Valuing Environmental Health Risk Reductions to Children

PROCEEDINGS OF

SESSION III: VALUING FETAL AND INFANT HEALTH EFFECTS

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Combining Psychological and Economic Methods to Improve Understanding of Factors Determining Adults' Valuation of Children's Health

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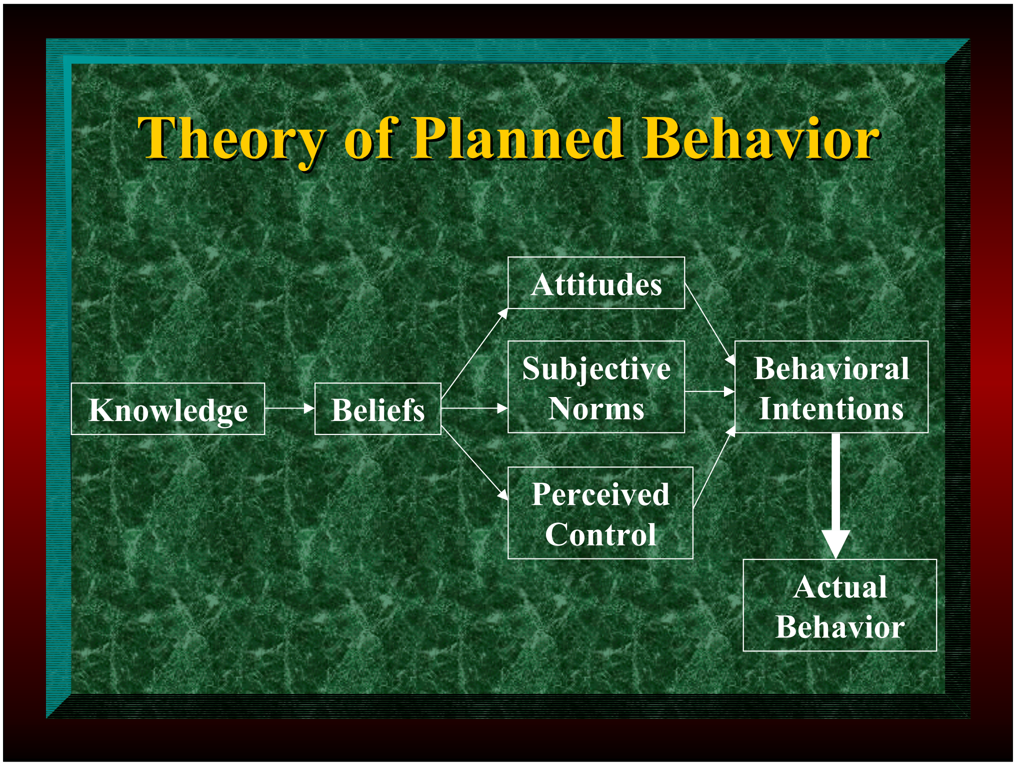
Research Question

- What are the factors that influence adults' willingness-to-pay to avert risks to children's health?
  - Stressor → Nitrate (NO_3) contaminated drinking water
  - Model → Theory of Planned Behavior
  - Method → Survey and choice task


Theory of Planned Behavior
Knowledge
Beliefs
Attitudes
Subjective Norms
Perceived Control
Behavioral Intentions
Actual Behavior

Participants

- 520 participants
  - 90 from Fort Collins (control group)
  - 215 from the Eastern Plains of Colorado (experimental)
    - 115 in consequential choice treatment
  - 215 from the San Luis Valley of Colorado (experimental)
    - 115 in consequential choice treatment
- The survey/methodology will be piloted on a sample of 30 participants (10 from each of the geographical areas listed above)

Procedure

- Survey will assess various components of TPB with respect to the stressor and the various behavior options
- Respondents will be presented with a contingent valuation task

Contingent Valuation Task

	Do Nothing	Purchase Bottled Water
Trips to Store		
Risk of Severe Health Effects		
Risk of Moderate Health Effects		

Procedure (cont.)

- Half of the respondents in the two experimental conditions will be instructed that one of the decisions they make in the contingent valuation task will be binding

Current Status

- Expert Advisory Groups
  - Survey development
  - Construction of option/attribute tables for contingent valuation task

Nitrate Advisory Group

- Survey should assess knowledge of different potential sources of nitrate contamination
- Survey should assess knowledge of how responsibilities differ for public and private water supplies
- Items regarding source reduction strategies should be broad

Nitrate Advisory Group

- Survey wording should avoid “test-like” quality
- Providing some participants with a reverse osmosis filter would be problematic

Health Advisory Group

- Should determine if the communities under investigation have had cases of blue baby syndrome
- Determine if each community has problems with contaminants other than nitrate
- Survey should include items pertaining to pre-natal exposure

Health Advisory Group

- Items should be framed in terms of both the respondents' own infants and infants in the community

Methodology Advisory Group

- Choice task should be simplified
- The different behavior options should be more compatible
- A practice round would be helpful in the consequential choice treatment
- Survey should provide information acknowledging that the options may be beneficial for other reasons

Methodology Advisory Group

- Costs for the different options should be constructed to be credible and to ensure that some participants will actually purchase the option

Next Steps

- Complete survey development
- Translate survey into Spanish
- Collect pilot data

September 2003

Pregnant Mother's Valuation of Own and of Child Health*

by

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ABSTRACT

The value an adult attaches to own health relative to child health is estimated when adult health inputs are choice variables and adult health is an input to child health. Mothers' weight gains during pregnancy and children's birthweights respectively measure adult and child health. Estimates suggest mothers value child health about six times more than own health, and that this relative value declines with number of siblings, increases with family income, and varies with maternal consumption patterns.

I. INTRODUCTION

This paper uses a pregnant woman's own - consumption in its various commodity - specific forms to estimate the value she attaches to own - health relative to the health of the fetus she carries. The current U.S. federal agency practice of transferring widely available adult health benefit measures unadjusted to children's health gives the issue policy relevance.[1] Also, except insofar as it reduces household resources available to a child, the "child development" influence of the commodity - specific particulars of a parent's own - consumption have been little studied in economics. Yet parents engage in many activities which directly or indirectly give them utility while simultaneously producing consequences for their children. Thus, for example, a parent may drink alcohol excessively and subsequently abuse or neglect her child, or a pregnant woman may indulge a diet which adversely affects the health of her fetus.

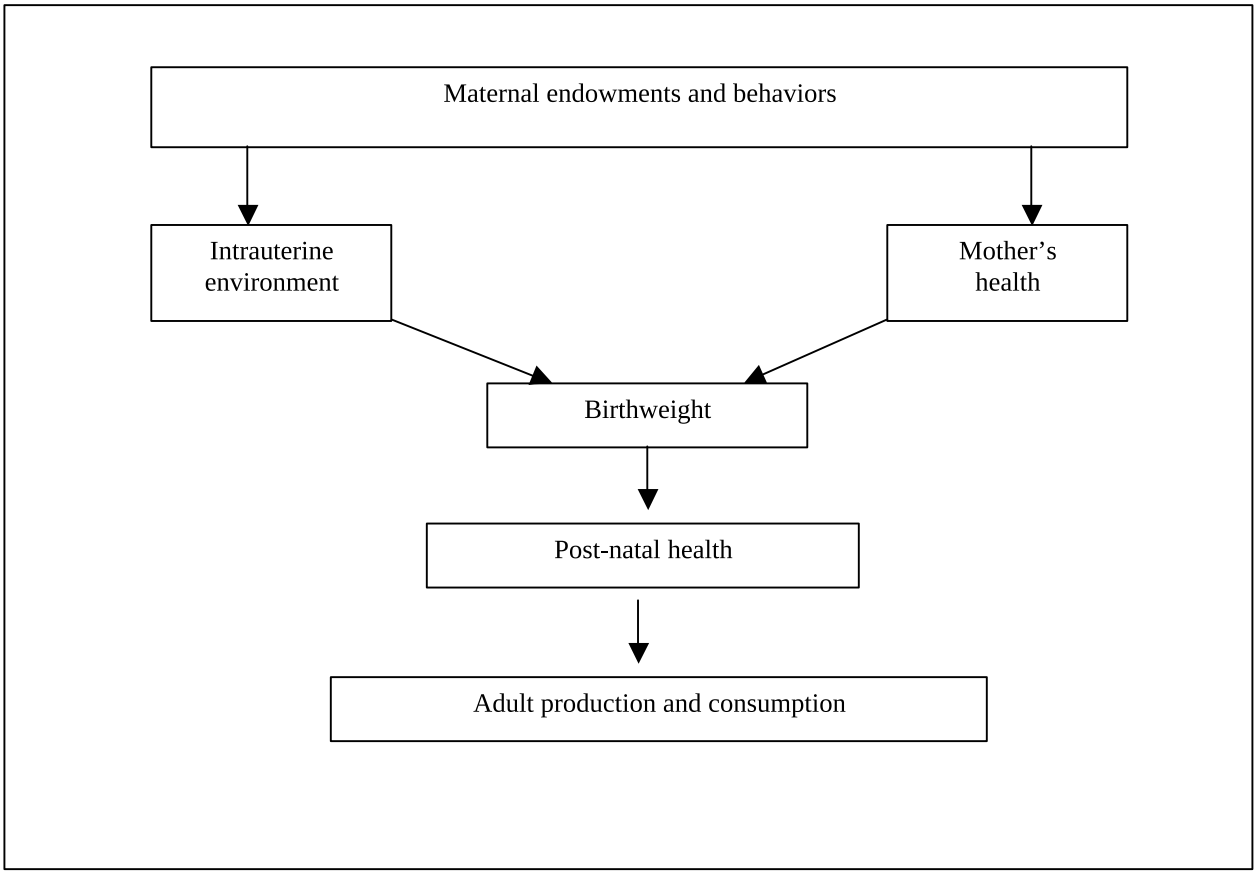
Because adults do not resemble children either biologically or economically, the current U.S. federal agency practice of using unadjusted adult health economic benefit measures to assess the benefits of improving children's health is suspect. Differences between the biological responses of adults and children to many identical environmental stressors are widely acknowledged. And children live with adults whose internal household allocation and investment behaviors can amplify or temper these biological responses. The degree of amplification or tempering many differ between adult and child because of differences in the choices adults make for themselves and for their children. For example, the scope of the activities adults choose for themselves is commonly less restricted than those they choose for their child. Also, adult investments in children's health can be riskier and thus the return to human capital investments less than equivalent own - health investments, given that children

[1]See, for example, the health benefit transfer procedures propounded in Kuchler and Golan (1999), and in U.S. Environmental Protection Agency (2000).

have no performance records indicative of potential investment payoffs. Markets to insure against this risk are more incomplete for children than for adults. But children have longer expected life spans than do adults, which allows them to accumulate more human capital than an adult whose capital stock is already largely built. Given the concavity of health investments (Grossman, 1972) in producing human capital, the marginal productivity of investments in children will exceed that of genetically similar adults. In general, the value to adults of own relative to children's health improvements is an empirical question influenced by the relative prices and the properties of the not always identical health hazard risk - reduction technologies applied to adults and to children. Thus a similar health hazard exposure may induce quite different marginal benefits and marginal costs for adult and for child health -- physical, intellectual, and emotional.

To estimate the relative value adults attach to own health relative to child health we focus on the intrauterine environment a pregnant woman provides her fetus. The impact of the intrauterine environment upon child health and development and ultimately upon that child's adult well-being is a recent concern in economics that has a very large literature in other disciplines. This noneconomic literature suggests the health of a fetus and its adult well-being are connected through the causal chain depicted in Figure 1 involving both adult caretaker behaviors and biological processes. The starting point is maternal health endowments and behaviors. Maternal endowments and behaviors are linked to the intrauterine environment and fetal growth, and to contemporaneous maternal health. The intrauterine environment and the mother's contemporanceous health positively affect birthweight, which is positively linked to the child's post-natal health (Institute of Medicine, 1990). Post-natal health is a significant positive

Figure 1. A Causal Chain



determinant of the child's ultimate adult production and consumption and of its societal contribution (Becker and Murphy, 1992).

For two reasons, our attention here is limited to the first three levels of Figure 1. First, as Figure 1 suggests, there is evidence that the effects of lower birthweight are long-term, even intergenerational (e.g. Hack et al., 1995; Barker, 1998; Currie and Hyson, 1999; Henriksen, 1999; Agee and Crocker, 2002). Lower birthweight children are less healthy than their peers, and they do less well in school. Increasing birthweight increases adult earnings and schooling (Behrman and Rosenzweig, 2001). Given that birthweight drives post-natal child health, it is plausible that an adults' relative valuation of own to post-natal child health reflects the in utero investment the pregnant mother made. If so, an estimate of the own/fetus health valuation will be predictive of the evolution of her own/child health valuation.

Second, maternal health has positive and negative impacts on post-natal child health. In the post-natal setting, increased parental consumption or investments in own health impact the household budget constraint, implying that child health and parent health are substitutes. Better parent health or more consumption then implies lesser child health. But better parent health frequently means the parent can provide the child a better quality of care, resulting in enhanced child physical, intellectual, and emotional health. For the young child the net effect of an increase in parental consumption or health investment depends on the sign of the sum of these two factors. This sign is an empirical question dependent upon the mix of phenotypes of individual household members and upon the determinants of intrahousehold resource allocations to these members. Grasping the complexities of the mix and the determinants can be a daunting analytical and empirical task, especially if adult and child behaviors are jointly determined or if household public goods are present. In contrast, the sign of the connection between maternal health and fetal child health is unambiguous: it is positive and unidirectional from mother to fetus.[2] This positive and unidirectional linkage is widely recognized in the medical literature.[3] A mother's morbidity and poor health habits result in growth retardation in utero, and, consequently, a

[2] See, however, The Economist (2003) which reviews literature suggesting that the fetus, when stressed, allocates a greater share of available resources to brain development. No evidence exists that this reallocation fully compensates for poor maternal health or health practices in all dimensions of post-natal child health.

[3] ACC/SCN (2000) provides a thorough review. Other reviews are to be found in Battaglia and Simmons (1979) and in Kramer (1987). This same literature presents evidence consistent with the marginal products of many post-natal inputs for lower birthweight children being less than those for normal birthweight children. Thus the disadvantage of lower birthweight may become progressively greater with age.

reduced birthweight for her child.[4] The health of the fetus defined in terms of its realized birthweight for a given gestation period is the result only of its genotype and the contemporaneous health behaviors and health state of its mother. No other intervening or mediating influences enter.

Both the biomedical health and the health economics literatures report the results of extensive research on the determinants of birthweight.[5] The economics literature can be distinguished from the biomedical literature by the emphasis of the former on the endogeneity of many health inputs, unobserved heterogeneity, and selectivity of women who become pregnant and who produce live births. This paper extends the previous economics literature in two ways. First, while continuing to account for input endogeneity and selectivity, it treats the pregnant mother's health as endogenous. Second, this treatment of the health of the pregnant mother as endogenous permits derivation of the value this mother attaches to own health relative to the health of her fetus. We find the contemporaneous, endogenous health of the pregnant mother to be a significant determinant of the health of her fetus, where fetus health is defined as its live birthweight. Our representative mother values the health of her fetal child about six times more than she values her own health.

The next section discusses the implications of the endogeneity of contemporaneous maternal health for estimates of birthweight production functions. A third section develops a model of birthweight production which provides restrictions for an econometric specification. The data used to estimate the birthweight production function are described in a fourth section

[4] The medical literature defines low birthweight (LBW) as a weight at birth less than 2500 grams, about 5.5 pounds. LBW results from premature birth and intrauterine growth retardation. This purportedly universal threshold fails to consider variations in genetically determined normal birthweights.

[5] Economic interest in the issue appears to have first appeared with Rosenzweig and Schultz (1982). Representative subsequent treatments in the economics literature include Grossman and Joyce (1990), Rosenzweig and Wolpin (1991), Levinson and Ullman (1998), Warner (1998), Evans and Ringel (1999), Joyce (1999), and Abevaya (2001).

and estimation results take up the fifth section. A summary of and caveats about results conclude.

II. THE ENDOGENEITY OF MATERNAL HEALTH

Epidemiological research (e.g., Kirchengast and Hartman, 1998; Shapiro et al., 2000) unequivocally concludes that a mother's weight gain during her pregnancy has a strong positive influence on her child's birthweight. This weight gain is a function of her preconception health endowment and her nutritional and morbidity state while pregnant (Institute of Medicine, 1990). Her nutritional and morbidity state while pregnant is influenced by her contemporaneous health input behavior (Osami and Sen, 2003). That is, the pregnant mother's health as measured by her contemporaneous weight gain is an endogenous input to her child's birthweight. Physicians recognize this as they recommend behaviors for individual mothers which they think will result in a weight gain for her conforming to guidelines recommended by the American College of Obstetrics and Gynecology (1998).

Although development economists (e.g., Strauss, 1986; Devlalikar, 1988) frequently treat weight as an endogenous variable in studies of labor productivity, none of the economics literature dealing with birthweight takes account of the possible endogeneity of the pregnant mother's health as measured by her pregnancy weight gain.[6] To see the consequences of this neglect for acquiring accurate insights into the determinants of birthweight, let the pregnant mother's health (her pregnancy weight gain), h^m, be determined by

$$h^m = h^m(z, y, v^m) \quad (1)$$

[6] Nor does it even account for the mother's anthropometry. Warner (1998) is an exception but he treats the mother's weight gain as exogenous.

where v^m is the mother's phenotype (her genetic and social inheritances), y represents the health infrastructure (predetermined or exogenous social, environmental, and economic factors such as her marital status, employment, income, education, and access to health services), and z is a vector of endogenous inputs such as prenatal care.

The health technology of the child (its birthweight) h^c is described by

$$h^c = h^c(h^m, z, y, v^c), \tag{2}$$

where v^c is the child's genotype. The relationship between the mother's and the child's health is made explicit in (2) by including the mother's health, h^m, as an argument in the child's health technology. This same relation between parent and child health also holds for a young child,[7] but it is most vivid for a fetus.

The effect of a marginal improvement of the exogenous health infrastructure, y, and of the endogenous health inputs, z, on the child's health is:

$$\frac{dh^c}{dy} = \frac{\partial h^c}{\partial y} + \frac{\partial h^c}{\partial h^m}\frac{\partial h^m}{\partial y} \tag{3}$$

$$\frac{dh^c}{dz} = \frac{\partial h^c}{\partial z} + \frac{\partial h^c}{\partial h^m}\frac{\partial h^m}{\partial z} \tag{4}$$

The differences between reduced forms that ignore the endogeneity of maternal health in the child's health technology and a structural system which accounts for endogeneity are the second terms in expressions (3) and (4). That is, the marginal products of changes in y and in z depend upon their direct biological effects, the $\partial h^c/\partial y$ and the $\partial h^c/\partial z$, and the indirect effects, the $(\partial h^c/\partial h^m)(\partial h^m/\partial y)$ and the $(\partial h^c/\partial h^m)(\partial h^m/\partial z)$, representing the mediating influence of the mother's health. To neglect these indirect effects is to presume that parents ignore the effect of

[7] For example, an ill parent can engage in fewer activities with her child. She is able to do less with and for her child.

own-health on child health. If the presumption is incorrect, then, for example, the negative effect of a decline in exogenous health infrastructure or in positive endogenous health inputs on child health will be understated. The decline directly reduces maternal health as well child health and the decline indirectly reduces child health via its effect on maternal health. Similarly, the presumption will understate the effectiveness of an infrastructure or chosen input increase since an improvement in the mother's health improves the child's health.

III. MODEL AND ECONOMETRIC PROCEDURES

A. Model

Let a cooperative equilibrium exist between parents such that household preferences can be described by a single preference function. Consider a two-period model, j = 1,2, where in the first period the resolution (abort, carry) of the pregnancy is determined. In the second period the fetus is carried to birth. The mother chooses the quantity of health inputs, z_j, to allocate to own and to child health in each period. She also chooses own consumption of a composite good, x_j. Her maximal expected two-period utility is then:

$$V = \max_{z_1, x_1} U(h_1^c(h_1^m(\cdot), z_1, y, v_1^c), x_1) + d\,(q\,(h_1^c)V^1(z_2^{1^*}, x_2^{1^*}) + (1 - q\,(h_1^c))V^2(x_2^{2^*})), \tag{5}$$

where

$$V^1 = \max_{z_2^1, x_2^1} U(h_2^c(h_2^m(z_2^1, y, v_1^m), z_2^1, y, v_2^c), x_2^1) \tag{6}$$

$$V^2 = \max_{x_2^2} U(0, x_2^2), \tag{7}$$

and

$$q\,(h_1^c) \in [0,1] \tag{8}$$

$$I_j = p_{x_j} x_j + p_{z_j} z_j. \quad (9)$$

I_j is income in period j, δ is the mother's fixed discount rate, and $q(h_1^c)$ is the probability that the child is born alive. It is assumed that the mother does not die with the birth of the child. The superscripts on z and x are 1 for a live birth of the child and 2 otherwise. $q(h_1^c)$ is a monotonically increasing continuous function of the child's first-period health. The mother's health is a pure investment commodity in that she values own health only as an input into her child's health (Grossman, 1972). While pregnant, the mother makes first-period allocations of health inputs based on her expectations of the child's survival, the health endowments, v^c and v^c, health input prices, p_z, social, environmental, and economic factors, y, and income, I, in both periods. In the second period, the child is born or not, uncertainty is resolved, and the allocation problem is static. The maximal expected utility for the live birth state is $V^1(z_2^{1^*}, x_2^{1^*})$, and $V^2(x_2^{2^*})$ otherwise. If the fetus is not born, its health is normalized to zero in the second period and the optimum is $x_2^{2^*} = \frac{I}{p_{x_2}}$. First-order conditions are derived in the Appendix.

Given a live birth, the mother's valuation of her child's health can be derived from the dual of her second-period allocation problem. Presuming that the expenditure function associated with this dual is continuous, strictly increasing, and unbounded above in U, as well as nondecreasing, homogenous of degree one, concave, and differentiable in prices, this problem can be written as

$$\min_{z_2^1, x_2^1} \; p_{x_2^1} x_2^1 + p_{z_2^1} z_2^1 \quad (10)$$

subject to:

$$U_2^1 = \overline{U}_2^1, \quad (11)$$

where $\overline{U}_2^1$ is the mothers maximal utility in the second period, given a live birth. Efficiency requires

$$U_2^1 - \overline{U}_2^1 = 0 \tag{12}$$

$$p_{x_2^1} + \lambda U_{x_2^1}^1 = 0 \tag{13}$$

$$p_{z_2^1} + \lambda \frac{\partial U_2^1}{\partial h_2^c}\left(\frac{\partial h_2^c}{\partial z_2^1} + \frac{\partial h_2^c}{\partial h_2^m}\frac{\partial h_2^m}{\partial z_2^1}\right) = 0, \tag{14}$$

where λ is the Lagrange multiplier.

With a live birth, solution of the problem in (10) and (11) yields parental demand functions for consumption, x_2^1, and the health inputs, z_2^1, which, when substituted into the budget constraint, yield the expenditure function for the second period

$$e_2^1(p_2, y, v_2, U_2^1) \tag{15}$$

By the envelope theorem, the mother's valuation of a change in the health infrastructure is:

$$\begin{aligned} \frac{\partial e_2(\cdot)}{\partial y} &= \lambda \frac{\partial U_2^1(\cdot)}{\partial y} \\ &= \lambda\left(\frac{\partial U_2^1}{\partial h_2^c}\frac{\partial h_2^c}{\partial y} + \frac{\partial U_2^1}{\partial h_2^c}\frac{\partial h_2^c}{\partial h_2^m}\frac{\partial h_2^m}{\partial y}\right) \end{aligned} \tag{16}$$

Substituting for λ from expression (14):

$$\frac{\partial e_2(\cdot)}{\partial y} = -p_{z_2}\frac{\dfrac{\partial h_2^c}{\partial y} + \dfrac{\partial h_2^c}{\partial h_2^m}\dfrac{\partial h_2^m}{\partial y}}{\dfrac{\partial h_2^c}{\partial z_2^1} + \dfrac{\partial h_2^c}{\partial h_2^m}\dfrac{\partial h_2^m}{\partial z_2^m}}, \tag{17}$$

which says that, given a live birth, a mother's marginal valuation of an exogenous improvement in health infrastructure is her monetized marginal rate of substitution between y and z.

A mother's marginal valuation of her child's health is:

$$\frac{\partial e_2(\cdot)}{\partial v_2^c} = \lambda \frac{\partial U_2^1}{\partial h_2^c}\frac{\partial h_2^c}{\partial v_2^c}$$
$$= \left(\frac{-\pi_{z_2^1}}{\frac{\partial h_2^c}{\partial z_2^1} + \frac{\partial h_2^c}{\partial h_2^m}\frac{\partial h_2^m}{\partial z_2^1}} \right)\left(\frac{\partial h_2^c}{\partial v_2^c} \right), \qquad (18)$$

that is, a mother's marginal valuation of an improvement in her child's health is defined as the tradeoff between family income and the marginal improvement. Similarly, a mother's valuation of own health is:

$$\frac{\partial e_2(\cdot)}{\partial v_2^m} = \lambda \frac{\partial U_2^1}{\partial h_2^c}\frac{\partial h_2^c}{\partial v_2^m}$$
$$= \left(\frac{-\pi_{z_2^1}}{\frac{\partial h_2^c}{\partial z_2^1} + \frac{\partial h_2^c}{\partial h_2^m}\frac{\partial h_2^m}{\partial z_2^1}} \right)\left(\frac{\partial h_2^c}{\partial h_2^m}\frac{\partial h_2^m}{\partial v_2^m} \right), \qquad (19)$$

A mother's value of own health relative to her value of child health is then

$$\frac{\frac{\partial e_2}{\partial v^m}}{\frac{\partial e_2}{\partial v^c}} = \frac{\partial h_2^c}{\partial h_2^m}\frac{(\partial h_2^m / \partial v_2^m)}{(\partial h_2^c / \partial v_2^c)}, \qquad (20)$$

which is the marginal improvement of own health relative to the marginal improvement in child health.

B. Econometric Procedures

In contrast to the great bulk of the biomedical literature, the economic literature on the household production of health emphasizes that technical processes together with prices and income condition a person's or a family's health input choices. Thus simple correlations between inputs and health outcomes cannot be used to determine causality. Specifically, unbiased estimates of technical family health relationships such as those derived above must be obtained from a behavioral framework in which health inputs are endogenous. To account for heterogeneity in the production of mother's and of child's (fetus') health, we propose the following four equation system: 1) the child's health production to determine survival selection through the first period; 2) the mother's health in the second period for children who survive the first period; 3) the surviving child's health in the second period; and 4) the mother's demands for health inputs in both periods.

Given the mother's utility maximizing quantities of health inputs, a linear representation of the child's period one health production is

$$h_1^c = (y, p_1, p_2)'a_1 + (I_1, I_2)'a_2 + m^c a_3 + h_1^m a_4 + e_1^c, \qquad (21)$$

where $m^c + e_1^c = v_1^c$. m^c is the child's observable endowment, and e_1^c is that facit of the endowment known to the mother but unobservable to anyone else. The $(y,p_1, p_2)'$ and $(I_1, I_2)'$ vectors determine the mother's utility-maximizing equilibrium quantities of the z_i. Second period prices and income appear in (21) because the child's first period survival depends on the mother's expected second period behaviors. For $h_1^c \leq 0$, the mother expects the child will not survive or a spontaneous abortion occurs. With $h_1^c > 0$ the mother carries the child to birth. The child's first period health is therefore an indicator variable taking a zero if the child is not born and one if it is born. Failure to account for selection in the resolution of pregnancies will bias estimates of the consequences of the mother's second period decisions (Grossman and Joyce, 1990). Unacknowledged adverse selection, where women who make relatively small investments in health care are more likely to give birth, will bias downward the estimated productivity of health investments. Favorable selection, which refers to women who are more likely to give birth when they make large investments, will, when unacknowledged, impart an upward bias.

The mother's second period health is

$$h_2^m = \hat{z}_2 b_1 + y b_2 + m^m b_3 + e_2^m, \quad (22)$$

and the surviving child's second period health is

$$h_2^c = \hat{z}_2^1 b_4 + y b_5 + \hat{h}_2^m b_6 + m^c b_7 + e_2^c. \quad (23)$$

Given that the child survives the first period, the estimating equation of the mother's second period decision rule for the z_2^1 is

$$z_2^1 = (p_2, I_2)' g_1 + (m^c, m^m)' g_2 + y g_3 + f_2, \quad (24)$$

where $f_2 = (e_2^c, e_2^m)$.

Our empirical strategy proceeds by obtaining first-stage estimates of the $\hat{z}_j$ and then applying the fitted values of these quantities to estimate the h_j^c and the h_2^m. First period health for the mother is considered to be predetermined. This is reasonable given that this first period corresponds to the three months immediately after conception. The four equation system is expressions (21) through (24) applies to our entire sample of pregnant women but expressions (22) and (23) are observed only for women for whom $h_1^c > 0$. Moreover, some health inputs such as prenatal care visits will be influenced by whether or not $h_1^c > 0$. These truncations imply that the error terms among expressions (21), (23), and (24) will be correlated since some of the same health input factors that influence first period child survival also influence second period child health. We correct for this problem by assuming that the joint distributions of (e_1^c, e_2^c) and of (e_1^c, f_2) have bivariate normal densities which allows application of Heckman's (1979) two-stop selection correction procedure. Following Grossman and Joyce (1990), we implement the procedure by estimating expression (21) as a bivariate probit function, compute the inverse of the Mills ratio, and then insert this inverse as a regressor into expressions (22), (23), and (24).

IV. DATA DESCRIPTION

Our data come from the 1988 National Maternal and Infant Health Survey (NMIHS), a data set specifically designed to acquire information on pregnancy outcomes for American women. After eliminating 13,479 observations with incomplete data, and data referring to adolescent mothers, mothers more than 35 years old, gestations less than 20 and more than 45 weeks, and birthweights less than 400 and more than 6,000 grams, our full sample of 12,876 mother/child observations remained with 10,644 live singleton births.[8] The NMIHS data was augmented with physician visit costs and with cigarette price per pack for each of 48 states (Montana and South Dakota refused to participate in the NMIHS).[9] About 25 percent of the sample mothers are homemakers exclusively. Their reservation wages were calculated using the 1983 estimated reservation wage equation of Hofler and Murphy (1994) inflated to 1988 by the U.S. Consumer Price Index. The wages variable thus represents observed wages for working mothers and calculated reservation wages for homemakers.

[8] Grossman and Joyce (1990) and Werner (1998) employ similar elimination criteria.
[9] Physician visit costs are calculated from the 2000 Medicare Physician Fee Schedule as the Nonfacility Fee Amount deflated to 1988 by the U.S. Bureau of Labor Statistics' Consumer Price Index. Cigarette prices include all applicable state taxes for 1988, as cited in the Tobacco Institute (1997).

Table 1 provides summary statistics and descriptions of the data we employ. A Durbin-Wu-Hausman test (Greene, 2000) suggested endogeneity for the mother's number of prenatal care visits while pregnant and the number of weeks she delayed her initial visit after her last menstrual period. If no care was sought, a delay of 45 weeks was assumed. This delay variable is thus a negative correlate of the quantity and quality of care and should thus have a negative coefficient in the probability of survival and birhtweight production function estimates. In addition to the mother's health, other variables the test proposed as potentially endogenous in one or more estimated expressions are the order of birth (parity) and smoking during the pregnancy.

A long list of variables finally treated as exogenous appears in one or more estimated expressions. Included among them are distance in minutes to a prenatal care facility and the days not engaged in paid work while pregnant as measures of the time sacrifices the mother made. The days the mother took off from work are thus treated as a medical necessity. Price measures include the mother's wages and the cost of a pack of cigarettes. Her anthropometric and sociodemographic features are represented by the mother's race, age, marital status, number of household children, number of household smokers, prior smoking habits, number of prior induced and spontaneous abortions, and prepregnancy body mass index (weight in kilograms divided by height squared in meters), and the child's gender. Attributes of the mother's pregnancy include the number of nights she was hospitalized while pregnant, gestation, and dichotomous variables to indicate whether or not general pregnancy problems/complications existed and whether efforts had to be made to prevent a premature delivery. The mother's education, household income, WIC support, Medicaid or insurance coverage, drug use, residence in a metropolitan area, mental health (CES Total Scale) while pregnant, and whether or not the pregnancy was wanted are included to reflect the mother's health knowledge, stress and attitudes, and her propensity to seek medical care.

Our objective is to estimate expression (20), the marginal contribution of mother's health to her child's health. Expression (20) says that this is simply the utility-maximizing marginal product of a one unit change in mother's health upon child health. Thus, a meaningful comparison of a change in mother's health (weight gain) relative to an improvement in child health (birthweight) induced by a common source requires a common measure. This is accomplished via a linear monotonic transformation of the distribution of mother's weight gain and child's birthweight such that these distributions have identical means and variances. The two transformations are:

$$h_i^c = \frac{birthweight\ in\ grams}{standard\ deviation\ of\ birthweight} \tag{25}$$

$$h_i^m = \frac{weight\ gain\ in\ grams}{standard\ deviation\ of\ weight\ gain} + \left(\bar{h}^c - mean\left(\frac{weight\ gain\ in\ grams}{standard\ deviation\ of\ weight\ gain}\right)\right). \tag{26}$$

The i subscript refers to a sample child or mother and $\bar{h}^c$ is the sample arithmetic mean for expression (25).

V. <u>RESULTS</u>

The potential selectivity bias in a straightforward estimate of the birthweight expression in (23) is quite strong since almost 18 percent of the pregnancies in our sample were aborted. If the mother's second period utility is positively correlated with the child's birthweight, then abortions, which cause birthweight to be observed only for live births, push the observed distribution of the mother's utility to the right. Following Heckman (1979), we correct this bias by estimating expression (21) in linear form for the full sample, using two-stage probit (Lee et al., 1980) while assuming a bivariate normal form. We then computed a correction factor, the inverse Mills ratio, for each of the sample women who gave birth. This ratio, which had an arithmetic mean of 0.3079, and a standard deviation of 0.0963, was then inserted as a regressor in expression (22), (23), and (24). As a regressor, this selection correction factor can be interpreted as proportional to the inverse of the probability that a pregnancy is terminated.

Because epidemiological evidence suggests that almost none of the mother's weight gain occurs in the first trimester (Kramer et al., 1992), mother's first period health is treated as exogenous in the birth probability equation and is measured by her anthropometric and sociodemographic endowments. A Durbin-Wu-Hausman test (Greene, 2000) suggested endogeneity of smoking, parity, the number of prenatal care visits, and delay of the first such visit in the birth probability equation. Reduced form demand functions for these variables were estimated by OLS for the full sample of 12,876 mother/child observations. All of the previously mentioned exogenous variables were treated as regressors except for all of the variables describing the mother's pregnancy attributes, prior abortions, drug use, and mother's body-mass-index (BMI) immediately before her current pregnancy. The fitted values for these four endogenous variables were then entered as regressors in the birth probability equation along with mother's age, mother's wantedness attitude, and the immediately aforementioned exogenous variables that were excepted from the demand estimates. Fitted versions of the number of prenatal care visits, delay of the first such visit, and parity were statistically significant positive correlates of birth probability and smoking was a statistically significant negative correlate. Of the exogenous variables entered in the birth probability equation, only the coefficients for mother's age and for her BMI were significant at less than 5 percent. Both exhibited negative signs.

Table 2 presents OLS estimates for the endogenous regressors in period 2. Since birth selection for the current pregnancy cannot affect parity and is presumed not to affect period 2 smoking behavior, the demand expressions for these two variables do not include the Mills correction and thus apply to both periods 1 and 2. Among the more notable of the results for the smoking expression is the positive impact of prior smoking or smoking while pregnant and the statistical insignificance of the impact of cigarette price upon smoking while pregnant. These results are consistent with an addiction to smoking.[10] The elasticity of the mother's smoking while pregnant with respect to prior smoking is 0.967. Her education has an elasticity of -.379, implying that she chooses to consume about 8 fewer daily cigarettes while she is pregnant when she has an additional year of education.

Consistent with Rosenzweig and Schultz (1983), more educated women who earn higher wages experience fewer pregnancies and have them later in life. However, the Table 2 finding that women living in urban environments have higher fertility is contrary to Rosenzweig and Schultz (1983). Black mothers and mothers who are depressed get pregnant less frequently, all else equal.

[10] Another source of addiction is alcohol intake. Rosenzweig and Wolpin (1991) and Warner (1995) find that alcohol use is not a significant influence upon birth weight. Our preliminary birthweight regressions confirmed this result, perhaps because more than 90 percent of the pregnant mothers in our full sample drank less than one alcoholic beverage per month. Some 83 percent of the full sample were nondrinkers while pregnant and only 1.1 percent drank more than one drink daily. Our NMIHS full sample is likely not rich enough to capture any birthweight effect from alcohol.

The estimated demand equations for the number of prenatal care visits (xvisit) and the delay in the initial visit (visit) exhibit favorable selection, contrary to Joyce (2001). Most other results are consistent with those obtained by Grossman and Joyce (1990). However, the Table 2 result that married women who are pregnant have lesser delays for their initial prenatal care visit contradicts Grossman and Joyce (1990). The Table 2 finding that an unwantedness attitude and a depressed state of mind reduce and delay prenatal care suggest that convincing pregnant women to seek medical help is more than a matter of simply manipulating economic and easily observed sociodemographic factors.

Table 3 presents 2SLS estimates for the mother's period 2 health (mother's weight gain, transformed). Only visit-hat is endogenous. It thus represents fitted values from the visits equation in Table 2. The Mills correction for selection is statistically insignificant. Most Table 3 explanatory variables, including visit-hat, are also insignificant but weight gain is positively responsive to black mothers and to women who were big before becoming pregnant, and negative with respect to mother's age. The positive and statistically significant result for wages is consistent with numerous biomedical and economic results (e.g., Grossman, 1972) indicating a positive association between health and wealth. The positive signs attached to the statistically significant coefficients for depression (ces-total) and drug use defy ready explanation.

Table 4 presents birthweight equations estimated by TSLS. Each column of Table 4 represents a combination of the endogeneity or the exogeneity of weight gain for mothers who gave live births, h_2^m, and a correction or lack of such for selection via the termination of a pregnancy. When a selection correction is made as in Columns (1) and (2), because the inverse Mills ratio is a non-linear function of the variables included in the first-stage probit model, the second-stage model is identified even if the regressors in the first and second stage models are identical. Nevertheless, as an extra identification precaution, two exclusion restrictions were imposed. First, there is at least one covariate in the first-stage not in the second-stage; second, there is at least one variable in the instruments for each endogenous variable that does not appear in the second-stage. Basically, enabling variables such as income, insurance, etc., were assumed to affect birthweight only indirectly through the mother's weight gain.

A version of Sargan's (1976) test, known as the Pagan-Hall (1983) test, for misspecification in models with instrumental variables failed to reject at the 1 percent level the hypothesis of no misspecification for our complete set of instruments.[11] However, a Breusch-Pagan (1979) test revealed heteroskedasticity between the error terms in the mother's weight gain and the child's birthweight equations. Consequently, three-stage least squares estimates were obtained. These 3SLS estimates caused the Mills selection correction variable to become insignificant in the birthweight equation and reduced the magnitude of the coefficient for the number of prenatal care visits without altering its statistical significance. Coefficient estimates and levels of statistical significance for the other covariates in Table 4, including especially the endogenous and the exogenous versions of the variables for mother's health, were essentially unchanged.[12] Given the focus of the paper upon the mother's value of own relative to child health, the following discussion centers upon Table 4 and its value implications.

All columns of Table 4 indicate that mother's pregnancy weight-gain is a positive and statistically significant influence upon the child's health. More importantly, by treating the

[11] See Godfrey (1988, pp. 174-176) for a succinct exposition of these tests.

[12] For example, the 2SLS estimate for $h_2^m - hat$ with selection is .160 with a standard error of .014; for the 3SLS estimate it is .170 with a standard error of .019.

mother’s weight gain as endogenous, one increases this positive influence by a factor of three. Failure to take into account the indirect effect of the mother’s health upon the child’s health greatly underestimates the importance of the mother’s health behaviors to the child’s health.

Apart from mother’s health, there are only very minor differences across columns in the coefficients for the Table 4 regressors. However, there are substantial differences for the selection and no selection results for the case of mother’s health endogeneity as well as that for exogeneity. The effect of the number of prenatal care visits is two times higher with than without selection, as is the effect of parity. An accounting of selection has little effect upon the birthweight influence of drugs, smoking, gestation, or gender.

Expression (20) implies that the coefficient on $h_2^m - hat$ in Table 4 measures the mother’s value of own relative to her child’s health. For the case of no selection, $h_2^m - hat$ has a value of .170, implying that the representative mother values her child’s health about six times more than her own health. Thus four conclusions emerge from Table 4: 1) pregnant mothers value child health more than own health; 2) mother’s health and child health are complements; 3) the indirect effect of maternal behaviors increases the estimated contribution mother’s health makes to child health; and 4) selection due to pregnancy termination does not affect the estimated contribution of maternal health to child health.

The contribution of maternal health to child health and thus the mother’s value of own to child health was also estimated for subsamples of the NMIHS women who gave live births. Table 5 gives the results. The most striking difference emerges for nulliparous women (this pregnancy is their first child) and women who already have at least one child. If mother’s health is endogenous, nulliparous women value their child's health relative to their own health more than twice as much as do other women who have had children. This result is consistent with the tradeoff between the quantity and the "quality" of children emphasized by Becker and Lewis (1973). Nonsmoking mothers appear to value their children more highly than do smokers. More income, as reflected in the income, medicaid/no medicaid, and married/not married subsamples seems to increase the relative value of child health. Education also increases this relative value, perhaps because of the opportunity costs of the time a mother expects she will subsequently have to devote to a born child.

VI. <u>SUMMARY AND CONCLUSIONS</u>

We have presented a framework suitable for estimating the value an adult attaches to own health relative to child health when health inputs are endogenous and adult health is an input to child health. Heretofore, no research has specifically examined the impact of adult behaviors on own health and thence upon child health. Though our focus is upon pregnant woman and the child they carry, the framework could, likely at considerable cost in analytical and empirical complexity, be extended to the care adults provide post-natal children. A parent's discretionary behaviors affect her contemporaneous health and this health impacts what she can do with and for her child. What she does with and for her child influences its health. By aiding her own health, the mother helps her child's health.

When the maternal health input to child health is treated as endogenous our empirical results indicate that, on average, pregnant mothers value the prospective health of their as yet unborn children about six times more than they value own health. Treatment of the maternal health input as exogenous will reduce the estimated impact of this input upon child health relative to the impact when it is treated as endogenous. Consequently, for a given observed child health improvement, part of the contribution of maternal health to this improvement will be attributed to other health inputs, thus reducing the estimated value of maternal health relative to child health.

Our empirical results also suggest that the mother's relative valuation of own and of child health is sensitive to her personal and family characteristics and behaviors such as number of siblings for the child, family income, and maternal consumption patterns (e.g., smoking).

The result that pregnant mothers value own health considerably less than they value child health promotes skepticism about the one-to-one transfer of adult health benefits measures to children. Whatever the average relative valuation employed, they also promote caution about use of a one-size-fits-all constant for these transfers.

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Table 1. Summary statistics, n=12,876

Variable	Mean	Std. Dev.	Description of variables
abortions	.4344517	.9231301	Number of previous abortions, induced and spontaneous
alive	.8265219	.3786747	Dichotomous: 1 if child was born alive
attitude	.4558356	.498065	Dichotomous: 1 if pregnancy was not wanted
bweight	2579.276	1111.054	Baby's birth weight in grams
ces_total	13.99845	12.10674	CES Depression scale for pregnant mother
children	1.180147	1.384186	Number of children in the household
cigprice	130.9913	9.75674	Price of one packet of cigarettes, including all taxes in cents (1988 US dollars)
distance	20.40993	16.35411	Distance in minutes to prenatal care provider
drugs	.0755332	.2642599	Dichotomous: 1 if mother used drugs in the 12 months before delivery
gender	.4740597	.499346	Dichotomous: Baby's gender 1 if female
gestation	35.97053	5.837431	Length of gestation in weeks
health_child	2.321469	1	Child's health index, transformation of child's birth weight
health_mother	2.321469	1	Mother's health index, transformation of mother's weight gain
income	25672.04	21067.1	Total annual household income, whole dollars (1988 US dollars)
insurance	.6350523	.4814341	Dichotomous: 1 if mother had health insurance at delivery time
mage	26.57325	4.242554	Mother's age in years
marital	.6201629	.485365	Dichotomous: 1 if married
mbmibefore	28.04287	5.512001	Mother's Body Mass Index before pregnancy
medicaid	.3010469	.4587308	Dichotomous: 1 if covered by Medicaid
meduc	12.59558	2.318349	Mother's education in years
metro	.777027	.4162565	Dichotomous: 1 if family lives in metropolitan area
nights	7.8185	13.80952	Number of nights hospitalized during pregnancy (excluding delivery)
parity	.8675456	1.428883	Number of previous pregnancies
premature	.3535259	.4780827	Dichotomous: 1 if action was taken to prevent premature delivery
prenatalcost	361.44	27.406	Cost of prenatal care visit, whole dollars (1988 US dollars)

Table 1. Summary statistics (cont.)

priorsmoke	5.077975	9.224811	Number of cigarettes smoked by the mother prior to pregnancy, per day
problems	.8952314	.3062669	Dichotomous: 1 if complications with pregnancy
race	.528425	.499921	Dichotomous: 1 if mother is black
smokers	.480817	.8589116	Number of smokers in the household
smoking	3.065995	6.889637	Number of cigarettes smoked by the mother during pregnancy, per day
totaldays	66.40775	110.6519	Total days the mother did not work
visit	10.41171	8.45774	Weeks since pregnancy started before first prenatal care visit
wages	37043.31	23570.97	Mother's wages annually, whole dollars (1988 US dollars)
wgain	9586.068	9881.782	Mother's weight gain during pregnancy, in grams, after birth
wic	.3422257	.4744731	Dichotomous: 1 if WIC food aid provided during pregnancy
xvisits	11.23893	6.130369	Number of prenatal care visits

Note: The mother's and the child's health index transformation is explained in the text. The WAGES variable also includes reservation wages for homemakers, as explained in the text.

Table 2. Demand Estimates

	visit		xvisit		smoking		parity	
	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t
distance	-.085	-18.12	.027	7.64	-.005	-2.14	-.003	-3.98
attitude	3.202	14.27	-1.381	-8.09	.189	2.37	.054	2.27
children	.535	8.38	-.273	-5.64	.231	8.00	.368	42.46
wic	-2.185	-9.95	1.440	8.63	-.121	-1.30	-.054	-1.94
insurance	-1.482	-7.01	.653	4.06	-.190	-2.09	-.318	-11.63
marital	-1.386	-6.92	.872	5.73	-.309	-3.23	-.010	-0.35
mage	-.123	-5.78	.046	2.84	.034	3.75	.034	11.71
race	-2.978	-9.20	2.463	10.00	-.068	-0.78	-.288	-11.14
meduc	-.227	-5.87	.208	7.07	-.092	-5.01	-.073	-13.19
wages	-.103e-04	-2.70	.688e-07	2.37	.476e-07	2.83	-.336e-07	-6.65
income	.266e-04	-5.36	.128e-04	3.39	-.930e-07	-3.96	.299e-08	0.42
medicaid	.929	4.01	-.460	-2.61	.084	0.81	.120	3.84
total days	.225e-04	0.03	.002	2.96	-.001	-1.98	.162e-07	0.02
metro	-.485	-2.46	.247	1.65	.063	0.68	.142	5.12
cigprice	.011	1.28	-.014	-2.17	-.002	-0.49	-.047e-03	-0.04
ces_total	-.073	-4.70	.060	5.06	.006	1.97	-.005	-5.09
prenatal cost	-.004	-1.33	.005	1.95	.001	0.50	.002	4.36
priorsmoke	.045	5.23	-.007	-1.13	.584	142.20	.012	10.12
mills	22.689	8.37	-17.234	-8.36	----	----	----	----
Constant	15.350	9.80	9.028	7.58	.349	0.50	.153	0.73
Observations	10,644		10,644		12,876		12,876	
F-statistic	102.42		48.30		1293.63		247.29	
R^2	.1548		.0795		.6443		.2572	

Note: All estimates were obtained by ordinary-least-squares.

Table 3. Mother's Period 2 Health (Weight Gain)

h_2^m	Coefficient	t
distance	-.001	-0.51
attitude	-.003	-0.08
children	.008	0.97
wic	-.074	-1.50
insurance	-.058	-1.50
marital	.002	0.05
mage	-.014	-5.58
race	.010	4.29
meduc	.005	0.84
wages	.126e-07	3.14
income	.123e-07	1.78
medicaid	-.003	-0.11
total days	.146e-03	-1.69
metro	-.032	-1.32
cigprice	-.458e-03	-0.48
ces_total	.004	4.35
prenatal cost	.001	1.67
priorsmoke	-.848e-04	-0.08
mbmibefore	.074	45.11
gestation	.003	2.08
drugs	.111	3.17
visit-hat	-.008	-0.56
mills	.161	0.76
Constant	.208	0.63
Observations	10,644	
F-statistic	99.45	
R^2	.1708	

Note: Estimated by two-stage-least-squares. Variables denoted with a "-hat" are endogenous.

Table 4. Child's Period 2 Health (Birthweight)

h_2^c	(1) Endogenous/ Selection		(2) Exogenous/ Selection		(3) Endogenous/ No Selection		(4) Exogenous/ No Selection	
	Coefficient	t	Coefficient	t	Coefficient	t	Coefficient	t
visit-hat	.018	1.49	.019	1.74	.008	1.70	.007	1.51
xvisits-hat	.051	5.07	.055	5.47	.029	3.20	.028	3.09
parity-hat	.039	3.96	.040	4.05	.020	2.18	.016	1.77
smoking-hat	-.012	-9.98	-.012	-10.29	-.010	-8.95	-.010	-8.95
drugs	-.071	-3.28	-.066	-3.03	-.068	-3.13	-.062	-2.83
$h_2^m - hat$	.160	11.51	----	----	.170	12.32	----	----
h_2^m	----	----	.055	9.76	----	----	.057	10.11
mills	.346	4.88	.423	6.00	----	----	----	----
gestation	.134	144.49	.136	147.20	.134	144.20	.136	147.00
gender	-.104	-9.45	-.104	-9.45	-.106	-9.60	-.106	-9.63
Constant	-3.639	-20.34	-3.530	-19.75	-3.185	-20.82	-2.956	-19.55
Observations	10,644		10,644		10,644		10,644	
F-statistic	2546.65		2533.73		2855.86		2836.60	
R^2	.6831		.6820		.6824		.6809	

Notes: All estimates were obtained by two-stage-least-squares. Variables denoted with a "-hat" are endogenous. The columns denote whether or not h_2^m was treated as endogenous, and whether or not a selection correction was made.

Table 5. Mother's Value of Own Relative to Child Health.

		With endogeneity			Without endogeneity		
Subsample	Observations	Coefficient	z	R^2	Coefficient	z	R^2
Whites	5234	.1546	5.19	.5189	.0552	6.25	.5558
Blacks	5410	.1789	6.38	.7000	.0527	7.14	.7165
No other children	3967	.1005	3.08	.6622	.0524	5.72	.6777
One or more children	6677	.2254	8.52	.6261	.0601	8.16	.6524
Pregnancy wanted	5628	.1621	5.42	.6562	.0531	6.78	.6688
Pregnancy not wanted	5016	.1810	6.45	.6211	.0604	6.82	.6319
Not insured	3922	.1717	5.32	.6125	.0658	5.97	.6200
Insured	6722	.1700	6.60	.6759	.0489	7.17	.6936
Unmarried	4158	.1902	6.40	.5650	.0712	6.88	.5925
Married	6486	.1561	5.05	.6842	.0458	6.52	.6971
Not on Medicaid	7344	.1589	5.95	.6863	.0535	8.05	.6940
On Medicaid	3300	.2065	6.01	.4565	.0663	5.83	.4897
Live outside metropolitan area	2312	.1955	3.29	.6234	.0813	6.30	.6279
Live inside metropolitan area	8332	.1673	7.83	.6038	.0509	7.84	.6134
Nonsmoker	7808	.1440	5.99	.6703	.0475	7.20	.6823
Smoker	2836	.2381	5.26	.4572	.0811	6.80	.4632
Education<=12 years	6458	.1864	6.85	.6240	.0614	7.62	.6388
Education >12 years	4186	.1391	4.58	.7044	.0472	5.37	.7132
Homemaker	4014	.1833	5.97	.5411	.0591	5.84	.5688
Employed	6630	.1718	6.41	.6939	.0563	8.13	.7060
Income<10000	3250	.1960	4.61	.4428	.0724	5.19	.4801
Income <=50000	6925	.1640	6.68	.6610	.0563	8.07	.6729
Income >50000	1059	.1497	3.74	.6747	.0196	1.21	.6852

The results are based on two-stage least squares without selection.

Appendix

Appendix

The problem of the parent is to maximize her expected "lifetime" utility. Her maximal expected "lifetime" utility in the first period is:

$$V = \max_{z_1, x_1} E\{U(h_1^c[h_1^m(.), z_1, y, v_1^c], x_1) + \tag{A.1}$$

$$d[q(h_1^c)V^1(z_2^{1^*}, x_2^{1^*}) + [1 - q(h_1^c)]V^2(x_2^{2^*})]\}$$

$$V^1 = \max_{z_1^2, x_2^1} U\left(h_2^c\left(h_2^m(z_2^1, y, v_2^m), z_2^1, y, v_2^c\right), x_2^1\right) \tag{A.2}$$

$$V^2 = \max_{x_2^2} U(0, x_2^2) \tag{A.3}$$

$$q(h_1^c) \in [0,1] \tag{A.4}$$

$$I_j = p_{x_j} x_j + p_{z_j} p_j \tag{A.5}$$

where x_j is period j parental consumption, I_j is period j income, δ is the parent's discount rate and θ is the probability of a "normal" pregnancy. We assume that each period's income is predetermined (labor supply decisions for the mother are exogenously determined), the parent's discount rate δ is fixed and the probability of the child born alive θ is a monotonically increasing continuous function of the child's health in the first period. Superscripts on x and z in equation (A.5) are omitted for notational simplicity. The mother chooses x_2^1 and z_2^1 at the beginning of period one.

Substituting the budget constraint (A.5) into equations (A.1), (A.2) and (A.3), the system becomes:

$$\begin{aligned} V = \max_{z_1} E\{U(h_1^c(h_1^m(z_1, y, v_1^m), z_1 y, v_1^c), I_1 - p_1 z_1) + \\ d[q(h_1^c(h_1^m(z_1, y, v_1^m), z_1 y, v_1^c), V_1(z_2^{1^*}) + (1 - q(h_1^c(h_1^m(z_1, y, v_1^m), z_1 y, v_1^c),)))V^2(z_2^{2^*})]\} \end{aligned} \tag{A.6}$$

$$V = \max_{z_2^1} \; U(h_2^c(h_2^m(z_2^1, y, v_2^m), z_2^1 y, v_2^c), I_2 - p_2 z_2^1) \tag{A.7}$$

$$V^2 = \max_{z_2^2} U(0, 1_2 - p_2 z_2^2) \qquad \text{(A.8)}$$

The optimal z_2^1 is the solution to equation (A.6). Efficiency requires that:

$$V^1 : \frac{\partial U}{\partial h_2^c}\frac{\partial h_2^c}{\partial z_2^1} + \frac{\partial U}{\partial h_2^c}\frac{\partial h_2^c}{\partial h_2^m}\frac{\partial h_2^m}{\partial z_2^1} = p_2 \frac{\partial U}{\partial c_1} \qquad \text{(A.9)}$$

The first term in equation (A.9) is direct effect on utility of a change in z on the child's health, as would be predicted if only the "reduced-form" effect was considered, and the second period, given that the child does not survive, the mother does not consume any health inputs for the child, therefore:

$$V^2 : x_2^2 = \frac{I_2}{p_{x_2}} \qquad \text{(A.10)}$$

Equation (A.8) states the familiar result of consumer theory that in order to maximize utility, the parent must allocate resources so as to make the ratios of marginal utilities equal to the ratios of prices.

Efficiency for equation (A.6) requires that:

$$\frac{\partial EU}{\partial h_1^c}\frac{\partial h_1^c}{\partial z_1} + \frac{\partial EU}{\partial h_1^c}\frac{\partial h_1^c}{\partial h_1^m}\frac{\partial h_1^m}{\partial z_1} - \frac{\partial EU}{\partial c_1}\frac{\partial c_1}{\partial z_1} p_1 + d\left[\frac{\partial q}{\partial z_1}V^1 - \frac{\partial q}{\partial z_1}V^2\right] = 0 \qquad \text{(A.11)}$$

where

$$\frac{\partial q}{\partial z_1} = \frac{\partial q}{\partial h_1^c}\left(\frac{dh_1^c}{dz_1} + \frac{\partial h_1^c}{\partial h_1^m}\frac{\partial h_1^m}{\partial z_1}\right) \qquad \text{(A.12)}$$

Equation (A.11) is the marginal change in the probability of survival in the second period from a change in z. The solution of the problem comes from solving the first-order condition (A.8), and then (A.10).

Valuing Fetal and Infant Health:
What Can Be Learned from Empirical Health Economics Research?

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I. Introduction

Despite many encouraging trends in environmental quality, serious environmental health threats to fetal, infant, and child health remain. For example, some research suggests that particulate matter air pollutants may be associated with higher infant mortality.[1] In 2001 approximately 25 percent of children lived in counties that exceeded the annual standard for particulate matter (US EPA 2003). This suggests a similarly large fraction of all pregnant women may be exposed to unhealthy levels of particulates The importance of fetal and infant health is underscored by the inclusion of data on birth defects in California as a Special Feature in the most recent EPA (2003) report on America's Children and the Environment. As the EPA notes, "birth defects are leading cause of infant death in the first year of life, accounting for about 20 percent of infant deaths in 1999." Although some birth defects are inherited, environmental and public health policies may be able to reduce nongenetic risk factors for birth defects, and improve fetal and infant health more generally.

Benefit-cost analysis of policies to improve fetal, infant and child health requires valuation of those health improvements. A number of studies extend market and non-market approaches to estimate willingness to pay for child health. Because children are not in the labor market and do not make independent consumption decisions, the studies focus on parents' decisions that affect the health and safety of their children. Analysis of parents' child safety seat use, automobile purchases, and bicycle helmet purchases provides estimates of willingness to pay

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[1] In addition to the references in US EPA (2003), Chay and Greenstone (1999, 2001) analyze data on infant mortality, birthweight, and air quality improvements in the early 1970s and the early 1980s. Their findings suggest a strong relationship between air quality as measured by total suspended particulates and infant mortality rates, and a somewhat weaker relationship between air quality and birthweight.

for child mortality risks , summarized as the value of a statistical life for a child (Carlin and Sandy 1991; Mount *et al.* 2000; and Jenkins, Owens and Wiggens 2001). Other child health effects valued include: child lead exposure (Agee and Crocker 1996); colds (Liu *et al*. 2000); risks of non-melanoma skin cancer (Dickie and Gerking 2001); lifetime cancer risks (Maguire, Owens and Simon 2001); and child health effects related to secondhand smoke exposure (Agee and Crocker 2001). However, there seem to be few if any existing estimates specific to the value of fetal and infant health.[2]

The goal of this paper is to examine the implications of empirical health economics research for the valuation of fetal and infant health. Section II sets the stage by reviewing illustrative empirical evidence on the various ways parents invest in prenatal health, including market purchases such as medical care, and lifestyle changes such as smoking cessation. Section III presents a simple version of the standard household health production model, to serve as the theoretical framework for the valuation expressions and the empirical research to be reviewed. Section IV reviews health economics research that estimates infant health production functions. Combining the estimates of the marginal product of prenatal care with estimates of the full price paid yields estimates of parental marginal willingness to pay for infant health. Section V reviews studies of maternal demand for cigarettes and alcohol during the pre-natal period, and discuss the implications for fetal and infant health valuation. Section VI discusses health economics studies

[2]In the recent review by Neumann and Greenword (2002), all of the studies of effects associated with prenatal exposure use the cost-of-illness approach. The review includes estimates of willingness to pay to reduce infants' mortality risks, based on Dickie and Nestor's (1999) analysis of the results of Joyce, Grossman and Goldman (1989).

that estimate the impacts of public policies on fetal and infant health, and explores whether these can be used to shed light on the health valuation question.

At the outset, limitations of the scope of this paper should be noted. The emphasis of the paper is on lessons from health economics, so the environmental economics research literature is not reviewed in depth. The valuation approach is to infer parents' willingness to pay for fetal and infant health based on their preferences as revealed in the markets for medical care, cigarettes, and so on. The paper does not review studies from three other approaches that shed light on health valuation: the cost-of-illness approach; the contingent valuation or stated preference approach; or the quality-adjusted life year approach used in cost-effectiveness analysis. To date, most evaluation studies relevant to fetal and infant health follow the cost-of-illness approach; for summaries of these studies see Neumann and Greenwood (2002). Cost-of-illness estimates provide a lower bound to willingness to pay (Berger *et al*. 1987, Kenkel 1994), so these estimates are a way to check the plausibility of willingness to pay estimates from other approaches. Two contingent valuation studies estimate willingness to pay related to infertility risks (Neumann and Johanneson 1994, Smith and Van Houten 1998), but the implications for the value of fetal and infant health are not clear. Finally, in principle it should be possible to follow the common approach in cost-effectiveness analysis and estimate the number of quality-adjusted life years lost from fetal and infant poor health and death. For example, the Harvard Catalogue of Preference Scores includes weights to calculate the quality-adjusted life years for children with a range of neurologic disabilities. However, in all of the cases the preference scores were measured based on author or clinical judgement, and so may not reflect either parental or societal preferences over these health states.

II. Parental Investments in Prenatal Health: An Overview

Table 1 provides an overview of maternal investments in prenatal health. The data are from the National Maternal and Infant Health Survey (NIMHS) 1988, conducted by the National Center for Health Statistics. The 1988 NMIHS consists of three independent national files of live births, fetal deaths and infant deaths. The full sample consists of 18,594 mothers who had a live birth, fetal death or infant death in 1988. Of these 18,594 mothers, 9,953 women had live births, 3,309 had late fetal deaths and 5,332 had infant deaths.[3] Table 1 presents the patterns of prenatal investments for the full sample and for each of the sub-samples.

As can be seen in Table 1, during the prenatal period women invest both money and time to improve fetal health. Virtually all (98 percent) of pregnant women in the U.S. receive prenatal medical care, and on average make almost 13 prenatal visits. Additional data from the NMIHS (not reported in Table 1) indicate that about a third of the women report paying for the prenatal care out of their own income. In addition, some of those whose care was covered by private insurance or Medicaid still incurred out-of-pocked costs due to copayments or coinsurance, although data on this was not collected in the NMIHS. Women also incurred time costs to travel to and receive prenatal care; the average travel time to prenatal care for NMIHS respondents was about 21 minutes.

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3 In 1988, there were 3,898,922 live births to women between 15 and 49 years of age, 15,259 fetal deaths of 28 weeks or more gestation, and 38,917 infant deaths to United States residents. The overall probability of the 1988 NMIHS selection was about 1 of every 354 live births, 1 of every 4 fetal deaths and 1 of every 6 infant deaths. The overall response rate for the national file of 18,594 mothers is 71%; it is 74% for live birth mothers, 69% for fetal death mothers, and 65% for infant death mothers.

In the full sample, 38 percent of pregnant women also attend prenatal childbirth class, but fewer women in the fetal death and infant death samples attend such classes. About 80 percent of pregnant women take multivitamins and/or minerals at least three days a week after they found out they were pregnant, up from about 25 percent of women who took vitamins before they found out they were pregnant.

Women also commonly make lifestyle changes after they find out they are pregnant. In the 1988 NIMHS, pregnancy is associated with a drop in the prevalence of smoking from 30 percent to 22 percent. Even those women who continue to smoke while pregnant still on average report that they decreased the amount, from about 16 cigarettes per day to 12 cigarettes per day. Pregnancy is also associated with a drop in the prevalence of drinking alcohol, from 45 percent to 21 percent. And those women who continue to drink while pregnant on average report that they decreased the amount, from 9 drinks per month to about 3 and a half drinks per month.   The only exception to these patterns is that is somewhat more common for women to quit exercising after they discover that they are pregnant than it is for women to start exercising.

The data in Table 1 are presented to make the broad point that during the prenatal period women make substantial investments in fetal health.   Table 1 neglects some investments, such as changes in maternal diet and illicit drug use, as well as all paternal investments in fetal health. On the other hand, because the data are self-reported, the changes in maternal behavior may be over-stated. It also should be noted that while women invest in fetal health, in many cases their choices are not optimal from the public health viewpoint, i.e. their choices do not maximize fetal health. For example, public health goals call for increasing the proportion of women who receive early and adequate prenatal care from its 1998 level of 74 percent to a 2010 target level of 90 percent (USDHSS 2000). Nevertheless, it is clear that many women are willing to sacrifice money, time, and cigarette and alcohol consumption to improve the health of their unborn children. The next section outlines the standard economic approach to modeling this behavior.

III. Conceptual Framework

This section considers a highly simplified one-period version of Grossman's (1972) household production model of the demand for health and health-related goods. Assume the mother receives utility from consuming a numeraire good X, her infant's health IH, and from smoking cigarettes S: U = U(X, IH,S). The mother may purchase in the market prenatal medical care (M), which does not provide utility directly, but is used to produce the commodity infant health according to a household production functions. Infant health is also assumed to depend on maternal smoking, and exogenous influences such as environmental quality, E: IH = IH (M, S, E).

The mother chooses X, S, and M to maximize her utility subject to a standard budget constraint and the household production function. The first order conditions for this maximization problem implicitly define goods demand functions for X, S, and M as functions of market prices, income, and the parameters that describe preferences (U (.)) and the technology of household production (IH (.)). Formally, the model also includes a commodity demand function for infant health, which is conceptually distinct from the infant health production function.

Before discussing empirical applications, some brief comments on this theoretical model are in order. Grossman's (1972) seminal model contains two key features: first, that health is a commodity produced in the household; and second, that health is a form of human capital. The focus here is on behavior during the prenatal period and the production of fetal and infant health, so the model is simplified to one period and abstracts from the dynamics of health capital over the life cycle. Grossman (2000) provides a comprehensive review of theoretical and empirical work based on his human capital model of health, while Currie (2000) contains an intertemporal model of parents' investments in child health. By focusing on the mother's utility function, the model also abstracts from the more complex problem of decision-making within the family. This extension is discussed in a series of recent health economics papers (Jacobson 2000, Case and Paxson 2001, Bolin, Jacobson and Lindgren 2001, 2002), as well as by Bergstrom (2003).

The general structure of the household production model of health provides the conceptual framework for a great deal of empirical research in health economics. One approach is to estimate a structural health production function as a function of endogenous health inputs and exogenous factors. Section IV of this paper reviews research on the household production of infant health in the U.S. , but the approach has also been commonly used in the context of low-income countries (e.g., Barrera 1990, the Cebu Study Team 1992).

The Grossman model also provides the explicit or implicit framework for empirical studies of the demand for various health-related goods. Section V of this paper reviews some recent research on the demand for cigarettes and alcohol by pregnant women. These papers are extensions of an extensive empirical literature reviewed in several chapters of the *Handbook of Health Economics:* Chaloupka and Warner (2000) review empirical studies of the demand for cigarettes; Cook and Moore (2000) review empirical studies of the demand for alcohol; and Kenkel (2000) reviews empirical work on the demand for prevention broadly defined. As Kenkel (2000, p. 1685) points out, while some empirical studies have tight links between the structure of the theoretical model and the empirical specification, more commonly the theoretical model only provides general guidance for the empirical investigations, for example in terms of the explanatory variables to be included in a demand model.

A number of recent studies take one step further away from structural models, and focus on reduced-form estimates of the impacts of public policies on health, including the impact of so-called "natural policy experiments." This approach can be used to study the impact of policy changes on health outcomes and on the use of health inputs. For example, Currie and Gruber (1996) examine the impact of Medicaid expansions on infant mortality; Currie and Grogger (2002) examine the combined impact of Medicaid expansions and welfare reform on both the use of prenatal care and fetal deaths. However, it is not in general appropriate to interpret the estimated equations as either structural production functions or demand functions. As Rosenzweig and Schultz (1983) demonstrate, the estimated coefficients from such hybrid equations will generally be mixtures of preference and technology parameters. Section VI discusses some examples from this body of research.

IV. Health Production Function Estimates and the Value of Infant Health

Willingness to Pay Expression

The health production function approach is a well-established method in environmental economics research on the valuation of health as a non-market commodity (Freeman 1993, pp. 344-360). It is a revealed preference approach to valuation, where consumers' demand for a health input reveals the value they place on the health output. The model in section III can be used to derive the standard expression for marginal willingness to pay ($MWTP_E$) for a health-improving change in environmental quality (E). To complete the model sketched above, assume a simple goods budget constraint: $Y = X + p_M M + p_S S$; where Y is income and p_M and p_S are the money prices of medical care and cigarettes. (Recall that X is the numeraire good so its price is normalized to one.) To find the $MWTP_{E,}$ set the total derivative of the utility function equal to zero and substitute in the first order conditions. After some manipulations, the change in income necessary to hold utility constant after a change in environmental quality can be expressed as a ratio of the technological parameters of the production function, which can be interpreted as the marginal rate of technical substitution between E and M in producing infant health:

$$MWTP_E = d\,Y/ d\,E = (IH_E / IH_M)\, p_M$$

As Freeman (1993, p. 349) stresses, one of the advantage of this expression is that on the right hand side "all of the measures are functions of observable variables that can be calculated given knowledge of the production function." Strictly speaking, the valuation expression involves the individual's perceptions of the parameters of the health production function. It is therefore typically assumed that, at least on average, individual perceptions are correct, so econometric knowledge of the production function translates into knowledge of consumers' perceptions of the production function. Unless extra data are collected on individual perceptions, this type of assumption is common in the revealed preference approach. For example, many studies of the value of a statistical life make comparable assumptions about the risks associated with labor market and consumption decisions (e.g. Viscusi 1992a, Jenkins, Owens, and Wiggins 2001).

The household health production approach has been used to estimate marginal willingness to pay for air quality-related health improvements for adults (Gerking and Stanley 1986) and infants (Joyce, Grossman and Goldman 1987). Dickie and Gerking (1991) extend the analysis to consider multiple symptoms, i.e. multiple health outputs. If the number of health inputs exceeds the number of symptoms to be valued, it is still possible to express the marginal willingness to pay for each symptom as a ratio of the technological parameters of the household health (symptom) production function. Agee and Crocker (2001) provide a recent example of the approach with multiple health outcomes, namely child and adult health. They use cross-sectional data on parents who are smokers from a 1991 follow-up of the 1988 National Maternal and Infant Health Survey (NMIHS). Each household in the sample has a three-year-old child. Agee and Crocker use these data to estimate a structural household production model of parents' smoking behavior, adult health, child secondhand smoke exposure, and child health.

The expression for $MWTP_E$ relies on the assumption that prenatal care is only demanded as an input into infant health production. In many cases, important health inputs either provide utility directly, such as cigarette smoking in the model sketched above, or enter some other household production function.[4] When an input like S is jointly demanded for several reasons, the $MWTP_E$ can not be expressed as the marginal rate of technical substitution between E and S. Instead, unobservable utility terms remain in the expression. Section V below discusses an approach to health valuation in this situation.

The approach in previous environmental economics studies is to estimate directly the necessary parameters of the health production function, including the marginal product of environmental quality on health (IH_E). As is noted elsewhere (Freeman 1993, p. 349, Dickie 1999), implementing this approach is thus very demanding of the data. Of particular relevance to

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4More accurately, cigarette smoking jointly enters the infant health production function, enters the mother's utility function directly, and enters the health production function of the mother. This extension is sketched below in section V.

the current literature review, health economics data sets often lack the necessary measures of environmental quality. However, marginal willingness to pay for an improvement in fetal and infant health ($MWTP_{IH}$), i.e. the marginal rate of substitution in consumption between X and IH, is not as demanding. It can be shown that:

$$MWTP_{IH} = U_{IH} / U_X$$

$$= (d\,Y / d\,E) / IH_E$$

$$= p_M / IH_M$$

The $MWTP_{IH}$ thus requires only an estimate of IH_M from health economics research on infant health production functions, and a corresponding measure of the price of prenatal care. The $MWTP_{IH}$ can be thought of as the value of a standardized improvement in environmental quality or any other exogenous change that yields a marginal change in infant health. It can be used to value any public policy change that improves infant health at the margin, assuming, of course, that the policy analyst has an outside estimate of the infant health improvement (i.e., a term analogous to IH_E).

Empirical Estimates of Infant Health Production Functions

Table 2 lists eleven studies that estimate the marginal product of prenatal care in improving infant health. Seven of the studies use microdata and measure infant health by birthweight in grams. Three studies use county- or state-level aggregate data and measure infant health by the percentage of infants born at a low birthweight (below 2500 grams); one study uses county-level data on neonatal mortality rates. The use of prenatal care is usually measured in terms of whether it was initiated in the first trimester of pregnancy or delayed. In addition to measures of prenatal care, all of the studies include endogenous health inputs such as maternal smoking and other variables such as maternal age and schooling.

The research on infant functions addresses a number of specification issues. The functions are generally specified to be linear, although Rosenzweig and Schultz (1983, 1988) also estimate Cobb-Douglas specifications, and Warner (1988) also estimates linear with interaction terms, quadratic, and square root specifications.[5] As might be expected, specifications have evolved over time to address new research questions. Several of the studies suggest that the parameters of the infant health production function vary significantly by race. In another extension, Warner (1998) emphasizes the importance of maternal anthropometric measures such as height and weight. Warner (1995, 1998) also explores whether subsequent more frequent prenatal visits substitute for delaying pre-natal care after the first trimester.

The research on infant health production also addresses a number of econometric issues. Following Rosenzweig and Schultz (1983), a central concern has been the endogeneity of the health inputs. Rosenzweig and Schultz show that with individual heterogeneity that is known to the mother but unobservable to the econometrician, ordinary least squares (OLS) yields biased estimates of the parameters of the health production function. Their empirical results suggest that women with health problems may seek prenatal care earlier to compensate, causing OLS to underestimate the productivity of prenatal care. Rosenzweig and Schultz and most subsequent studies use two stage least squares or a related instrumental variables technique to treat prenatal care and other health inputs as endogenous. This approach generates a research debate across the

5Rosenzweig and Schultz (1983) also consider the translog specification, but it is rejected in favor of the Cobb-Douglas.

studies about the validity of the identifying exclusion restrictions and the explanatory power of the instrumental variables as predictors of input demand.

Grossman and Joyce (1990) argue that in addition to treating health inputs as endogenous, it is important to control for self-selection in the resolution of pregnancies as live births or induced abortions. The selectivity bias could be in either direction. They find strong selection effects for blacks but not whites, with the results suggesting that among blacks the unobserved factors that increase the probability of a live birth are correlated with unobserved factors that increase use of prenatal care and increase birthweight. Subsequent studies that use vital statistics data also control for selectivity bias (Joyce 1994, Liu 1998). However, other recent studies such as Warner (1998) that use data from surveys of mothers can not, because the data necessary to estimate the selection equation are lacking.

Because of the variety of specifications, econometric methods, and data sets used, it is difficult or impossible to determine a single 'best' estimate of the marginal product of prenatal care in improving health. There is a strong consensus in the research that prenatal care is productive, but the precise magnitude varies. A few examples illustrate typical results. After controlling for the endogenous choice of health inputs, Rosenzweig and Schultz (1983) results imply that prenatal care delay decreases birthweight by approximately 50 grams. Warner (1995) estimates a monthly delay productivity of between 25 and 30 grams for black mothers. After controlling for both endogeneity and selectivity bias, Liu (1998) estimates that each month of prenatal care delay decreases birthweight by 76 grams. To consider a different health outcome measure, Corman, Joyce and Grossman (1987) estimate that prenatal care reduces black mortality by 1.82 deaths per 1000 live births, but reduces white mortality by only 0.30 deaths per 1000 live births.

Illustrative Calculations of Willingness to Pay for Infant Health

Marginal willingness to pay for infant health can be calculated by combining an estimate of the marginal productivity of prenatal care in improving infant health with an estimate of the price of prenatal care. Ideally, the price should be specific to the sample used to estimate the infant health production function, in terms of both geographic area and time period. In addition, although the simple model presented above abstracted from these complications, price should be measured as the out-of-pocket cost paid by the mother after insurance, plus additional travel and time costs incurred to receive the care. In practice, developing such a price measure is challenging, so the following calculations should be viewed as illustrative.

Suppose the full price (out-of-pocked monetary costs plus travel and time costs) of reducing one month of prenatal care delay is $300. From the studies reviewed above, this reduction in delay might increase birthweight by 25 to 76 grams. Assuming the increase is 50 grams, the implication is that maternal marginal willingness to pay is about $6 per extra gram of birthweight.

As another illustrative calculation, combining the cost of prenatal care with the estimate from Joyce, Grossman and Goldman (1989) of the marginal product of prenatal care in reducing neonatal mortality yields the willingness to pay for a small reduction in neonatal mortality risks. As is conventional, this can be conveniently summarized as the value of a statistical life. Dickie and Nestor (1998) conduct the needed calculations to derive the per birth value of $43,000 to $750,000 for whites and $59,00 to $1,450,000 for blacks.

V. Demand Function Estimates and the Value of Infant Health

Willingness to Pay Expression

The model sketched in section III can be extended to focus on mothers' consumption choices that affect both their own health and fetal health. Suppose now that the parent receives utility from consuming S, X, and her own health H, and additional utility from her child's health IH. Assume the parent's utility is a separable function of consumption utility (U) and utility (W) from child health: utility = U (X, S, H) + W (IH). Parent health and child health are produced according to household production functions: H = H(S) and IH = IH (S). (This abstracts from the use of prenatal care, to simplify the presentation). A smoking parent chooses S and X to maximize her utility subject to a standard budget constraint and the household production functions; call these optimizing choices S* and X *, with the corresponding parental and child health consequences H* and IH*. For the parent who finds it optimal to quit smoking, call her optimizing choices of consumption S** = 0 and X**, with the corresponding parental and child health consequences H** and IH**. The net benefits of quitting smoking are therefore given by:

$$\text{(1)} \qquad NB = \{U [0, X^{**}, H^{**})] + W [IH^{**}]\} - \{U [S^{*}, X^{*}, H^{*}] + W [IH^{*}]\}$$

Equation (1) can be seen as the motivation for the empirical research on smoking during pregnancy discussed below. If NB > 0, the individual is observed to quit smoking; otherwise the individual remains a smoker. Equation (1) provides the basis for comparative static predictions about the determinants of smoking cessation. Pregnancy increases the net benefits of smoking cessation through the W[ ] terms in equation (1). Standard arguments suggest that cigarette prices, income, and various demographic characteristics and life cycle events also enter as possible determinants of NB.

To derive the implications of maternal smoking decisions for valuing infant health, consider a smoker who quits because of pregnancy or a new child. Before children her optimal choice was to smoke, so the parent's direct utility from consumption is lower when she quits to improve child health:

(2) $? \; U = U(0, X^{**}, H^{**}) - U(S^{*}, X^{*}, H^{*}) < 0$

Measured in utility units, ? U is the net consumption utility foregone in order to invest in infant health. But for the smoker who finds it optimal to quit, NB > 0, which implies:

(3) $? U < ? W = W[IH^{**}] - W[IH^{*}]$

From (3), the consumption utility foregone is generally a lower bound to the parent's utility gain from the infant health improvement due to smoking cessation. For the marginal quitter, the consumption utility foregone will just equal the utility of the child health improvement. Thus, an estimate of the dollar value of the consumption utility foregone provides a measure that is a lower bound to the value of the infant health improvement from maternal smoking cessation.

Methods from applied welfare economics provide a precise definition of the value of the consumption utility foregone from maternal smoking cessation. To account for the dollar value of this utility loss, the framework can be re-stated in terms of the indirect utility function. Let v (p, Y) be the indirect sub-utility function for parent's consumption of S, X and H. Given prices ps0 , px0 and income Y^0 , define the indirect sub-utility from consumption before child health concerns with choices S*, X* and H* as v* = v(ps0, px0, Y^0). Given the same prices and income, but rationing the consumer to S** = 0, let her indirect sub-utility be given by v** = v(ps0, px0, Y^0; s** = 0). A dollar-valued measure of the utility from goods consumption foregone to invest in health is the compensating variation (CV) in income implicitly defined by:

$$(4) \qquad v(ps0, px0, Y^0) = v(ps0, px0, Y^0 + CV; S^{**} = 0)$$

This compensating variation is the amount the consumer would have to be paid after she has quit smoking to give her just as much consumption utility as she received when she was a smoker. Because the parent quit smoking due to infant health concerns, CV will be the operable definition of the parent's willingness to pay for infant health.

The CV can be approximated using standard methods from applied welfare economics (Deaton and Muellbauer 1980, Varian 1978). In that approach, the CV implicitly defined by equation (4) can be related to an area of consumer's surplus measured to the left of a compensated (utility-held-constant or Hicksian) demand curve for cigarettes. The appropriate area is measured with reference to a "virtual price" of cigarettes, ps1 that would convince the consumer to quit smoking even before child health concerns (see Neary and Roberts 1980, and a similar application by Kenkel 2002). The empirical estimates reviewed below provide measures of the effect of pregnancy, a new child, and cigarette prices on the decision to quit smoking. The estimated effects can be used to calculate the virtual price increase that has the same effect as a pregnancy or new child. Consumers' surplus can then be calculated using estimates of the price elasticity of smoking. Although the price elasticity estimates will correspond to an ordinary demand curve, the area CV measured with an ordinary demand curve approximates the exact measure of compensating variation (Willig 1976).

The simple model used to derive parents' willingness to pay for infant health abstracts from addiction, a potentially important aspect of decisions about cigarette and alcohol consumption. Consumers' surplus needs to be carefully interpreted in the context of an addictive good. Most smokers report a desire to quit, but this does not invalidate economic models of smoking (Viscusi 1992b). The fact that they continue to smoke despite a stated desire to quit means that quitting is costly; addiction may mean that this cost is better interpreted as the pain of quitting rather than the foregone pleasure of smoking. Regardless how this cost is interpreted, estimates of the costs smokers incur to quit smoking when pregnant reveal their willingness to pay for child health.

Another concern is that estimates of smokers' or drinkers' willingness to pay for infant health underestimate the average parents' willingness to pay. Research suggests that smokers have different risk preferences from nonsmokers (Hersch and Pickton 1995, Viscusi and Hersch 2001). Assuming their willingness to pay for child health shows the same patterns, the estimates of average smokers' willingness to pay will be a lower bound to average parents' willingness to pay for child health. A related issue is that smokers appear to process risk information differently (Viscusi, Magat, and Huber 1999). Smokers may have placed a low weight on reports linking secondhand smoke to child health. In this case, smokers may be relatively unwilling to change their behavior partly because they are using low risk assessments. These limitations should be kept in mind.

Empirical Estimates of Maternal Demand for Cigarettes and Alcohol During Pregnancy

Table 3 lists six empirical studies of the demand for cigarettes and alcohol during pregnancy. Four of the studies explore the determinants of pregnant women's smoking participation, i.e. whether or not they are regular smokers. One study explores the determinants of both smoking participation and the daily consumption of cigarettes conditional on being a current smoker; another study explores the determinants of drinking participation and the monthly consumption of alcohol conditional on being a drinker. Three of the studies of smoking participation use data from the national natality files, which starting in 1989 include an indicator of whether the mother smoked during pregnancy. The first such study by Evans and Ringel (1999) uses a sample of over 10 million births between 1989 and 1992, and the subsequent studies by Ringel and Evans (2001) and Gruber and Koszegi (2001) increase the sample size further by extending the sample period. Colman, Grossman and Joyce (2003) use an alternative data set overseen by the CDC, and by pooling together data from 10 states over the years 1993 - 1999 obtain a sample of 115,000 women. The remaining two studies – Bradford's (2002) study of smoking and Kenkel and Lin's (2003) study of drinking – use a sample of about 6,000 women from the 1988 NMIHS, and its 1991 Followup. Although it is a smaller sample over a limited time period, the NMIHS provides much more detailed information about smoking and drinking behavior and the women's circumstances.

The main focus of research on the demand for cigarettes and alcohol during pregnancy is to estimate the price-elasticity of demand, to explore whether higher taxes might be effective to change these prenatal behaviors and thus improve health. For example, Ringel and Evans (2001) estimate a price elasticity of -0.7, which suggests that cigarette taxes may be a powerful tool to reduce smoking during pregnancy. However, as Corman, Grossman and Joyce (2003) point out, their estimate may be too optimistic: real cigarette prices have risen 60 percent since 1997, but smoking during pregnancy dropped by only 7.6 percent, not the 42 percent drop implied by a price elasticity of -0.7.

Bradford (2002) uses data from the 1988 NMIHS and its 1991 Followup to conduct a more in-depth study of smoking behavior during pregnancy. Kenkel and Lin (2003) also use the NMIHS data to conduct a similar study of drinking behavior during pregnancy. The NMIHS is a sample of women who were pregnant in 1988, and some but not all of these women were again pregnant when they were re-surveyed in the 1991 Followup. As a result, these studies are able to estimate the impact of both pregnancy and prices on maternal behaviors. For example, Bradford finds that during pregnancy light smokers reduce consumption by 1.6 cigarettes per day, moderate smokers reduce their consumption by 3.4 cigarettes per day, and heavy smokers reduce their consumption by 5.7 cigarettes per day. Analogously, Kenkel and Lin estimate that during pregnancy, a drinking mother reduces her alcohol consumption by 4.5 drinks per month, and again there are differences in the response of light and heavy drinkers. Because they also estimate the price elasticity of cigarette and alcohol demand by pregnant women, the studies by Bradford (2002) and Kenkel and Lin (2003) can be used to implement the valuation approach based on consumers' surplus calculations.

Illustrative Calculations of Willingness to Pay for Infant Health

To illustrate the approach to infant health valuation, this section presents back-of-the-envelope calculations of the values that are revealed by smoking and alcohol consumption decisions. Bradford (2002) estimates that light smokers voluntarily forego from $610 to $800 in consumers' surplus in response to pregnancy, while heavy smokers having their first child forego over $2,800 in surplus during pregnancy. According to information from the USDHSS (2001), smoking during pregnancy increases the rate of perinatal mortality (still births and neonatal deaths) from about 8 per 1,000 births to about 10 per 1,000 births. A heavy smoker who quits while pregnant therefore gives up $2,800 to reduce perinatal mortality risks by 0.002. Together these numbers imply that the value of a statistical life for an infant is $1.4 million. While many caveats obviously apply, this back-of-the-envelope estimate compares reasonably well to other estimates of the value of life of adults and older children.

Analogously, Kenkel and Lin (2003) calculate the consumers' surplus drinking mothers give up during pregnancy. On average, during the entire pregnancy, the forgone consumer surplus for an average drinking mother is about $37.8.[6] However, this average obscures important differences between three groups of drinking mothers: light drinkers, moderate drinkers, and heavy drinkers. It is useful to explore the surrendered consumer surplus for sub-populations since studies have shown that heavy drinking mothers impose higher risks on their unborn children than moderate and light drinking mothers do.[7] A drinking mother with less than 31 drinks monthly is defined as a light drinker; one with 31 to 59 drinks monthly is defined as a moderate drinker, one with at least 60 drinks monthly is defined as a heavy drinker. This definition is the same as that in most alcohol studies. On average, a heavy drinking mother surrenders $451.3 in consumer surplus; a moderate drinking mother surrenders $ 247.9 and a

6 For those drinking mothers who choose to quit during pregnancy, the surplus foregone can only be viewed as a lower bound of their perceived value to invest in their unborn child's health.

7 In Quelette et al. (1977), babies born to heavy drinkers had twice the risk of abnormality over those born to abstainers or moderate drinkers. They find that 32% of infants born to heavy drinkers demonstrated congenital anomalies; as compared to 14% in the moderate group and 9% in the abstinent group.

light drinking mother surrenders $24.2. Heavy drinkers, compared to moderate and light ones, give up much more in consumer surplus since they perceive a larger benefit from reducing alcohol consumption during pregnancy. A conservative incidence rate is that among heavier drinking women the incidence of Fetal Alcohol Syndrome (FAS) is 1 in every 1000 live births.[8] Because an average heavy drinking mother reveals her willingness to pay to reduce probability of FAS by 1/1000 is $451.3, this implies the value of a statistical case of FAS is $451, 300. By way of comparison, the cost of illness estimates of Harwood and Napolitano (1985) value a case of FAS at about $347,000 (in 1990$).

VI. Impact of Public Policies on Infant Health and Implications for Valuation

Willingness to Pay Expression

There are at least two challenges to estimating willingness to pay from empirical studies of the impact of public policies on infant health. First, it may not be possible to recover the necessary structural parameters from the reduced form equations estimated. Second, in many cases a change in public policy represents a non-marginal change. The first point is similar to Rosenzweig and Schultz's (1983) criticism of what they term "hybrid" health equations. In a so-called hybrid equation, one input, for example prenatal care, and variables like income and prices that are the determinants of the other inputs, are regressed against a measure of health. The results are often interpreted as the causal effect or marginal product of prenatal care. However, Rosenzweig and Schultz (1983) argue that this interpretation is invalid: they show that the

8 Estimates of FAS prevalence vary from 0.5 to 3 per 1000 live births in most populations. However, the prevalence rate in some American Indian communities is as high as 9 per 1000 births.

estimated effect of prenatal care on health from such an equation embodies both technology parameters of the health production function and preference parameters of the utility function.

Even compared to a hybrid health equation, the approach of many empirical health economics studies is further away from structural estimation of the household health production function. For example, Currie and Gruber (1996) estimate the impact of Medicaid expansions on infant mortality. In essence, Medicaid as a determinant of the use of prenatal care has been substituted into the hybrid equation. The resulting reduced-form equation may be a desirable approach to estimate the impact of the specific policy change. But the estimated effect of Medicaid now combines the impact of Medicaid on the use of prenatal care (a demand effect) and the impact of the use of prenatal care on infant health (a production function effect). It might be possible to use additional information or assumptions about some of the structural demand parameters to disentangle the effects. If the policy change can be treated as a marginal change, it would be then be possible to derive estimates of the marginal product of prenatal care in producing infant health. Such an estimate could be used in the expression derived above for the marginal willingness to pay for infant health.

However, as has been already noted, in many cases discrete policy changes represent non-marginal changes. Bockstael and McConnell (1983) suggest that it may be possible to value such changes with reference to the areas behind appropriate marginal value and marginal cost curves. Bockstael and McConnell provide a general discussion of welfare measurement in the household production framework, emphasizing the distinction between a commodity such as infant health and the market goods that are used as inputs to produce the commodity. They show how the welfare effect of a change in the level of a public good can be measured either in the hypothetical 'market' for the commodity (output) or in an actual market for a good (input). The welfare measure in the goods market is empirically implementable, and corresponds to the change in the area behind a compensated demand curve for an input that is caused by a change in the level of a public good. Dickie and Gerking (1991) use this approach to infer willingness to pay for ozone control from the demand for medical care.

Some empirical studies estimate the impact of a policy on both the commodity infant health and its impact on the use of a health input like prenatal care. This raises the hope that the results are informative about the change in the area behind the demand curve for prenatal that results from the policy change. As in the similar example of Dickie and Gerking (1991), it is probably reasonable to assume that prenatal care satisfies the assumptions needed for the Bockstael and McConnell (1983) approach to be valid. And although privately and publicly insured consumers may pay little or no out–of-pocket monetary costs for prenatal care, a demand curve can be still derived with respect to travel and time costs incurred. With estimates of the demand curve and how the policy changes the demand curve, in principle it should be possible to implement the welfare measurement derived by Bockstael and McConnell (1983). However, the problem of recovering structural parameters from reduced-form equations re-appears. In this case, the problem is to recover a demand function from a reduced-form equation showing the impact of a policy change on input usage. For example, it may not be clear if the estimated effect of the policy is on the demand side through changes in consumers incentives or the supply side through changes in providers' incentives. It may again require extra information or assumptions to identify the parameters of the demand function needed to implement the Bockstael and McConnell (1983) welfare measure.

Empirical Estimates of the Impact of Public Policies on Infant Health

Table 4 lists 10 studies of the impact of public policies on infant health. In all but one study, the focus is on public policies such as Medicaid that are targeted at low-income and disadvantaged populations. All of the studies examine the impact of a policy on some measure of infant birthweight, with the focus often being on low birthweight and very low birthweight as the most serious adverse outcomes. At least four of the studies also estimate the impact of the policy under study on the use of prenatal care. At least some of the remaining studies measure prenatal care, but it may not be used as an outcome variable. For example, Currie and Cole (1993) include prenatal care use as an explanatory variable to estimate the impact of AFDC participation on infant birthweight, controlling for differences in prenatal care use. Currie and Cole (1993) do not provide a structural interpretation of the estimated impact of AFDC participation, but note that it may combine an income effect with an additional effect due to improved access to a range of other services from the welfare system.

Illustrative Calculations of Willingness to Pay for Infant Health

Existing research on the impact of natural policy experiments on infant health inputs and outcomes does not support calculations of willingness to pay for infant health. As discussed above, such calculations require additional information or assumptions to: (a) recover structural parameters from the estimation results; and (b) implement the appropriate welfare measure for a marginal or non-marginal change. Alternatively, an avenue for future work might be to re-analyze these data sets to estimate the value of infant health.

VII. Discussion

The review of empirical health economics research suggests a potential vein to be mined for information on the value of fetal and infant health. As discussed in section III, it is probably most straight-forward to derive estimates of maternal marginal willingness to pay for infant birthweight. Because birthweight is associated with infant mortality and a range of subsequent outcomes, it is a useful summary of infant health. Similarly, estimates of the value of birthweight are potentially useful for the benefit-cost analysis of a variety of environmental and public health policies. For example, food safety regulations to prevent exposure to *Toxoplasma gondii* reduce risks for infants (Roberts and Frenkel 1990). Previous analyses that value reduced infant mortality risks based on the discounted present value of lifetime earnings may substantially underestimate willingness to pay.

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Prenatal Investment-Exercise

	Full Sample	Live Birth Sample	Fetal Death Sample	Infant Death Sample
	N=18,594	N=9,953	N=3,309	N=5,332
exercise 3+ times a week before found out pregnancy	47%	47%	42%	43%
exercise 3+ times a week after found out pregnancy	42%	42%	36%	34%
start to do exercise 3+ times after found out pregnancy	7%	8%	6%	6%
quit doing exercise after found out pregnancy	13%	13%	13%	15%
months of doing exercise during pregnancy	2.76	2.77	2.07	1.87

Prenatal Investment-Prenatal Care

	Full Sample	Live Birth Sample	Fetal Death Sample	Infant Death Sample
	N=18,594	N=9,953	N=3,309	N=5,332
prenatal childbirth class	38%	38%	27%	19%
prenatal care	98%	98%	97%	94%
number of prenatal visits	12.87	12.90	11.32	10.27

Prenatal Investment-Vitamins Intake (at least 3 days a week during the three 3 months before found out pregnancy)

	Full Sample	Live Birth Sample	Fetal Death Sample	Infant Death Sample
	N=18,594	N=9,953	N=3,309	N=5,332
multivitamins and/or minerals	26%	26%	25%	25%
Vitamin A	2%	2%	2%	2%
Vitamin C	4%	4%	5%	4%
Folic Acid	1%	1%	1%	1%
Calcium	4%	4%	4%	4%
Iron	9%	9%	10%	11%
Zinc	1%	1%	1%	1%

Prenatal Investment-Vitamins Intake (at least 3 days a week during the three 3 months after found out pregnancy)

	Full Sample	Live Birth Sample	Fetal Death Sample	Infant Death Sample
	N=18,594	N=9,953	N=3,309	N=5,332
multivitamins and/or minerals	81%	81%	79%	76%
Vitamin A	3%	3%	3%	3%
Vitamin C	4%	4%	4%	4%
Folic Acid	3%	3%	3%	2%
Calcium	8%	8%	8%	8%
Iron	33%	33%	33%	35%
Zinc	2%	2%	1%	2%

Prenatal Investment-start to take vitamins at least 3 days a week after found out pregnancy

	Full Sample	Live Birth Sample	Fetal Death Sample	Infant Death Sample
	N=18,594	N=9,953	N=3,309	N=5,332
multivitamins and/or minerals	57%	57%	56%	52%
Vitamin A	2%	2%	2%	2%
Vitamin C	2%	2%	2%	2%
Folic Acid	2%	2%	2%	2%
Calcium	6%	6%	6%	6%
Iron	27%	27%	26%	27%
Zinc	1%	1%	1%	1%

Prenatal Investment-Cigarette Consumption

	Full Sample	Live Birth Sample	Fetal Death Sample	Infant Death Sample
	N=18,594	N=9,953	N=3,309	N=5,332
smoking participation before the 12 months of delivery	30%	30%	33%	37%
smoking participation after found out pregnancy	22%	22%	25%	30%
number of cigarettes per day before found out pregnancy	4.84	4.83	5.28	5.84
number of cigarettes per day after found out pregnancy	2.69	2.68	3.01	3.43
quit smoking after found out pregnancy	8%	8%	8%	7%

Prenatal Investment-Conditional Cigarette Consumption

	Full Sample	Live Birth Sample	Fetal Death Sample	Infant Death Sample
number of cigarettes per day before found out pregnancy	16.15 (N=5,978)	16.15 (N=2,986)	16.24 (N=1,083)	15.92 (N=1,908)
number of cigarettes per day after found out pregnancy	12.06 (N=4,720)	12.07 (N=2,326)	12.15 (N=838)	11.60 (N=1,556)

Prenatal Investment-Alcohol Consumption

	Full Sample	Live Birth Sample	Fetal Death Sample	Infant Death Sample
	N=18,594	N=9,953	N=3,309	N=5,332
drinking participation before the 12 months of delivery	45%	45%	42%	43%
drinking participation after found out pregnancy	21%	21%	16%	18%
number of drinks monthly before found out pregnancy	4.07	4.06	3.92	4.39
number of drinks monthly after found out pregnancy	0.72	0.72	0.78	1.09
quit drinking after found out pregnancy	25%	25%	26%	25%

Prenatal Investment-Conditional Alcohol Consumption

	Full Sample	Live Birth Sample	Fetal Death Sample	Infant Death Sample
number of drinks monthly before found out pregnancy	9.03 (N=7,185)	9.02 (N=3,781)	9.37 (N=1,318)	10.24 (N=2,086)
number of drinks monthly after found out pregnancy	3.50 (N=3,145)	3.47 (N=1,738)	5.03 (N=522)	6.17 (N=885)

Table 2: Infant Health Production Function Estimates

Study	Health output	Data
Rosenzweig & Schultz (1983)	Birthweight in grams	1967-69 U.S. National Natality Followback Surveys
Corman, Joyce and Grossman (1987)	Neonatal mortality; Low birthweight (below 2500 grams)	county-level data
Rosenzweig and Schultz (1988)	Birthweight (grams)	1980 National Natality Survey
Joyce, Grossman and Goldman (1989)	Neonatal mortality	1977 county-level data
Grossman and Joyce (1990)	Birthweight (grams)	1984 New York City Vital Statistics
Jones (1990)	Low birth weight (below 2500 grams)	1984 state-level data
Frank, et al. (1992)	Low birthweight (below 2500 grams)	1975 - 1984 county-level data from natality files
Joyce (1994)	Birthweight (grams)	1984 New York City Vital Statistics
Warner (1995)	Birthweight (grams)	1980 - 1990 New York City Vital Statistics
Warner (1998)	Birthweight (grams)	1988 NMIHS
Liu (1998)	Birthweight (grams)	1984 Virginia birth and abortion certificates

Table 3: Maternal Cigarette and Alcohol Demand during Pregnancy

Study	Demand measure	Data
Evans and Ringel (1989)	Smoking participation	1989 - 1992 national natality files
Ringel and Evans (2001)	Smoking participation	1989 - 1995 national natality files
Gruber and Kosegi (2001)	Smoking participation	1989 - 1996 national natality files
Bradford (2002)	Smoking participation; conditional quantity demanded	1988 National Maternal and Infant Health Survey, and 1991 Followup
Colman, Grossman and Joyce (2003)	Smoking participation	1993 - 1999 Pregnancy Risk Assessment Monitoring System
Kenkel and Lin (2003)	Drinking participation;. Conditional quantity demanded	1988 National Maternal and Infant Health Survey, and 1991 Followup

Table 4: Empirical Estimates of Public Policies on Infant Health

Study	Policy	Outcome
Devaney, Bilheimer and Schore (1992)	WIC participation; prenatal care	birthweight; Medicaid costs
Currie and Cole (1993)	AFDC participation	birthweight
Reichman and Florio (1996)	New Jersey Health Start Program	birthweight; hospital costs
Currie, Nixon and Cole (1996)	restrictions on Medicaid funding of abortion	birthweight; pregnancy outcomes
Currie and Gruber (1996)	Medicaid expansions	birthweight; infant mortality
Levinson and Ulman (1998)	Medicaid managed care	prenatal care; birthweight
Joyce (1999)	New York State's Prenatal Care Assistance Program	birthweight
Dubay, Kaestner and Waidmann (2001)	malpractice insurance reform	prenatal care; birthweight
Gray (2001)	Medicaid physician fees	prenatal care; birthweight
Currie and Grogger (2002)	Medicaid expansions; Welfare reform	Use of prenatal care; fetal deaths

Valuing Fetal and Infant Heath Effects

Trish Hall
US EPA

Valuing Environmental Health Risk
Reductions to Children- Oct. 20,
2003

Overview

- Introduction
- Why valuation is important
- Discussion of the papers from a policy perspective
- Summary

Why is it important to value fetal and infant health effects?

- The ability to monetize benefits is critical to the regulatory development process
  - Benefit transfer using adult values is controversial
- Improved information regarding fetal and infant health effects
  - Birth defects
  - Fetal loss
  - Endocrine disrupters

Why is it important to value fetal and infant health effects?

- Magnitude of the problem: Fetal Loss Example
  - Approximately one million fetal losses per year in the US
    - small change in risk = large reduction in cases = large benefits

Comparison in brief

- Mother's decisions regarding her own health reveals how she values the health of her unborn child
- Specific values of unborn child or infant are not considered
- Same data set: 1988 National Maternal and Infant Health Survey
- A good first step

Policy Implications:
Nastis & Crocker

- Conclusion: A mother values the health of her fetal child about six times more than she values her own health
- Interpretation?
  - Fetal child can be valued at six times the adult value (either VSL or WTP)?

Points to Consider

Nastis & Crocker

- Impact of elimination criteria
  - did not include gestations less than 20 weeks
  - only considered singleton births to mothers 35 or younger excluding adolescents
- Specific findings may not have an impact on national-level analysis
  - A mother's first-borne child is valued more than her subsequent children
  - Nonsmoking mother value their children more highly than smokers do

Policy Implications

Kenkel

- Conclusion: Varies depending on which approach is used
  - prenatal care and birthweight
  - cessation of smoking or drinking
- Interpretation:
  - Designed to explore existing health data but illustrative calculations could be beneficial to policy analysis

Policy Implications

Kenkel

- Conclusion from Prenatal care and Birthweight:
  - Marginal WTP $6 per extra gram of birth weight
- Interpretation?
  - Could be useful if we can determine a relationship between exposure and birthweight

Policy Implications

Kenkel

- Conclusion: VSL for an infant can be calculated using the two methodologies
  - Prenatal care = $43,000 to $1.5 million
  - Smoking cessation = $1.4 million
- Interpretation-
  - Provides estimate of magnitude of loss from mother's perspective
  - Application may be limited

Points to Consider

Kenkel

- Voluntary vs. Involuntary Risks
  - smoking/drinking vs. exposure to environmental contaminants
- Consider using elimination criteria outlined in Nastis & Cocker

Note about Terminology

- Both papers use terms such as child, fetal child, neonate, and infant interchangeably
  - consistency needed
  - clarify what specific valuation refers too

Summary

- Fetal and infant valuation is an extremely complex issue but also extremely important to public policy
- Quantitative applications limited
  - but improves are ability to discuss the magnitude of impacts

Summary of Q&A Discussion Following Session III

Glenn Harrison (University of Central Florida) opened by saying, “I guess only Kerry Smith could with a straight face say that he did a study of fertility amongst couples and concluded that there is an important interaction between the male and female,” to which Dr. Smith retorted, “This came as a big surprise to me!”

Directing his next comment to Tom Crocker and Don Kenkel, Harrison continued by stating what he felt was a very important issue for the purpose of this workshop: the fact that “the extent to which the mother or the parent cares about the kid’s health relative to her own, or we try to draw the similar source of conclusions about the ratio of willingness to pay” may depend on other motives in addition to the commonly assumed motive of health concerns. He noted that Dr. Smith and Dr. Crocker were careful to talk about *contemporaneous* sets of choices, and he suggested, “But let’s have a minimal–*minimal*–two-period contemporal choice by the mother, where the mother–forgive me if there are any pregnant women in the house, because they’ll kill me–where the mother *only* cares about the consumption value of the child, from her own perspective, in the future period. In other words, if the kid is born unhealthy, it’s a *pain* for the mother–it reduces her consumption in the following period, and that at least deserves some weight–we’ll let the data put what actual weight is on it.” Harrison went on to explore the situation in which the mother cares about the child’s health *exactly* to the extent of her own, claiming that “it could be contemporaneous because it could cause pregnancy complications for the mother herself if she doesn’t look after the kid, so that they’re highly correlated, but very physically.” He closed by reiterating that “it could be that everything you two [i.e., Crocker and Kenkel] label as the ratio of caring about the infant’s health to the mother’s health is simply the mother caring about her future consumption, and it’s got nothing to do with the children.” This is a fundamental idea, he said, that “everyone at this workshop has to address somehow rather than just *impose* their politically correct view on the observed behavior.”

Tom Crocker responded that he absolutely agreed that “introducing an additional period, or a sequence of periods, after the birth into the mother’s expected utility” makes sense. He stated that it was mentioned but not made explicit in the model “in that the mother has to worry about how much effort she will have to put forth and the extent to which she can care for the child.” He acknowledged that this was a good point, though a very complex issue.

Don Kenkel said that he agreed also and explained that in the interest of constructing a simple model, he had assumed that the only reason women were interested in good health was through the preference function. For clarification, he asked Dr. Harrison whether he was saying that health decisions also enter the budget constraint with regard to future consumption. When Harrison confirmed this, Kenkel responded that he had “assumed that away” and acknowledged Dr. Smith’s point that these assumptions are important to the willingness to pay expression and interpretations.

Harrison then followed up with a related observation regarding the smoking data that had been cited. He emphasized that the data revealed *dramatic* reductions in expectant mothers' smoking *during* the pregnancy (and he acknowledged that the timing—after the first trimester or before—is an important issue) followed by a resumption of smoking or of higher levels of smoking after the pregnancy is over. To make his point, he further stated that if the data show that the mothers tend to resume the same level of smoking that they engaged in before the pregnancy, then there would be some basis for assuming that the smoking modification was motivated by concerns for the fetuses' health. Reiterating Dr. Smith's point, he closed by saying, "You've gotta have some more handles in order to draw that and tease those motives."

Don Kenkel responded by saying, "Empirically, you're exactly right–a lot of women quit smoking, but *just* during pregnancy, and there's this *incredible* recidivism effect where after the pregnancy is over they start back up smoking."

Dr. Crocker added, "From a structural perspective, what you're saying also implies that to explain the consumption of drinking or smoking post-natal requires that one go back and look at the mother's decisions while she was pregnant, simply because her decisions while she was pregnant may very well affect her demand for inputs–smoking, drinking–after the child is born."

Dr. Smith commented that one of the reasons why he and his colleagues were interested in looking at the restrictions of the negative preferences anew is that "weak complementarity and weak substitution are actually examples of discontinuities in preferences, where there is a change–and that's really what's important about them–and we lose track of that when we focus exclusively on the zero consumption level." He went on to agree with Glenn Harrison that there are lots of other points of discontinuity where there are abrupt changes in behavior, and he stated that these situations provide *really important* information for answering some of these questions. He concluded by adding that "oftentimes, in the health data sets and these kinds of other behaviors there are real opportunities to get at those discontinuities, and we're just failing to use them."

Dr. Crocker commented that he doesn't understand the appeal to weak complementarity when dealing with health considerations. He stated that it makes sense when dealing with recreation—for example, if your pond is polluted and you don't fish, then you'll have no demand for fishing rods. He concluded by saying, "But if you're in poor health, why it is that you have no demand for health inputs is a bit beyond me. I would think you'd have *more* of a demand for health inputs, for cleaner air, if in fact you're in poor health."

Glenn Harrison replied that there are certain segments of the population for whom the non-pecuniary costs of availing themselves of health inputs are massive. He cited the "huge differences in black/white fetal death rate and infant death rate" that most studies attribute largely to the real costs of getting off work, traveling to a healthcare setting, arranging baby care, and so forth. In closing he said that "there are some stories there" for anyone who takes the time to tease the racial differences apart.

Partly in response to Dr. Crocker's comment, Dr. Smith offered this clarification: "If a person is not sick chronically with asthma or something else, you don't have a demand for care-giving activities. That would be an example of weak complementarity. If on the other hand, you live in an area where there is a high level of ozone or something and you have a child . . . in a highly polluted area with ozone or something, you might take some mitigating behavior, which would be more like weak substitution–you would not allow the child to play outside, let's say, on an ozone-alert day or something like that. So, the point is the discontinuity arises as a consequence of the child's condition and what state the child is in in relationship to the environmental conditions, and it could be either weak complementarity or it could be weak substitution."

Scott Grosse (Centers for Disease Control and Prevention) responded to Dr. Crocker's paper by saying that he thought the meaning of "health" needs to be made clearer. He stated that weight gain during pregnancy is only one dimension of an expectant mother's health and that there are many other dimensions of the mother's health that possibly relate differently to the infant's health. He also suggested that it would be useful to have a comparable measure, such as healthy days–healthy days of the child, healthy days of the mother–by which one could actually make a comparison. Dr. Grosse went on to point out that gestational diabetes actually leads to higher birth weight and that anemia might present a different relationship for every dimension of maternal health. Factors such as these make it very difficult to generalize about the relative value of weight gain during pregnancy.

In agreement, Don Kenkel replied, "And to make Kerry's point: We have multiple attribute health production–health outputs, as they say. Just think of the extra structure we have to impose to estimate all the different marginal products."