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Determinants of the Health of American Preschool Children:

Estimated Health Demand and Production Functions

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Introduction

In the world's wealthiest country, poverty and poor health are the experience of far too many American children. Over one-fifth of all children in the United States live in families whose incomes are below the poverty line. The poverty rate for U.S. children is higher than for any other industrialized country (Blank, 1997). Lower incomes are linked to poor health through a variety of factors. Per capita health expenditures on preschool children are the lowest of any age group. This is only due in part to the fact that children of this age are not prone to expensive diseases such as cancer or heart disease. Moreover, this age group is one of the least studied by the medical community (Wolfe and Sears, 1997).

To address children's health issues effectively requires a clear understanding of the underlying determinants. This study contributes to that goal by estimating health demand and production functions for U.S. preschool children (ages 2-5 years) using data from the most recent National Health and Nutrition Examination Survey. The conceptual framework for this analysis is Gary Becker's household model (Becker, 1965). The household production and demand functions obtained from this model have been widely used to study health and nutrition issues in developing countries (Behrman and Deolalikar, 1988; Strauss and Thomas, 1998). However, they have received much more limited use in the analysis of the health of U.S. children (Rosenzweig and Schultz, 1983).

The National Health and Nutrition Examination Survey (NHANES) collected by the

National Centers for Health Statistics and the Centers for Disease Control and Prevention provides a rich data set for analyzing factors affecting children's health. NHANES III was collected between 1988 and 1994. This nationally representative survey contains the results of a four-hour medical exam. Extensive demographic and socioeconomic data are also included. The measure of health used in this research is the physician's overall evaluation of a child's health. The measure is a five point scale, with one representing excellent health and five representing poor health. Since this health measure has discrete values, an ordered probit model is employed to estimate both the health production and demand functions.

. The next section of this paper discusses the literature from both the economics and the health and nutrition fields. The third section outlines the household model. The fourth section describes the data in more detail and the variables used in the research. The fifth section outlines the econometric model and discusses other statistical issues. One drawback of the ordered probit model is the difficulty interpreting the coefficients from the regression. Calculation of the marginal effects addresses this issue. The empirical results are presented in the next section. The conclusion summarizes the work and discusses the policy implications.

Selected Literature Review

Several fields have contributed to research on children's health. The health and nutrition literature provides practical measures of health and explores factors which affect children's health. The economic literature examines social, demographic, and economic determinants of health, using the household model.

Measurements of Child Health

According to the medical community, one of the best measurements of health is the physician's overall evaluation (Wolfe and Sears, 1997). This measurement generally ranks an individual's health on a 1 to 5 or 1 to 10 scale. The doctor's evaluation takes into account the child's size and weight, and other indicators of health such as disease and illness history, and the results of a medical examination (Wolfe and Sears, 1997). In developing country studies, one of the most common measures of a child's health is his or her size, in particular the child's height and weight (Behrman and Deolalikar, 1988). However, these indicators are less appropriate in the United States where the child's size is less likely to reflect his/her overall health, and because of obesity the relationship is not unidirectional; bigger children are not necessarily healthier.

Factors Which Contribute to Health

The literature provides considerable guidance on the factors which affect health either positively or negatively.

Nutrition

Because nutrition and health are so closely linked, it follows that factors related to good nutrition are likely to lead to good health. Children who eat a high amount of saturated fats, for example, have been found to be prone to obesity (Greenwood, et al., 1993). The majority of U.S. children may eat enough of some nutrients, but not enough of others. In general, researchers study either individual nutrient intake, such as calcium or vitamin C, or look at the overall diet quality using an index (USDA, 1995).

There are several social-demographic factors which affect diet quality. Hihn and Lane's (1986) literature review of studies covering individual nutrients suggests that mother's education has a positive impact on diet quality, while increased hours worked in the labor market have a negative impact. The studies reviewed also find that income is not significant in determining diet quality, except among the poorest groups. Race, ethnicity, and the level of urbanization variables are significant for individual nutrients. Morgan (1986) finds the following factors have a positive impact on diet quality: food assistance program participation, education of the household heads, one head is employed, and that there are two heads of the household. Other factors which affect diet quality are the stage in the family lifecycle, region, and level of urbanization.

In the medical literature, Deen (1993) finds the following can lead to malnutrition: poverty, lack of social support for the family, child abuse and neglect, lack of parental education or illiteracy, drug or alcohol abuse, teen pregnancy, and chronic illness. Ethnic and race variables are often significant (Nelson et al., 1993).

Breastfeeding

The positive health impacts on infants of breastfeeding are well known. Breastfeeding provides both nutritional and immunological benefits. In fact, this is the best way to transmit antibodies and other immune components from the mother to the child. Breast milk helps infants fight off infections and develop their own immune system and provides the best nutrition for them (Herbert, Suback-Sharpe and Kasdan, 1995). The possible effect of breastfeeding as infants on the health of older children needs to be more thoroughly researched.

Economic and Social Status

Economic and social status affects health in many ways including housing, neighborhoods, education, access to medical services, and better nutrition. More parental education is associated with higher incomes and higher social classes. Lower incomes are associated with higher mortality and ill health, and the wider the range of income in the population, the greater the impact income has on both (Purdy, 1996). One reason is that the poor do not seek medical attention as quickly (Singleton, 1994).

Food Stamp Program

Since income does impact the food consumption of the poor, one way to improve the diet quality of the poor is through the Food Stamp Program. Ninety-two percent of food stamp recipients are at or below the poverty line, and 42% are below half the poverty line (Skolnick, 1995). Many studies have found the program does improve the diets of the poor. The Physicians Task Force found that food stamps had a large role in reducing the level of hunger (Senauer, Asp and Kinsey, 1991). Basiotis (1983) studied the impact of food stamp participation on the availability of food, by specific food groups. In a later study, Basiotis

(1998) concluded the additional food budget improves the quality of participating household's diets. Devaney and Moffitt (1991) found that the dietary effects of food stamp benefits were greater than for similar changes in cash income.

Special Supplemental Program for Women, Infants and Children (WIC)

Like the Food Stamp Program, WIC's main contribution to children is through better nutrition. The program includes nutrition education and a nutrition status assessment, and targets specific food items including fruit juice, cereal, milk and infant formula. Basiotis (1987) found WIC had a positive impact on all components of the U.S. Department of Agriculture's Healthy Eating Index except saturated fat. A WIC/Medicaid study found that every dollar spent on a pregnant woman's participation saved between $1.77 and $3.13 in medical costs after the child was born (Matsumoto, 1992).

Social and Environmental Factors

Social and environmental factors with an adverse affect on health include crowded conditions, frequent moves to new cities or neighborhoods, a high child to adult ratio, cigarette smoke and other indoor pollutants, outdoor air pollutants, and unsanitary conditions (Singleton, 1994). Sewell (1993) expands the factors to include social support for the parents and parental education. When parents are able to take a break and interact with other adults, they are often more able to respond to their children's needs. Wachs (1993) reports that in designing a health improvement intervention program, observing how a child and caregiver interact is the first step.

Results from Health Production and Demand Studies

Health production and demand functions have been widely used in economics to study children's health in developing countries. Most studies use the child's size as a dependent variable, which is an indirect measure of the health status of the child. Behrman and Deolalikar (1988) present an overview of the literature before 1988. Strauss and Thomas (1998) provide a more recent review. The key variables which have been found to have a positive effect on the child's health include: mother's age and education, household income, the amount of time a mother spends with her children, availability of health services, and caloric intake. Variables for which the effects vary by country are level of urbanization, birth order, and sex of the child.

The household model has been used much less frequently to study health in developed countries. Variyam, et al., (1999) analyzes determinants of children's nutrition using the Healthy Eating Index as a measure of diet quality in the United States. Rosenzweig and Schultz (1983) study the birth weight of infants using U.S. data. They analyze the effect of the number of months a woman was pregnant before seeking prenatal treatment, birth order, age of the mother at birth, and health habits of the mother. They find the most significant negative factors are a delay in seeking treatment and the mother's smoking during pregnancy. Yamada (1989) in a study of Japanese infants uses both neonatal and infant mortality as the proxy for health. He finds delay in seeking prenatal care and the mother's smoking are negative factors for the health of infants, as well as the mother's consuming alcohol during pregnancy, and higher levels of air pollutants. Consumption of calcium and iron have positive effects on health.

Household Model

In this model, the household is assumed to maximize the family members' health, consumption of other household produced goods and services, and leisure. The production function for the i^{th} child's health (H_i) can be specified as:

$$H_i = h(Z_h , X_h, T_h, 0) \quad (1)$$

where Z_h is a vector of quantities of household produced goods used to produce health, X_h is a vector of quantities of market goods required to produce health, T_h is the time required to produce health, and 0 is the endowments of both the household and individuals involved in producing health.

Maximization of the utility function subject to the health production function (1) and full income constraint, which combines the time and budget constraints, yields the demand function for the i^{th} child's health:

$$H_i = f(P_h , W, N, 0) \quad (2)$$

where P_h is a vector of market prices for the goods in X_h and also the market inputs to produce Z_h , W is a vector of market wages for household members, N is the household's non-labor or unearned income, and 0 continues to represent the vector of endowments. This analysis estimates (1) and (2), with some necessary modifications given the data, using the physician's overall evaluation of the child's health as H_i .

Data and Variables

This section discusses the data and variables used in the analysis.

National Health and Nutrition Examination Survey III

The National Institutes for Health began collecting nationally representative health data in 1960. NHANES III is the seventh in a series of studies designed to collect information on the health status of the population of the United States. Since the NHANES III data will be used to update and correct the growth charts of children ages two months to five years, this group was oversampled. In addition, in order to examine risk factors associated with health in African-Americans and Mexican-Americans, these groups were also oversampled.

The National Center for Health Statistics (NCHS) and the Centers for Disease Control and Prevention (CDC) collected the NHANES III between 1988-94. Survey workers collected demographic data and information on general health, use of health services, and housing characteristics in an interview in the home. Nearly three-quarters of the participants also received a four-hour medical exam at a mobile Medical Exam Center (MEC). The MECs moved from city to city, preserving consistency in the medical exam. The survey included many tools to induce those selected for the study to participate, especially those selected for the medical portion of the survey. Participants in the medical exam received $30 and the possibility of an additional $20 depending on the nature of the exam and the participant's required fasting schedule. In addition, the survey staff were specially trained to convince participants to both be interviewed and receive a medical exam. In the end 77% of those who originally made appointments at a MEC, received medical exams at a center.

Within the selected area segments, interviewers screened 106,000 households to identify

participants for the study. Based on the screening data, survey designers selected 40,600 sample persons from these households. The survey interviewed 35,000 persons and examined 30,100 persons in the mobile exam units (NCHS, 1994). The household survey and youth interview covered 3,824 children ages two to five, and 3,600 children received medical exams. Once missing data were accounted for, the final regression estimates include 2,993 observations for the demand equation and 2,313 observations for the production function. Since there are more variables in the production function, there are more observations with missing variables than in the demand equation.

Variables

Dependent Variable

The dependent or response variable is the physician's overall evaluation of the child's health, as already indicated. In the survey the physician was not the child's regular doctor. The evaluation was based on the comprehensive medical exam. As will be discussed in the econometric section, the values used in the estimation are actually on a 0-3 scale, where zero represents excellent, and three is a combination of fair and poor health. The distribution of these variables for both the demand and production function estimations is given in Table 1. The physicians considered over three-fourths of the children examined to be in excellent health.

Explanatory Variables

NHANES included a 24-hour dietary recall. For young children, the nutritionist interviewed the parents with the child present. Like most studies of this size, the intake data for

the micronutrients were based on fixed conversion factors from food. An overall nutrient index was calculated and tried in preliminary regressions. Basiotis (1987) recommended calculating the principle components of the micronutrients, and taking the dot product of the principle components and the child's consumption vector to calculate a single index. Preliminary results indicated the index was not a significant contributor to the health of children. Instead of the index, calcium intake was used both as a measure of calcium adequacy, and a proxy for the other nutrients. Calcium intake was expected to have a positive impact on health.

Since some U.S. children are developing eating habits which could lead to obesity, the study also included the percent of calories from saturated fat (Greenwood, et al., 1993). This variable was expected to have a negative impact on health. Two other variables which are related to nutrition were binary variables for food stamp and WIC participation by anyone in the household. Because of the way the data were collected, the food stamp variable measured whether anyone in the household participated in the last twelve months, and the WIC variable measured whether anyone in the household participated in the last month. Since food stamps and WIC may increase food consumption and improve nutrition, participation was expected to have a positive impact on health.

In addition to nutrition, there were other inputs which the study considered important to the health of children. The first was a binary variable indicating whether or not the child was covered by private medical insurance or was eligible for CHAMPUS, an insurance program for dependents of military personnel. If not, the child might have been eligible for Medicaid or had no insurance. Since private insurance generally allows parents to take their children to the

doctor more than children without insurance, this was expected to have a positive impact on health. In addition, consistency in health care is important to catch minor conditions before they become major. Going to one place for health care was measured by a binary variable, and was expected to have a positive impact on health.

The number of rooms in the house or apartment was included to measure both the ability of the child to play actively indoors, and as a measure of the size and quality of the dwelling. The number of rooms was expected to have a positive impact on health. Pediatricians and nutritionists do not agree on the importance of vitamin supplements; they are useful as a supplement to a healthy diet, but are not a replacement for one. Whether or not the child took vitamin or mineral supplements was included as a binary variable, and the expected sign was not suggested by the literature. One health input which was assumed to have a negative impact was whether or not anyone smokes in the household. This was self-reported in NHANES, but the question was asked during the home interview, which made it more difficult for the interviewee to lie.

The final set of variables reflect endowments of both the child and the household. The child's endowments include how many days the child was breastfed after birth, the child's birth weight, the biological mother's age at birth, and the age and sex of the child. Since this study included children ages two to five, a few children were still consuming breast milk, but most were not. The medical literature suggests that babies who were breastfed longer should be healthier when they are older.

The child's birth weight is a proxy for how healthy the child was at birth. This is a common measure of health in infants. Teenage mothers may not be ready physically or

mentally for motherhood. Older mothers were thus expected to have healthier children. The oldest mother in the sample was forty-five, and the youngest was twelve. Girl babies are normally healthier than boy babies, and this effect may continue into the preschool age group, causing the binary variable indicating the child was female to have a positive effect.

The household also had several endowments. Many of these were measures of the parents' ability to provide a healthy environment including access to health knowledge and services, parents' employment status, and their social support network. Unfortunately, the data set only included information for the adult who answered the survey questions. This study assumed the interviewee was the child's primary caretaker. In 90% of the cases, this person was the child's mother, and in 5% the child's father. Variables which were expected to have a positive impact on health included: years of schooling of the caretaker, the mother and father were born in the United States, the parents speak primarily English in the home, the caretaker was either married or previously married at the time of the interview and a higher Poverty Income Ratio (PIR).

The PIR reflects the household's income divided by the federal poverty line for that household's composition. If the PIR is less than one, the family is below the federal poverty line. PIR measures what the family is able to afford since household size is already accounted for by the poverty line. In the health production function, this variable was used to reflect social class. It was assumed a higher social class meant more access to health information from better informed friends and family and the media, and better access to health services. Non-labor income and adult wages were not collected in the survey.

Daycare is often believed to be a place where viruses and other infections are

transmitted. If this is true, a child who was in daycare more than ten hours per week would be less healthy. On the other hand, daycare provides for social interaction which may contribute to health. Other endowments which were expected to have a negative impact included the caretaker was employed at the time of the interview, and family size. If the caretaker was employed outside the home, he or she had less time and energy to spend with the child, nurture the child, and provide healthy meals and a clean home. The benefits of the additional income from working are already reflected in a higher PIR. Other variables which reflect household endowments are race and ethnic binary variables (White Non-Hispanic, Black Non-Hispanic, Mexican-American, and other) which account for culture, region of the country (Northeast, South, Midwest, and West), and level of urbanization.

The detailed description and summary statistics for each variable are listed in Table 2.

Econometric Model

Although health is a continuous variable, it is often measured in discrete categories. An appropriate econometric model for cases in which a continuous measure is represented by a discrete scale is the ordered probit model.

Ordered Probit

The health production and demand functions can be interpreted as having the following specification:

$$h(\ '\ \$)x\%, \tag{3}$$

where h^* is the actual health, x is a vector of explanatory variables, $ is the vector of coefficients, and , is the error vector. Clearly the values of $, x, and , are different for the health production and health demand functions. Note that h^* is a continuous variable and represents the child's actual health. What is observed is the doctor's evaluation of the child's health on a scale from one to five, with one being the best. There were very few children in "fair" and "poor" health so the analysis combines these two categories. The ordered probit model assumes that the rankings begin with zero, so the scale used in the analysis is zero (excellent) to three (fair/poor).

Since the actual health is a continuous variable, the physician's evaluation reflects an arbitrary cut-off between excellent and very good, very good and good, and good and fair/poor. In the model, the cut-offs are represented as μ_i ($i = 0,1,2$), and are the levels of actual health which define the difference between the levels of observed health (for example between "good" and "very good"). The ranking used in the study is:

$$\begin{array}{lcl} h = 0 & \textit{Excellent} & \textit{if } h^* \leq \mu_0 \\ h = 1 & \textit{Very Good} & \textit{if } \mu_0 < h^* \leq \mu_1 \\ h = 2 & \textit{Good} & \textit{if } \mu_1 < h^* \leq \mu_2 \\ h = 3 & \textit{Fair/Poor} & \textit{if } \mu_2 < h^* \end{array} \qquad (4)$$

where h is the observed health measure. In order to preserve the order of the h's, it must be that

$$\mu_0 < \mu_1 < \mu_2 \qquad (5)$$

An ordered response model was first considered by Aitchison and Silvey in 1957 and Ashford in 1959 (Maddala, 1983). They assume that the error terms are normally distributed across observations and can be normalized such that they have a mean of zero, and a variance of one. The probability that h (measured health) will equal 0, 1, 2, or 3 is given by:

$$
\begin{aligned}
Prob[h = 0] &= \Phi(\mu_0 - \beta' x) \\
Prob[h = 1] &= \Phi(\mu_1 - \beta' x) - \Phi(\mu_0 - \beta' x) \\
Prob[h = 2] &= \Phi(\mu_2 - \beta' x) - \Phi(\mu_1 - \beta' x) \\
Prob[h = 3] &= 1 - \Phi(\mu_2 - \beta' x)
\end{aligned}
\tag{6}
$$

where Φ is the cumulative standard normal distribution. As usual, the maximum likelihood method can be used to find values for β and the μ's. This method uses the maximum likelihood principle that the best explanation of a set of data is the one which maximizes the likelihood function.

Marginal Effects

A drawback to the ordered probit model is that the estimated parameters are difficult to interpret. Greene (1997) demonstrates that one way to understand the parameters is to calculate the marginal effect of a change in a continuous explanatory variable on the probability of being in each category. That is, calculate the first derivative of equation 6 for each $\boldsymbol{x}$. The marginal estimates are given by:

$$
\begin{aligned}
\frac{\partial(Prob[h=0])}{\partial x} &= -N(\mu_0 - \beta' x)\beta \\
\frac{\partial(Prob[h=1])}{\partial x} &= -N(\mu_1 - \beta' x)\beta + N(-\beta' x)\beta \\
\frac{\partial(Prob[h=2])}{\partial x} &= -N(\mu_2 - \beta' x)\beta + N(\mu_1 - \beta' x)\beta \\
\frac{\partial(Prob[h=3])}{\partial x} &= N(\mu_2 - \beta' x)\beta
\end{aligned}
\tag{7}
$$

The maximum likelihood calculations of β, the μ's, and the marginal effects for each statistically significant, continuous explanatory variable were calculated by Limdep version 7.0 using equation 7 (Greene, 1998).

For binary predictor variables, this result does not apply. In order to study the effect of a binary variable, Greene (1997) suggests calculating the difference in probabilities when the equation is evaluated at both levels of the binary variable with other explanatory variables at their mean values. For example, the probability of being in each health category can be calculated for food stamp participants and non-participants, holding other predictors at their means. The marginal change due to food stamps is then the difference between the two probabilities. The marginal probabilities for a specific variable, such as food stamps, across the four health categories will sum to zero, with some differences due to rounding-off.

Simultaneity and Unobserved Heterogeneity

This estimation technique does not account for either the possibility of endogenous explanatory variables causing simultaneity, or unobserved heterogeneity. Simultaneity occurs when the value of a predictor variable is affected by the response variable on the left-hand side and is correlated with the model error. If this is the case, the coefficients are biased estimators.

The standard technique for dealing with simultaneity is to use two-stage least squares, a special case of instrumental variables. In the literature on health production and demand functions, unobserved heterogeneity is the effect individual unobserved characteristics have on the child's health. These characteristics are inherent traits which affect health, but were not measured by the survey.

Food intake, for example, is normally assumed to be endogenous when the measure of health is the child's size. Clearly, larger children will eat more, so it makes sense to assume that not only will food intake affect the child's size, but the child's size will affect food intake. However, this study used the physician evaluation of the child's health, which is less likely to directly affect the child's food intake.

The other potential endogenous variable was household income. Since adults who are less healthy cannot perform as much work and earn less, income is generally assumed to be endogenous when studying adult health. Children who are too young to work do not directly affect household income if they are unhealthy. Children's health does affect family income, if one of the parents must take unpaid leave from work to care for the child. Many employers though, allow parents to use their own sick leave, take personal days, or work from home, while caring for sick children. Therefore, it is not clear if simultaneity represents a problem. Moreover, in the NHANES data appropriate variables to serve as instruments were not available for identification so two-stage estimation could not be used.

Finally, PIR is used in two different conceptual ways in this study. Reduced-form health demand functions include prices, income, and health endowments. In this case, PIR represents the household income. The health production function includes health inputs and

health endowments. In this estimate, PIR represents a health input, namely the social-economic category or class.

Empirical Results

This section presents the results of using the ordered probit model to estimate the health demand and production functions. In addition to the estimated coefficients, the standard errors and p-values are given for each variable. The marginal effects are given for variables which are statistically significant at the 10% level or better. The marginal probabilities for the continuous variables can be interpreted as the increased or decreased probability the child would have been in a particular health category, given one more unit of the explanatory variable. The marginal probabilities for binary variables were calculated at the means of every other variable (including other binary variables). This value can be interpreted as the change in the probability of being in a health category given a change in the binary variable of interest from zero to one.

Health Demand Equation

The demand equation results are given in Table 3. The variables which are significant in the doctor's evaluation of health include participation in the Food Stamp and WIC Programs, the poverty income ratio, region, living in an urban area, number of days breastfed after birth, and being Mexican-American. The cut-off values which separate the health categories (μ_0, μ_1, μ_2) are also listed in Table 3. Note that Limdep assumes $\mu_0 = 0$. The equation correctly predicted the health of 78% of the children. The marginal probabilities for statistically significant variables are shown in Table 4.

Children in households which participate in the Food Stamp and WIC Programs have a

higher probability of being in excellent health. This is not surprising since the literature shows that both programs improve nutrition. The marginal probabilities (Table 4) show that children in households which participate in the Food Stamp Program have a 4.35 percentage point higher probability of being in excellent health (health = 0), and have a lower probability of being in very good, good, or fair/poor health (health = 1, 2, or 3). The negative effects for the latter three categories sum to –4.34 percentage points. The results are similar for WIC; the probability the child would have been in excellent health increased by 3.81 percentage points if the household participated in the WIC Program, and the child has a lower probability of being in each of the other health categories.

A higher PIR is associated with a higher probability of the child being in excellent health. The effect is fairly small though; a rise of one (for example from 100% of the poverty line to 200% of the poverty line) increases the probability by only 2.6 percentage points. Households in the Midwest, which is the omitted category, do better than those in the Northeast, but those in the South and West do better than the Midwest. The marginal probabilities for the regional variables are quite high. Children in the West have an increase of 5 percentage points in the probability of being in excellent health compared to children in the Midwest, and children in the South have an increase of 14.9 percentage points. Children in the South and West also have negative marginal probabilities for very good, good and fair/poor health, implying these children have a lower probability of being at these health levels.

The results for the South may seem somewhat counter-intuitive. However, it is important to note that this estimate already accounts for participation in the Food Stamp and WIC programs, the parents' education and marital status, saturated ft intakes and the poverty

income ratio. The regional variables are thus picking up other factors such as differences in prices, pollution, climate, regional food and other cultural practices. Living in an urban area increases the probability the child is in excellent health by nearly 5 percentage points.

Every day longer the child was breastfed increases the probability by .01 percentage points that the child is in excellent health. This implies that if a child had been fed breast milk for nine months longer, the probability the child would be in excellent health increases by 2.74 percentage points. The only race and ethnic variable which is significant is Mexican-American. Compared to "other" which includes Asians and everyone who is neither Mexican-American, Non-Hispanic White nor Black. The probability of a Mexican-American child being in excellent health is 15 percentage point lower than "other" children.

Health Production Function

The health production results are given in Table 5, and the marginal probabilities for the statistically significant coefficients in Table 6. The estimated equation correctly predicts 79% of the children's health levels. In terms of nutrition, increasing the consumption of saturated fat by one percent of total calories, decreases the probability the child would be in excellent health by 0.79 percentage points (see Table 6). If the household increased the child's intake of calcium by one mg, the probability the child would be in excellent health would increase by 0.01 percentage points. There are 300 mg of calcium in an 8 ounce glass of milk, so adding one more glass of milk to the child's daily diet would increase the probability of being in excellent health by 3 percentage points.

If the household participated in the WIC and the Food Stamp Programs, the probability the child is in excellent health increases, and is lower for other health categories. Children in

households which received food stamps increase their probability of being in excellent health by 5.6 percentage points. Children in WIC households have 3.6 percentage points higher probability than non-WIC households of being in excellent health.

Again, Mexican-American is the only race-ethnicity variable which is significant. Mexican-American children's probability of being in excellent health is 9.7 percentage points lower than "other" children. Children whose mothers were born in the United States are 9.1 percentage points less likely to be in excellent health than those whose mothers were born in other countries. This result may seem counter-intuitive. However, recall that this effect is independent of other factors which are associated with being an immigrant that might negatively affect the child's health, which are included in the equation, such as parent's education and the poverty income ratio. This result reflects the positive aspects of being an immigrant such as general ambition and initiative.

Children in the Northeast have a lower probability of being in excellent health than children in the Midwest, while children in the South and West have higher marginal probabilities for excellent health. The poverty income ratio (PIR) in the health production function represents the socioeconomic class of the family. A higher standard of living increased the probability the child is in excellent health.

If the child had private health insurance or CHAMPUS, the child's probability of being in excellent health is 6.5 percentage points lower. This result is surprising. One possible explanation which requires further study is that the majority of private health insurance plans in this sample might have had either sizable deductibles and/or sizable copayments. Because of these out-of-pocket expenses, parents with private health insurance might be less likely to seek

medical attention than children on Medicaid. In addition, unobserved heterogeneity may be a factor in that parents with less healthy children feel a greater need to have health insurance.

Several recent studies suggest that second hand smoke is dangerous for children's respiratory systems. The results confirm these concerns. Children in households with a smoker are 4 percentage points less likely to be in excellent health than in households without a smoker. The statistically significant child health endowment variables include the number of days the child was breastfed after birth, and the sex of the child. The marginal effect for the number of days the child was breastfed is the same as in the demand function. Girls have a higher probability than boys of being in excellent health, which confirms previous studies.

Conclusions

This research used the household model to study the health of U.S. preschool children. The data were from the latest National Health and Nutrition Examination Survey. Ordered probit demand and production equations were estimated for the physician's overall evaluation of the child's health.

The empirical results suggest some important policy implications related to determinants of child health which government policies and programs can influence. The Food Stamp and WIC Programs have a substantial beneficial impact on child health. In the demand relation, children in households participating in the Food Stamp Program increased their probability of being in excellent health by 4.35 percentage points and by 3.81 percentage points for WIC, ceteris paribus. The increased probabilities were 5.58 and 3.60 percentage points in the production relation. The consistency and magnitude of these effects provide strong evidence in

support of these federal food assistance and nutrition programs.

The impact of breastfeeding indicates that more needs to be done to encourage mothers to breastfeed. If the average infant was breastfed nine months longer, he/she would have an increase of 2.74 percentage points in the probability of being in excellent health as a preschooler. In particular with such a high proportion of young women in the labor force, breastfeeding needs to be made more compatible with employment. Nutrition is an important factor. Government programs and healthcare professionals should educate parents on providing better nutrition. Decreasing saturated fat consumption by 2.6% from the average of 12.6% of total calories to the recommended intake of 10% or less, would increase the probability of being in excellent health by 2 percentage points. An additional daily eight ounce glass of milk with 300 mg of calcium would raise the likelihood by 3 percentage points.

The direct impact of income, as reflected in the poverty income ratio, is surprisingly small. An increase in income that takes a household from the poverty level to twice that level, would increase the child's chances of being in excellent health by 3.2 percentage points in the production function and 2.6 percentage points in the demand equation. However, the higher income would likely have a number of beneficial indirect effects which improve child health. The production results confirm the deleterious effects of smoking not only on the smoker, but also on other household members. If anyone smoked, children were 4 percentage points less likely to be in excellent health. Contrary to some common perceptions, neither the fact that the primary caretaker was employed, nor that the child was in daycare more than ten hours per week, or the age of the mother had a significant impact on the child's health.

Determinants of child health that need to be further studied are the regional effects,

being Mexican-American, private insurance, and a U.S. born mother. The regional effects are relatively large, positive for the South and West and negative for the Northeast compared to the Midwest. The negative effects of private insurance and the mother being American by birth are puzzling. They clearly need to be confined and better explained. Finally, the health issues of Mexican-American children need to be more fully explored to better understand the underlying factors contributing to their relatively poor health.

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Table 1. Distribution of Health Categories

Score	Category	Number of Observations	
		Demand	Production
0	Excellent	2,332	1,823
1	Very	269	214
2	Good	378	264
3	Fair/Poor	14	12

Table 2. Summary Statistics for Explanatory Variables

	Mean	Std Dev
Nutrition and Food Programs		
Calcium intake (mg)	795.20	437.40
Percent calories saturated fat	12.61	3.69
=1, Anyone participate in FS, 12 months	0.34	0.48
=1, Anyone participate in WIC, 1 month	0.26	0.44
Health Inputs		
=1, Private insurance or CHAMPUS	0.63	0.48
=1, Goes to one place for health care	0.91	0.29
Number of rooms in dwelling	5.34	1.79
=1, Taken vitamin in last month	0.41	0.49
=1, Anyone smoke in dwelling	0.38	0.49
Health Endowments		
Number of days breastfed	83.39	161.22
=1, Mother smoked during pregnancy	0.19	0.39
Birth weight (g)[a]	3293.55	626.30
Biological mother's age at birth (years)	25.66	5.76
Child age in months	41.46	10.81
=1 if female	0.51	0.50
Household Endowments		
=1, Non-Hispanic White	0.30	0.46
=1, Non -Hispanic Black	0.30	0.46
=1, Mexican American	0.35	0.48
Number years of schooling, adult	11.17	3.70
=1, Adult employed, last 2 weeks	0.71	0.46
Family size	4.73	1.80
=1, Mother US born	0.74	0.44
=1, Father US born	0.72	0.45
=1, Parents speak English	0.72	0.45
=1, Adult married or living together	0.72	0.45
=1, Adult ever married	0.15	0.36
=1, Northeast	0.12	0.32
=1, South (including Texas)	0.43	0.49
=1, West	0.29	0.45
=1, Urban area	0.54	0.50
=1, Child in daycare > 9 hrs/wk	0.32	0.47
Poverty Income Ratio	1.66	1.33

[a]3,293.55 grams is equal to 7.26 lbs.

Table 3. Estimated Health Demand Equation

	Coefficient	Standard Error	P-value
Constant	-0.4112	0.26	0.11
Food Programs			
Food Stamps	-0.1466	0.072	0.04
WIC	-0.1293	0.065	0.05
Income			
Poverty Income Ratio	-0.0905	0.03	0.00
Region			
Northeast	0.5637	0.095	0.00
South	-0.5118	0.077	00.0
West	-0.1722	0.09	0.06
Urban	-0.1642	0.063	0.01
Health Endowments			
Days Breastfed	-0.0003	0.00017	0.06
Birth Weight	-6.1E-06	3.9E-05	0.88
Age in months	0.0005	0.0024	0.84
Child is female	-0.0202	0.052	0.70
Household Endowments			
Non-Hispanic White	0.0854	0.15	0.56
Non-Hispanic Black	0.1529	0.14	0.28
Mexican-American	0.4751	0.14	0.00
Parent's Education	-0.0079	0.0092	0.39
Parents Spoke English in Home	0.0623	0.081	0.44
Parents Married	0.0300	0.088	0.73
Parent Ever Married	0.0027	0.097	0.98
Child in Day Care	0.0272	0.059	0.65
Threshold Parameters for Health			
μ_1	0.3778	0.022	0.00
μ_2	1.9081	0.097	0.00
Log Likelihood Function	-1982.9		
Chi-Squared	208.8		
Predicted Correct	79 %		

Table 4. Health Demand Equation Marginal Probabilities [a]

Prob. Health[b]	=0	=1	=2	=3
Food Programs				
Food Stamps	0.0435	-0.0132	-0.0286	-0.0016
WIC	0.0381	-0.0116	-0.0251	-0.0014
Income				
Poverty Income Ratio	0.0257	-0.0082	-0.0167	-0.0009
Region				
Northeast	-0.1930	0.0451	0.1360	0.0122
South	0.1490	-0.0452	-0.0984	-0.0058
West	0.0505	-0.0155	-0.0331	-0.0018
Urban	0.0498	-0.0147	-0.0331	-0.0020
Health Endowments				
Days Breastfed	0.0001	0.0000	-0.0001	0.0000
Household Endowments				
Mexican-American	-0.1500	0.0412	0.1020	0.0071

[a]Marginal probabilities are only calculated for variables which were significant at the 10 percent or better level. Values for continuous variables were calculated using Limdep 7.0. Values for binary variables were calculated as described in the text.

[b]0 = Excellent, 1 = Very Good, 2 = Good, 3 = Fair/Poor

Table 5. Estimated Health Production Function

	Coefficient	Standard Error	P-value
Constant	-0.5511	0.3832	0.15
Food Intake			
Calcium	-0.0003	8.1E-05	0.00
Saturated Fat	0.0293	0.0089	0.00
Food Stamps	-0.2087	0.0947	0.03
WIC	-0.1359	0.0815	0.10
Health Inputs			
Private Insurance	0.2416	0.0795	0.00
Goes to 1 Clinic	-0.0812	0.1261	0.52
Rooms in House	-0.0134	0.0220	0.54
Takes Vitamins	-0.0811	0.0661	0.22
Anyone Smokes	0.1430	0.0747	0.06
Health Endowments			
Days Breastfed	-0.0004	0.0002	0.10
Mom smoked, pregnant	-0.0166	0.0940	0.86
Birth weight	-2.4E-05	4.6E-05	0.60
Mother age at birth	0.0033	0.0064	0.60
Age in months	0.0005	0.0028	0.87
Child is female	-0.1049	0.0609	0.08
Household Endowments			
Non-Hispanic White	-0.1360	0.1670	0.42
Non-Hispanic Black	-0.0884	0.1632	0.59
Mexican-American	0.3373	0.1627	0.04
Parent's Education	-0.0054	0.0114	0.64
Parent Employed	0.1237	0.0887	0.16
Family Size	-0.0153	0.0225	0.50
Mother, US Born	0.3578	0.1103	0.00
Father, US Born	-0.1164	0.1067	0.28
Parents Married	-0.0654	0.1144	0.57
Parent Ever Married	-0.0614	0.1266	0.63
Northeast	0.6581	0.1093	0.00
South	-0.5150	0.0908	0.00
West	-0.2942	0.1069	0.01
Live in Urban Area	-0.0559	0.0763	0.46
Child in Day Care	-0.0179	0.0712	0.80
PIR	-0.1199	0.0377	0.00
Threshold Parameters for Health			
μ_1	0.4228	0.0283	0.00
μ_2	1.9130	0.1152	0.00
Log likelihood function		-1455.4	
Chi-Squared		248.1	
Predicted Correct		79%	

Table 6. Health Production Function Marginal Probabilities[a]

Prob. Health[b]	=0	=1	=2	=3
Constant	0.1491	-0.0552	-0.0895	-0.0044
Food Intake				
Calcium	0.0001	0.0000	0.0000	0.0000
Saturated Fat	-0.0079	0.0029	0.0048	0.0002
Food Stamps	0.0558	-0.0208	-0.0334	-0.0016
WIC	0.0360	-0.0140	-0.0220	-0.0010
Health Inputs				
Private Insurance	-0.0650	0.0240	0.0390	0.0020
Rooms in House				
Anyone Smokes	-0.0400	0.0140	0.0240	0.0010
Health Endowments				
Days Breastfed	0.0001	0.0000	-0.0001	0.0000
Household Endowments				
Mexican-American	-0.0970	0.0340	0.0600	0.0030
Mother, US Born	-0.0910	0.0350	0.0540	0.0020
Northeast	-0.2150	0.0610	0.1420	0.0120
South	0.1370	-0.0500	-0.0820	-0.0040
West	0.0770	-0.0290	-0.0450	-0.0020
PIR	0.0324	-0.0120	-0.0195	-0.0010

[a]Marginal probabilities are only calculated for variables which were significant at the 10 percent or better level. Values for continuous variables were calculated using Limdep 7.0. Values for binary variables were calculated as described in the text.

[b]0 = Excellent, 1 = Very Good, 2 = Good, 3 = Fair/Poor