at age one, but reported their child had never been diagnosed at wave 3. Alternatively, I can recode the responses to whether a child was ever diagnosed with asthma (asked when the child reached three years of age) to include positive responses from the same question asked when the child was age one. This alternative definition of asthma reveals asthma among 22.38 percent of the sample.

	Survey Responses	**Alternative Definition**
Asthma at age one	13.63%	13.63%
Asthma at age three	19.71%	22.38%

Table 5.2 presents parameter estimates from models explaining asthma diagnosis at Wave 3 using the new definition of asthma diagnosis at age three. The parameter estimates here are slightly larger than those found in Table 5.1, but the results largely are the same in terms of statistical significance in Models 1 (all inputs treated as exogenous) and 2 (all maternal inputs treated as endogenous). The only major difference in this case is in Model 3, where all inputs are treated as endogenous. While the coefficient estimates (and statistical significance) are the same as before, well-baby visits are now statistically significant at the five percent level. Table 2 reports results of models where having ever been diagnosed with asthma (at age three) is regressed against maternal smoking at year one, as well as the other maternal inputs and low birthweight. The results here echo those found in the previous models (Table 1), but differences are found in Model 3, where all low birthweight and other inputs are treated as

endogenous. Although, as before, well-baby vists are positively related to an asthma diagnosis at the ten percent level , the statistical significance of low birthweight drops from the five percent to the ten percent level of significance.

Table 5.1: Parameter Estimates from Models Explaining Asthma Diagnosis at Age Three using Age Three Smoking Behavior

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.084***	(0.029)	0.099***	(0.037)	0.506**	(0.245)
Maternal Inputs						
Smoked, age three	0.006	(0.021)	-0.095	(0.123)	-0.118	(0.127)
Breastfed	0.038**	(0.019)	0.102	(0.129)	0.175	(0.118)
Sufficient Visits	0.112***	(0.022)	0.317	(0.256)	0.505	(0.312)
Child Characteristics						
Child's age, in years	-0.031	(0.054)	-0.039	(0.046)	-0.036	(0.049)
Child is male	0.080***	(0.017)	0.082***	(0.016)	0.083***	(0.016)
Parental Characteristics						
Mother is black	0.027	(0.030)	0.023	(0.041)	0.024	(0.034)
Mother is latino	0.060*	(0.033)	0.047	(0.041)	0.053	(0.042)
Mother is other ethnicity	0.080	(0.054)	0.100**	(0.041)	0.128***	(0.046)
Mother is immigrant	-0.109**	(0.048)	-0.159***	(0.054)	-0.170***	(0.051)
Years in U.S., if immigrant	0.001	(0.003)	0.002	(0.003)	0.003	(0.003)
Mother's age	0.001	(0.002)	0.001	(0.003)	0.000	(0.003)
Biological father's age	-0.002	(0.002)	-0.001	(0.002)	-0.002	(0.002)
Income	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Mother completed high school	-0.030	(0.022)	-0.029	(0.028)	-0.020	(0.036)
Mother attended some college	-0.001	(0.023)	-0.018	(0.031)	-0.026	(0.034)
Mother has bachelor's degree	0.011	(0.038)	-0.026	(0.040)	-0.033	(0.047)
Medicaid	0.046**	(0.021)	0.042*	(0.024)	0.032	(0.026)
Local Characteristics						
Ozone (ppm)	-0.155	(0.266)	-0.209	(0.240)	-0.167	(0.322)
Particulate matter (ppm/100)	-0.004	(0.005)	-0.005	(0.005)	-0.005	(0.007)
Carbon monoxide (ppm)	-0.012	(0.098)	0.001	(0.106)	-0.009	(0.118)
Percent hispanic	0.031	(0.063)	-0.015	(0.076)	-0.041	(0.080)
Percent black	0.061	(0.045)	0.034	(0.051)	0.017	(0.047)
Percent other ethnicity	0.784	(0.584)	0.764	(0.677)	0.784	(0.627)
Percent foreign-born	-0.094	(0.096)	-0.120	(0.090)	-0.137	(0.103)
Percent with h.s. degree	-0.155	(0.105)	-0.210*	(0.108)	-0.232**	(0.108)
Percent unemployed	-0.160	(0.225)	-0.338	(0.364)	-0.503	(0.371)
Percent vacant housing	0.352**	(0.162)	0.427**	(0.189)	0.477**	(0.203)
Percent on welfare	-0.047	(0.222)	0.027	(0.302)	0.125	(0.282)
Tract variables missing	-0.048	(0.110)	-0.121	(0.108)	-0.146	(0.130)
Interview Characteristics						
2002 Interview	0.044	(0.029)	0.049*	(0.026)	0.027	(0.037)
Intercept	0.319	(0.227)	0.396	(0.253)	0.328	(0.284)

Note: Standard errors are in parentheses. *** indicates significance at the 1% level; ** 5%; * 10%.

Table 5.2: Parameter Estimates from Models Explaining Asthma Diagnosis at Age Three (Alternative Definition) using Age Three Smoking Behavior

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.090***	(0.030)	0.107***	(0.032)	0.553**	(0.270)
Maternal Inputs						
Smoked, age three	0.014	(0.022)	-0.137	(0.121)	-0.132	(0.143)
Breastfed	0.040**	(0.019)	0.055	(0.129)	0.142	(0.118)
Sufficient Visits	0.095***	(0.024)	0.326	(0.291)	0.562**	(0.263)
Child Characteristics						
Child's age, in years	-0.024	(0.056)	-0.030	(0.063)	-0.027	(0.057)
Child is male	0.082***	(0.018)	0.083***	(0.017)	0.085***	(0.015)
Parental Characteristics						
Mother is black	0.028	(0.031)	0.012	(0.042)	0.018	(0.042)
Mother is latino	0.080**	(0.035)	0.059	(0.045)	0.070*	(0.043)
Mother is other ethnicity	0.085	(0.056)	0.101**	(0.048)	0.131**	(0.065)
Mother is immigrant	-0.126**	(0.050)	-0.171***	(0.056)	-0.178***	(0.051)
Years in U.S., if immigrant	0.000	(0.003)	0.002	(0.003)	0.003	(0.002)
Mother's age	0.001	(0.002)	0.001	(0.002)	0.000	(0.003)
Biological father's age	-0.002	(0.002)	-0.002	(0.001)	-0.002	(0.002)
Income	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Mother completed high school	-0.045**	(0.023)	-0.046	(0.039)	-0.030	(0.036)
Mother attended some college	0.004	(0.024)	-0.007	(0.035)	-0.015	(0.028)
Mother has bachelor's degree	0.019	(0.040)	-0.016	(0.037)	-0.018	(0.039)
Medicaid	0.054**	(0.022)	0.048*	(0.027)	0.035	(0.023)
Local Characteristics						
Ozone (ppm)	-0.146	(0.278)	-0.209	(0.283)	-0.158	(0.269)
Particulate matter (ppm/100)	-0.004	(0.006)	-0.005	(0.006)	-0.005	(0.005)
Carbon monoxide (ppm)	0.027	(0.103)	0.041	(0.108)	0.025	(0.091)
Percent hispanic	0.004	(0.066)	-0.055	(0.076)	-0.081	(0.084)
Percent black	0.066	(0.047)	0.032	(0.056)	0.014	(0.067)
Percent other ethnicity	0.789	(0.611)	0.769	(0.656)	0.744	(0.692)
Percent foreign-born	-0.056	(0.100)	-0.074	(0.099)	-0.091	(0.131)
Percent with h.s. degree	-0.207*	(0.110)	-0.261**	(0.109)	-0.281**	(0.121)
Percent unemployed	-0.238	(0.235)	-0.428	(0.399)	-0.632**	(0.275)
Percent vacant housing	0.269	(0.169)	0.361	(0.233)	0.424**	(0.182)
Percent on welfare	0.043	(0.232)	0.131	(0.306)	0.234	(0.307)
Tract variables missing	-0.104	(0.115)	-0.180	(0.126)	-0.207	(0.143)
Interview Characteristics						
2002 Interview	0.041	(0.030)	0.043	(0.032)	0.019	(0.035)
Intercept	0.350	(0.238)	0.478	(0.330)	0.377	(0.259)

Note: Standard errors are in parentheses. *** indicates significance at the 1% level; ** 5%; * 10%.

5.2.3 Asthma Diagnosis at Age One

At age one, 13.63 percent of the children were reported as having been diagnosed with asthma. Table 5.3 presents the estimated relationships between low birthweight and other maternal inputs on an asthma diagnosis at age one. In Model 1, where all inputs are treated as exogenous, low birthweight is positively related to a diagnosis of asthma at year three. However, none of the other variables are statistically significant. In Model 2 low birthweight is treated as exogenous but the other maternal inputs are modeled. Here, low birthweight is still positively related to an asthma diagnosis, but the other inputs remain statisically insignificant. However, when low birthweight is modeled along with the other inputs (Model 3), it too becomes statistically insignificant.

Why do low birthweight and each of the other inputs appear unrelated to asthma at age one? Doctors may simply be more reluctant to diagnose infants with asthma because of the difficulty in doing so with very young children. Infants have smaller airways and are more prone to various respiratory ailments. For example, in very young children, wheezing (one of the common symptoms of asthma) can be caused by any number of factors, including prenatal smoking. Some of these wheezing phenotypes are benign and are outgrown by the third birthday. There are also wheezing symptoms that can be caused by viral or other respiratory infections that are not necessarily precursors to asthma (Mutius, 2000). There are newer technologies that have emerged that are designed to increase the accuracy of asthma diagnoses in young children – but these new methods are being used in children who are at least three years old.[3] In summary, it is unsurprising that neither low birthweight nor any other inputs are related to an asthma diagnosis at age one.

[3]One form of new testing is exhaled nitric oxide (FE_{NO}), a non-invasive method that is being used to test for lung inflammation. One study finds that (FE_{NO}) is superior to other more traditional forms of testing in identifying pre-school aged children who have asthma (Malmberg et al., 2003).

Table 5.3: Parameter Estimates from Models Explaining Asthma Diagnosis at Age One using Smoking at Age One

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.088***	(0.025)	0.085***	(0.032)	0.171	(0.236)
Maternal Inputs						
Smoked, age one	0.012	(0.017)	-0.054	(0.118)	-0.100	(0.120)
Breastfed	0.012	(0.016)	-0.077	(0.158)	-0.070	(0.210)
Sufficient Visits	0.034	(0.031)	-0.202	(0.408)	-0.641	(0.525)
Child Characteristics						
Child's age, in years	0.043	(0.040)	0.041	(0.046)	0.039	(0.039)
Child is male	0.083 ***	(0.015)	0.083***	(0.016)	0.084***	(0.017)
Parental Characteristics						
Mother is black	0.049*	(0.026)	0.019	(0.044)	-0.006	(0.042)
Mother is latino	0.072**	(0.029)	0.049	(0.034)	0.028	(0.042)
Mother is other ethnicity	0.082*	(0.047)	0.074*	(0.044)	0.080	(0.054)
Mother is immigrant	-0.119***	(0.041)	-0.119**	(0.058)	-0.152*	(0.080)
Years in U.S., if immigrant	0.001	(0.003)	0.002	(0.002)	0.003	(0.002)
Mother's age	0.000	(0.002)	0.000	(0.003)	-0.001	(0.002)
Biological father's age	-0.001	(0.002)	-0.001	(0.002)	-0.001	(0.001)
Income	0.000	(0.001)	0.000	(0.000)	0.000	(0.001)
Mother completed high school	-0.029	(0.019)	-0.020	(0.032)	0.000	(0.028)
Mother attended some college	-0.009	(0.020)	-0.002	(0.032)	-0.012	(0.043)
Mother has bachelor's degree	-0.020	(0.033)	-0.015	(0.034)	-0.021	(0.038)
Medicaid	0.036**	(0.018)	0.035**	(0.018)	0.036**	(0.015)
Local Characteristics						
Ozone (ppm)	-0.219	(0.212)	-0.224	(0.242)	-0.217	(0.219)
Particulate matter (ppm/100)	-0.005	(0.005)	-0.005	(0.005)	-0.005	(0.005)
Carbon monoxide (ppm)	0.050	(0.068)	0.059	(0.069)	0.062	(0.084)
Percent hispanic	-0.052	(0.057)	-0.052	(0.061)	-0.053	(0.057)
Percent black	0.001	(0.040)	0.009	(0.042)	0.024	(0.044)
Percent other ethnicity	-0.251	(0.544)	-0.273	(0.403)	-0.145	(0.487)
Percent foreign-born	0.084	(0.082)	0.136	(0.097)	0.188*	(0.110)
Percent with h.s. degree	-0.109	(0.094)	-0.080	(0.127)	-0.063	(0.125)
Percent unemployed	0.043	(0.185)	0.046	(0.244)	0.015	(0.230)
Percent vacant housing	0.125	(0.134)	0.172	(0.196)	0.246	(0.193)
Percent on welfare	0.085	(0.172)	0.046	(0.176)	0.040	(0.242)
Tract variables missing	-0.074	(0.104)	-0.063	(0.120)	-0.078	(0.123)
Interview Characteristics						
2001 Interview	-0.022	(0.028)	-0.020	(0.034)	-0.018	(0.028)
Intercept	0.145	(0.166)	0.419	(0.390)	0.820	(0.515)

Note: Standard errors are in parentheses. *** indicates significant at the 1 % level; ** 5%; * 10% .

5.3 Prenatal Inputs and Birthweight

In the following section, I examine the effects of prenatal inputs on low birthweight, or the probability that an infant weighs less than 2500 grams at birth ($P(W_0 < 2500 \text{ grams})$).[4] The prenatal inputs include prenatal care in the first trimester and prenatal smoking. Weight at birth is measured in order to capture initial child health.

5.3.1 Prenatal Care in the First Trimester

More than 82 percent of the expectant mothers in the sample reported attending their first prenatal care visit during the first trimester. The results of the estimation can be found in the first two columns of Table 5.4. Interestingly, race does not appear to play a critical role in determining prenatal care initiation in the first trimester of pregnancy, with the exception of mothers who fall in the other ethnicity category. These mothers are less likely to attend care in the first trimester. However, due to the extremely small size of this category (N=70) and its considerable ethnic heterogeneity, it is difficult to ascribe any meaning to the significance of this variable. Older mothers are more likely to attend care, which is not unexpected, given that this group is more likely to face pregnancy complications (Jolly et al., 2000). Women who are cohabitating and have more adults in the household are more likely to go to early care, while women with more children are less likely to do so. Having more children may either proxy for more experience with pregnancy (and thus less urgency to initiate care) and/or the time and resource constraints associated with more offspring. Women who have more income, as well as college-educated women are also more likely to initiate care in the first trimester. Finally, more obstetricians per 100,000 women are associated with earlier prenatal care.

5.3.2 Prenatal Smoking

Prenatal smoking is another input that is thought to affect birthweight. 19.81 percent of the mothers in the sample reported smoking during their pregnancy. In contrast to prenatal care, there are clearly strong ethnic differences in smoking behavior. Black, latino and immigrant mothers are *much* less likely to smoke in comparison with white mothers – between 17 and

[4]Models using a continuous specification of birthweight can be found in Appendix Table 12

19 percent. Mothers in the other ethnicity category are also less likely to smoke. Older women and those receiving Medicaid assistance are more likely to smoke. However, women with more income, education and who are religious (attend weekly church services) are less likely to smoke. There is also some evidence that the ethnic composition of a neighborhood is associated with health behavior – those mothers who lived in more heavily Hispanic (or latino) census tracts were less likely to smoke. Those who lived in census tracts where greater percentages of the residents were high school graduates were also less likely to smoke. There appears to be a non-linear effect of cigarette prices. At lower levels, an increase in the price of cigarettes is associated with more smoking, but after prices exceed a threshold of 200 cents, there is an inverse relationship between prices and smoking behavior.[5]

5.3.3 Low Birthweight

The child health outcome in the first period is low birthweight, also a measure of initial child health. 9.79 percent of the sample children were born weighing less than 2500 grams. Of the two prenatal health behaviors, only smoking has a significant effect on low birthweight. Mothers who smoke are 26 percent more likely to give birth to low birthweight infants. Despite controlling for prenatal inputs, ethnicity is still associated with initial child health. Black and latino mothers are more likely to have low birthweight infants, at the one and five percent levels of significance, respectively. Oddly, mothers who completed some college were more likely to give birth to low birthweight children, but only at the ten percent level of significance. Although in theory a health production function should only contain health inputs/behaviors and biological characteristics, I include measures of income, education and neighborhood factors that also may serve as indicators of resource access or omitted health inputs. Medicaid usage also has a positive relationship with low birthweight and is likely serving as a proxy for low-income/resource access. Women who lived in tracts with greater percentages of residents on welfare or were from other ethnicities or had more vacant neighborhood housing, were less likely to have low birthweight children. The coefficients on the neighborhood variables do

[5]The marginal effect of cigarette prices on prenatal smoking behavior, $\frac{\partial S_0}{\partial P_c} = .004 - 0.00000837 * 2 * \overline{P_c}$. This implies that smoking behavior begins to decline among pregnant women after cigarette prices exceed $2 per pack.

not move in the expected direction here–one would expect areas of greater poverty to have poorer health outcomes. Given the fairly low level of statistical significance, it is likely that correlations are somewhat spurious.

Table 5.4: Parameter Estimates from Models Explaining Endogenous Prenatal Inputs and Low Birthweight

Variable	Prenatal Care in 1st Trimester		Prenatal Smoking		Low Birthweight	
Maternal Inputs						
Prenatal care in 1st trimester					0.171	(0.111)
Prenatal Smoking					0.262***	(0.068)
Child Characteristics						
Child is male					-0.012	(0.013)
Parental Characteristics						
Mother is black	0.010	(0.030)	-0.192***	(0.028)	0.074***	(0.025)
Mother is latino	-0.041	(0.036)	-0.178***	(0.018)	0.052**	(0.026)
Mother is other ethnicity	-0.147**	(0.072)	-0.069*	(0.036)	0.011	(0.033)
Mother is immigrant	0.040	(0.042)	-0.160***	(0.022)	-0.021	(0.029)
Years in U.S., if immigrant	0.000	(0.003)	0.007	(0.005)	0.001	(0.002)
Mother's age	0.005**	(0.002)	0.006***	(0.002)	0.002	(0.002)
Married	0.040	(0.026)	-0.105***	(0.022)		
Cohabitating	0.040**	(0.020)	-0.010	(0.020)		
Biological father's age	-0.002	(0.002)	0.004***	(0.002)	-0.001	(0.001)
No. of adults in household	0.024**	(0.011)	0.011	(0.011)		
Grandmother present	-0.023	(0.025)	0.008	(0.025)		
No. of children in household	-0.021***	(0.006)	0.003	(0.006)		
Income	0.001**	(0.001)	-0.002***	(0.001)	0.000	(0.001)
Mother completed high school	0.002	(0.020)	-0.097***	(0.023)	0.031*	(0.018)
Mother attended some college	0.016	(0.021)	-0.028	(0.021)	-0.003	(0.016)
Mother has bachelor's degree	0.099***	(0.030)	-0.113***	(0.023)	0.009**	(0.029)
Medicaid	-0.032	(0.020)	0.041**	(0.019)	0.042**	(0.019)
Mother is religious	-0.007	(0.018)	-0.085***	(0.016)		
Local Characteristics						
Percent hispanic	0.010	(0.059)	-0.177***	(0.062)	0.035	(0.048)
Percent black	-0.014	(0.044)	0.008	(0.042)	-0.005	(0.044)
Percent other ethnicity	0.480	(0.646)	0.248	(0.557)	-0.566*	(0.326)
Percent foreign-born	-0.143	(0.091)	0.162	(0.106)	-0.083	(0.056)
Percent with h.s. degree	0.073	(0.098)	-0.168*	(0.100)	-0.066	(0.080)
Percent unemployed	-0.047	(0.175)	-0.009	(0.177)	0.085	(0.169)
Percent vacant housing	0.125	(0.136)	0.043	(0.129)	-0.189*	(0.103)
Percent on welfare	-0.084	(0.156)	-0.125	(0.160)	-0.186*	(0.110)
Obstetricians per 100k	0.002*	(0.001)				
Cigarette price (cents)			0.004*	(0.002)		
Cigarette price, squared			-0.000*	(0.000)		
Anti-Smoking Laws			-0.001	(0.056)		
Spring birth					0.054***	(0.013)
Summer birth					0.044**	(0.019)
Interview Characteristics						
1999 Interview	-0.027	(0.020)	-0.008	(0.027)	0.086***	(0.014)
Intercept					-0.181	(0.112)

Note: Both prenatal inputs are estimated using the probit method; marginal effects are reported. Standard errors are in parentheses.*** indicates significance at the 1% level; ** 5%; * 10%.

5.4 Postnatal Smoking

In the previous section on prenatal inputs and birth outcomes, I explored the determinants of prenatal smoking. In the following section, I will discuss the factors that influence mothers' smoking decisions when their children are one and three years of age, respectively. All postnatal smoking behavior is theorized to be influenced by initial child health. In the first set of models (Model I), low birthweight is treated as exogenous and smoking is estimated using the probit method. The marginal effects of the estimation are reported rather than the coefficients. In the second set of models (Model II), low birthweight is treated as endogenous, requiring that smoking be estimated using the linear probability technique.

5.4.1 Smoking at Age Three

When their children are aged three, 25.51 percent of the mothers in the sample report having smoked during the month preceding the survey. Table 5.5 presents the parameter estimates of models explaining age three smoking behavior. The first set of estimates, Model I, treats birthweight as exogenous. Low birthweight is associated with a higher probability of smoking at the one percent level. A logical assumption would be that mothers would alter their smoking behavior (e.g., reduce intensity or quit) if their child's initial health was poor. Instead, we see that these women continue to smoke even more in comparison to mothers who had children of normal birthweight. Smoking at age three, much like prenatal smoking, is strongly correlated with ethnicity. In comparison to white women, black and latino are much less likely to smoke. The effect appears to be even stronger for immigrant women, who are 22 percent less likely than native-born women to smoke when their children are three years old. Also less likely to smoke are women who are married, educated and religious. At age three, there is even stronger evidence of neighborhood characteristics affecting or being correlated with health behavior. While women who live in primarily black and hispanic census tracts are less likely to smoke, mothers who live in tracts with greater proportions of welfare recipients are more likely to smoke. Mothers who live in tracts with a greater percentage of residents falling into the 'other' ethnicity category (e.g asian, pacific islander) are also more likely to smoke. Finally, women who reside in cities/counties with anti-smoking laws are ten percent less likely

to smoke than those who do not.

In Model II, where birthweight is modeled, the coefficient on low birthweight has increased by a factor of almost 12 (from 0.090 to 1.064). This can be interpreted to mean that women who had low birthweight children are more than twice as likely to smoke when their children reach the age of three compared to women with normal birthweight children. Clearly, there are many potential health inputs that influence birthweight, such as nutrition, levels of activity, drinking and drug use (Guilkey et al., 1989). Due to data limitations, I have only been able to control for a very small proportion of those inputs, prenatal care and smoking. The coefficient estimate on low birthweight may be picking up some unobserved factors that I have not controlled for that influence both birthweight *and* subsequent smoking behavior. These unobserved factors could include a tendency to engage in other unhealthy behaviors. Another potential explanation is that mothers who have low birthweight children may experience stress arising from the medical issues surrounding having a sick infant. These stressors may increase the likelihood that mothers will smoke – hence, the increased coefficient on low birthweight. The parameter estimates in Model II, including parental and local characteristics, are qualitatively the same as those in Model I.

5.4.2 Smoking at Age One

When the children in the sample reached the age of one, 27.93 of their mothers reported having smoked in the month preceding the survey. Smoking at age one is a function of low birthweight and other parental and local characteristics (Table 5.6). Model I treats low birthweight as exogenous. Similarly to smoking at age three, mothers who had low birthweight children are more likely (14 percent) to smoke when their children are one year old. As before, black and latino mothers are much less likely to smoke compared to white mothers. Immigrant mothers are also much less likely to smoke than mothers born in the United States. Other factors negatively associated with age one smoking are being married, having completed high school, some college, or having a bachelor's degree and being religious. Of the parental characteristics, only one is positively associated with smoking. Mothers who have greater numbers of adults in the household are more likely to smoke. Local characteristics continue to be strongly

associated with smoking behavior. Mothers who live in more heavily hispanic census tracts are much less likely to smoke, as are those who live in tracts where greater proportions of the residents are high school degree recipients. Mothers who live in tracts with more vacant housing units are more likely to smoke. There is also a non-linear effect of cigarette prices. At lower levels, an increase in cigarette prices is positively associated with smoking, but at higher levels[6] are associated with decreased levels of smoking incidence. Mothers who live in areas with anti-smoking legislation are also much less likely to report smoking in their children's first year of life.

Model II treats low birthweight as endogenous. Modeling low birthweight causes the parameter estimate to increase seven-fold from the previous estimate (from 0.146 to 1.082) and implies that mothers of low birtweight children are more than twice as likely to smoke during the first year. As explained previously, these results can be attributed to either other factors that might influence low birthweight and smoking behavior and/or postpartum stress attributable to giving birth to a low birthweight child. The parameter estimates on parental and local characteristics are again qualitatively the same in Model II compared to Model I.

[6]Similarly to prenatal smoking, the marginal effect of cigarette prices on mothers' smoking behavior is ,$\frac{\partial S_0}{\partial P_c} = .007 - 0.0000117 * 2 * \overline{P_c}$. The solution implies that smoking behavior begins to decline among mothers (when their children are aged one) after cigarette prices exceed nearly $3 per pack.

Table 5.5: Parameter Estimates from Models Explaining Smoking at Age Three

Variable	Model I Birthweight Exogenous		Model II Birthweight Endogenous	
Initial Child Health				
Low birthweight	0.090***	(0.034)	1.064***	(0.211)
Parental Characteristics				
Mother is black	-0.128***	(0.032)	-0.150***	(0.029)
Mother is latino	-0.117***	(0.030)	-0.118***	(0.032)
Mother is other ethnicity	0.063	(0.072)	0.078	(0.055)
Mother is immigrant	-0.220***	(0.028)	-0.136***	(0.030)
Years in U.S., if immigrant	0.008	(0.005)	0.002	(0.002)
Mother's age	0.000	(0.002)	-0.004	(0.003)
Married	-0.086**	(0.037)	-0.057	(0.043)
Cohabitating	0.014	(0.033)	0.009	(0.040)
Biological father's age	-0.001	(0.001)	0.000	(0.001)
No. of adults in household	0.015	(0.014)	0.017	(0.018)
Grandmother present	0.032	(0.037)	0.025	(0.047)
No. of children in household	0.004	(0.008)	0.012	(0.009)
Pregnant during period	-0.016	(0.021)	-0.025	(0.020)
Income	0.000	(0.000)	0.000	(0.001)
Mother completed high school	-0.089***	(0.025)	-0.093***	(0.023)
Mother attended some college	-0.050**	(0.024)	-0.033	(0.023)
Mother has bachelor's degree	-0.165***	(0.027)	-0.114***	(0.036)
Mother is religious	-0.098***	(0.019)	-0.083***	(0.020)
Local Characteristics				
Percent hispanic	-0.249***	(0.071)	-0.247***	(0.057)
Percent black	-0.125***	(0.049)	-0.122**	(0.050)
Percent other ethnicity	1.103*	(0.631)	1.142	(0.606)
Percent foreign-born	0.075	(0.127)	0.071	(0.118)
Percent with h.s. degree	-0.150	(0.115)	-0.118	(0.109)
Percent unemployed	0.026	(0.240)	-0.051	(0.268)
Percent vacant housing	0.088	(0.171)	0.140	(0.160)
Percent on welfare	0.491**	(0.244)	0.635***	(0.223)
Tract variables missing	-0.142**	(0.064)	-0.147	(0.122)
Cigarette price (cents)	-0.002	(0.002)	-0.001	(0.001)
Cigarette price, squared	0.000	(0.000)	0.000	(0.000)
Anti-Smoking Laws	-0.100**	(0.041)	-0.069	(0.047)
Interview Characteristics				
2001 Interview	-0.030	(0.023)	-0.071***	(0.026)
Intercept			0.748***	(0.285)

Note: Model I is estimated using the probit method; marginal effects are reported.
Standard errors are in parentheses.*** indicates significance at the 1% level; ** 5%; * 10%.

Table 5.6: Parameter Estimates from Models Explaining Smoking at Age One

Variable	Model I Birthweight Exogenous		Model II Birthweight Endogenous	
Initial Child Health				
Low birthweight	0.146***	(0.037)	1.082***	(0.241)
Parental Characteristics				
Mother is black	-0.212***	(0.034)	-0.231***	(0.034)
Mother is latino	-0.159***	(0.030)	-0.162***	(0.045)
Mother is other ethnicity	0.020	(0.069)	0.043	(0.064)
Mother is immigrant	-0.231***	(0.032)	-0.163***	(0.028)
Years in U.S., if immigrant	0.006	(0.005)	0.002	(0.002)
Mother's age	0.003	(0.002)	-0.001	(0.002)
Married	-0.099***	(0.028)	-0.068***	(0.022)
Cohabitating	0.018	(0.022)	0.008	(0.025)
Biological father's age	-0.001	(0.001)	-0.001	(0.001)
No. of adults in household	0.025*	(0.013)	0.024*	(0.014)
Grandmother present	-0.038	(0.031)	-0.040	(0.028)
No. of children in household	0.003	(0.008)	0.012	(0.008)
Pregnant during period	-0.024	(0.028)	-0.027	(0.025)
Income	-0.001	(0.001)	-0.001	(0.001)
Mother completed high school	-0.109***	(0.026)	-0.104***	(0.027)
Mother attended some college	-0.064**	(0.025)	-0.047**	(0.023)
Mother has bachelor's degree	-0.133***	(0.035)	-0.103***	(0.037)
Mother is religious	-0.117***	(0.020)	-0.098***	(0.020)
Local Characteristics				
Percent hispanic	-0.188**	(0.076)	-0.179***	(0.070)
Percent black	-0.045	(0.053)	-0.042	(0.050)
Percent other ethnicity	0.988	(0.743)	1.182	(0.855)
Percent foreign-born	0.168	(0.130)	0.169	(0.110)
Percent with h.s. degree	-0.262**	(0.125)	-0.187	(0.121)
Percent unemployed	-0.423	(0.245)	-0.462**	(0.217)
Percent vacant housing	0.226*	(0.174)	0.317*	(0.190)
Percent on welfare	0.144	(0.221)	0.277	(0.178)
Tract variables missing	-0.171	(0.066)	-0.144	(0.131)
Cigarette price (cents)	0.008*	(0.005)	0.007*	(0.004)
Cigarette price, squared	-0.000*	(0.000)	0.000*	(0.000)
Anti-Smoking Laws	-0.115***	(0.041)	-0.089**	(0.041)
Interview Characteristics				
2001 Interview	0.005	(0.024)	0.047**	(0.023)
Intercept			-0.509**	(0.674)

Note: Model I is estimated using the probit method; marginal effects are reported.
Standard errors are in parentheses.*** indicates significance at the 1% level; ** 5%; * 10%.

5.5 Other Endogenous Inputs

Other endogenous inputs in the model include breastfeeding, measured at age one, and adequate well-baby visits measured at ages one and three. As with postnatal smoking, each of the other inputs are a function of low birthweight. There are two models that will be presented for each of the inputs. In Model I, low birthweight is treated as endogenous and the endogenous input is estimated using the probit method. As before, the marginal effects are reported rather than the coefficients. In Model II low birthweight is treated as endogenous and each of the inputs is estimated using the linear probability model.

5.5.1 Breastfeeding

At age one, more than 54.49 percent of the children had been breastfed at some point. Model I displays results from a specification where low birthweight is treated as endogneous. Unlike postnatal smoking, there appears to be no statistically significant relationship between the incidence of breastfeeding and low birthweight. Black mothers are much less likely to initiate breastfeeding, compared to white women. Although the employment decision is not included in the model specification, the decision to breastfeed is almost certainly correlated with the decision to work. In the data, 75 percent of the mothers report working during the child's first year. While 71 percent of the white mothers report working, over 82 percent of the black mothers work. Thus, the coefficient may be reflect different preferences for work among black mothers. Maternal age is also negatively associated with the likelihood of breastfeeding. Married women are more likely to breastfeed, as well as those with increasing levels of educational attainment. Religiosity is also positively associated with breastfeeding. The association of local characteristics with breastfeeding provide interesting results. Women who live in census tracts with higher percentages of residents who are immigrants are more likely to breastfeed, as are those who live in tracts with greater proportions of high school graduates. Given that the time costs of breastfeeding are considerably higher for employed mothers, it follows that mothers who live in census tracts with greater rates of unemployment are also more likely to breastfeed. The price of infant formula is also positively related to the likelihood of breastfeeding. Since breastmilk and formula can be considered substitute

goods (although they are often used in conjunction), there should be an inverse relationship between formula prices and the rate of breastfeeding initiation. Lastly, women who live in areas that have laws supporting public breastfeeding area are also more likely to initiate the practice.

In Model II, low birthweight is treated as endogenous. In this scenario, the coefficient on low birthweight is large and statistically significant at the one percent level. Mothers who have low birthweight children are more two times less likely to breastfeed, a result that is in agreement with previous research (Rosenzweig and Wolpin, 1988). Most of the other estimates are qualitatively similar to those in Model I, with a few exceptions. Mothers falling in the 'other' ethnicity category are less likely to breastfeed. Also, mothers with greater numbers of children are less likely to initiate breastfeeding, reflecting the time/resource tradeoff between raising other children and breastfeeding the focal child. The coefficients on the percentage of immigrants in the mother's census tract and state breastfeeding laws are no longer statistically significant.

Table 5.7: Parameter Estimates from Models Explaining Breastfeeding

Variable	Model I Birthweight Exogenous		Model II Birthweight Endogenous	
Initial Child Health				
Low birthweight	-0.053	(0.039)	-1.029***	(0.233)
Parental Characteristics				
Mother is black	-0.112***	(0.041)	-0.089***	(0.035)
Mother is latino	-0.048	(0.047)	-0.062	(0.039)
Mother is other ethnicity	-0.099	(0.082)	-0.159***	(0.060)
Mother is immigrant	0.354***	(0.046)	0.274***	(0.040)
Years in U.S., if immigrant	-0.006	(0.005)	-0.003	(0.003)
Mother's age	-0.006**	(0.003)	-0.001	(0.003)
Married	0.064*	(0.035)	0.031	(0.038)
Cohabitating	-0.003	(0.026)	0.009	(0.021)
Biological father's age	0.001	(0.001)	0.000	(0.001)
No. of adults in household	-0.008	(0.016)	-0.005	(0.012)
Grandmother in household	-0.003	(0.039)	0.005	(0.030)
No. of children in household	-0.012	(0.010)	-0.021**	(0.009)
Pregnant during period	0.030	(0.034)	0.032	(0.028)
Income	0.004***	(0.001)	0.002***	(0.001)
Mother completed high school	0.025	(0.030)	0.023	(0.025)
Mother attended some college	0.178***	(0.029)	0.155***	(0.025)
Mother has bachelor's degree	0.194***	(0.047)	0.137***	(0.043)
Mother is religious	0.083***	(0.026)	0.061***	(0.021)
Local Characteristics				
Percent hispanic	0.045	(0.096)	0.051	(0.090)
Percent black	0.059	(0.063)	0.050	(0.045)
Percent other ethnicity	-1.364	(0.844)	-1.175	(0.882)
Percent foreign-born	0.281**	(0.133)	0.169	(0.118)
Percent with h.s. degree	0.438***	(0.150)	0.291*	(0.166)
Percent unemployed	0.532*	(0.296)	0.421*	(0.252)
Percent vacant housing	0.166	(0.216)	0.062	(0.168)
Percent on welfare	-0.384	(0.288)	-0.433**	(0.216)
Tract variables missing	0.354***	(0.072)	0.317*	(0.189)
Price of infant formula	0.253**	(0.123)	0.215**	(0.090)
Breastfeeding laws	0.054*	(0.030)	0.041	(0.026)
Interview Characteristics				
2001 Interview	0.069**	(0.031)	0.012	(0.027)
Intercept			-0.227	(0.268)

Note: Model I is estimated using the probit method; marginal effects are reported.
Standard errors are in parentheses.*** indicates significance at the 1% level; ** 5%; * 10%.

5.5.2 Well-Baby Visits

In the following section, I examine the factors that affect whether parents take their children to adequate well-baby visits or not during the first and third years of life. Both well-baby visits up to age one and age three are thought to be a function of initial child health. In the first specification (Model I), low birthweight is treated as exogenous and adequate well-baby visits is estimated using the probit method. The marginal effects of the estimation are reported. In the second model, (Model II), low birthweight is treated as endogenous, requiring that smoking be estimated using the linear probability technique.

5.5.3 Well-Baby Visits at Age Three

At age three, 18.19 percent of the children in the data had attended four or more well-baby visits in the past year. In Model I, low birthweight is treated as an exogenous variable, whereas in Model II it is treated as endogenous. In contrast to the coefficient estimates on other inputs, low birthweight is statistically insignificant in both sets of models. This result is a little surprising. Intuitively, one would expect mothers of low birthweight children to take them to more well-baby visits. However, I have not measured the number of times that children went to the doctor for illness, which may reflect the behavior of mothers with children that are more likely to have medical issues. In Model I, mothers with more adults residing in the household are more likely to attend adequate well-baby visits, perhaps because there are more people to share child caretaking duties. Mothers who completed high school are less likely to take their children to adequate visits at age three, but mothers on Medicaid were more likely to do so. Mothers who lived in predominantly hispanic and black census tracts or tracts where there was more unemployment were more likely to take their children to adequate well-child visits. However, mothers who lived in neighborhoods with more vacant housing were less likely to take their children to adequate well-baby visits. The parameter estimates in Model II do not differ substantively from Model I, except that the coefficient on the percentage of hispanic residient in the mother's census tract becomes statistically insignificant.

Table 5.8: Parameter Estimates from Models Explaining Well-Baby Visits at Age Three

Variable	Model I Birthweight Exogenous		Model II Birthweight Endogenous	
Initial Child Health				
Low birthweight	-0.006	(0.028)	0.021	(0.200)
Parental Characteristics				
Mother is black	-0.022	(0.029)	-0.022	(0.028)
Mother is latino	-0.007	(0.033)	-0.006	(0.031)
Mother is other ethnicity	-0.028	(0.053)	-0.027	(0.046)
Mother is immigrant	0.010	(0.047)	0.011	(0.054)
Years in U.S., if immigrant	-0.004	(0.003)	-0.004	(0.003)
Mother's age	0.000	(0.002)	0.000	(0.002)
Married	-0.041	(0.037)	-0.040	(0.042)
Cohabitating	-0.049	(0.031)	-0.049	(0.033)
Biological father's age	0.000	(0.001)	0.000	(0.001)
No. of adults in household	0.022*	(0.013)	0.022	(0.016)
Grandmother present	0.020	(0.032)	0.020	(0.035)
No. of children in household	0.010	(0.007)	0.010	(0.008)
Pregnant during period	0.005	(0.019)	0.004	(0.017)
Income	0.000	(0.000)	0.000	(0.000)
Mother completed high school	-0.065***	(0.021)	-0.065***	(0.019)
Mother attended some college	0.000	(0.022)	0.001	(0.024)
Mother has bachelor's degree	0.015	(0.037)	0.016	(0.031)
Medicaid	0.038*	(0.021)	0.037*	(0.022)
Mother is religious	0.018	(0.018)	0.019	(0.017)
Local Characteristics				
Percent hispanic	0.111*	(0.060)	0.111	(0.069)
Percent black	0.081*	(0.044)	0.081*	(0.042)
Percent other ethnicity	0.690	(0.571)	0.692	(0.684)
Percent foreign-born	0.048	(0.096)	0.050	(0.097)
Percent with h.s. degree	0.087	(0.101)	0.089	(0.099)
Percent unemployed	0.750***	(0.216)	0.750***	(0.245)
Percent vacant housing	-0.301**	(0.157)	-0.298*	(0.153)
Percent on welfare	-0.052	(0.217)	-0.050	(0.232)
Tract variables missing	0.170	(0.106)	0.172*	(0.103)
Pediatricians per 100k children	0.000	(0.000)	0.000	(0.000)
Interview Characteristics				
2001 Interview	0.010	(0.020)	0.009	(0.022)
Intercept			0.007	(0.110)

Note: Model I is estimated using the probit method; marginal effects are reported.
Standard errors are in parentheses.*** indicates significance at the 1% level; ** 5%; * 10%.

5.5.4 Well-Baby Visits at Age One

At age one, 93.97 percent of the children in the data had attended four or more well-baby visits during the first year of life. As before, Model I, treats low birthweight as exogenous variable and Model II treats it as endogenous. I find that the coefficient estimate on low birthweight is again insignificant in both model specifications. In Model I, immigrant mothers are less likely to take their children to adequate well-child visits in the first year. This result is unsurprising – immigrants face a host of barriers to care, including language and cultural differences. Mothers with more adults and children in the household are less likely to attend adequate well-baby visits in the first year. Having more children requires that time and resources be taken away from one child to another – hence the negative association between well-child visits and more children. Mothers who completed high school has a positive association with more well-child visits. Lastly, I find that mothers who lived in more heavily immigrant census tracts were more likely to take their children to more well-child visits. This result is somewhat counterintuitive, given that immigrant mothers are *less* likely to take their children to well-child visits. However, there seems to be evidence that communities can have positive influences on health behaviors (Freudenberg et al., 1994), resolving the seemingly paradoxical results. In Model II, there are several differences. In addition to immigrant women, latino mothers are now less likely to take their children to adequate well-child visits. More interesting is that having a grandmother in the household is positively related to having more well-child visits. It appears that maternal influence, at least to a small degree, helps to drive the focal mothers' behaviors.

Table 5.9: Parameter Estimates from Models Explaining Well-Baby Visits at Age One

Variable	Model I Birthweight Exogenous		Model II Birthweight Endogenous	
Initial Child Health				
Low birthweight	-0.030	(0.019)	-0.137	(0.122)
Parental Characteristics				
Mother is black	-0.022	(0.018)	-0.021	(0.017)
Mother is latino	-0.030	(0.024)	-0.034*	(0.020)
Mother is other ethnicity	0.012	(0.030)	0.003	(0.023)
Mother is immigrant	-0.081*	(0.048)	-0.066**	(0.029)
Years in U.S., if immigrant	0.003	(0.002)	0.003	(0.002)
Mother's age	0.000	(0.001)	0.000	(0.001)
Married	0.010	(0.014)	0.009	(0.015)
Cohabitating	0.000	(0.010)	0.004	(0.012)
Biological father's age	0.000	(0.000)	0.000	(0.000)
No. of adults in household	-0.011**	(0.005)	-0.016*	(0.009)
Grandmother present	0.019	(0.012)	0.032*	(0.019)
No. of children in household	-0.008**	(0.004)	-0.011**	(0.005)
Pregnant during period	0.006	(0.013)	0.006	(0.015)
Income	0.000	(0.000)	0.000	(0.000)
Mother completed high school	0.053***	(0.016)	0.054***	(0.015)
Mother attended some college	-0.023	(0.016)	-0.021	(0.014)
Mother has bachelor's degree	-0.002	(0.026)	-0.014	(0.023)
Medicaid	0.010	(0.012)	0.014	(0.015)
Mother is religious	0.000	(0.010)	-0.001	(0.011)
Local Characteristics				
Percent hispanic	0.015	(0.034)	0.018	(0.047)
Percent black	0.034	(0.026)	0.031	(0.030)
Percent other ethnicity	-0.041	(0.371)	-0.018	(0.412)
Percent foreign-born	0.138**	(0.057)	0.139**	(0.056)
Percent with h.s. degree	0.040	(0.058)	0.038	(0.079)
Percent unemployed	-0.003	(0.110)	0.005	(0.131)
Percent vacant housing	0.081	(0.079)	0.098	(0.128)
Percent on welfare	-0.078	(0.097)	-0.106	(0.142)
Tract variables missing	0.003	(0.058)	-0.040	(0.093)
Pediatricians per 100k children	0.000	(0.000)	0.000	(0.000)
Interview Characteristics				
2001 Interview	-0.001	(0.011)	-0.008	(0.014)
Intercept			0.920***	(0.085)

Note: Model I is estimated using the probit method; marginal effects are reported.
Standard errors are in parentheses.*** indicates significance at the 1% level; ** 5%; * 10%.

5.6 Asthma Diagnosis by Ethnicity

In the following section, Tables 5.10-5.12 present the estimates of the effects of maternal inputs and birthweight from models estimated separately by ethnicity. Estimated effects of child, maternal and local characteristics can be found in the appendix The more complete models can be found in the appendix. I stratified the sample in order to determine whether or not there are any differences in the relationships between maternal inputs and child asthma for the full sample (n=2105), blacks (n=1041), whites (n=504) and latinos (n=490). It is evident that there can be substantial differences in maternal behavior across groups. For example, black and latino mothers are much less likely to smoke relative to whites (Tables 5.5 and 5.6) and latino and immigrant mothers are much more likely to have breastfed their children (Table 5.7). Any results that follow must be interpreted with caution, due to the much smaller sample sizes, particularly for whites and latinos. I will focus on any differences in the final models where all inputs are treated as endogenous (Model 3).

5.6.1 Asthma at Age Three, Smoking at Age Three

In contrast to the full sample, where low birthweight has a strong relationship with an asthma diagnosis at age three, low birthweight is not significant for blacks (Table 5.10), whites (Table 5.11) or latinos (Table 5.12). However, in the latino sample, there is a *positive* and significant relationship between breastfeeding and a diagnosis of asthma. The children born to latino mothers were more likely to be diagnosed with asthma if they had been breastfed. As aforementioned, the relationship with asthma and breastfeeding is not altogether clear. The survey also does not contain information on mixed infant/child feeding methods. For example, latino mothers are more likely to bottlefeed longer relative to whites or blacks[7], a practice that has been linked to childhood obesity, particularly among latino children at age three (Kimbro et al., 2007). Given the strong links found between childhood obesity and the development of pediatric asthma (Shamssain, 2006), this may explain why breastfeeding is associated with a higher likelihood of asthma diagnosis among latinos. The results using smoking at age one

[7] In a study of bottlefeeding practices found among whites, blacks and Mexican-Americans, 36.8% of Mexican American children were still bottle-fed at ages 2 to 4, compared with 16.9% of white and 13.8% of black children (Brotanek et al., 2005).

do not differ qualitatively from the previous results.

5.6.2 Asthma at Age One

When each of the inputs is treated as endogenous, almost none of the estimated coefficients on the inputs is significant in either the full sample or the black, white and latino samples. However, here we see that low birthweight black children are more likely to be diagnosed with asthma at age one. This confirms the findings of a study which found that black low birthweight infants were five times more likely to develop asthma than other children born at low birthweight (Joseph et al., 2002).

Table 5.10: Parameter Estimates from Models Explaining Asthma Diagnosis in Blacks

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Asthma Diagnosis at Age Three Using Age Three Smoking Behavior						
Initial Child Health						
Low birthweight	0.099**	(0.040)	0.094	(0.052)	0.480	(0.406)
Maternal Inputs						
Smoked, age three	-0.005	(0.030)	0.039	(0.194)	-0.024	(0.193)
Breastfed	0.051*	(0.028)	0.108	(0.215)	0.133	(0.257)
Sufficient Visits	0.107***	(0.033)	0.329	(0.337)	0.421	(0.381)
Asthma Diagnosis at Age Three Using Age One Smoking Behavior						
Initial Child Health						
Low birthweight	0.103**	(0.040)	0.123	(0.051)	0.512	(0.416)
Maternal Inputs						
Smoked, age one	-0.026	(0.031)	-0.232	(0.256)	-0.390	(0.260)
Breastfed	0.049*	(0.028)	-0.088	(0.282)	-0.206	(0.367)
Sufficient Visits	0.108***	(0.033)	0.304	(0.277)	0.382	(0.418)
Asthma Diagnosis at Age One Using Age One Smoking Behavior						
Initial Child Health						
Low birthweight	0.095***	(0.036)	0.074	(0.059)	0.639*	(0.362)
Maternal Inputs						
Smoked, age one	0.006	(0.028)	0.010	(0.253)	-0.168	(0.273)
Breastfed	0.014	(0.025)	0.105	(0.365)	-0.019	(0.401)
Sufficient Visits	0.039	(0.048)	-0.659	(0.594)	-1.178	(0.754)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 5.11: Parameter Estimates from Models Explaining Asthma Diagnosis in Whites

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Asthma Diagnosis at Age Three Using Age Three Smoking Behavior						
Initial Child Health						
Low birthweight	0.060	(0.055)	0.077	(0.074)	0.735	(0.380)
Maternal Inputs						
Smoked, age three	-0.011	(0.035)	-0.138	(0.225)	-0.197	(0.203)
Breastfed	0.016	(0.036)	-0.076	(0.236)	-0.018	(0.256)
Sufficient Visits	0.103**	(0.047)	0.716	(0.772)	1.085*	(0.571)
Asthma Diagnosis at Age Three Using Age One Smoking Behavior						
Initial Child Health						
Low birthweight	0.062	(0.055)	0.047	(0.068)	0.386	(0.481)
Maternal Inputs						
Smoked, age one	-0.017	(0.034)	0.219	(0.211)	0.245	(0.251)
Breastfed	0.015	(0.035)	0.220	(0.353)	0.270	(0.335)
Sufficient Visits	0.103**	(0.047)	0.774	(0.613)	1.052*	(0.509)
Asthma Diagnosis at Age One Using Age One Smoking Behavior						
Initial Child Health						
Low birthweight	0.082**	(0.039)	0.016	(0.057)	-0.120	(0.468)
Maternal Inputs						
Smoked, age one	-0.010	(0.024)	-0.044	(0.200)	-0.110	(0.285)
Breastfed	-0.008	(0.026)	0.000	(0.333)	-0.215	(0.461)
Sufficient Visits	-0.043	(0.058)	-2.344**	(1.075)	-1.449	(1.162)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 5.12: Parameter Estimates from Models Explaining Asthma Diagnosis in Latinos

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Asthma Diagnosis at Age Three Using Age Three Smoking Behavior						
Initial Child Health						
Low birthweight	0.083	(0.075)	0.108	(0.104)	0.152	(0.573)
Maternal Inputs						
Smoked, age three	0.061	(0.050)	-0.019	(0.391)	0.100	(0.400)
Breastfed	0.047	(0.040)	0.421	(0.248)	0.595**	(0.299)
Sufficient Visits	0.095**	(0.045)	0.412	(0.491)	0.638	(0.504)
Asthma Diagnosis at Age Three Using Age One Smoking Behavior						
Initial Child Health						
Low birthweight	0.092	(0.074)	0.077	(0.101)	0.130	(0.637)
Maternal Inputs						
Smoked, age one	0.129***	(0.047)	0.311	(0.306)	0.292	(0.323)
Breastfed	0.048	(0.039)	0.649**	(0.307)	0.752*	(0.345)
Sufficient Visits	0.098**	(0.045)	0.400	(0.495)	0.663	(0.495)
Asthma Diagnosis at Age One Using Age One Smoking Behavior						
Initial Child Health						
Low birthweight	0.092	(0.065)	0.085	(0.090)	-0.381	(0.648)
Maternal Inputs						
Smoked, age one	0.078*	(0.042)	0.139	(0.379)	0.415	(0.376)
Breastfed	0.004	(0.035)	-0.105	(0.492)	0.292	(0.578)
Sufficient Visits	0.077	(0.060)	0.523	(0.481)	0.040	(0.756)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

5.7 Asthma Attacks

5.7.1 Asthma Attacks at Age Three

Of the children who had been diagnosed with asthma at age three, 53 percent had experienced at least one asthma attack in the year preceding the survey. Results are reported in Table 5.13. Models 1, 2 and 3 analyze the effects of low birthweight and other maternal inputs on asthma attacks at age three. Model 1 treats low birthweight and maternal health inputs as exogenous. Each of the coefficients on the inputs is statistically insignificant, with the exception of that on well-baby visits, which is positive and statistically significant at the one percent level. Keeping in mind that any coefficients in Model 1 are likely to be biased (due to endogeneity), it is worth noting that children who attend more well-baby visits are simply more likely to have asthma attacks. In this case, children who attend adequate well-baby visits at age three are more than 15 percent more likely than those who do not to have an asthma attack. In Model 2, low birthweight remains exogenous, but the other inputs are modeled and treated as endogenous. It appears that after purging the input measures of unobservables that may be correlated with asthma attack, well-baby visits become statistically insignificant. It is likely that mothers who know their children's health endowment are more likely to act on it by taking their children to more well-baby visits (or even asthma-related checkups) in order to help prevent asthma-related morbidity. However, smoking at age three has a negative and significant relationship with an asthma diagnosis at age three. Conventional wisdom and most research would take the position that a mother's smoking should make it *more* likely that a child would have an asthma attack, rather than less likely. However, when smoking is modeled (treating low birthweight as exogenous), there is a strong correlation between smoking at age three and low birthweight. Mothers do not appear to alter their smoking behavior (at least in terms of of cessation rates) upon having a low birthweight child. However, it is possible that mothers may have altered the intensity of their smoking based on a past diagnosis of asthma. Evidence for this theory is mixed. One study found that parental smoking behavior did not change after a pediatric asthma diagnosis (Liema et al., 2004). Other studies reported that telling parents of asthmatic children not to smoke failed to alter parental smoking behavior

or child health (Wakefield et al., 2002). Unfortunately, the more detailed questions about smoking intensity are measured in the third wave of the survey, making it very difficult to infer anything about changes in smoking behavior. When each of the inputs is treated as endogenous (Model 3), none of the inputs are statistically significant.

5.7.2 Asthma Attacks at Age One

At age one, 63 percent of the children who had been diagnosed with asthma had experienced at least one asthma attack in the previous year. Table 5.14 displays estimates of the parameters on low birthweight and each of the maternal inputs. In Model 1, each of the inputs is treated as endogenous and none are statistically significant. On the surface, it appears that maternal inputs have no relationship to asthma attacks at age one. However, when maternal inputs are modeled, with low birthweight treated as endogenous (Model 2), maternal smoking is positively related to the probability of an asthma attack. In fact, the coefficient of 1.07 implies that asthmatic children with mothers who smoke are more than *twice* as likely to have an asthma attack compared to asthmatic children with non-smoking mothers. These results are very interesting compared to the results at age three, where smoking is negatively related to asthma attacks. Evidence suggests that the negative effects of smoking are even stronger in younger children (Jones et al., 2000). In Model 3, where each of the endogenous inputs is modeled, the results are the same. Maternal smoking in the first year is still positively related to the likelihood of an asthma attack.

Table 5.13: Parameter Estimates from Models Explaining Asthma Attacks at Age Three

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.095	(0.072)	0.131	(0.090)	0.231	(0.974)
Maternal Inputs						
Smoked, age three	-0.080	(0.057)	-0.622**	(0.332)	-0.600	(0.384)
Breastfed	0.037	(0.054)	-0.274	(0.362)	-0.307	(0.459)
Sufficient Visits	0.154***	(0.057)	0.073	(0.659)	0.496	(0.657)
Child Characteristics						
Child's age, in years	0.027	(0.159)	-0.022	(0.161)	-0.006	(0.183)
Child is male	0.048	(0.052)	0.055	(0.054)	0.055	(0.056)
Parental Characteristics						
Mother is black	0.008	(0.095)	-0.113	(0.123)	-0.110	(0.115)
Mother is latino	-0.016	(0.100)	-0.094	(0.131)	-0.085	(0.096)
Mother is other ethnicity	-0.221	(0.182)	-0.255	(0.201)	-0.260	(0.213)
Mother is immigrant	-0.212	(0.198)	-0.284	(0.213)	-0.267	(0.263)
Years in U.S., if immigrant	0.015	(0.015)	0.016	(0.015)	0.018	(0.014)
Mother's age	0.005	(0.006)	0.005	(0.007)	0.004	(0.007)
Biological father's age	0.005	(0.005)	0.003	(0.005)	0.004	(0.005)
Income	-0.001	(0.002)	0.000	(0.002)	0.000	(0.002)
Mother completed high school	0.071	(0.062)	0.013	(0.072)	0.049	(0.093)
Mother attended some college	0.032	(0.070)	0.046	(0.091)	0.051	(0.106)
Mother has bachelor's degree	-0.090	(0.128)	-0.140	(0.161)	-0.120	(0.179)
Medicaid	0.079	(0.067)	0.078	(0.070)	0.063	(0.074)
Local Characteristics						
Ozone (ppm)	-0.057	(0.795)	-0.191	(0.773)	-0.189	(0.819)
Particulate matter (ppm/100)	0.003	(0.016)	0.001	(0.015)	0.001	(0.015)
Carbon monoxide (ppm)	0.061	(0.281)	0.049	(0.278)	0.044	(0.295)
Percent hispanic	0.086	(0.194)	-0.067	(0.256)	-0.119	(0.219)
Percent black	0.022	(0.136)	-0.041	(0.142)	-0.067	(0.162)
Percent other ethnicity	0.650	(1.534)	1.382	(2.151)	1.114	(2.179)
Percent foreign-born	-0.210	(0.302)	-0.145	(0.285)	-0.179	(0.334)
Percent with h.s. degree	0.011	(0.319)	0.047	(0.341)	0.009	(0.345)
Percent unemployed	0.240	(0.563)	0.307	(0.785)	-0.027	(0.755)
Percent vacant housing	-0.567	(0.391)	-0.412	(0.435)	-0.330	(0.465)
Percent on welfare	0.016	(0.527)	0.347	(0.609)	0.381	(0.596)
Tract variables missing	-0.010	(0.329)	-0.012	(0.367)	-0.091	(0.345)
Interview Characteristics						
2001 Interview	0.075	(0.086)	0.067	(0.080)	0.053	(0.098)
Intercept	-0.114	(0.669)	0.584	(0.759)	0.515	(0.847)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 5.14: Parameter Estimates from Models Explaining Asthma Attacks at Age One

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.013	(0.082)	-0.151	(0.112)	-0.109	(0.830)
Maternal Inputs						
Smoked, age three	0.055	(0.058)	1.073*	(0.699)	1.171**	(0.785)
Breastfed	0.092	(0.067)	1.159	(0.894)	1.479	(1.106)
Sufficient Visits	-0.102	(0.139)	-2.137*	(1.333)	-2.152	(1.804)
Child Characteristics						
Child's age, in years	0.084	(0.161)	0.033	(0.183)	0.042	(0.123)
Child is male	0.133**	(0.061)	0.165**	(0.057)	0.154**	(0.065)
Parental Characteristics						
Mother is black	-0.018	(0.135)	0.285	(0.287)	0.344	(0.336)
Mother is latino	0.025	(0.140)	0.253	(0.201)	0.249	(0.240)
Mother is other ethnicity	-0.010	(0.251)	0.117	(0.328)	0.159	(0.330)
Mother is immigrant	0.010	(0.409)	-0.297	(0.445)	-0.318	(0.441)
Years in U.S., if immigrant	0.003	(0.034)	0.016	(0.035)	0.014	(0.033)
Mother's age	-0.002	(0.006)	-0.003	(0.008)	-0.001	(0.009)
Biological father's age	0.017***	(0.006)	0.020***	(0.006)	0.019***	(0.007)
Income	0.005	(0.002)	0.002	(0.003)	0.002	(0.004)
Mother completed high school	-0.011	(0.063)	0.214*	(0.100)	0.207*	(0.124)
Mother attended some college	0.122	(0.090)	-0.027	(0.148)	-0.073	(0.159)
Mother has bachelor's degree	-0.054	(0.213)	-0.002	(0.232)	-0.057	(0.231)
Medicaid	0.114	(0.070)	0.121*	(0.074)	0.122*	(0.072)
Local Characteristics						
Ozone (ppm)	1.260	(0.700)	1.374	(0.844)	1.484**	(0.980)
Particulate matter (ppm/100)	0.029	(0.015)	0.029	(0.018)	0.031**	(0.022)
Carbon monoxide (ppm)	-0.320	(0.225)	-0.383*	(0.212)	-0.388	(0.217)
Percent hispanic	0.136	(0.282)	0.262	(0.301)	0.289	(0.202)
Percent black	0.015	(0.192)	0.102	(0.188)	0.069	(0.156)
Percent other ethnicity	1.948	(2.962)	1.529	(3.267)	2.116	(2.998)
Percent foreign-born	-0.220	(0.483)	-0.602	(0.587)	-0.604	(0.450)
Percent with h.s. degree	-0.501	(0.404)	-0.513	(0.541)	-0.622	(0.526)
Percent unemployed	0.129	(0.383)	0.015	(0.439)	-0.034	(0.430)
Percent vacant housing	0.346	(0.653)	0.131	(0.604)	0.214	(0.625)
Percent on welfare	-0.685	(0.559)	-0.952	(0.709)	-0.965	(0.685)
Tract variables missing	0.703	(0.698)	0.709	(0.811)	0.703	(0.803)
Interview Characteristics						
2001 Interview	-0.028	(0.100)	-0.117	(0.153)	-0.122	(0.119)
Intercept	-0.683	(0.697)	0.205	(1.704)	-0.022	(1.944)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

5.8 Asthma Hospitalizations

5.8.1 Asthma Hospitalizations at Year 3

Of the children diagnosed with asthma at age three, 40 percent of them had been hospitalized with an asthma-related condition in the year preceding the survey. Table 5.15 displays the results of the estimation. When all of the inputs are treated as exogenous, (Model 1), only well-baby visits is statistically significant. Children who have had more well-baby visits are more likely to have experienced an asthma-related hospitalization. Again, in this case, mothers who take their children to more well-baby visits may feel that children who are in poorer health need to attend more visits. When treating maternal inputs as endogenous (Model 2) and then all inputs as endogenous (Model 3) , none of the inputs are statistically significant.

5.8.2 Asthma Hospitalizations at Year 1

At age one, 58 percent of asthmatic children had been hospitalized due to asthma. Estimates of the parameters of each model can be found in Table 5.16. In Model 1, where all inputs are exogenous, there are no statistically significant coefficients. However after endogenizing each of the maternal inputs in Model 2, I find that well-baby visits is *negative* and statistically significant, in contrast to the results found in Table (X). When low birthweight is treated as endogenous (in addition to each of the maternal inputs) in Model 4, the coefficient on well-baby visits grows even larger. This suggests that parents who take their children to more well-baby visits in the *first* year may be more proficient at helping their child avoid more severe asthma-related complications or are better able to manage asthma attacks/episodes at home. These results imply that, at least at very young ages, compliance with well-baby visits (which may proxy for preventative asthma care) can help prevent more severe asthma-related complications.

Table 5.15: Parameter Estimates from Models Explaining Asthma Hospitalizations at Age Three

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.015	(0.070)	0.009	(0.066)	0.756	(0.906)
Maternal Inputs						
Smoked, age three	0.020	(0.056)	-0.035	(0.394)	-0.047	(0.411)
Breastfed	-0.030	(0.052)	0.018	(0.349)	0.052	(0.399)
Sufficient Visits	0.186***	(0.055)	0.456	(0.606)	0.680	(0.801)
Child Characteristics						
Child's age, in years	-0.069	(0.156)	-0.103	(0.150)	-0.099	(0.164)
Child is male	0.037	(0.051)	0.038	(0.045)	0.044	(0.058)
Parental Characteristics						
Mother is black	-0.032	(0.093)	-0.024	(0.127)	-0.022	(0.121)
Mother is latino	0.064	(0.098)	0.078	(0.123)	0.100	(0.088)
Mother is other ethnicity	-0.087	(0.178)	-0.032	(0.202)	0.001	(0.185)
Mother is immigrant	-0.072	(0.193)	-0.158	(0.272)	-0.122	(0.281)
Years in U.S., if immigrant	0.009	(0.015)	0.011	(0.019)	0.010	(0.021)
Mother's age	-0.002	(0.006)	0.000	(0.006)	-0.003	(0.007)
Biological father's age	0.005	(0.005)	0.004	(0.004)	0.004	(0.004)
Income	0.000	(0.002)	0.001	(0.002)	0.001	(0.003)
Mother completed high school	0.042	(0.060)	0.048	(0.092)	0.062	(0.088)
Mother attended some college	-0.032	(0.069)	-0.057	(0.083)	-0.054	(0.092)
Mother has bachelor's degree	-0.153	(0.125)	-0.186	(0.148)	-0.168	(0.145)
Medicaid	0.025	(0.065)	0.024	(0.073)	-0.003	(0.062)
Local Characteristics						
Ozone (ppm)	0.293	(0.777)	0.175	(0.705)	0.232	(0.807)
Particulate matter (ppm/100)	0.012	(0.015)	0.010	(0.014)	0.011	(0.016)
Carbon monoxide (ppm)	0.041	(0.274)	0.043	(0.286)	0.029	(0.285)
Percent hispanic	0.076	(0.189)	-0.026	(0.253)	-0.044	(0.228)
Percent black	0.273**	(0.133)	0.206	(0.161)	0.193	(0.169)
Percent other ethnicity	-0.037	(1.500)	-0.075	(1.924)	0.027	(2.329)
Percent foreign-born	0.265	(0.322)	0.144	(0.459)	0.175	(0.392)
Percent with h.s. degree	0.104	(0.296)	0.078	(0.343)	0.099	(0.355)
Percent unemployed	0.072	(0.312)	0.032	(0.432)	0.066	(0.360)
Percent vacant housing	0.389	(0.551)	0.166	(0.778)	-0.047	(0.935)
Percent on welfare	-0.336	(0.382)	-0.276	(0.432)	-0.168	(0.436)
Tract variables missing	-0.118	(0.515)	0.016	(0.624)	0.150	(0.647)
Interview Characteristics						
2001 Interview	-0.003	(0.085)	-0.006	(0.098)	0.033	(0.106)
Intercept	-0.039	(0.700)	0.140	(0.666)	-0.006	(0.833)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10% .

Table 5.16: Parameter Estimates from Models Explaining Asthma Hospitalizations at Age One

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.093	(0.082)	0.089	(0.084)	0.477	(0.865)
Maternal Inputs						
Smoked, Age 3	0.070	(0.067)	0.627	(0.610)	0.598	(0.648)
Breastfed	-0.008	(0.065)	0.823	(0.878)	0.982	(1.102)
Sufficient Visits	0.011	(0.127)	-3.751*	(1.837)	-4.231**	(2.370)
Child Characteristics						
Child's age, in years	0.223	(0.150)	0.194	(0.218)	0.176	(0.193)
Child is male	0.094	(0.063)	0.116*	(0.065)	0.118*	(0.069)
Parental Characteristics						
Mother is black	0.075	(0.128)	0.196	(0.246)	0.175	(0.271)
Mother is latino	0.043	(0.137)	0.081	(0.181)	0.058	(0.224)
Mother is other ethnicity	0.102	(0.228)	0.227	(0.253)	0.235	(0.225)
Mother is immigrant	-0.540	(0.342)	-0.904*	(0.499)	-0.930*	(0.606)
Years in U.S., if immigrant	0.043	(0.029)	0.056*	(0.034)	0.054	(0.039)
Mother's age	-0.001	(0.007)	-0.004	(0.008)	-0.005	(0.009)
Biological father's age	0.010	(0.006)	0.011**	(0.007)	0.012**	(0.006)
Income	0.003	(0.003)	0.002	(0.003)	0.002	(0.004)
Mother completed high school	-0.115	(0.071)	0.153	(0.133)	0.175	(0.161)
Mother attended some college	0.220**	(0.087)	0.037	(0.163)	0.011	(0.195)
Mother has bachelor's degree	0.111	(0.219)	0.088	(0.316)	0.088	(0.241)
Medicaid	0.086	(0.080)	0.094	(0.090)	0.100	(0.084)
Local Characteristics						
Ozone (ppm)	-0.087	(0.862)	0.124	(1.047)	0.118	(0.901)
Particulate matter (ppm/100)	-0.002	(0.019)	0.001	(0.022)	0.001	(0.019)
Carbon monoxide (ppm)	-0.182	(0.223)	-0.202	(0.213)	-0.222	(0.259)
Percent hispanic	0.236	(0.256)	0.362	(0.293)	0.406	(0.294)
Percent black	0.186	(0.175)	0.284	(0.178)	0.312*	(0.215)
Percent other ethnicity	1.917	(2.679)	2.151	(2.526)	2.595	(2.480)
Percent foreign-born	0.218	(0.384)	0.440	(0.493)	0.465	(0.503)
Percent with h.s. degree	0.472	(0.340)	0.445	(0.404)	0.466	(0.371)
Percent unemployed	0.818	(0.639)	0.669	(0.525)	0.596	(0.644)
Percent vacant housing	0.168	(0.443)	0.167	(0.565)	0.188	(0.543)
Percent on welfare	0.676	(0.676)	0.478	(0.525)	0.544	(0.761)
Tract variables missing	0.320	(0.415)	-0.080	(0.537)	-0.073	(0.572)
Interview Characteristics						
2001 Interview	0.027	(0.104)	-0.047	(0.152)	-0.055	(0.126)
Intercept	-0.800	(0.697)	1.916	(1.958)	2.303	(2.340)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10% .

5.9 Simulations

Table 5.17 gives an overview of the smoking behavior of the mothers in the sample over time. Surprisingly, about two thirds of the sample report that they had not smoked in the prenatal period or when their child was aged one or three. About fifteen percent of the sample appear to be persistent smokers, having reported that they had recently smoked each time the survey was taken. About 14 percent of the sample did not smoke prenatally, but began (or resumed) smoking by the time their children were three years of age. Finally, of the 111 mothers who smoked during the prenatal period (5 percent), most (N=91) eventually reported that they did not smoke after their children turned three years old.

Table 5.18 displays the results of simulations designed to show the total effect of prenatal smoking during each period based on Model 3, where each of the inputs [8] is treated as endogenous. The predicted distributions of each of the endogenous inputs and outcomes are presented in the second column.[9][10] The first set of simulations predict the effect of prenatal smoking on birthweight ($\frac{\partial W_0}{\partial S_0}$). Essentially, the procedure involves using the estimated coefficients from the birthweight and prenatal care equations to predict the distribution of low birthweight, alternately imposing the condition that $S_0 = 0$ and $S_0 = 1$. With the restriction that no mothers smoke in the prenatal period, 4.6 percent of sample children are born at a low birthweight, a forty-six percent decrease in likelihood from the sample average (9.9 percent). The results from simulations where all of the mothers are forced to smoke are even more striking – 30.1 percent of the children would be born at a low birthweight, an increase in the predicted value of low birthweight by a factor of three. These results imply that going from a scenario where mothers are non-smokers during the prenatal period to one where they do smoke results in an increase in the likelihood of low birthweight by a factor of more than

[8] Prenatal smoking and prenatal care are the relevant inputs for birthweight and breastfeeding, while postnatal smoking, breastfeeding and well-baby visits are inputs for asthma diagnosis.

[9] The actual sample distributions of each of the inputs are compared to the predicted distribution to demonstrate the fit of the model. The numbers are identical, rounded to three significant figures.

[10] The following results are presented with the caveat that there are no standard errors associated with each of the percentages. However, the simulations are still a method for presenting the quantitative implications of the models.

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The second set of simulations demonstrate the effects of prenatal smoking on the likelihood of an asthma diagnosis during the child's first year. In this case, I again re-estimated the birthweight equation as before (imposing the same restrictions that $S_0 = 0$ and $S_0 = 1$) and then estimating the asthma at age one equation. The total effects of smoking on asthma also involve computing the effects of low birthweight on the other endogenous inputs, including age one smoking, breastfeeding and well-baby visits. It appears that whether the mothers smoke or not during the prenatal period does have demonstrable effects on the likelihood of an asthma diagnosis. Compared to prenatal non-smokers, mothers who smoked during pregnancy were more than 35 percent more likely to be diagnosed with asthma (12.5 percent versus 18.3 percent).[11] [12]

Finally, the last set of simulations predict the effects of smoking behavior during the prenatal period and age three on the probability of an asthma diagnosis at age three. A similar procedure to those described in previous sections was applied.[13] The effects of prenatal smoking on an asthma diagnosis appears to have a slightly smaller effect at age three than at age one. The model simulation predicts that 18.6 percent of the children with mothers who did not smoke during pregnancy will be diagnosed with asthma age three, while 23.9 percent of those born to prenatal smokers will be diagnosed with asthma at age three. Compared to prenatal non-smokers, I find mothers who smoke are 28 percent more likely to have children diagnosed with asthma at age three.[14]

As a counterpoint, I also predict the distribution of asthma using the coefficients from

[11] $\frac{\partial A_1}{\partial S_0 S_1} = \frac{\partial A_1}{\partial W_0} \times \frac{\partial W_0}{\partial S_0} + \frac{\partial A_1}{\partial S_1} \times \frac{\partial S_1}{\partial W_0} \times \frac{\partial W_0}{\partial S_0} + \frac{\partial A_1}{\partial F_1} \times \frac{\partial F_1}{\partial W_0} \times \frac{\partial W_0}{\partial S_0} + \frac{\partial A_1}{\partial D_1} \times \frac{\partial D_1}{\partial W_0} \times \frac{\partial W_0}{\partial S_0}$

[12] Another approach to computing the total *net* effect of prenatal smoking is to compare the predicted distribution of health inputs when a mother smokes prenatally and when she does not. After differencing each input to find the net change in each behavior, I simply multiply the net change by the coefficient implied by Model 3 ($\frac{\partial A_1}{\partial W_0}$; $\frac{\partial A_1}{\partial S_1}$; $\frac{\partial A_1}{\partial F_1}$; $\frac{\partial A_1}{\partial D_1}$). Using this method, I find the percentage point change in the probability that a child will be diagnosed with asthma is 5.73, similar to the results that would be obtained subtracting the predicted values of asthma using the previous method discussed.

[13] Again, the total effect is: $\frac{\partial A_2}{\partial S_0 S_2} = \frac{\partial A_2}{\partial W_0} \times \frac{\partial W_0}{\partial S_0} + \frac{\partial A_2}{\partial S_2} \times \frac{\partial S_2}{\partial W_0} \times \frac{\partial W_0}{\partial S_0} + \frac{\partial A_2}{\partial F_1} \times \frac{\partial F_1}{\partial W_0} \times \frac{\partial W_0}{\partial S_0} + \frac{\partial A_2}{\partial D_2} \times \frac{\partial D_2}{\partial W_0} \times \frac{\partial W_0}{\partial S_0}$.

[14] Similarly, I calculate the net effect of prenatal smoking by comparing the predicted distributions of each of the inputs when a mother is a prenatal smoker and when she is not. The percentage point change is 5.44 , a result that is very close to that using the previously described method.

Model I, where each of the inputs is treated as exogenous (and assumed to be biased).[15] At age three, the model simulation predicts that 20.36 percent of children born to mothers who smoke prior to birth are diagnosed with asthma, compared to those who do not (19.6 percent). These results imply that failing to account for unobserved hetereogeneity can lead to inaccurate estimates of the potential impact of smoking on an asthma diagnosis at age three, since simulations from the preferred model (Model 3) imply that 23.9 percent of children of mothers who smoke prior to birth are diagnosed with asthma and that 18.6 percent of the children of non-smokers (in the prenatal period) have asthma. Similarly, at age one, simulations of the model predict that 14.34 percent of children with mothers who smoked during pregnancy will be diagnosed with asthma, compared to 13.46 percent of those who do not (a less than 1 percent change), again underestimating the impact of prenatal smoking. In comparison, the preferred model shows that mothers who eschew smoking during pregnancy are 35 percent less likely than mothers who do smoke to have a child diagnosed with asthma (12.5 percent vs. 18.3 percent).

I have shown that the effects of prenatal smoking potentially has a large impact on low birthweight, which in turn affects subsequent health behaviors and asthma diagnoses. Thus, a policymaker who desires to reduce the incidence of pediatric asthma should examine ways to reduce prenatal smoking. One potential mechanism is through raising the price of cigarettes. Previous model estimates (see Table 5.4) show that when the price of a pack of cigarettes exceed $2, smoking rates among pregnant women in the sample decrease. I perform several other simulations, where I increase the per-pack price of cigarettes faced by each woman. Given the fact at least twelve states are currently considering increases in tobacco taxes in order to reduce budget deficits (Wolf, 2007), it is worth noting whether these policy changes will result in any spillover effects with regards to child health. In the sample, approximately 19.8 percent of the women in the sample smoke in the prenatal period. I perform simulations to gauge the effect of raising the price per pack by $0.25, $0.50, $0.75 and $1.00.[16] When the price of cigarettes increases by $0.25, the prenatal smoking rates drop to 18.7 percent, a

[15] See appendix for table.

[16] See Appendix for table.

modest decrease of 5.6 percent. The predicted distribution continues to decline when prices are raised by 50 cents (16.8 percent) and 75 cents (14.36 percent). The most dramatic change comes from increasing the per pack cost of cigarettes by $1.00. In this case, the predicted distribution of prenatal smoking rates drops to 11.59 percent, a more than 40 percent decline from the smoking rates in the data.

Table 5.17: Mothers' Smoking History

	Smoked Prenatal	**Smoked Age One**	**Smoked Age Three**	**Percent Total**	**N**
Smoking Outcomes					
Never Smoked					
	No	No	No	66%	1385
Sometimes Smoked					
	No	Yes	Yes	6%	126
	No	No	Yes	4%	85
	No	Yes	No	4%	92
	Yes	Yes	No	3%	64
	Yes	No	No	1%	27
	Yes	No	Yes	1%	20
Always Smoked					
	Yes	Yes	Yes	15%	306
Total				100%	2105

Table 5.18: Simulations of Prenatal Smoking Behavior on Low Birthweight, Other Inputs and Asthma Diagnosis at Ages One and Three Using Model 3 (Preferred Model)

	Predicted Distribution	Simulation: prenatal non-smoker	Simulation: prenatal smoker
Outcome			
Child Health			
Low Birthweight	0.098	0.046	0.307
Asthma Diagnosis, Age One	0.136	0.125	0.183
Asthma Diagnosis, Age Three	0.197	0.186	0.239
Maternal Inputs			
Smoking, age one	0.279	0.223	0.506
Smoking, age three	0.198	0.200	0.478
Breastfeeding	0.545	0.600	0.329
Sufficient visits, age one	0.940	0.947	0.912
Sufficient visits, age three	0.182	0.181	0.186

Chapter 6

Conclusions and Future Research

Previous research on pediatric asthma either fails to control for the endogeneity of maternal inputs and/or model the effects of endogenous initial child health on subsequent maternal behaviors. I have demonstrated that not doing so can lead to biased parameter estimates of the effects of inputs on childhood asthma. My results, suggest not only that low birthweight is an important determinant of pediatric asthma diagnosis at age three, but that the most powerful effects of smoking are indirect through its effects on birthweight. Results from simulations suggest that increases in the per pack price of cigarettes may be one mechanism for reducing prenatal smoking rates. I also find that maternal inputs are most important in younger children. Smoking at age one is positively related to the likelihood of an asthma attack, suggesting that the effects of smoking are even more damaging in younger children. However, having adequate well-baby visits is *negatively* related to the likelihood of an age one asthma hospitalization, meaning that attending preventative care is key in reducing the likelihood of severe asthma-related complications.

While I believe that this work is a good starting point for examining the effects of maternal decisions on child health, I would like to expand the estimation techniques that I use to address unobserved hetereogeneity. Estimating all of the inputs jointly over time and modeling the distribution of the unobservables would be a more efficient and precise way to model the child health production function. In addition, the discrete factor method does not presuppose the distribution of the unobserved hetereogeneity (Mroz, 1999). The linear probability model, while a useful tool, suffers from several drawbacks – the error terms exhibit

severe non-normal distribution and heteroskedasticity. Also, the predicted probabilities tend to fall outside of the 0-1 interval (Verbeek, 2000). In terms of the data, I would like to continue my work in child asthma with data that has more complete information on family history and the household/neighborhood environment. Some of my results hint at the importance of environment in determining health behaviors and outcomes. I also would like to more precisely measure maternal inputs in the future. The benefits of breastfeeding (or lack thereof) that I find in the data may be a direct result of measurement – it is unclear in the data whether mothers exclusively breastfed. I also would like exact numbers of well-child visits from year to year. The negative relationship between well-child visits and asthma morbidity show that preventative care can and should be further studied.

Learning how to pick just a *few* of my ideas to study and model was one of the biggest challenges of the entire dissertation process. My overarching agenda has, and always will be, to use the tools I have acquired to disentangle the ways in which race and ethnicity are associated with health. Simply establishing that race, a suspect social construct at best, is correlated with health gives the policymaker poor information on how to address health disparities with limited resources. It is my hope that by modeling the relationships between race and socioeconomic status with access to care and health behavior that I can one day equip policymakers with better decision-making tools.

Appendix: Additional Charts and Graphs

Table 1: Parameter Estimates from Models Explaining Asthma Diagnosis at Age One Smoking Behavior

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.085***	(0.029)	0.094***	(0.038)	0.413**	(0.210)
Maternal Inputs						
Smoked, age one	0.002	(0.020)	-0.019	(0.123)	-0.043	(0.120)
Breastfed	0.038**	(0.019)	0.123	(0.157)	0.179	(0.183)
Sufficient Visits	0.112***	(0.022)	0.313	(0.245)	0.483*	(0.279)
Child Characteristics						
Child's age, in years	-0.031	(0.054)	-0.041	(0.053)	-0.038	(0.055)
Child is male	0.080***	(0.017)	0.081***	(0.016)	0.082***	(0.017)
Parental Characteristics						
Mother is black	0.026	(0.030)	0.036	(0.046)	0.033	(0.052)
Mother is latino	0.059*	(0.033)	0.059	(0.043)	0.061	(0.045)
Mother is other ethnicity	0.080	(0.054)	0.099*	(0.058)	0.120**	(0.055)
Mother is immigrant	-0.110**	(0.048)	-0.149***	(0.053)	-0.159***	(0.053)
Years in U.S., if immigrant	0.001	(0.003)	0.002	(0.002)	0.002	(0.002)
Mother's age	0.001	(0.002)	0.001	(0.003)	0.001	(0.002)
Biological father's age	-0.002	(0.002)	-0.001	(0.002)	-0.002	(0.002)
Income	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Mother completed high school	-0.031	(0.022)	-0.023	(0.034)	-0.015	(0.033)
Mother attended some college	-0.001	(0.023)	-0.018	(0.033)	-0.025	(0.033)
Mother has bachelor's degree	0.010	(0.038)	-0.016	(0.034)	-0.022	(0.041)
Medicaid	0.046**	(0.021)	0.042*	(0.023)	0.033	(0.023)
Local Characteristics						
Ozone (ppm)	-0.156	(0.266)	-0.201	(0.281)	-0.171	(0.234)
Particulate matter (ppm/100)	-0.004	(0.005)	-0.005	(0.006)	-0.005	(0.005)
Carbon monoxide (ppm)	-0.012	(0.098)	-0.002	(0.106)	-0.008	(0.091)
Percent hispanic	0.030	(0.063)	0.005	(0.062)	-0.017	(0.067)
Percent black	0.061	(0.045)	0.043	(0.047)	0.031	(0.048)
Percent other ethnicity	0.787	(0.584)	0.697	(0.645)	0.697	(0.697)
Percent foreign-born	-0.094	(0.096)	-0.119	(0.092)	-0.136	(0.108)
Percent with h.s. degree	-0.156	(0.105)	-0.199	(0.126)	-0.221**	(0.106)
Percent unemployed	-0.160	(0.225)	-0.339	(0.305)	-0.489	(0.328)
Percent vacant housing	0.352**	(0.162)	0.417***	(0.162)	0.461**	(0.218)
Percent on welfare	-0.045	(0.222)	-0.011	(0.278)	0.056	(0.304)
Tract variables missing	-0.049	(0.110)	-0.105	(0.139)	-0.129	(0.110)
Interview Characteristics						
2002 Interview	0.044	(0.029)	0.050*	(0.030)	0.034	(0.032)
Intercept	0.322	(0.227)	0.335	(0.300)	0.288	(0.248)

Note: Standard errors are in parentheses. *** indicates significance at the 1% level; ** 5%; * 10% .

Table 2: Parameter Estimates from Models Explaining Asthma Diagnosis at Age Three (Alternative Definition) using Age One Smoking Behavior

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.091 ***	(0.030)	0.100***	(0.047)	0.442*	(0.234)
Maternal Inputs						
Smoked, age one	0.000	(0.021)	-0.039	(0.128)	-0.033	(0.149)
Breastfed	0.039 **	(0.019)	0.077	(0.142)	0.158	(0.164)
Sufficient Visits	0.095***	(0.024)	0.319	(0.256)	0.539*	(0.279)
Child Characteristics						
Child's age, in years	-0.023	(0.056)	-0.033	(0.048)	-0.029	(0.053)
Child is male	0.082 ***	(0.018)	0.083***	(0.018)	0.084***	(0.017)
Parental Characteristics						
Mother is black	0.026	(0.031)	0.025	(0.046)	0.033	(0.060)
Mother is latino	0.078 **	(0.035)	0.072*	(0.041)	0.082*	(0.049)
Mother is other ethnicity	0.086	(0.056)	0.098	(0.062)	0.124**	(0.055)
Mother is immigrant	-0.129***	(0.050)	-0.157	(0.057)	-0.167***	(0.042)
Years in U.S., if immigrant	0.000	(0.003)	0.002	(0.003)	0.002	(0.002)
Mother's age	0.001	(0.002)	0.001	(0.002)	0.001	(0.003)
Biological father's age	-0.002	(0.002)	-0.002	(0.002)	-0.002	(0.002)
Income	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Mother completed high school	-0.046**	(0.023)	-0.037	(0.033)	-0.023	(0.027)
Mother attended some college	0.004	(0.024)	-0.006	(0.031)	-0.015	(0.030)
Mother has bachelor's degree	0.017	(0.040)	-0.002	(0.043)	-0.007	(0.036)
Medicaid	0.055 **	(0.022)	0.048**	(0.023)	0.036	(0.023)
Local Characteristics						
Ozone (ppm)	-0.150	(0.278)	-0.203	(0.280)	-0.155	(0.298)
Particulate matter (ppm/100)	-0.004	(0.006)	-0.005	(0.005)	-0.005	(0.006)
Carbon monoxide (ppm)	0.027	(0.103)	0.038	(0.104)	0.025	(0.130)
Percent hispanic	0.001	(0.065)	-0.028	(0.067)	-0.052	(0.077)
Percent black	0.065	(0.047)	0.046	(0.053)	0.029	(0.065)
Percent other ethnicity	0.801	(0.611)	0.675	(0.635)	0.645	(0.644)
Percent foreign-born	-0.057	(0.100)	-0.071	(0.090)	-0.093	(0.117)
Percent with h.s. degree	-0.210*	(0.110)	-0.244*	(0.128)	-0.270**	(0.128)
Percent unemployed	-0.238	(0.235)	-0.430	(0.321)	-0.616*	(0.347)
Percent vacant housing	0.271	(0.169)	0.349**	(0.174)	0.402*	(0.217)
Percent on welfare	0.047	(0.232)	0.076	(0.244)	0.157	(0.261)
Tract variables missing	-0.107	(0.115)	-0.157	(0.137)	-0.189	(0.148)
Interview Characteristics						
2002 Interview	0.041	(0.030)	0.045*	(0.027)	0.027	(0.028)
Intercept	0.360	(0.237)	0.405	(0.268)	0.315	(0.246)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10% .

Table 3: Parameter Estimates from Models Explaining Age Three Asthma Diagnosis in Blacks Using Age Three Smoking Behavior

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.099**	(0.040)	0.094	(0.052)	0.480	(0.406)
Maternal Inputs						
Smoked, age three	-0.005	(0.030)	0.039	(0.194)	-0.024	(0.193)
Breastfed	0.051*	(0.028)	0.108	(0.215)	0.133	(0.257)
Sufficient Visits	0.107***	(0.033)	0.329	(0.337)	0.421	(0.381)
Child Characteristics						
Child's age, in years	-0.067	(0.081)	-0.078	(0.088)	-0.076	(0.080)
Child is male	0.081***	(0.026)	0.081	(0.023)	0.086	(0.025)
Parental Characteristics						
Mother is immigrant	-0.188	(0.149)	-0.224	(0.117)	-0.247	(0.127)
Years in U.S., if immigrant	0.009	(0.012)	0.013	(0.010)	0.015	(0.009)
Mother's age	0.002	(0.003)	0.002	(0.003)	0.001	(0.004)
Age of biological father	-0.002	(0.003)	-0.002	(0.002)	-0.002	(0.003)
Income	0.000	(0.001)	0.000	(0.001)	0.000	(0.001)
Mother completed high school	-0.023	(0.033)	-0.004	(0.044)	-0.006	(0.048)
Mother attended some college	-0.052	(0.035)	-0.064	(0.049)	-0.064	(0.061)
Mother has bachelor's degree	-0.001	(0.076)	-0.006	(0.099)	-0.006	(0.074)
Medicaid	0.041	(0.035)	0.035	(0.036)	0.030	(0.034)
Local Characteristics						
Ozone (ppm)	-0.061	(0.374)	-0.139	(0.367)	-0.086	(0.377)
Particulate matter (ppm/100)	-0.002	(0.007)	-0.003	(0.007)	-0.002	(0.007)
Carbon monoxide (ppm)	-0.014	(0.143)	-0.001	(0.121)	-0.007	(0.140)
Percent hispanic	0.128	(0.153)	0.112	(0.160)	0.090	(0.192)
Percent black	0.072	(0.063)	0.060	(0.076)	0.051	(0.053)
Percent other ethnicity	0.329	(0.953)	-0.039	(0.987)	0.067	(0.846)
Tract variables missing	-0.050	(0.173)	-0.094	(0.195)	-0.108	(0.161)
Percent foreign-born	-0.141	(0.231)	-0.117	(0.196)	-0.135	(0.250)
Percent with h.s. degree	-0.165	(0.164)	-0.182	(0.185)	-0.193	(0.150)
Percent unemployed	-0.450	(0.297)	-0.662	(0.435)	-0.696	(0.420)
Percent vacant housing	0.524**	(0.212)	0.593	(0.303)	0.617	(0.202)
Percent on welfare	-0.071	(0.295)	-0.048	(0.200)	0.000	(0.266)
Interview Characteristics						
2002 Interview	0.040	(0.041)	0.046	(0.039)	0.023	(0.046)
Intercept	0.414	(0.337)	0.418	(0.376)	0.377	(0.369)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 4: Parameter Estimates from Models Explaining Age Three Asthma Diagnosis in Blacks Using Smoking at Age One

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.103**	(0.040)	0.123	(0.051)	0.512	(0.416)
Maternal Inputs						
Smoked, age one	-0.026	(0.031)	-0.232	(0.256)	-0.390	(0.260)
Breastfed	0.049*	(0.028)	-0.088	(0.282)	-0.206	(0.367)
Sufficient visits	0.108***	(0.033)	0.304	(0.277)	0.382	(0.418)
Child Characteristics						
Child's age, in years	-0.066	(0.081)	-0.086	(0.076)	-0.09	(0.067)
Child is male	0.080***	(0.026)	0.079	(0.025)	0.083	(0.026)
Parental Characteristics						
Mother is immigrant	-0.192	(0.149)	-0.194	(0.137)	-0.191	(0.137)
Years in U.S., if immigrant	0.009	(0.012)	0.012	(0.012)	0.014	(0.010)
Mother's age	0.002	(0.003)	0.001	(0.004)	0.000	(0.004)
Age of biological father	-0.002	(0.003)	-0.002	(0.003)	-0.002	(0.002)
Income	0.000	(0.001)	0.000	(0.001)	0.000	(0.001)
Mother completed high school	-0.026	(0.033)	-0.032	(0.050)	-0.041	(0.050)
Mother attended some college	-0.052	(0.035)	-0.042	(0.053)	-0.023	(0.060)
Mother has bachelor's degree	0.000	(0.076)	0.006	(0.083)	0.017	(0.086)
Medicaid	0.043	(0.035)	0.035	(0.027)	0.030	(0.041)
Local Characteristics						
Ozone (ppm)	-0.062	(0.374)	-0.256	(0.363)	-0.274	(0.398)
Particulate matter (ppm/100)	-0.002	(0.007)	-0.005	(0.007)	-0.005	(0.007)
Carbon monoxide (ppm)	-0.016	(0.143)	0.023	(0.137)	0.030	(0.139)
Percent hispanic	0.126	(0.153)	0.087	(0.161)	0.074	(0.192)
Percent black	0.071	(0.063)	0.058	(0.064)	0.058	(0.062)
Percent other ethnicity	0.344	(0.953)	-0.042	(1.081)	0.052	(1.172)
Tract variables missing	-0.051	(0.172)	-0.083	(0.203)	-0.071	(0.205)
Percent foreign-born	-0.143	(0.231)	-0.063	(0.191)	-0.060	(0.258)
Percent with h.s. degree	-0.163	(0.164)	-0.177	(0.165)	-0.166	(0.193)
Percent unemployed	-0.45	(0.297)	-0.642	(0.378)	-0.687	(0.419)
Percent vacant housing	0.520**	(0.212)	0.658	(0.270)	0.720	(0.253)
Percent on welfare	-0.064	(0.295)	-0.094	(0.217)	-0.090	(0.233)
Interview Characteristics						
2002 Interview	0.039	(0.041)	0.046	(0.038)	0.025	(0.039)
Intercept	0.413	(0.337)	0.672	(0.425)	0.756	(0.388)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 5: Parameter Estimates from Models Explaining Age One Asthma Diagnosis in Blacks

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.095***	(0.036)	0.074	(0.059)	0.639*	(0.362)
Maternal Inputs						
Smoked, age one	0.006	(0.028)	0.010	(0.253)	-0.168	(0.273)
Breastfed	0.014	(0.025)	0.105	(0.365)	-0.019	(0.401)
Sufficient Visits	0.039	(0.048)	-0.659	(0.594)	-1.178	(0.754)
Child Characteristics						
Child's age, in years	0.042	(0.059)	0.038	(0.073)	0.027	(0.070)
Child is male	0.103 ***	(0.024)	0.103	(0.027)	0.111	(0.031)
Parental Characteristics						
Mother is immigrant	-0.091	(0.134)	-0.167	(0.135)	-0.173	(0.147)
Years in U.S., if immigrant	0.002	(0.011)	0.005	(0.006)	0.007	(0.006)
Mother's age	0.001	(0.003)	0.001	(0.004)	-0.002	(0.003)
Age of Biological Father	-0.003	(0.002)	-0.003	(0.002)	-0.003	(0.002)
Income	0.000	(0.001)	0.000	(0.001)	0.000	(0.001)
Mother completed high school	-0.01	(0.030)	0.031	(0.056)	0.041	(0.053)
Mother attended some college	0.001	(0.031)	-0.027	(0.061)	-0.015	(0.068)
Mother has bachelor's degree	-0.057	(0.068)	-0.071	(0.070)	-0.058	(0.071)
Medicaid	0.057 *	(0.031)	0.060	(0.027)	0.058	(0.029)
Local Characteristics						
Ozone (ppm)	-0.277	(0.323)	-0.232	(0.325)	-0.234	(0.320)
Particulate Matter (ppm/100)	-0.006	(0.007)	-0.005	(0.007)	-0.005	(0.007)
Carbon monoxide (ppm)	0.027	(0.096)	0.024	(0.103)	0.036	(0.121)
Percent hispanic	0.037	(0.136)	0.068	(0.142)	0.055	(0.150)
Percent black	0.043	(0.058)	0.067	(0.052)	0.084	(0.064)
Percent other ethnicity	-0.699	(0.969)	-0.594	(0.752)	-0.404	(0.774)
Tract variables missing	-0.062	(0.170)	-0.119	(0.223)	-0.079	(0.260)
Percent foreign-born	0.054	(0.205)	0.109	(0.253)	0.223	(0.247)
Percent with h.s. degree	-0.11	(0.154)	-0.107	(0.211)	-0.037	(0.233)
Percent unemployed	-0.036	(0.251)	-0.091	(0.360)	-0.113	(0.336)
Percent vacant housing	0.130	(0.186)	0.179	(0.235)	0.357	(0.237)
Percent on welfare	-0.104	(0.234)	-0.145	(0.267)	-0.137	(0.238)
Interview Characteristics						
2001 Interview	-0.016	(0.040)	-0.024	(0.047)	0.002	(0.043)
Intercept	0.218	(0.254)	0.783	(0.616)	1.249	(0.749)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 6: Parameter Estimates from Models Explaining Age Three Asthma Diagnosis in Whites Using Age Three Smoking

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Asthma Diagnosis at Age Three Using Age Three Smoking Behavior						
Initial Child Health						
Low birthweight	0.060	(0.055)	0.077	(0.074)	0.735	(0.380)
Maternal Inputs						
Smoked, age three	-0.011	(0.035)	-0.138	(0.225)	-0.197	(0.203)
Breastfed	0.016	(0.036)	-0.076	(0.236)	-0.018	(0.256)
Sufficient Visits	0.103**	(0.047)	0.716	(0.772)	1.085*	(0.571)
Child Characteristics						
Child's age, in years	0.112	(0.103)	0.116	(0.118)	0.130	(0.105)
Child is male	0.040	(0.030)	0.045	(0.031)	0.051	(0.030)
Parental Characteristics						
Mother is immigrant	0.048	(0.138)	0.036	(0.175)	0.056	(0.179)
Years in U.S., if immigrant	-0.006	(0.008)	-0.003	(0.020)	-0.002	(0.011)
Mother's age	0.001	(0.004)	0.000	(0.004)	-0.001	(0.004)
Age of Biological Father	-0.002	(0.003)	-0.002	(0.003)	-0.003	(0.003)
Income	0.000	(0.000)	0.000	(0.001)	0.000	(0.001)
Mother completed high school	-0.086*	(0.047)	-0.066	(0.067)	-0.034	(0.067)
Mother attended some college	0.059	(0.043)	0.073	(0.043)	0.075	(0.054)
Mother has bachelor's degree	0.042	(0.054)	0.033	(0.079)	0.031	(0.062)
Medicaid	0.014	(0.035)	-0.014	(0.051)	-0.050	(0.049)
Local Characteristics						
Ozone (ppm)	-0.498	(0.469)	-0.562	(0.381)	-0.489	(0.433)
Particulate Matter (ppm/100)	-0.013	(0.010)	-0.014	(0.007)	-0.013	(0.009)
Carbon monoxide (ppm)	0.035	(0.202)	0.058	(0.198)	0.015	(0.256)
Percent hispanic	0.141	(0.112)	0.054	(0.207)	0.006	(0.173)
Percent black	0.058	(0.107)	-0.011	(0.130)	-0.053	(0.147)
Percent other ethnicity	2.520	(1.803)	2.207	(2.445)	2.362	(2.328)
Tract variables missing	-0.064	(0.213)	-0.145	(0.277)	-0.202	(0.233)
Percent foreign-born	-0.107	(0.232)	-0.121	(0.206)	-0.146	(0.194)
Percent with h.s. degree	-0.164	(0.209)	-0.181	(0.217)	-0.224	(0.203)
Percent unemployed	0.043	(0.664)	-0.31	(0.973)	-0.825	(1.017)
Percent vacant housing	0.042	(0.404)	0.255	(0.374)	0.431	(0.465)
Percent on welfare	-0.843	(0.759)	-0.743	(0.889)	-0.475	(0.896)
Interview Characteristics						
2002 Interview	-0.052	(0.060)	-0.058	(0.057)	-0.102	(0.063)
Intercept	0.225	(0.428)	0.304	(0.459)	0.233	(0.435)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 7: Parameter Estimates from Models Explaining Age Three Asthma Diagnosis in Whites Using Age One Smoking

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.062	(0.055)	0.047	(0.068)	0.386	(0.481)
Maternal Inputs						
Smoked, age one	-0.017	(0.034)	0.219	(0.211)	0.245	(0.251)
Breastfed	0.015	(0.035)	0.220	(0.353)	0.270	(0.335)
Sufficient Visits	0.103**	(0.047)	0.774	(0.613)	1.052*	(0.509)
Child Characteristics						
Child's age, in years	0.112	(0.103)	0.113	(0.110)	0.127	(0.120)
Child is male	0.041	(0.030)	0.042	(0.029)	0.045	(0.031)
Parental Characteristics						
Mother is immigrant	0.050	(0.138)	0.050	(0.187)	0.042	(0.144)
Years in U.S., if immigrant	-0.006	(0.008)	-0.004	(0.017)	-0.001	(0.006)
Mother's age	0.001	(0.004)	0.001	(0.004)	0.001	(0.005)
Age of Biological Father	-0.002	(0.003)	-0.002	(0.003)	-0.003	(0.003)
Income	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Mother completed high school	-0.086 *	(0.047)	-0.027	(0.068)	0.007	(0.067)
Mother attended some college	0.057	(0.043)	0.056	(0.070)	0.058	(0.058)
Mother has bachelor's degree	0.041	(0.054)	0.050	(0.074)	0.049	(0.073)
Medicaid	0.014	(0.035)	-0.019	(0.045)	-0.051	(0.044)
Local Characteristics						
Ozone (ppm)	-0.489	(0.469)	-0.419	(0.438)	-0.344	(0.414)
Particulate Matter (ppm/100)	-0.013	(0.010)	-0.012	(0.009)	-0.01	(0.008)
Carbon monoxide (ppm)	0.031	(0.202)	0.034	(0.212)	0.008	(0.209)
Percent hispanic	0.139	(0.112)	0.097	(0.140)	0.076	(0.166)
Percent black	0.057	(0.107)	-0.009	(0.134)	-0.036	(0.140)
Percent other ethnicity	2.552	(1.804)	2.188	(2.721)	2.247	(3.197)
Tract variables missing	-0.066	(0.213)	-0.169	(0.263)	-0.213	(0.220)
Percent Foreign-Born	-0.104	(0.232)	-0.191	(0.188)	-0.232	(0.242)
Percent with h.s. degree	-0.164	(0.209)	-0.205	(0.225)	-0.235	(0.186)
Percent unemployed	0.035	(0.663)	-0.307	(0.823)	-0.738	(0.928)
Percent vacant housing	0.047	(0.404)	0.158	(0.436)	0.278	(0.471)
Percent on welfare	-0.838	(0.759)	-0.746	(0.711)	-0.585	(0.760)
Interview Characteristics						
2002 Interview	-0.052	(0.060)	-0.054	(0.053)	-0.083	(0.060)
Intercept	0.232	(0.428)	-0.108	(0.456)	-0.223	(0.485)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 8: Parameter Estimates from Models Explaining Age One Asthma Diagnosis in Whites

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.082**	(0.039)	0.016	(0.057)	-0.120	(0.468)
Maternal Inputs						
Smoked, age one	-0.010	(0.024)	-0.044	(0.200)	-0.110	(0.285)
Breastfed	-0.008	(0.026)	0.000	(0.333)	-0.215	(0.461)
Sufficient Visits	-0.043	(0.058)	-2.344**	(1.075)	-1.449	(1.162)
Child Characteristics						
Child's age, in years	0.051	(0.069)	0.054	(0.082)	0.045	(0.069)
Child is male	0.030	(0.021)	0.029	(0.019)	0.030	(0.024)
Parental Characteristics						
Mother is immigrant	-0.083	(0.099)	-0.203	(0.101)	-0.12	(0.160)
Years in U.S., if immigrant	0.002	(0.006)	0.007	(0.007)	0.005	(0.005)
Mother's age	0.002	(0.003)	0.001	(0.003)	0.001	(0.003)
Age of Biological Father	-0.003	(0.002)	-0.003	(0.002)	-0.003	(0.002)
Income	-0.001	(0.001)	0.000	(0.001)	0.000	(0.001)
Mother completed high school	-0.078**	(0.034)	0.011	(0.054)	-0.01	(0.062)
Mother attended some college	0.006	(0.031)	-0.031	(0.053)	0.003	(0.076)
Mother has bachelor's degree	0.032	(0.038)	0.020	(0.043)	0.035	(0.061)
Medicaid	0.005	(0.026)	0.006	(0.024)	0.003	(0.032)
Local Characteristics						
Ozone (ppm)	-0.327	(0.317)	-0.328	(0.297)	-0.42	(0.300)
Particulate Matter (ppm/100)	-0.007	(0.007)	-0.008	(0.006)	-0.009	(0.006)
Carbon monoxide (ppm)	0.141	(0.148)	0.142	(0.219)	0.171	(0.223)
Percent hispanic	-0.081	(0.085)	-0.067	(0.088)	-0.077	(0.104)
Percent black	-0.059	(0.077)	-0.007	(0.073)	0.006	(0.073)
Percent other ethnicity	0.144	(1.274)	0.200	(1.438)	-0.033	(1.625)
Tract variables missing	-0.005	(0.157)	-0.071	(0.194)	0.013	(0.251)
Percent foreign-born	0.262*	(0.140)	0.449	(0.277)	0.529	(0.273)
Percent with h.s. degree	-0.072	(0.148)	0.012	(0.181)	0.070	(0.215)
Percent unemployed	-0.413	(0.423)	-0.433	(0.476)	-0.4	(0.515)
Percent vacant housing	0.394	(0.262)	0.538	(0.364)	0.603	(0.364)
Percent on welfare	0.443	(0.491)	0.346	(0.788)	0.274	(0.734)
Interview Characteristics						
2001 Interview	0.038	(0.052)	0.032	(0.071)	0.035	(0.061)
Intercept	0.215	(0.281)	2.296	(1.107)	1.607	(1.073)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 9: Parameter Estimates from Models Explaining Age Three Asthma Diagnosis in Latinos Using Age Three Smoking

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.083	(0.075)	0.108	(0.104)	0.152	(0.573)
Maternal Inputs						
Smoked, age three	0.061	(0.050)	-0.019	(0.391)	0.100	(0.400)
Breastfed	0.047	(0.040)	0.421	(0.248)	0.595**	(0.299)
Sufficient Visits	0.095**	(0.045)	0.412	(0.491)	0.638	(0.504)
Child Characteristics						
Child's age, in years	-0.069	(0.110)	-0.088	(0.104)	-0.095	(0.100)
Child is male	0.115***	(0.036)	0.116	(0.035)	0.108	(0.034)
Parental Characteristics						
Mother is immigrant	-0.11	(0.067)	-0.283	(0.104)	-0.306	(0.092)
Years in U.S., if immigrant	0.001	(0.004)	0.005	(0.004)	0.005	(0.003)
Mother's age	0.003	(0.004)	0.004	(0.005)	0.005	(0.006)
Age of Biological Father	-0.001	(0.004)	-0.001	(0.004)	-0.001	(0.004)
Income	0.000	(0.002)	-0.001	(0.002)	-0.001	(0.002)
Mother completed high school	-0.029	(0.044)	-0.026	(0.065)	-0.005	(0.056)
Mother attended some college	0.052	(0.050)	-0.015	(0.058)	-0.043	(0.062)
Mother has bachelor's degree	0.043	(0.112)	-0.05	(0.128)	-0.076	(0.134)
Medicaid	0.054	(0.042)	0.058	(0.050)	0.055	(0.051)
Local Characteristics						
Ozone (ppm)	-1.339	(1.261)	-1.026	(1.017)	-1.024	(1.108)
Particulate Matter (ppm/100)	-0.037	(0.028)	-0.03	(0.021)	-0.029	(0.022)
Carbon monoxide (ppm)	-0.084	(0.286)	-0.077	(0.257)	-0.061	(0.316)
Percent hispanic	-0.121	(0.129)	-0.174	(0.158)	-0.149	(0.170)
Percent black	0.116	(0.129)	0.081	(0.143)	0.088	(0.157)
Percent other ethnicity	-0.457	(1.303)	-0.516	(0.997)	-0.666	(1.386)
Tract variables missing	-0.183	(0.283)	-0.351	(0.289)	-0.361	(0.314)
Percent foreign-born	-0.104	(0.160)	-0.203	(0.176)	-0.248	(0.160)
Percent with h.s. degree	-0.305	(0.250)	-0.446	(0.233)	-0.454	(0.245)
Percent unemployed	0.392	(0.521)	0.099	(0.770)	-0.026	(0.766)
Percent vacant housing	0.036	(0.405)	0.110	(0.402)	0.137	(0.459)
Percent on welfare	-0.163	(0.492)	-0.065	(0.691)	-0.103	(0.636)
Interview Characteristics						
2002 Interview	0.179*	(0.095)	0.180	(0.093)	0.194	(0.088)
Intercept	2.000	(2.000)	0.922	(0.680)	0.763	(0.758)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 10: Parameter Estimates from Models Explaining Age Three Asthma Diagnosis in Latinos Using Age One Smoking

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.092	(0.074)	0.077	(0.101)	0.130	(0.637)
Maternal Inputs						
Smoked, age one	0.129***	(0.047)	0.311	(0.306)	0.292	(0.323)
Breastfed	0.048	(0.039)	0.649**	(0.307)	0.752*	(0.345)
Sufficient Visits	0.098**	(0.045)	0.400	(0.495)	0.663	(0.495)
Child Characteristics						
Child's age, in years	-0.086	(0.110)	-0.083	(0.113)	-0.092	(0.098)
Child is male	0.111 ***	(0.036)	0.118	(0.032)	0.109	(0.035)
Parental Characteristics						
Mother is immigrant	-0.082	(0.067)	-0.283	(0.098)	-0.31	(0.108)
Years in U.S., if immigrant	0.000	(0.004)	0.004	(0.004)	0.005	(0.004)
Mother's age	0.004	(0.004)	0.005	(0.005)	0.006	(0.005)
Age of Biological Father	-0.002	(0.004)	-0.001	(0.004)	-0.001	(0.003)
Income	0.000	(0.002)	-0.001	(0.001)	-0.001	(0.001)
Mother completed high school	-0.022	(0.044)	-0.002	(0.065)	0.013	(0.064)
Mother attended some college	0.059	(0.050)	-0.035	(0.060)	-0.061	(0.059)
Mother has bachelor's degree	0.049	(0.111)	-0.066	(0.099)	-0.094	(0.124)
Medicaid	0.051	(0.042)	0.061	(0.048)	0.056	(0.056)
Local Characteristics						
Ozone (ppm)	-1.38	(1.253)	-1.011	(0.926)	-0.987	(1.104)
Particulate Matter (ppm/100)	-0.039	(0.028)	-0.03	(0.019)	-0.029	(0.024)
Carbon monoxide (ppm)	-0.124	(0.284)	-0.109	(0.259)	-0.094	(0.285)
Percent hispanic	-0.106	(0.128)	-0.147	(0.132)	-0.142	(0.177)
Percent black	0.126	(0.128)	0.081	(0.122)	0.078	(0.151)
Percent other ethnicity	-0.501	(1.295)	-0.534	(1.048)	-0.618	(1.111)
Tract variables missing	-0.141	(0.282)	-0.376	(0.288)	-0.384	(0.338)
Percent foreign-born	-0.109	(0.159)	-0.257	(0.152)	-0.283	(0.192)
Percent with h.s. degree	-0.278	(0.249)	-0.465	(0.245)	-0.468	(0.274)
Percent unemployed	0.413	(0.517)	0.095	(0.737)	-0.027	(0.692)
Percent vacant housing	0.055	(0.401)	0.056	(0.499)	0.124	(0.503)
Percent on welfare	-0.125	(0.489)	-0.019	(0.624)	-0.047	(0.620)
Interview Characteristics						
2002 Interview	0.184*	(0.094)	0.186	(0.090)	0.197	(0.091)
Intercept	1.179	(0.734)	0.691	(0.759)	0.606	(0.757)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 11: Parameter Estimates from Models Explaining Age One Asthma Diagnosis in Latinos

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.092	(0.065)	0.085	(0.090)	-0.381	(0.648)
Maternal Inputs						
Smoked, age one	0.078*	(0.042)	0.139	(0.379)	0.415	(0.376)
Breastfed	0.004	(0.035)	-0.105	(0.492)	0.292	(0.578)
Sufficient Visits	0.077	(0.060)	0.523	(0.481)	0.040	(0.756)
Child Characteristics						
Child's age, in years	0.080	(0.093)	0.070	(0.111)	0.089	(0.079)
Child is male	0.092 ***	(0.032)	0.088	(0.036)	0.089	(0.042)
Parental Characteristics						
Mother is immigrant	-0.123**	(0.060)	-0.034	(0.128)	-0.163	(0.189)
Years in U.S., if immigrant	0.003	(0.004)	0.001	(0.004)	0.004	(0.004)
Mother's age	0.001	(0.004)	0.000	(0.005)	0.003	(0.005)
Age of Biological Father	0.001	(0.003)	0.002	(0.004)	0.002	(0.004)
Income	0.002	(0.001)	0.002	(0.001)	0.001	(0.002)
Mother completed high school	-0.057	(0.039)	-0.075	(0.058)	-0.025	(0.066)
Mother attended some college	-0.03	(0.044)	-0.005	(0.076)	-0.072	(0.102)
Mother has bachelor's degree	-0.172*	(0.099)	-0.147	(0.087)	-0.196	(0.103)
Medicaid	0.038	(0.036)	0.033	(0.040)	0.045	(0.040)
Local Characteristics						
Ozone (ppm)	-0.677	(0.704)	-0.573	(0.965)	-0.551	(0.846)
Particulate Matter (ppm/100)	-0.015	(0.016)	-0.013	(0.022)	-0.013	(0.020)
Carbon monoxide (ppm)	0.119	(0.191)	0.143	(0.215)	0.135	(0.219)
Percent hispanic	-0.151	(0.129)	-0.185	(0.129)	-0.144	(0.118)
Percent black	-0.076	(0.124)	-0.122	(0.128)	-0.104	(0.108)
Percent other ethnicity	0.000	(1.287)	-0.264	(0.969)	-0.208	(1.427)
Tract variables missing	-0.206	(0.280)	-0.207	(0.316)	-0.359	(0.329)
Percent foreign-born	-0.045	(0.151)	-0.097	(0.198)	-0.166	(0.183)
Percent with h.s. degree	-0.199	(0.231)	-0.213	(0.277)	-0.286	(0.273)
Percent unemployed	0.090	(0.479)	0.172	(0.557)	0.180	(0.590)
Percent vacant housing	0.173	(0.349)	0.108	(0.379)	0.021	(0.339)
Percent on welfare	0.537	(0.426)	0.509	(0.451)	0.509	(0.512)
Interview Characteristics						
2001 Interview	-0.046	(0.078)	-0.035	(0.087)	-0.063	(0.090)
Intercept	0.323	(0.439)	-0.059	(0.722)	0.106	(0.580)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 12: Parameter Estimates from Models Explaining Endogenous Prenatal Inputs and Birthweight (in grams)

Variable	Prenatal Care in 1st Trimester		Prenatal Smoking		Low Birthweight	
Maternal Inputs						
Prenatal Care, 1st Trimester					-0.231	(0.279)
Smoked, prenatal					-0.518***	(0.166)
Child Characteristics						
Child is male					0.067**	(0.027)
Parental Characteristics						
Mother is black	0.010	(0.030)	-0.192***	(0.028)	-0.257***	(0.070)
Mother is latino	-0.041	(0.036)	-0.178***	(0.018)	-0.221***	(0.070)
Mother is other ethnicity	-0.147**	(0.072)	-0.069*	(0.036)	0.011***	(0.033)
Mother is immigrant	0.040	(0.042)	-0.160***	(0.022)	0.133**	(0.068)
Years in U.S., if immigrant	0.000	(0.003)	0.007	(0.005)	-0.001	(0.004)
Mother's age	0.005**	(0.002)	0.006***	(0.002)	-0.001	(0.004)
Married	0.040	(0.026)	-0.105***	(0.022)		
Cohabitating	0.040**	(0.020)	-0.010	(0.020)		
Biological father's age	-0.002	(0.002)	0.004***	(0.002)	0.002	(0.002)
No. of adults in household	0.024**	(0.011)	0.011	(0.011)		
Grandmother present	-0.023	(0.025)	0.008	(0.025)		
No. of children in household	-0.021***	(0.006)	0.003	(0.006)		
Income	0.001**	(0.001)	-0.002***	(0.001)	-0.000	(0.001)
Mother completed high school	0.002	(0.020)	-0.097***	(0.023)	-0.077**	(0.036)
Mother attended some college	0.016	(0.021)	-0.028	(0.021)	0.025	(0.032)
Mother has bachelor's degree	0.099***	(0.030)	-0.113***	(0.023)	0.036	(0.067)
Medicaid	-0.032	(0.020)	0.041**	(0.019)	0.042**	(0.019)
Mother is religious	-0.007	(0.018)	-0.085***	(0.016)		
Local Characteristics						
Percent hispanic	0.010	(0.059)	-0.177***	(0.062)	-0.053	(0.085)
Percent black	-0.014	(0.044)	0.008	(0.042)	-0.046	(0.078)
Percent other ethnicity	0.480	(0.646)	0.248	(0.557)	0.573	(0.875)
Percent foreign-born	-0.143	(0.091)	0.162	(0.106)	0.199	(0.127)
Percent with h.s. degree	0.073	(0.098)	-0.168*	(0.100)	0.086	(0.081)
Percent unemployed	-0.047	(0.175)	-0.009	(0.177)	-0.120	(0.260)
Percent vacant housing	0.125	(0.136)	0.043	(0.129)	0.334	(0.234)
Percent on welfare	-0.084	(0.156)	-0.125	(0.160)	0.318	(0.262)
Obstetricians per 100k	0.002*	(0.001)				
Cigarette price (cents)			0.004*	(0.002)		
Cigarette price, squared			0.000*	(0.000)		
Anti-Smoking Laws			-0.001	(0.056)		
Spring birth					-0.027	(0.030)
Summer birth					-0.057	(0.041)
Interview Characteristics						
1999 Interview	-0.027	(0.020)	-0.008	(0.027)	-0.111***	(0.029)
Intercept					3.670***	(0.307)

Note: Both prenatal inputs are estimated using the probit method; marginal effects are reported. Standard errors are in parentheses.*** indicates significance at the 1% level; ** 5%; * 10%.

Table 13: Parameter Estimates from Models Explaining Asthma Attacks at Age Three

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.087	(0.072)	0.119	(0.078)	0.163	(0.887)
Maternal Inputs						
Smoked, age one	-0.072	(0.058)	-0.626*	(0.343)	-0.602*	(0.333)
Breastfed	0.035	(0.054)	-0.329	(0.270)	-0.379	(0.446)
Sufficient Visits	0.155***	(0.057)	-0.017	(0.653)	0.379	(0.874)
Child Characteristics						
Child's age, in years	0.028	(0.159)	-0.021	(0.161)	-0.006	(0.162)
Child is male	0.049	(0.053)	0.057	(0.054)	0.057	(0.051)
Parental Characteristics						
Mother is black	0.006	(0.095)	-0.124	(0.144)	-0.122	(0.109)
Mother is latino	-0.020	(0.101)	-0.104	(0.130)	-0.096	(0.124)
Mother is other ethnicity	-0.222	(0.182)	-0.267	(0.190)	-0.276*	(0.222)
Mother is immigrant	-0.219	(0.198)	-0.276	(0.241)	-0.254	(0.246)
Years in U.S., if immigrant	0.016	(0.015)	0.017	(0.015)	0.018	(0.015)
Mother's age	0.006	(0.006)	0.005	(0.006)	0.004	(0.006)
Biological father's age	0.005	(0.005)	0.003	(0.005)	0.004	(0.004)
Income	-0.001	(0.002)	0.000	(0.002)	0.000	(0.002)
Mother completed high school	0.077	(0.062)	0.013	(0.093)	0.048	(0.077)
Mother attended some college	0.029	(0.070)	0.049	(0.082)	0.057	(0.095)
Mother has bachelor's degree	-0.094	(0.128)	-0.135	(0.159)	-0.113	(0.168)
Medicaid	0.070	(0.067)	0.071	(0.069)	0.057	(0.076)
Household Characteristics						
Household cluttered	0.061	(0.064)	0.054	(0.066)	0.056	(0.064)
Household cluttered, missing	-0.134	(0.153)	-0.183	(0.146)	-0.185	(0.131)
Local Characteristics						
Ozone (ppm)	-0.145	(0.798)	-0.311	(0.860)	-0.312	(0.938)
Particulate matter (ppm/100)	0.001	(0.016)	-0.002	(0.017)	-0.002	(0.018)
Carbon monoxide (ppm)	0.081	(0.282)	0.077	(0.314)	0.071	(0.288)
Percent hispanic	0.089	(0.194)	-0.053	(0.261)	-0.102	(0.215)
Percent black	0.018	(0.137)	-0.035	(0.170)	-0.061	(0.161)
Percent other ethnicity	0.680	(1.541)	1.431	(1.751)	1.156	(2.084)
Percent foreign-born	-0.222	(0.304)	-0.137	(0.314)	-0.166	(0.342)
Percent with h.s. degree	0.010	(0.320)	0.062	(0.326)	0.032	(0.353)
Percent unemployed	0.260	(0.564)	0.400	(0.820)	0.092	(0.885)
Percent vacant housing	-0.570	(0.391)	-0.442	(0.390)	-0.364	(0.420)
Percent on welfare	0.010	(0.527)	0.338	(0.534)	0.367	(0.456)
Tract variables missing	-0.002	(0.330)	0.024	(0.369)	-0.048	(0.361)
Interview Characteristics						
2001 Interview	0.080	(0.087)	0.073	(0.098)	0.061	(0.112)
Intercept	-0.095	(0.670)	0.657	(0.776)	0.601	(0.873)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 14: Parameter Estimates from Models Explaining Asthma Attacks at Age One

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.004	(0.083)	-0.170*	(0.104)	-0.206	(0.937)
Maternal Inputs						
Smoked, age one	0.061	(0.075)	1.134*	(0.604)	1.253*	(0.631)
Breastfed	0.090	(0.072)	1.125	(0.953)	1.467	(1.050)
Sufficient Visits	-0.108	(0.136)	-2.128	(1.282)	-2.128	(1.640)
Child Characteristics						
Child's age, in years	0.089	(0.168)	0.037	(0.175)	0.048	(0.164)
Child is male	0.128**	(0.066)	0.161***	(0.067)	0.149**	(0.066)
Parental Characteristics						
Mother is black	-0.028	(0.141)	0.284	(0.284)	0.353	(0.250)
Mother is latino	0.020	(0.154)	0.260	(0.223)	0.261	(0.195)
Mother is other ethnicity	-0.002	(0.251)	0.121	(0.316)	0.168	(0.275)
Mother is immigrant	0.024	(0.505)	-0.255	(0.556)	-0.286	(0.485)
Years in U.S., if immigrant	0.003	(0.047)	0.016	(0.038)	0.014	(0.034)
Mother's age	-0.002	(0.008)	-0.003	(0.008)	-0.001	(0.010)
Biological father's age	0.017***	(0.005)	0.020***	(0.006)	0.019***	(0.006)
Income	0.005**	(0.002)	0.003	(0.004)	0.003	(0.004)
Mother completed high school	-0.007	(0.062)	0.226*	(0.115)	0.220*	(0.123)
Mother attended some college	0.122	(0.101)	-0.017	(0.167)	-0.067	(0.179)
Mother has bachelor's degree	-0.046	(0.222)	0.027	(0.216)	-0.034	(0.269)
Medicaid	0.113*	(0.084)	0.119	(0.085)	0.120*	(0.069)
Household Characteristics						
Household cluttered	0.059	(0.072)	0.072	(0.064)	0.075	(0.059)
Household cluttered, missing	0.013	(0.168)	0.002	(0.198)	0.003	(0.175)
Local Characteristics						
Ozone (ppm)	1.247	(0.854)	1.347	(1.065)	1.471*	(0.697)
Particulate matter (ppm/100)	0.029	(0.019)	0.029	(0.022)	0.031*	(0.015)
Carbon monoxide (ppm)	-0.308	(0.218)	-0.365*	(0.275)	-0.369*	(0.231)
Percent hispanic	0.137	(0.254)	0.270	(0.261)	0.296	(0.279)
Percent black	0.019	(0.193)	0.109	(0.208)	0.074	(0.178)
Percent other ethnicity	1.970	(3.288)	1.431	(2.779)	1.966	(3.215)
Percent foreign-born	-0.201	(0.343)	-0.559	(0.546)	-0.577	(0.544)
Percent with h.s. degree	-0.495	(0.348)	-0.497	(0.476)	-0.614	(0.433)
Percent unemployed	0.136	(0.302)	0.042	(0.442)	-0.019	(0.471)
Percent vacant housing	0.342	(0.702)	0.145	(0.898)	0.227	(0.652)
Percent on welfare	-0.672	(0.708)	-0.942	(0.599)	-0.968	(0.790)
Tract variables missing	0.744	(0.745)	0.743	(0.831)	0.737	(0.785)
Interview Characteristics						
2001 Interview	-0.022	(0.118)	-0.110	(0.136)	-0.118	(0.117)
Intercept	-0.719	(0.651)	0.123	(1.522)	-0.138	(1.718)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10%.

Table 15: Parameter Estimates from Models Explaining Asthma Hospitalizations at Age Three

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.004	(0.070)	-0.008	(0.060)	0.660	(0.850)
Maternal Inputs						
Smoked, age three	0.030	(0.057)	-0.024	(0.351)	-0.033	(0.432)
Breastfed	-0.034	(0.052)	-0.046	(0.332)	-0.026	(0.411)
Sufficient Visits	0.188***	(0.055)	0.327	(0.689)	0.515	(0.675)
Child Characteristics						
Child's age, in years	-0.069	(0.155)	-0.105	(0.140)	-0.103	(0.147)
Child is male	0.036	(0.051)	0.038	(0.054)	0.044	(0.041)
Parental Characteristics						
Mother is black	-0.037	(0.093)	-0.039	(0.103)	-0.038	(0.125)
Mother is latino	0.059	(0.098)	0.071	(0.105)	0.092	(0.108)
Mother is other ethnicity	-0.087	(0.177)	-0.047	(0.163)	-0.019	(0.176)
Mother is immigrant	-0.081	(0.193)	-0.145	(0.256)	-0.105	(0.287)
Years in U.S., if immigrant	0.010	(0.015)	0.011	(0.020)	0.010	(0.018)
Mother's age	-0.001	(0.006)	0.000	(0.006)	-0.002	(0.006)
Biological father's age	0.005	(0.005)	0.004	(0.005)	0.004	(0.005)
Income	0.000	(0.002)	0.001	(0.002)	0.001	(0.003)
Mother completed high school	0.051	(0.060)	0.050	(0.081)	0.061	(0.091)
Mother attended some college	-0.035	(0.069)	-0.049	(0.085)	-0.043	(0.078)
Mother has bachelor's degree	-0.158	(0.124)	-0.176	(0.133)	-0.159	(0.164)
Medicaid	0.012	(0.066)	0.016	(0.073)	-0.009	(0.066)
Household Characteristics						
Household cluttered	0.104*	(0.062)	0.099	(0.064)	0.098	(0.066)
Household cluttered, missing	-0.165	(0.149)	-0.150	(0.146)	-0.150*	(0.136)
Local Characteristics						
Ozone (ppm)	0.157	(0.777)	0.010	(0.762)	0.069	(0.961)
Particulate matter (ppm/100)	0.009	(0.015)	0.007	(0.015)	0.008	(0.018)
Carbon monoxide (ppm)	0.076	(0.275)	0.094	(0.275)	0.077	(0.389)
Percent hispanic	0.079	(0.189)	-0.006	(0.212)	-0.020	(0.243)
Percent black	0.264 **	(0.133)	0.212	(0.151)	0.199	(0.164)
Percent other ethnicity	0.045	(1.501)	0.064	(2.097)	0.155	(2.337)
Percent foreign-born	0.078	(0.296)	0.072	(0.316)	0.097	(0.358)
Percent with h.s. degree	0.077	(0.312)	0.072	(0.355)	0.112	(0.342)
Percent unemployed	0.422	(0.549)	0.302	(0.994)	0.122	(0.604)
Percent vacant housing	-0.339	(0.381)	-0.317	(0.424)	-0.214	(0.433)
Percent on welfare	-0.123	(0.514)	0.004	(0.751)	0.130	(0.720)
Tract variables missing	0.279	(0.321)	0.202	(0.403)	0.240	(0.360)
Interview Characteristics						
2001 Interview	-0.011	(0.084)	-0.015	(0.091)	0.021	(0.112)
Intercept	-0.010	(0.698)	0.208	(0.710)	0.079	(0.847)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10% .

Table 16: Parameter Estimates from Models Explaining Asthma Hospitalizations at Age One

Variable	Model 1 Exog. Birthweight Exog. Smoking Exog. Other Inputs		Model 2 Exog. Birthweight Endog. Smoking Endog. Other Inputs		Model 3 Endog. Birthweight Endog. Smoking Endog. Other Inputs	
Initial Child Health						
Low birthweight	0.098	(0.083)	0.091	(0.082)	0.447	(0.870)
Maternal Inputs						
Smoked, age one	0.065	(0.068)	0.594	(0.700)	0.573	(0.743)
Breastfed	-0.009	(0.065)	0.766	(0.831)	0.915	(0.947)
Sufficient Visits	0.019	(0.128)	-3.775**	(1.779)	-4.242***	(1.748)
Child Characteristics						
Child's age, in years	0.222	(0.150)	0.193	(0.190)	0.175	(0.158)
Child is male	0.099	(0.064)	0.121*	(0.057)	0.122*	(0.074)
Parental Characteristics						
Mother is black	0.087	(0.129)	0.192	(0.243)	0.172	(0.307)
Mother is latino	0.035	(0.137)	0.062	(0.193)	0.040	(0.267)
Mother is other ethnicity	0.093	(0.228)	0.212	(0.228)	0.218	(0.249)
Mother is immigrant	-0.560	(0.343)	-0.911*	(0.497)	-0.930	(0.511)
Years in U.S., if immigrant	0.044	(0.029)	0.057**	(0.035)	0.055	(0.037)
Mother's age	-0.001	(0.007)	-0.004	(0.008)	-0.006	(0.008)
Biological father's age	0.010	(0.006)	0.011**	(0.006)	0.012**	(0.006)
Income	0.003	(0.003)	0.002	(0.003)	0.002	(0.003)
Mother completed high school	-0.116	(0.072)	0.152	(0.118)	0.175	(0.126)
Mother attended some college	0.216**	(0.087)	0.040	(0.149)	0.016	(0.136)
Mother has bachelor's degree	0.103	(0.220)	0.085	(0.243)	0.089	(0.262)
Medicaid	0.093	(0.080)	0.101	(0.071)	0.106	(0.072)
Household Characteristics						
Household cluttered	-0.027	(0.070)	-0.018	(0.068)	-0.011	(0.074)
Household cluttered, missing	-0.153	(0.158)	-0.163	(0.203)	-0.159	(0.166)
Local Characteristics						
Ozone (ppm)	-0.142	(0.866)	0.047	(0.956)	0.040	(0.810)
Particulate matter (ppm/100)	-0.004	(0.019)	-0.001	(0.020)	-0.001	(0.016)
Carbon monoxide (ppm)	-0.177	(0.224)	-0.192	(0.222)	-0.210	(0.227)
Percent hispanic	0.249	(0.257)	0.375	(0.307)	0.420	(0.261)
Percent black	0.176	(0.176)	0.277	(0.167)	0.307	(0.170)
Percent other ethnicity	1.736	(2.690)	1.942	(2.882)	2.373	(3.040)
Percent foreign-born	0.241	(0.385)	0.485	(0.534)	0.508	(0.508)
Percent with h.s. degree	0.470	(0.340)	0.459	(0.344)	0.482	(0.442)
Percent unemployed	0.769	(0.643)	0.622	(0.627)	0.555	(0.652)
Percent vacant housing	0.196	(0.445)	0.216	(0.565)	0.233	(0.738)
Percent on welfare	0.692	(0.680)	0.488	(0.694)	0.550	(0.856)
Tract variables missing	0.302	(0.416)	-0.083	(0.513)	-0.071	(0.520)
Interview Characteristics						
2001 Interview	0.020	(0.105)	-0.053	(0.122)	-0.062	(0.114)
Intercept	-0.762	(0.700)	2.020	(2.045)	2.392	(1.893)

Note: Standard errors are in parentheses. *** indicates significance at the 1 % level; ** 5%; * 10% .

Table 17: Simulations of Prenatal Smoking Behavior on Low Birthweight, Other Inputs and Asthma Diagnosis at Ages One and Three Using Model 1 (All Inputs Exogenous)

	Predicted Distribution	Simulation: prenatal non-smoker	Simulation: prenatal smoker
Outcome			
Child Health			
Low Birthweight	0.097	0.078	0.177
Asthma Diagnosis, Age One	0.136	0.134	0.143
Asthma Diagnosis, Age Three	0.197	0.186	0.204
Maternal Inputs			
Smoking, age one	0.279	0.277	0.291
Smoking, age three	0.255	0.253	0.262
Breastfeeding	0.545	0.546	0.541
Sufficient visits, age one	0.940	0.940	0.940
Sufficient visits, age three	0.182	0.182	0.182

Table 18: Simulations of Changes in Cigarette Taxes on Prenatal Smoking Behavior

	Predicted Distribution
Simulated Change in Policy	
Baseline	0.198
Price Increase of $0.25	0.187
Price Increase of $0.50	0.168
Price Increase of $0.75	0.144
Price Increase of $1.00	0.116

Note: The baseline price level is assumed to be $2 per pack.

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