Estimating the Effect of the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) on Children's Health

Andrea Carlson, Center for Nutrition Policy and Promotion, USDA
Ben Senauer, Department of Applied Economics, University of Minnesota

Presented at the American Agricultural Economics Annual Meeting, July 28-31, 2002, Long Beach, CA.

Estimating the Effect of the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) on Children's Health

Andrea Carlson, Center for Nutrition Policy and Promotion, USDA
Ben Senauer, Department of Applied Economics, University of Minnesota

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, including less access to health services and health information, plus a more limited ability to obtain acceptable and nutritious foods. One government program which addresses these problems is the Special Supplemental Nutrition Program for Women, Infants and Children (WIC). The WIC program provides foods with specific nutrients to pregnant and lactating women, and to children up to age five in low-income households, as well as nutrition and health assessment and education. Family income must be less than 185 percent of the poverty level, and a health professional determine the individuals to be at nutritional or other health risk to be eligible for the program. Persons in households who participate in certain programs such as Medicaid or Temporary Assistance for Needy Families are automatically eligible. The program had 7.2 million participants in fiscal 2000, including some 3.6 million children, at a total cost of $3.97 billion, which included $2.85 billion in food benefits and the remainder for nutrition and health services and administrative costs (U.S. Census Bureau, 2001 and USDA, FNS, 2002).

Several studies have examined the nutritional impact of the WIC program. Others have assessed specific medical outcomes, most frequently related to childbirth, infants and pregnant women or postpartum mothers. However, no analysis has yet evaluated the impact of WIC on the overall health of preschool age children, which is the focus on this study. Addressing children's health issues effectively requires a clear understanding of the underlying determinants. This study contributes to that goal by estimating a health function for U.S. preschool children (ages 2-5 years) using data from the third National Health and Nutrition Examination Survey (NHANES III). The underlying conceptual framework for this analysis is Gary Becker's household model (Becker, 1965). The health functions obtained from this model have been widely used to study health and nutrition issues in developing countries and have received more limited use in the analysis of the health of U.S. children (Behrman and Deolalikar, 1988; Strauss and Thomas, 1998; Rosenzweig and Schultz, 1983). This paper focuses on the link between the WIC Program and the health of preschool aged children.

The National Health and Nutrition Examination Surveys (NHANES) collected by the Centers for Disease Control and Prevention provide 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. 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. Because of the very few children rated in poor health, they are combined with the fair category in the analysis. Hence, there are four categories: excellent, very good, good and fair/poor. An ordered probit model was used in the empirical analysis.

The next section of this paper provides an overview of the WIC program and briefly reviews some of the relevant previous research. The third section outlines the household and probit models. The fourth describes the data in more detail, and the empirical results are presented in the next section. The conclusion summarizes the results for WIC and makes some comments on the use of the Primary Sampling Units or PSUs in the NHANES data set.

Background

The WIC program is administered by USDA's Food and Nutrition Service. In most cases WIC recipients receive monthly vouchers or checks used to purchase a food package designed to supplement their diet. In a few locations, other distribution systems are still used, such as directly providing the food package at the health clinic. WIC is meant to only supplement the diet and does not cover the total nutritional needs of participants. The nutrition education provided under the program provides guidance on obtaining a balanced diet with all the necessary nutrients.

WIC focuses on nutrients which have been food deficit in the diet of the target population - protein, calcium, iron and vitamins A and C. The foods in the WIC package also provide vitamins D and B-6 and folate. The types and amounts of foods in the WIC package are based on the age and nutrient needs of the individual. Milk and/or cheese, iron-fortified cereal, 100-percent fruit and/or vegetable juices, eggs, peanut butter and/or beans/peas are typically included in the food package for children. The average cost of the WIC food package per month was $31.20 in 1996 and $34.31 in 2000 (USDA, FNS, 2002 and Oliveira and Gunderson, 2000).

Evaluations have found clear evidence of the beneficial impacts of the WIC program. A General Accounting Office (GAO) study found prenatal WIC benefits reduced low birth weights by 25 percent and very low weights by 44 percent. This GAO report concluded that each one dollar spent on prenatal WIC reduced public and private spending on health care by a discounted present value of $3.50, with most of the savings ($2.89) in the first year of the baby's life (GAO, 1992). Such evidence of the positive impact of WIC has led to increased funding by Congress from $728 million in 1980 to $2.12 billion in 1990. Funding has leveled off since 1997 at about $3.8-4.0 billion per year, with about $2.8 billion of that going to the food subsidy (USDA, FNS, 2002). Children have been the most rapidly increasing group of WIC recipients. Total participation rose 63 percent from 1990 to 1998, whereas the number of children participating grew by 81 percent. Consequently, more of the children at risk are being covered. It was estimated that 69 percent of children eligible for WIC participated in 1996 (Oliveira and Gunderson, 2000).

In terms of nutrition, Basiotis, Johnson, Morgan and Chen (1987) found WIC had a positive impact on all components of the U.S. Department of Agriculture's Healthy Eating Index except saturated fat.[1] At least two studies found that WIC children were less likely to have a low iron intake than non-WIC participants of similar income (Brown and Tieman, 1986; Oliveira and Gunderson, 2000). WIC participants had higher intakes of Vitamins C, A, B-6 and folate (Oliveira and Gunderson, 2000) and grains, fruit, dairy, and meat (Basiotis, Johnson, Morgan, and Chen, 1987). WIC participants had a lower intake of added sugars (Wilde, McNamara, and Ranney, 1999), total fat, cholesterol and sodium (Basiotis, Johnson, Morgan, and Chen, 1987). Rose, Habicht, and Devaney (1998) also found WIC participation increased the consumption of ten nutrients.

Variyam (2001) used quantile regression to assess the effect of WIC on eligible preschool children and found that evaluation at just the conditional mean can be deceiving. He discovered the impact of WIC varied considerably by quantile for iron and zinc. For calcium the effects were basically equal across quantile, but even for this nutrient there was variation in the impacts across quantiles of other important variables such as age and gender. Arcia, Crouch and Kulka (1990) found WIC participants purchased more nutritious food, more nutrient-dense food and spent less on food away from home.

In terms of medical outcomes, infants born to mothers who participate in WIC have higher birth weights and the prevalence of low and very low birth weight is lower than for eligible non-participants (Owen and Owen, 1997). In addition, the incidence of iron deficiency anemia is lower among toddlers, preschool children and postpartum women in the WIC program (Owen and Owen, 1997 and Pehrsson, et al., 2001). Prenatal WIC participation was associated with significant Medicaid savings in the first 60 days after birth, ranging from $277 to $598 depending on the state (Devaney, Billheimer and Schore, 1992). Another study found that the mother's participation in WIC before and after birth reduced neonatal mortality (Corman, Joyce and Grossman, 1987). Finally, at least two studies have found that WIC participation can improve child immunization rates, if the WIC program office continually assesses participant's immunization records and makes the appropriate referrals (Hutchins et al., 1999; Shefer and Massoudi, 1999). In sum, the previous research on the WIC program, although extensive, has given less attention to the impact on children and has focused on specific outcomes such as iron intake or immunization rates.

The Model

Health production and demand functions have been widely used in economics to study children's health in developing countries (Behrman and Deolalikar, 1988 and Strauss and Thomas, 1998). More limited use has been made of the household production model to analyze determinants of child health and diet quality in the United States. One analysis which did use this model found mother's health and nutrition knowledge were significant in child's diet quality (Variyam, Blaylock, and Lin, 1998). Another household production analysis concluded that delays in the mother seeking pre-natal care, as well as smoking or alcohol consumption during pregnancy, contributed to low birth weights, which are often associated with poor health in infants (Rosenzweig and Schultz, 1983).

Based on Becker's (1965) model, the household is assumed to maximize utility in terms of the family members' health, consumption of other household produced goods and services, and leisure. The health production function for the i^{th} child's health (H_i) can be specified as:

$$H_i = h(I_i, C_i, F_i, G_i,) \tag{1}$$

where I_i is a vector of inputs to health such as food consumption, participating the WIC Program and medical care, C_i is a vector of characteristics of the child such as the child's age and gender, F_i is a vector of household characteristics such as the parents' education, and G_i is a vector of community and/or geographic characteristics such as region of the country. The maximization of utility subject to time and income constraints yields reduced-form health demand functions, which contain only exogenous explanatory factors (Behrman and Deolalikar, 1988; Senauer and Garcia, 1991).

This study estimates a health function. Some household characteristics such as participation in the WIC and Food Stamp Programs may be jointly determined with health. WIC gives preference to children who are at nutritional risk or have certain health conditions. Similarly, parents may make a greater effort to apply for WIC or food stamps if their child is not healthy. These variables should be tested for endogeneity, since the estimates may be biased due to simultaneity and unobserved heterogeneity.

The health function can be specified as:

$$H^*_I = \beta' \mathbf{x} + \varepsilon \tag{2}$$

where H^*_I is the child's actual health, **x** is a vector of explanatory variables, β' is the vector of coefficients, and ϵ is the error term. Although actual health is a continuous variable, what is observed is the physician's evaluation into five categories,

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

where H is the observed health, and the μ_j's are cut-off values for health. Note that if health were plotted on a horizontal axis, more health would be to the left, and less health to the right. Thus, the physician rates the child in "excellent" health (H= 0) if the child's actual health, H* is below μ_0, in "very good health" (H= 1) if the child's actual health falls between μ_0 and μ_1. The cut-off points are estimated by the model. In order to preserve the order of the h's, it must be that

$$\mu_0 < \mu_1 < \mu_2 \tag{4}$$

Greene (1993) and the STATA Reference manual (Stata Corporation, 1999) describes the ordered probit model in detail. 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:

$$\begin{aligned} Prob[h=0] &= \Phi(\mu_0 - \beta' x) \\ Prob[h=1] &= \Phi(\mu_1 - \beta' x) - \Phi(\mu_0 - \beta' x) \\ Prob[h=2] &= \Phi(\mu_2 - \beta' x) - \Phi(\mu_1 - \beta' x) \\ Prob[h=3] &= 1 - \Phi(\mu_2 - \beta' x) \end{aligned} \tag{5}$$

where Φ is the cumulative standard normal distribution. The maximum likelihood method can be used to find values for β and the μ's. The parameters in β reflect the effect of changes in **x** on the probability of the child being in excellent health. Maximum likelihood was used to estimate the ordered probit model (Stata Corporation, 1999).

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 5 for each $\boldsymbol{x}$. The marginal estimates are given by:

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

Where ϕ is the probability density function for the standard normal. The maximum likelihood calculations of β were calculated using STATA version 7, while marginal effects for continuous variables were calculated using equation 6 in Excel 2000.

For binary predictor variables, the first derivative 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. Therefore, the marginal effect of a binary variable is:

$$\text{Prob}\ (y = 1 | \bar{x}_*, b = 1) - \text{Prob}\ (y = 1 | \bar{x}_*, b = 0) \tag{7}$$

where $\bar{x}_*$ equals the mean of all the other variables and b is the binary explanatory variable. For example, the probability of being in excellent health can be calculated for WIC participants and non-participants, with all other inputs held at their mean value. The marginal change due to WIC is then the difference between the two probabilities.

Data and Variables

The National Institutes for Health began collecting nationally representative health data in 1960. The third National Health and Nutrition Examination Survey (NHANES III) is the most recent 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 were used to update and correct the growth charts of children ages two months to five years, this group was over sampled. In order to examine risk factors associated with health in African-Americans and Mexican-Americans, these groups were also over sampled.

The Centers for Disease Control and Prevention 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, including the 12 physicians and other persons involved with the exams, 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 exam 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 percent of those who originally made appointments at a MEC, received medical exams at a center (U.S. DHHS, 1994).

Within area segments selected for the survey, interviewers screened 106,000 households to identify participants for the study. Based on the screening data, survey designers selected 40,600 sample persons from those households. The survey interviewed 35,000 persons and examined 30,100 persons in the mobile exam (U.S. DHHS, 1994). A total of 3,104 kids ages 24 to 60 months (including 24 and 60 months) actually received medical exams by a doctor.[2] A number of these observations had to be excluded from the empirical analysis because of missing values for one or more of the variables. We also randomly selected one child from each family, if there was more than one child age 2 to 5 years old. This brought the total down to 2,632 observations, which is referred to as the “full” sample in the analysis.

A special sample of children who live in households which are believed to be eligible for WIC was also developed. Following the work of Kramer-LeBlanc, Mardis, Gerrior, and Gaston (1999), a household was considered eligible for WIC if the household income was less than or equal to 185 percent of poverty or someone in the household qualified for Medicaid. The total number of children in this sample, after missing variables and multiple child families were accounted for, was 1,554 children. This is referred to as the “WIC eligible” sample. The sample weights for subjects with a medical exam were used in this study. Weights were provided so the sample would be more nearly representative of the U.S. population, and WIC eligible population.

Variables

Dependent Variable

According to the medical community, one measure 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 height and weight, and other indicators of health such as disease and illness history, and the results of a medical examination. “The American Children: Key National Indicators of Well-Being

2001," produced by the Federal Interagency Forum on Child and Family Statistics lists the physician's evaluation as the first measure of general health status for children (Federal Interagency Forum on Child and Family Statistics, 2001). Other studies in the health literature also use this variable as a measure of overall health (Alaimo, Olson, and Frongillo, 2001).

The dependent or response variable is the physician's overall evaluation of the child's health. In the survey the physicians were not the children's regular doctor, but moved with the Mobil Exam Centers. Throughout the six years of data collection, only 12 different doctors saw all participants which helped to create a highly standardized evaluation. The physicians based their evaluation on the comprehensive medical exam before the lab results were complete. They rated the children at one of five levels: excellent, very good, good, fair and poor. Because so few children were rated in poor health, that category was combined with fair, so the analysis is conducted for four levels of health.

Explanatory Variables

As discussed above in the conceptual model section, the explanatory variables are divided into characteristics of the child, household and geographic location. The explanatory variable of most interest is whether the household participated in the WIC program. We chose whether anyone in the household was participating, rather than just the child, because household food is generally shared between family members. In addition, WIC coupons may free up money in the family's food budget for other members to consume.

As mentioned above, WIC is not an entitlement program, and preference is given to children who have certain health conditions or are considered nutritionally at risk. Thus, WIC participation may be jointly determined with health. Similarly, if parents believe their children are less healthy than other children, they may be more likely to apply for the Food Stamp Program. Although the Food Stamps Program is an entitlement program, people who choose to participate are more likely to believe they will have a low income for a longer period of time than others with similar incomes who do not participate (Blank and Ruggles, 1995). Since WIC and Food Stamp Program participation may be jointly determined with child health these variables should be tested for endogeneity using the Hausman test.

Other household characteristics which might be expected to affect child health include income and how crowded the house is, and a set of variables which attempt to measure the parents' ability to provide a healthy environment. The variables included for the parent or other caretaker who answered survey questions for the child are the person's education level, whether they speak English at home, whether he/she is currently married, and if not currently, then was the adult married before.

The child's characteristics include how many days the child was breast-fed after birth, whether the child's birth weight was less than 2,500g, the child's race and ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other), and the age and sex of the child.

Regions of the country (Northeast, South, Midwest, and West) are included in two of the models. In the other two models presented in the next section, a set of binary variables representing 49 pseudo primary sampling units (PSUs) from the survey are used instead of the regions. Children in the same PSU are located in the same county. Although, there were 81 actual PSUs in the data collection, the data set only lists 49 pseudo PSUs, which are a combination of the original 81. In all but 5 of these cases, the pseudo PSUs are made up of persons living in the same county. Public health clinics are administered at the county level, so a variable which distinguishes between counties may be predictive of health. In addition, persons in the same PSU are likely to be exposed to many similar environmental and socioeconomic factors not included as specific explanatory variables, which could affect health, such as levels of pollution or labor options. This variable might also capture differences in the administration of the WIC program across counties.

Empirical Results

This section presents the results of using the ordered probit model to estimate the health function. Four equations or models were estimated with the two samples and regions or PSUs. As mentioned above, there are theoretical reasons why WIC and food stamp participation might be endogenous. Greene (1993) recommends using a Hausman test as the first step to check for endogeneity. Variables used for identification in making this test included adult employment, urbanization, the mother was 18 years or less at the time of the child's birth, percent of the child's life on WIC, whether the child and parents were born in the United States, whether the parents speak English in the home, the length of time the family has lived at the address and the child has lived in the city, and phase of the survey (Phase I: 1988-91; Phase II: 1992-94). The last variable was included as a proxy for year, since year is not included in the data set. These variables had particularly low t-statistics when used to predict the children's health status, yet were good predictors of participation in the WIC and Food Stamp Programs. The Hausman test showed that WIC and Food Stamp Program participation are not endogenous variables.

Estimated Health Equations

WIC, the Poverty Income Ratio, and the regional or most of the PSUs binary variables are the only determinants which were significant in all four models at the p = .1 or better level. WIC was significant at the p = 0.05 level in all four models. The marginal change for WIC participation is calculated using equation 7. Participation in the WIC program increases the probability the child is in excellent health by 4.6 to 11.4 percentage points depending on the model. Thus if a child not enrolled in WIC has a 75 percent chance of being in excellent health, participation in the WIC program will raise this to a 80 to 86 percent chance of being in excellent health. Higher marginal values were found in the WIC eligible sample, indicating that poor children benefit more from the program. However, the strong effect in the full sample shows that even if poor children are compared to the rest of the population, they still fair better if they participate in WIC.

The Poverty Income Ratio was also significant in all four models. The marginal impact of PIR is calculated using the partial derivatives as calculated using equation 6. The marginal value ranges from 2.9 to 9.6 percentage points. Note that this is actually quite small. A rise from a PIR of 1 to 2 (by one unit) means going from 100 percent of the poverty line to 200 percent; for a family of four the rise in 1999 was equivalent to a shift in income from $17,029 to $34,058 (U.S. Census Bureau, 2001). The WIC program is apparently much more effective at improving child health than even large increases in household income, though the marginal value is higher when estimating the WIC eligible sample rather than the full sample.

There is a substantial regional impact on child health, with children living outside the Northeast having a higher probability of being in excellent health by 12.2 to 23.4 percentage points. This result is not confirmed by other studies, and may be unique to this data set. One explanation for the apparent lower level of health could be a result of the primary sampling units (PSUs) selected in the Northeast. The data are only designed to represent the country as a whole; the persons selected within a given region may not be representative of the region. It could be simply coincidental that the PSUs selected in the Northeast have a higher concentration of less healthy children than other parts of the Northeast.

The models involving PSUs or counties shed some light on this. In these model, binary variables representing each of the 48 pseudo-PSUs are created. As discussed above, in most cases the children within the same PSU live in the same county. To avoid multi-colinearity, one county is omitted from the regression. In keeping with the models using region of the country, one county from the Northeast is omitted. In the WIC eligible sample 41 of the 47 counties were significant at the $p = 0.1$ level or better, while 43 of 47 were significant in the full sample. Within the Northeast, 4 of the 7 counties included in the regressions are significantly different from the omitted county in both the full and WIC eligible sample. Each of these has a positive marginal impact, meaning children in these counties have a higher probability of being in excellent health than the ones in the omitted county. The remaining 3 counties in the Northeast were not statistically different from the omitted county. Thus 3 of the 6 non-significant counties in the WIC eligible sample, and 3 of the 4 non-significant counties in the full sample were in the Northeast. The children living in the counties (or PSUs within counties) selected from the NE seem to be the least healthy. Further study with other data sets is required before we can conclude that children in the Northeast are less healthy after controlling for income, WIC and Food Stamp Program participation, language, marital and educational status of the adult, crowding of the household, the child's age, gender, race and ethnicity, and the child's birth weight and how long the child was breast-fed. We also tried omitting counties from other parts of the country. This changed the significance of individual counties, but the total number of significant counties changed by only one or two counties, indicating that there is considerable variation among the other counties as well.

It is also interesting to note that most of the county binary variables show a stronger marginal impact than the regions. We conclude from this that the PSUs or counties are capturing more of the geographic and neighborhood characteristics than the 4 regions which explain children's health. If children are otherwise similar, the PSU represents differences in neighborhood and environmental characteristics, as well as differences between the omitted county and the one being examined in the way programs are administered. This is an important control variable which many data sets do not have.

Conclusions

This research used a household model to study the impact of the WIC Program and other factors on the health of U.S. preschool children. The data were from the Third National Health and Nutrition Examination Survey. Ordered probit equations were estimated for the physician's overall evaluation of the child's health.

Participation in the WIC program, the Poverty Income Ratio (PIR) and regional or county controls were all significant in predicting children's health. Children in households participating in WIC are five to eleven percentage points more likely to be in excellent health, ceteris paribus, with the effect being stronger in the WIC eligible sample. The consistency and magnitude of these effects provide strong evidence in support of this program. The WIC Program is more effective at improving child health compared to even large increases in household income. Moreover, the beneficial effect of WIC on health is greatest for children in the poorer households which are eligible for the program.

A second finding is the importance of county and neighborhood in determining children's health. Nearly all Primary Sampling Units (PSUs) were significantly different from each other. Children within the same PSU were selected from the same local area, and at a minimum the same county. In the NHANES III data set, the PSU variable can be used to control for neighborhood and county characteristics in household models. In predicting children's health, neighborhood and county are important since factors such as the physical environment, neighborhood resources, and the local public health department influence health.

REFERENCES

Alaimo, K., C. Olson, and E.A. Frongillo. "Food Insufficiency and American School-Aged Children's Cognitive, Academic, and Psychosocial Development." *Pediatrics* 108(2001): 44-54.

Arcia, G.T., L.A. Crouch and R.A. Kulha. "Impact of the WIC Program on Food Expenditures." *American Journal of Agricultural Economics* 72(1990):218-26.

Ball, T. and A. L. Wright. "Health Care Costs of Formula-Feeding in the First Year of Life." *Pediatrics* 103(1999): 870-6.

Basiotis, P. P., C .S. Kramer-LeBlanc, and E. T. Kennedy. "Maintaining Nutrition Security and Diet Quality: The Role of the Food Stamp Program and WIC." *Family Economics and Nutrition Review* 11(1998): 4-16.

Beaudry, M. and Sylvie. "Relation Between Infant Feeding and Infections During the First Six Months of Life." *Journal of Pediatrics* 126(1995): 191-7.

Becker, G. "A Theory of the Allocation of Time." *The Economic Journal* 75(1965): 493-517.

Behrman, J. and A .Deolalikar. "Chapter 14: Health and Nutrition." *Handbook of Development Economics.* H. Chenery and T. N. Srinivasan, eds., 631-711. New York: Elsevier Science Publisher, 1988.

Blank, R. *It Takes a Nation: A New Agenda for Fighting Poverty.* Princeton, NJ: Princeton University Press, 1997.

Blank, R. and P. Ruggles. "When Do Women Use Aid to Families With Dependent Children and Food Stamps? The Dynamics of Eligibility Versus Participation." *The Journal of Human Resources* 31(1995): 57-89.

Brown, J. and P. Tieman. "Effect of Income and WIC on the Dietary Intake of Preschoolers: Results of a Preliminary Study." *Journal of the American Dietetic Association* 86(1986): 1189-91.

Buescher, P., L .Larson, M. D. Nelson, and A. Lenihan. "Prenatal WIC Participation Can Reduce Low Birth Weight and Newborn Medical Costs: A Cost-Benefit Analysis of WIC Participation in North Carolina." *Journal of the American Dietetic Association* 93(1993): 163-6.

Centers for Disease Control and Prevention (CDC). "Nutritional Status of Children Participating in the Special Supplemental Nutrition Program for Women, Infants, and Children

--- United States, 1988-1991." *Morbidity and Mortality Weekly Report* 45(1996): 65-9.

Corman, H., T. Joyce and M. Grossman. "Birth Outcome Production Function in the U.S.." *Journal of Human Resources* 22(1987):339-60.

Cushing, A., J. Samet, W. Lambert, B. Skipper, W. Hunt, S. Young, and L. McLaren. "Breast-feeding Reduces Risk of Respiratory Illness in Infants." *American Journal of Epidemiology* 147(1998): 863-70.

Devaney, B., L. Bilheimer and T. Schore. "Medicaid Costs and Birth Outcomes: The Effects of Prenatal WIC Participation and the Use of Prenatal Care." *Journal of Policy Analysis and Management* 11(1992):573-92.

Federal Interagency Forum on Child and Family Statistics. *America's Children: Key National Indicators of Well-Being 2001*. Washington, DC: Forum on Child and Family Statistics, Government Printing Office.

General Accounting Office (GAO), Human Resources Division. "Early Intervention: Federal Investments Like WIC Can Produce Savings." GAO/HRD-92-18. April 1992.

Greene, W. H. *Econometric Analysis,* 3rd ed. New York: Prentice-Hall, 1993.

Hutchins, S., J. Rosenthal, P. Eason, E. Swint, H. Guerrero, and S. Hadler. "Effectiveness and Cost-Effectiveness of Linking the Special Supplemental Program for Women, Infants, and Children (WIC) and Immunization Activities." *Journal of Public Health Policy* 20(1999): 408-26.

Kramer-LeBlanc, C., A. Mardis, S. Gerrior and N. Gaston. *Review of the Nutritional Status of WIC Participants*. Washington, D.C.: USDA, Center for Nutrition Policy and Promotion. Report Number CNPP-8.

Oliveira, V. and C. Gundersen. *WIC and the Nutrient Intake of Children.* Washington, D.C.: Food and Rural Economics Division, Economic Research Service, USDA. Food Assistance and Nutrition Research Report. Report Number 5, 2000.

Owen, A. L. and G. M. Owen. "Twenty Years of WIC: A Review of Some Effects of the Program." *Journal of the American Dietetic Association* 97(1997):777-82.

Pehrsson, P. R., P. B. Moser-Veillon, L. S. Sims, C. W. Suitor and E. Russek-Cohen. "Postpartum Iron Status in Nonlactating Participants and Nonparticipants in the Special Supplemental Nutrition Program for Women, Infants and Children." *American Journal of Clinical Nutrition* 73(2001):86-92.

Rose, D., J.P. Habicht, and B. Devaney. "Household Participation in the Food Stamp and WIC Programs Increases the Nutrient Intakes of Preschool Children." *The Journal of Nutrition*

128(1998): 548-55.

Rosenzweig, M. and T. P. Schultz. "Estimating a Household Production Function: Heterogeneity, the Demand for Health Inputs, and Their Effects on Birth Weight." *Journal of Political Economy* 91(1983): 723-46.

Senauer, Ben and Marito Garcia. "Determinants of the Nutrition and Health Status of Preschool Children: An Analysis with Longitudinal Data," *Economic Development and Cultural Change* 39(1991): 371-390.

Shefer, A. and M. Massoudi. "Missed Opportunities to Improve Immunization Status Among High-Risk Children in the WIC Program." *Journal of Public Health Management Practice* 5(1999): 82-5.

Stata Corporation. *Stata Reference Manual,* Release 6 ed. College Station, TX: Stata Press, 1999.

Strauss, J. and D. Thomas. "Health, Nutrition, and Economic Development." *Journal of Economic Literature* 36(1998): 766-817.

U.S. Census Bureau. Statistical Abstract of the United States, 1999. Washington, D.C., 2001.

U.S. Department of Agriculture, Food and Nutrition Service (USDA, FNS). "WIC Program Participation and Costs." Website www.fns.usda.gov/pd.wisummary.htm, data as of March 27, 2002.

U.S. Department of Health and Human Services (DHHS) and National Centers for Disease Control and Prevention (CDC). *Plan and Operation of the Third National Health and Nutrition Examination Survey, 1988-94*. Washington, D.C.: 1994.

----- "Update: Blood Lead Levels -- United States, 1991-1994." *Morbidity and Mortality Weekly Report* 46(1997): 141-6.

----- "Recommendations to Prevent and Control Iron Deficiency in the United States." *Morbidity and Mortality Weekly Report* 47(1998): 1-36.

Variyam, J. "WIC Participation and the Nutrient Intake of Preschoolers." Paper presented at the Annual Meetings of the American Agricultural Economics Association, Chicago, IL, August 5-8, 2001.

Variyam, J., J. Blaylock., and B. H. Lin. "Mother's Nutrition Knowledge and The Diet Quality of Preschool Children." Paper Presented at USDA S-278 Working Group Meeting, St. Louis. MS, October, 1998.

Wilde, P., P. McNamara, and C. Ranney. "The Effect of Income and Food Programs on Dietary Quality: A Seemingly Unrelated Regression Analysis With Error Components." *American Journal of Agricultural Economics* 81(1999): 959-71.

Wolfe, B. and J. Sears. "Health Indicators for Preschool Children Ages One to Four." *Indicators of Children's Well-Being.* R. M. Hauser, B. V. Brown, and W. R. Prosser, eds., 76-94. New York: Russell Sage Foundation, 1997.