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Household Environmental Protection and the Intergenerational Transmission of Human Capital

--Working Paper*--

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Household Environmental Protection and the Intergenerational Transmission of Human Capital

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ABSTRACT. The estimated discount rate of parents is used to test a choice-based intergenerational model of the contribution of environment to the cognitive skills of a child of a given endowment. A lower parental discount rate is shown to imply higher cognitive skills of the young child. In the context of the model, estimates also imply that environmental conditions and human capital formation are not separable. Lesser environmental quality raises the costs of human capital formation in children and lesser human capital reduces parents' demand for environmental quality. Environmental quality differences among families, just genetic differences, may persist across generations.

> *The difference of natural talents in different men is, in reality, much less than we are aware of; and the very different genius which appears to distinguish men . . .,, when grown to maturity, is not ... so much the cause, as the effect of the division of labor* (Smith, *[1776] 1937, p. 15*).

1. Introduction. The influence of human capital or knowledge about the laws of nature and the nature of man on economic growth and the evolution of income inequality receives increasing attention in both the technical economic literature, e.g., Levy and Murname *(1992),* and in popular commentary, e.g., Murray *(1984).* Human capital is thought to be the primary engine of growth, the major component of wealth in developed economies, to be increased by and to increase the scope of markets, and to play significant roles in fertility choice, socialization, and migration. Little attention has been given, however, to how human capital can affect one's treatment of the natural environment or how this environment can mold one's accumulation and protection of human capital. Central to any attempt to deal with either of these questions is the extent to which intergenerational redistributions, especially from adults to young children, are influential. Since children do not vote and have only trivial assets or activities over which they can exercise substantial discretion, the practical aspects of the intergenerational redistribution issue revolve around the productivity of parental and social investments in environments that can affect a child's prospective human capital. Given that parents have limited resources, they must often make time and effort choices between their immediate consumption and the provision of environmental enhancements and protections that will

advance a child's current health and adult prospects. When approaching adulthood the child takes what its parents, community, and genes have handed it and set its course for an adult life.

This study uses an unusual data set to estimate the relationship between the environmental protections that parents offer children and the intergenerational transmission of human capital. We focus on lead, a persistent micropollutant that has become ubiquitous in even remote environments and which is widely acknowledged in the biomedical literature to produce long-term cognitive skill deficits in young children who axe exposed to everyday ambient concentrations common to the world's urban areas (Smith et al., *1989).* Following Agee and Crocker *(1998),* the next section presents a simple model in which changes in parents' demand for own-consumption translate into changes in the environmental quality they provide their child, hence into changes in the benefits to them of building their child's human capital. The model hinges upon parents having imperfect access to capital markets in that they must either sell assets, increase parental market labor, or reduce household consumption to finance investments in their children which cannot be borrowed and made the children's future obligation. A third section describes the data we employ, while the fourth section presents empirical tests of model propositions. The connection we find between parents' own-consumption, their child's cognitive skills, and the child's environment leads us to conclude that environmental quality differences among families, just like genetic differences, may persist across generations.

II. **Parental Investments in Children's Cognitive Skills.** Consider a two-period, two generation lifetime setting in which the generations overlap each period. In period 1, parents with unified preferences derive utility

$$U(s_1, \alpha_1(n) n c_2) \tag{1}$$

in a weakly separable fashion from own-consumption, s_1, over their certain lifespans, and from the current health and thus the expected value, c_2, of the adult prospects in period 2 of their child. U(·) is twice differentiable and concave. So as to remove fertility decisions from the problem, we interpret the parents' number of children, n, to be predetermined. Diminishing marginal utility of children implies that parental first period altruism, α_1, is negatively

related to child numbers (Becker et al., 1990). Parents have no favorites among their individual children, as is commonly assumed (Wilhelm, 1996). Children are passive with respect to their parents' consumption and investment decisions.

Parents maximize U(·) subject to the constraint

$$X + nc_2(Q_1; E_2) = p_1(Q_1)s_1. \tag{2}$$

The left-hand-side of (2) states that parents possess total exogenous money wealth, X_1, and the expected value, c_2, to them in period 2 of their children as adults. This expected value may include consumption support as well as the money equivalent of companionship and emotional support. On the right-hand-side , parents allocate this wealth and expected value between period 1 own-consumption, s_1, and the provision of environmental quality for their child. Greater parental provision of period 1 environmental quality, Q_1, progressively increases the unit value, p, of own-consumption such that $p' > 0$, and $p'' > 0$. In effect the quality of the child's environment and the parents' period 1 own-consumption are substitutes.

Q_1 is conditioned on whatever public goods society exogenously provides the child. Parents have no second-period earnings, but the presence of the second term, $c_2\ (Q_1; E_2)$, on the left-hand-side of (2) implies that the parents' lifetime wealth increases with the child's adult prospects.[1] $c_2\ (Q_1; E_2)$ is defined as

$$c_2\ (Q_1; E_2) \equiv w \cdot z_2\ (Q_1; E_2) + \varepsilon_2\,, \tag{3}$$

where z_2 is a continuous concave cognitive skill or adult prospect production function, w is the rental rate of these skills, and ε_2 is a stochastic term representing market luck. For simplicity, we assume w equals unity. E_2 is the child's exogenous phenotype, the autonomous background expression of the cultural, environmental**,** and the genetic attributes that the child inherits. We presume as a first approximation that these attributes are transmitted by way of a stochastic linear equation

$$E_2 = \lambda + \theta E_1 + v, \tag{4}$$

where λ denotes the child's community or social endowment (Coleman, 1988), θ represents the degree (or vector of degrees) of "inheritability" of the attributes, E_1, that the child's grandparents transmitted to the parents, and *v* measures unsystematic components in heritability. Expression (4) is presumed fixed over the child's lifespan and is shared in common with its siblings. Parents cannot invest in the child's endowment. In sum, $c_2\ (Q_1;\ E_2)$ implies that the cognitive skill impact of the child's inheritance is conditioned by the quality of the environment that the child's parents provide.

Parents' equilibrium levels of s_1 and c_2 obtained from the primal optimization problem in expressions (1) through (4) will vary with their demand, Q_1^*, for environmental quality**.** Substitution of Q_1^* into U (·) yields an indirect utility function

$$V = V\,(p_1\,(Q_1^*),\ nc_2\,(Q_1^*;\ E_2),\ X_1) \tag{5}$$

which follows from the primal result that parents produce that level of environmental quality which equates the money equivalents of their marginal utilities of consumption and their child's cognitive skills, given that the parents are wealth-constrained and cannot borrow for own-consumption and child investments and then make payments on these borrowings the child's adult obligations. Therefore expression (5) implies that parents invest in their child's environment until the marginal rate of return on this investment equals their substitution rate between own-consumption, s_1, and the child's adult prospects (see the Appendix). Becker and Tomes, (1986, p. S11) refer to this substitution rate as the parents' rate of discount for these prospects, $\rho \equiv (\partial U / \partial s_1)\,(\partial U / \partial Q_1)$, their "shadow cost" of investing in the child's environmental quality. As in Becker and Tomes, the parents' demand for environmental quality can then be written in terms of the parents' discount rate for developing the child's cognitive skills and hence the expected value of its adult prospects,

$$Q_1^* = Q_1^*(\rho(X_1; E_2, n); E_2) = Q_1^*(\rho(X_1; n); E_2)\,. \tag{6}$$

In expression (6), wealthier parents for whom the left-hand-side of (2) is relatively high apply a lower discount rate and consequently provide a better environment for their child, i.e., $(\partial Q_1^* / \partial \rho)(\partial \rho / \partial X_1) > 0$ Note that expression (5) requires $(\partial V / \partial p_1) p_1^{'} + (\partial V / \partial c_2)(\partial c_2 / \partial Q_1^*)\alpha_1(n)n = 0$ at equilibrium quality Q_1^*, implying that c'$_2$ > 0 since, by construction, $p_1^{'} > 0$, $\partial V / \partial p_1 < 0$ and $\partial V / \partial c_2 > 0$. Thus, increases in environmental quality increase the value parents attach to the child's cognitive skills.

To see the impact of a change in environmental quality upon parents' own-consumption, s_1, totally differentiate the Marshallian demand $s_1 (p_1 (Q_1), c_2 (Q_1; E_2, X_1))$ to obtain

$$\frac{\partial s_1}{\partial Q_1} = \frac{\partial s_1}{\partial p_1} p_1^{'} + \frac{\partial s_1}{\partial c_2} c_2^{'}. \tag{7}$$

This expression says that the demand for own-consumption arises from the impact of environmental quality provision upon the parental benefits of improving the child's adult prospects as well as upon the unit value of own-consumption. By construction, $p_1^{'} > 0,$ and by implication, $c_2^{'} > 0.$ Also, $\partial s_1 / \partial p_1 < 0,$ since an increase in unit value of own-consumption is consistent with a reduction in quality demanded. Given that the budget constraint in expression (2) makes parents' own-consumption and the child's adult prospects substitutes such that $\partial s_1 / \partial c_2 < 0$, it then follows that $\partial s_1 / \partial Q_1 < 0.$

Now consider how a change in the child's autonomous inheritance will affect parents' demands for own-consumption and hence their investment in their child's environment. Substitute Q_1^* from (6) into the parents' equilibrium level of own-consumption and differentiate to obtain

$$\frac{ds_1^*}{dE_2} = \left[\left(\frac{\partial s_1^*}{\partial p_1}\right) p_1^{'} + \left(n \frac{\partial s_1^*}{\partial c_2}\right)\frac{\partial c_2}{\partial Q_1^*}\right]\left[\left(\frac{dQ_1^*}{d\rho}\right)\frac{\partial \rho}{\partial E_2} + \frac{\partial Q_1^*}{\partial E_2}\right]. \tag{8}$$

The first bracketed term on the right-hand-side of (7) is the effect of any change in environmental quality upon parents' willingness to invest in developing the child's cognitive skills. Q_1^* must change as E_2 changes. The second right-hand-side term reflects the indirect and direct effect of a change in E_2 upon the parents' demand for environmental quality. Not surprisingly, parents' own consumption and children's endowments are indirectly linked through ρ ; that is, constraints on financing investments in children introduce an accentuating positive effect of parents' wealth on children's adult prospects. [2]

III. **Data.** The foregoing model carries precise implications for the quality of the environment that parents choose for their children: they equate the marginal rate of return to investments in the child's skills to their marginal rate of substitution between own-consumption and the child's skills. Data on parents' equilibrium return rates for investing in these environments would thus enable us to distinguish the determinants among families of parental investments in their children and the distribution of skills among these children. We have no observed data on parents' equilibrium return rates for their children. However, in Agee and Crocker (1996), we use data on screening for children's body burdens of lead to estimate the discount rates that parents attach to investments in avoiding risks of their child developing long-term cognitive deficits from low-level lead exposure. This section describes the lead screening data and the Agee and Crocker framework used to estimate parental discount rates from this data. Together with information in the same data set on the assessed intelligence (IQ) of parents and children, these estimated discount rates allow us to test the foregoing choice-based, intergenerational model of the contribution of environment to the cognitive skills (as measured by assessed IQ) of a child of a given endowment.

The lead screening data. Our data were originally gathered for Needleman, et al. (1979; 1990). They involve observations on 256 children each from separate families in two adjoining Boston, Massachusetts area communities in 1975-78, and again in 1985. Each household had an own child who attended the first or second grades between 1975 and 1978. Thus these children were very unlikely to be old enough to reflect meaningfully about the effect of their cognitive development choices upon their parents' altruism toward them. Information on each child's medical history and current health status, and the parents' time allocations, employment, and a variety of personal characteristics was gathered in the 1975-78 survey. The lead content of shed teeth was used to measure each child's body lead burden. All sample children had a birth weight above 2500 grams, were discharged from a medical

facility following birth at the same time as the mother, had not previously received medical treatment for lead-related health effects, did not have a history of noteworthy head injury, and were not retarded (i.e., IQ > 70).

While parents completed a Peabody Picture Vocabulary IQ Test (Dunn, 1959), their child was given the Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974). We presume that cognitive skills are measurable without systematic error in terms of assessed intelligence (IQ). After completion of these IQ examinations, a child psychiatrist informed the parents of their child's lead status, its expected consequences, and medically appropriate courses of action for the child. Over the next few years, parents then had to make a choice between doing nothing for the child or investing in changing its environment, i.e., its lead burden. In 1985, the original data set was supplemented by information about 1985 parental wage levels and the medical treatments, if any, which the child had undergone in the interim.

Parents' Discount Rate. Agee and Crocker (1996) used parents' implicit valuations of children's reduced body lead burdens to infer the subjective discount rate parents apply to their children. The inferences were based upon an ex ante model of endogenous risk in which parents' perceived risk of their of their child developing lead-induced neurological deficits varied with parental choices of medical treatments and reductions of the child's exposures to lead in the home environment. Perceived risk represented a continuous measure over a real interval of perceived probability or expected severity of neurological deficits. For a reduction in perceived risk associated with a reduction, $\ell - \overline{\ell}$, of the child's body lead burden, ℓ, the parents' indirect utility function, $V(\cdot)$, was defined in annualized terms as

$$\overline{V} = V\left(Y_1 - \delta CS, \ell - \overline{\ell}, q\right), \tag{9}$$

where Y_1, is annual income, q is real prices, and δCS is the annualized Hicksian compensating surplus. δCS is the maximum income in annualized terms that parents are willing to forego in order to reduce perceived risks to their child while maintaining their original utility level, $\overline{V}$. The parents' rate of discount, ρ, generates an annualizing term, δ, equal to $\rho/(1+\rho)$.[3] A small reduction in the child's lead burden was thus valued in terms of the parents' annualized marginal implicit price of risk, P_ℓ. P_ℓ was obtained by totally differentiating (9) with respect to ℓ and setting the result equal to zero:

$$P_\ell \equiv -\left(\frac{dCS}{d\ell}\right) = -\frac{(1/\delta)(\partial V/\partial \ell)}{(\partial V/\partial Y_1)}. \tag{10}$$

Agee and Crocker (1996) estimate expression (10) by deriving an observable expression for the endogenous implicit price variable, P_ℓ, and by specifying V(·) with an indirect addilog utility function (Parks, 1969). The empirical version of (10) used the function,

$$\frac{1}{\delta} = (\text{INCOME, DADPRSNT, MOMAGE, MOMEDUC,}$$
$$\text{DADEDUC, SEX, NUMCHLD}), \tag{11}$$

in log-linear form to explain differences in parental discount rates, where all right-hand-side variables were assumed determined prior to rather than contemporaneously with the parents' demands to reduce their children's body lead burdens. Annual parental income (INCOME), presence of the father in the household (DADPRSNT), the mother's age (MOMAGE), and educational attainments of parents (MOMEDUC, DADEDUC) combine to measure household differences in wealth. The child's gender (SEX) and number of siblings (NUMCHILD) measure sources of differences in parental altruism per child.

The adjusted R^2 for the estimate of (11) was 0.90, a coefficient which we presume to be large enough to allay the concerns of Bound et al. (1995) and Nelson and Startz (1990) about inconsistent estimates when the correlation between instruments and the endogenous explanatory variable is low. More parental income, maternal education, and presence of the father reduced the discount rate that parents applied to investments in their children's cognitive skills (see also Parsons and Goldin, 1989), while more paternal education increased this rate. Consistent with expression (1), no gender preference appeared. The parental discount rate increased with the number of the child's siblings.

Table 1 supplies descriptive statistics of sample parents' discount rate $\hat{\rho}$ calculated from the fitted values for expression (10). The mean implicit discount rate for the entire sample is 4.7 percent, with a 2.2 percent standard error. The table shows that sample parents with annual incomes below the 1979 U.S. median of $16,841 applied discount rates of approximately 7.2 percent on average, while those above the median applied rates of 3.2 percent.[4]

Children in families without a high school diploma were discounted at about 7 percent, while families with both parents having had at least some college were discounted at about 2.6 percent, which is fairly close to the Vicusi and Moore (1989) estimate of the long-term AAA bond rate of 3.2 percent.

IV. **Parents' Environmental Investments and Children's IQs.** In Section II the distribution across families of wealth and children's endowments determines the distribution of equilibrium parental investments for their children's environments. Substituting the Q_1^* in expression (6) into the cognitive skill production function in expression (3) yields

$$z_2^* = z_2^*(Q_1^*(\rho; E_2); E_2) = \varphi_2(\rho; E_2) \tag{12}$$

A linear approximation to this relation is

$$z_2 = a + b\rho + cE_2 + \eta_2, \tag{13}$$

where η_2 measures unsystematic components of the determinants of the child's cognitive skills. Our interest focuses on the marginal contribution to the child's cognitive skills of the systematic parent-child connections expressed in ρ, the discount rate that parents applied to their investments in reducing the child's body burden of lead. Given that parents apply a weakly positive discount rate and that increased child endowments raise the marginal productivity of parents' time and money expenditures on these environmental investments we expect our estimate of the *b* parameter to be negative.

The unobservability of E_2 complicates the straightforward estimation of (13). If E_2 is correlated with ρ, a failure to include some measure of E_2 would bias any estimate of the coefficient of ρ. We therefore postulate an incidental equation to describe the relation between the unobserved E_2 and an observable variable, the average of the assessed IQs of the child's parents (PARENTIQ). To derive this equation, we lag expression *(12)* by one generation and substitute from (4) to obtain (Behrman and Taubman, 1985):

$$\text{PARENTIQ} = A + BE_2 + \mu \tag{14}$$

where $A = a - (c\lambda / \theta), B = c / \theta,\ and\ \mu = b\rho_0 - (cv_2 / \theta) + \eta_1$ (0 denotes grandparents). This expression recognizes that a child does not inherit an IQ from its parents. Instead the child inherits a set of cultural and genetic attributes, as well as grandparent-to-parent nurturance. The expression of that inheritance, called the *phenotype* (the observable cognitive skills of a child), results from the interaction of the inheritance with current environmental influences. Expression (13) is therefore to be interpreted as the child's inheritance measured in terms of parental phenotype. Substitution of expression (14) into (13) yields

$$z_2 = \overline{a} + \psi\ (PARENTIQ) + b\rho + \overline{\eta}_2\ , \tag{15}$$

where $\overline{a} = a(1-\theta) + c\lambda$, and $\overline{\eta}_2 = cv_2 - \theta(b\rho_0 + \eta_1) + +\eta_2$. However, since PARENTIQ and $+\overline{\eta}_2$ in expression (15) are correlated, the ordinary least squares (OLS) estimator of *b* and ψ will be biased and inconsistent. Specifically, if E_2 and ρ are negatively correlated, measurement error introduced by way of (14) will impart a downward asymptotic bias to *b* (Garber and Klepper, 1980). In effect, ρ will pick up some of the positive effects of E_2 which, because of measurement error, are not attributed to the PARENTIQ surrogate. As is well known, this same error will cause the estimated coefficient for PARENTIQ to be biased toward zero. Consequently, we interpret our estimates of *b* and ψ in Tables *2* and 3 as lower bounds on the true influences of the parental discount rate for body lead burden reducing investments and heritability of family endowments upon the development of a young child's cognitive skills.

Table 2 reports OLS estimates of expression (13) using assessed Full-scale and Verbal IQ scores as measures of children's cognitive skills. Both sets of estimates include as predetermined covariates the child's birth weight (BIRTHWT), length of hospital stay after birth (HOSPINF), order in which English was learned (ORDENGL), and number of head injuries (NUMHDINJ) to control for exogenous, strictly post-natal factors that do not influence p but which representative biomedical thinking (e.g., Needleman et al., 1990) believes are associated with differences in children's assessed IQ's. Also predetermined are the indirect influences in (11) which we postulate operate on IQ

recursively through their effects upon the estimated discount rate, $\hat{\rho}$, that parents apply to investments in reducing their child's body lead burden. That is, as our analytical framework commands, we treat the parental discount rate as a price that intervenes between the child's cognitive skills and factors that, with little or no theoretical justification, nearly all cognitive skill studies maintain directly influence these skills. A dichotomous measure of whether the sample child's mother works outside the home (MOMWRKS) is also treated as predetermined. Some recent research suggests that the young children of working mothers develop cognitive skill deficits, e.g., Hill and O'Neill (1994).

In the first and third columns of Table 2, coefficients for the PARENTIQ and $\hat{\rho}$ covariates have the expected signs and provide statistically significant explanations of the variations in children's assessed Full-scale and Verbal IQs. For the intervals to which our sample refers, the table suggests that if parents' discount rates increase from roughly 3 percent to 7 percent (the average difference in Table 1 between lower and higher income and educated parent subsamples) the IQs of sample children decrease by about 3 points.[5] This can be compared to the 9 point decrease in PARENTIQ that is associated, on average, with a 3 point decrease in each of the child's Full-scale and Verbal IQ's.

Table 1 reports that the discount rate Agee and Crocker **(**1996**)** estimated which parents applied to investments in reducing their child's body lead burden increased slightly with this burden. Because parents were ignorant about its presence prior to the physician consultation **(**Needleman et al., 1979), this burden was part of the child's autonomous inheritance. In accordance with expression (8), one possible interpretation of these higher estimated rates is that a greater burden reduced parents' perceived effectiveness of investments in their child's cognitive skills, thereby increasing parents' propensity to consume and accentuating the effect that the inherited burden poses upon the child's adult prospects. The choice that parents made about own-consumption affected their child's environment and, in turn, the expected consequences of the environment affected their choices. Here we test the empirical validity of this interpretation. The alternative hypotheses are that only the autonomous body lead burden or only parents' investments and not the effect of autonomous lead upon the mix of parents' own-consumption and investments in reducing the child's lead burden as reflected in the parents' discount rate influenced the child's cognitive skills.[6] We now test these three distinct hypotheses by linearly approximating (12) as

$$Z_2 = \bar{a} + \psi\left(PARENTIQ\right) + b\rho + e\rho * \ell + \eta_2, \tag{16}$$

where ρ captures the willingness of the parents to invest in reducing the child's lead burden, ℓ represents its inherited body lead burden, and $\rho * \ell$ is the interaction between the parent-supplied environment and the inheritance. The second and fourth columns of Table 2 report OLS estimates of expression (16), again using Full-scale and Verbal IQs as measures of children's cognitive skills.

The coefficients for the discount rate and the body lead burden covariates in the second and fourth columns of Table 2 have the expected signs and provide qualitatively significant explanations of variations in the child IQ measures. We cannot therefore reject either the autonomous economy (discount rate) or the autonomous nature (body lead burden) conjectures. Note, however, that the term, $\hat{\rho}$ * PBHIGH, which represents interaction between the parental investments and the child's body lead burden is also significant.

For the interaction term, $\hat{\rho}$ * PBHIGH, lead is set equal to one and defined as high *(N = 195)* if the child's lead burden is in excess of *6* ppm. Otherwise the term is set equal to zero and defined as low *(N = 61).* The derivative

$$\frac{\partial\, Full\ Scale\ IQ}{\partial \hat{\rho}} = \textit{-1.54 + 0.85 = -0.69} \tag{17}$$

for high lead children, and the derivative

$$\frac{\partial\, Full\ Scale\ IQ}{\partial \hat{\rho}} = \textit{-1.54} \tag{18}$$

for low lead children suggest that low lead children are more sensitive than the high lead children to changes in the caregiving environment as registered in parents' discount rates. That is, neither the body lead burden nor the caregiving environment conjectures alone are sufficient to explain variations in the Full-scale IQs of our sample children. Similar results apply to their verbal IQs.

Agee and Crocker *(1996)* showed that the discount rates applied to children in this sample varied inversely with the parents' socioeconomic status or human capital stock. Elevated body lead burdens in this sample and in the general American population (Schwartz and Levin, *1992)* are associated with lower socioeconomic status. Hence, given that these associations are durable, natural conditions and human capital formation are not separable. Lesser environmental quality raises the costs of human capital formation and lesser human capital reduces the demand for environmental quality. Thus human capital differences are not so much the cause of environmental quality differences but are rather the intervening bridge by which parents' discount rates and all the economic factors and social ties which induce them are transformed into choices for different environments. Environmental quality differences among families, just like genetic differences, may then persist across generations if the factors that influence parents' discount rates are unchanged.

V. Conclusions. This paper qualitatively demonstrates that the discount rates which a set of American parents applied to own-investments in their young children's adult prospects influenced those children's cognitive skills. Construction and interpretation of the estimates is guided by an intergenerational utility maximization framework in which the development of cognitive skills is dependent in part upon the specific environment in which the skills are nurtured. Lower discount rates imply that parents make greater investments in improving their children's environments. Improved environments enhance the children's cognitive skills. The policy implications are plain: a high parental discount rate applied to environmental investments in children today implies that these children when adults will apply a high discount rate tomorrow, in the absence of some compensating activity. Given that higher cognitive skills lead directly to better adult prospects and indirectly to better prospects through increased learning and additional years of schooling, reduced parental incentives to nurture the cognitive skills of their children perpetuate lesser cognitive skills through the generations. Environmental differences among families, just like genetic differences, may persist across generations.

Some caveats are in order. First, if the parents' net rate of return to non-child (financial) investments is positively related to their earnings and education, our findings would be confounded by a price effect masquerading as a wealth effect. Second, the durability of the effects we have identified cannot be determined from our data. We do not allow differences in families' fertility decisions to appropriate the cognitive skills effects of the differences in

their discount rate. Finally, the major limitation in our approach is that we cannot control for variations in cognitive skills that are not reflected in the IQ test scores we use as indicators of these skills.

Table 1. Acronyms, Definitions, Sample Means, and Standard Deviations

Variable	**Definition**	**Mean (Standard Deviation) (N = 256)**
Endogenous Variables		
FULSCLIQ	Age standard full-scale IQ measurement by the Wechsler Intelligence Scale for Children-Revised	104.88 (13.28)
VERBALIQ	Age standardized Verbal IQ measured by the Weschler Intelligence Scale for Children-Revised	101.87 (13.54)
Explanatory Variables		
$\hat{\rho}$	Parent's Implicit discount rate in percent for their child's cognitive development.	4.70 (2.2)
	(i) By household income:	
	Below 1979 U.S. Median (N = 256)	7.2 (2.8)
	Above 1979 U.S. Median (N = 256)	3.2 (.05)
	(ii) By education:	
	Both parents without H.S. Diploma (N = 49)	7.0 (.07)
	Both parents with some college or more (N = 21)	2.6 (0.7)
	(iii) By number of children:	
	One or two (N = 97)	4.3 (1.9)
	Four or more (N = 41)	5.0 (2.5)
	(iv) By body lead burden:	
	Low (N = 61)	4.3 (2.2)
	Moderate (N = 136)	4.7 (2.4)

	High (N = 59)	4.9 (1.9)
PBLEVEL	Dentine Lead level in arithmetic mean ppm over 3 shed teeth.	15.055 (11.99)
$\hat{\rho} *$ PBHIGH	Body lead burden in excess of a mean of 6 ppm taken over 3 shed teeth (1-yes, 0-no).	3.63 (2.83)
BIRTHWT	Subject child's birth weight in ounces.	116.84 (19.14)
DADEDUC	Father's education in grades completed as of 1978.	11.92 (2.57)
DADPRSNT	Father lives with the mother and child(ren); 1-yes, 0-no.	0.72 (0.48)
HOSPINF	Number of days subject child was in hospital after birth.	5.62 (7.17)
INCOME	Annual wage income of parents in 1980 dollars:1 = INCOME < \$7,000, 2 = \$7,000 $\leq$ INCOME < \$8,500…, 14 = INCOME > \$25,000.	8.73 (2.30)
MOMAGE	Mother's age in years in 1978.	30.24 (4.76)
MOMEDUC	Mother's education in grades completed as of 1978.	11.61 (2.17)
MOMWRKS	Mother works; 1-yes, 0-no.	0.81 (0.40)
NUMCHLD	Number of children in family in 1978.	2.94 (1.13)
NUMHDINJ	Subject child's number of lifetime head injuries.	0.07 (0.35)
ORDENGL	Order in which subject child learned the English language.	1.16 (0.59)
PARENTIQ	Mean parental IQ measured by the Peobody Picture Vocabulary Test.	110.83 (13.93)
SEX	Gender of the subject child; 1-male, 0-female.	0.50 (0.50)

Table 2. OLS Estimates of Child IQ Production Functions (N = 256)

Variable	Full-Scale IQ[a]		Verbal IQ[a]	
	(1)	(2)	(3)	(4)
Constant	69.48 (7.70)	70.23 (7.83)	73.09 (7.82)	73.82 (7.93)
$\hat{\rho}$	-0.77 (-2.04)	-1.54 (-2.87)	-0.76 (-1.95)	-1.51 (-2.73)
PBLEVEL	-0.17 (-2.04)	-0.23 (-3.25)	-0.18 (-2.74)	-0.24 (-3.31)
$\hat{\rho}$ * PBHIGH		0.85 (2.01)		0.84 (1.91)
BIRTHWT	0.05 (1.15)	0.05 (1.24)	0.06 (1.35)	0.06 (1.43)
HOSPINF	0.007 (0.60)	0.06 (0.53)	0.07 (0.61)	0.07 (0.55)
MOMWRKS	1.51 (0.79)	1.59 (0.83)	2.69 (1.35)	2.76 (1.39)
NUMHDINJ	-2.50 (-0.22)	-2.53 (-1.16)	-2.97 (-1.30)	-3.00 (-1.32)
ORDENGL	-0.51 (-0.22)	-1.07 (0.44)	-2.81 (-1.16)	-1.25 (0.49)
PARENTIQ	0.32 (5.55)	0.30 (5.29)	0.26 (4.45)	0.25 (4.20)
$\overline{R}^2$	0.18	0.19	0.15	0.16
X^2 (8)	58.01	62.15	49.37	53.09

APPENDIX

To show that parents invest in the child's environment until their marginal rate of return equals their substitution rate between own-consumption and the child's adult prospects, define the rate of return, 1+r, as

$$1+r\,(Q_1;E_2)=\partial c_2/\partial Q_1 \tag{A.1}$$

From expression (2) in the text

$$s_1=\frac{X_1+nc_2(Q_1;E_2)}{p_1(Q_1)} \tag{A.2}$$

which, when (A.2) is substituted into expression (1) of the text, means that the parents' primal optimization problem can be written as

$$\underset{Q_1}{\text{Max}}\ U(s_1(Q_1;E_2,X_1),\alpha,(n)nc_2(Q_1;E_2)) \tag{A.3}$$

The first-order-condition is

$$\frac{\partial U}{\partial s_1}\ \frac{\partial s_1}{\partial Q_1}+\alpha_1(n)n\ \frac{\partial U}{\partial c_2}\ \frac{\partial c_2}{\partial Q_1}=0. \tag{A.4}$$

Rearranging (A.4), we get

$$\frac{\partial s_1/\partial Q_1}{\partial c_2/\partial Q_1}=-\frac{(\alpha_1 n)(\partial U/\partial c_2)}{\partial U/\partial s_1}, \tag{A.5}$$

or

$$1+r=-\frac{(\partial U/\partial s_1)(\partial s_1/\partial Q_1)}{(\alpha_1 n)(\partial U/\partial c_2)}=-\frac{\partial U/\partial Q_1}{(\alpha_1 n)(\partial U/\partial c_2)}. \tag{A.6}$$

FOOTNOTES

1. Moreover, we assume that parents recognize that children must have enough consumption to survive when they become adults. Formally, we deal with parents' concerns about their child's adult survival level of consumption, X_2^0, by supposing that $\partial U / \partial X_2 \rightarrow \infty as\, X_2 \rightarrow X_2^0$, and that $U(X_2)$ is undefined for $X_2 < X_2^0$.

2. Although imperfect access to capital market financing raises the positive effect of parents' earnings on children's adult prospects, Becker and Tomes (1986) show that this introduces a possible negative relation between the earnings of grandparents and grandchildren, such as is found in Wahl (1986).

3. See, for example, Hausman (1979, p. 35), and Viscusi and Moore (1989). The parents' present value of compensating surplus for a reduction their child's lead burden is

$$\frac{CS}{\left\{(1+\rho)\left[1-(1+\rho)^{-\tau}\right]\right\}},$$

where, τ is the perceived duration in years of the child's lead-induced health effects. Assuming that parents perceive the effects to be lifelong for their child and thus roughly infinite in duration, the above expression reduces to *CS/(1 + p).* Thus in annualized terms, parental compensating surplus is

$$\delta CS = \left[\frac{\rho}{(1+\rho)}\right] CS.$$

4. Relative to U.S. adults over age 25 (U.S. Census, 1982), sample parents have a higher mean number of years of schooling completed; 81 percent of sample parents completed high school and 16 percent have graduated from college compared to 1980 U.S. percentages of 66.3 and 16.3 (72.7 and 20.0 in Massachusetts). Sample households' median income of $17,000 is slightly higher than the 1979 U.S. median of $16,841.

5. This lower bound estimate fits well with existing social psychology research on class differences in assessed IQs. For example, in a sample of 261 adopted children, Scarr and Weinberg (1983) found that children with natural parents in the lowest third of sample parent educational attainments who were adopted by parents in the highest third of educational attainments scored an average of 6.7 points higher on IQ tests than did comparable children who remained with their natural parents. Likewise, children with natural parents in the highest third of sample parent educational attainments who were adopted by parents in the lowest third of educational attainments scored an average of 3.5 points lower.

6. In the child lead exposure literature, these hypotheses can be found respectively in Needleman et al. (1990), Milar et al. (1980), and Werner et al. (1968).

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Willingness to Pay for Reductions in Infertility Risks: A Contingent Valuation Study

--Working Paper*--

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1. Introduction

Millions of couples in the U.S. experience infertility every year—approximately 7-8% of married couples according to recent statistics. As the number of married couples, particularly those in the older age groups, has increased over the last few decades and with an increasing tendency for these couples to delay childbearing, the number of infertile couples and the demand for infertility-related medical services has increased steadily. Rough estimates suggest that, in recent years, as much as $2 billion is being spent annually on its diagnosis and treatment. One result of this trend has also been that more attention is now being focused on preventive measures to reduce the incidence of infertility.

Infertility is associated with a wide range of medical conditions, some of which are related to behavioral and environmental factors. Although it is inevitably linked to the aging process for women, many conditions that contribute to male and female infertility are inherently preventable. For this reason, as part the Healthy People 2000 initiative, government and other public health organizations have made reducing the prevalence of infertility one their primary objectives. The potential for chemicals in the environment to be a source of reproductive problems has also led agencies such as the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) to push for more active testing and surveillance of suspected endocrine disrupting chemicals. In spite of these public and private efforts and the growing sense of urgency surrounding this issue, relatively few studies have examined the value to the public of reducing the occurrence of infertility.

The purpose of this paper is to report on "research-in-progress" concerning household choices to reduce the risks of infertility and what these choices imply about the value of reducing these risks. More specifically, we report on the development and results of a pilot-scale contingent valuation survey that we have conducted as a means of evaluating how this methodology performs for measuring willingness-to-pay for reductions in infertility risks. The primary long-term motivation for this project has been to support the needs of environmental policymakers in evaluating the benefits of their programs, particularly those that are expected to have human reproductive health implications. Nonetheless, the implications of this research should be equally applicable to other policy areas affecting reproductive health. A related objective of this project has been to explore alternative models of household behavior as they relate to the separate preferences of individuals within a household and to examine what these models imply for nonmarket valuation in general. We use household choices related to infertility as one context for evaluating these models, and in this paper we discuss some preliminary results of this

application. A more detailed discussion of this facet of our research can be found in Smith and Van Houtven (1998).

2. Infertility and Its Causes

According to the standard medical definition, infertility occurs when a couple who has not been using contraception does not become pregnant within at least one year. Based on data from National Survey of Family Growth (NSFG), which has become the primary source of information on infertility in the U.S., in 1995 approximately 7% of all married couples (and 12% of those who were not surgically sterile) were infertile. This is similar but slightly less than the NSFG's estimates of infertility rates in the 1980's, which were closer to 8%. These statistics contradict somewhat the notion of an infertility epidemic that has sometimes been portrayed in the popular media. Nonetheless, over the last twenty years, there have clearly been significant increases in both the range of infertility treatment options available to couples and in the demand for these services. Much of this trend can be attributed to the demands of an aging of the baby-boom cohort and a growing tendency to delay childbearing (Mosher and Bachrach, 1996). Approximately 1 million couples every year now seek professional medical assistance for infertility problems, and about half of these are eventually successful in conceiving a child.

Although the age of the female partner is clearly the single most important factor, infertility has been associated with a wide range of male and female medical conditions and to an even broader range of factors that contribute to each of these conditions. For women the most common conditions are problems with ovulation, blocked or scarred fallopian tubes, and endometriosis, whereas for men infertility is most often a result of abnormal or too few sperm. Overall, female and male conditions contribute equally to the prevalence of infertility in the U.S. population.

Many of these conditions are related to behavioral and environmental factors and are therefore inherently preventable (Gilbert and Weisberg, 1993). Sexually transmitted disease in particular is an important causal factor; however, diet, drug use, and stress have also been linked to infertility. In addition, a number of environmental toxicants have long been associated with adverse reproductive outcomes. In recent years, particular attention has been paid to a variety of compounds that are suspected to disrupt the functioning of human (and wildlife) endocrine systems, with one potential result of exposures being an increase in infertility rates.

3. Existing Estimates of the Value of Reducing Infertility

Despite the high demand for infertility services in the U.S. population and the potential for public policy to play a role in infertility prevention, relatively little attention has thus far been devoted to examining the value of reducing infertility. In 1987, the Office of Technology Assessment (OTA, 1988) estimated that expenditures for diagnosing and treating infertility totaled about $1 billion annually, and less formal estimates suggest that these expenditures have been closer to $2 billion in recent years (Colborn, Dumanoski, and Myers, 1996). However, it is likely that these estimates represent only a small fraction of the total welfare losses associated with the incidence of infertility. For example, they do not account for the less tangible losses incurred by those who decide not to pursue medical options, nor does it account for the time commitment and the pain, suffering, and often disappointment incurred by those who do.

Most, if not all, of the existing valuation studies related to infertility have focused on couples' or individuals' willingness to pay for infertility treatment, in particular for access to and use of advanced reproductive technologies such as in-vitro fertilization (IVF). Granberg et al. (1995) conducted a small scale survey of 40 couples seeking treatment at infertility clinics in Sweden and asked them to state the maximum they would be WTP for having a child. More than half indicated a WTP of more than $15,000; however, the small size and non-randomness of sample make it difficult to generalize these results. Also, it is unclear from the discussion to what extent "having a child" meant a certainty of success through IVF.

Ryan has conducted two similar studies in the UK and Australia. The first (Ryan, 1996) involved a contingent valuation survey of over 300 women using a fertility service in Sidney, Australia. Using a payment card approach, respondents were asked to state the maximum amount they would be WTP for a single IVF attempt. The mean WTP was about $3100 per attempt. Assuming an average success rate per attempt of 10%, this translates to roughly $31,000 for a "statistical" pregnancy. In the second study (Ryan, 1997) Ryan conducted a similar survey of over 450 women using a fertility service in Aberdeen, Scotland. In this case respondents were presented with a randomized bid and a dichotomous (take-it-or-leave-it) choice. The mean WTP per attempt was roughly $8000, implying about $80,000 per statistical pregnancy. Although the sample sizes were much larger than those used by Granberg et al., the ability to generalize these results is again hindered by the selection of the sample, which only involves individuals who are already seeking infertility services. Presumably, these are individuals with a relatively strong preference for increasing their chances of having a child.

To our knowledge, only one study has been conducted in the U.S. that measures individuals' values related to infertility. Neumann and Johannesson (1994) conducted a pilot CV study using a convenience sample of 231 individuals who were potential childbearers. Using a payment card approach, respondents were asked to state their WTP for IVF treatment. The question was framed in two ways—an *ex post* and an *ex ante* framework. The *ex post* framework was similar to the one used by Granberg et al. and Ryan, which asked respondents about their "out-of-pocket" WTP for IVF, *in the event* that they experienced infertility. In the *ex ante* framework, individuals were asked to assume that they did not know their fertility status and were then asked to state their WTP for insurance programs (one private and funded through premiums and another public and funded through taxes) that would cover IVF treatment. As has been argued by Gafni (1991) the *ex ante* insurance framework presents a more realistic "commodity" to respondents who generally do not pay the full cost of major medical interventions at the point of service. Based on responses to the *ex post* scenario and a 10 percent proposed success rate for IVF, average WTP for a statistical pregnancy was almost $180,000. This value is considerably higher than in the other studies, which is surprising given that the sample was not restricted to individuals who had already made active use of infertility services. However, it is possible that more hypothetical nature of the scenario had a positive effect on expressed WTP. Responses to the *ex ante* insurance question implied mean WTP for a statistical pregnancy that were an order of magnitude higher—$1.8 million1. Given the additional uncertainty that is inherent in the *ex ante* scenario, a higher is value compared to the *ex post* scenario is perfectly plausible (Schmalensee, 1972; Graham, 1981); however, there is little basis with which to judge the plausibility of the magnitude of this increase.

4. Study Objectives and Design

To study household choices related to infertility and to examine what these choices imply about the value of reducing infertility risks, we have developed and administered a pilot-level contingent valuation (CV) survey. Several features of this study distinguish it from previous research on infertility and, in some ways, from CV and non-market valuation research in general. Below, we highlight some of these differences as they relate to the objectives and design of the study.

1 It should be noted that the WTP estimates were considerably lower – roughly $60,000 and $300,00 per statistical child for the *ex post* and *ex ante* scenarios respectively – when the success rates of IVF were proposed to be 25 percent to 100 percent.

Ex-ante prevention perspective. Perhaps the most important distinction between this study and the infertility valuation studies described above is that the "commodity" offered to respondents through our CV scenario is not linked to specific type of treatment for infertility (such as IVF). Rather, the scenario provides respondents with a means of reducing their future risks of experiencing infertility. In other words, it explores WTP for the prevention of infertility rather than for its treatment. In either case, respondents are provided with an opportunity to make a purchase that will ultimately increase their chances of successfully conceiving a child (i.e., to express their WTP for a "statistical" pregnancy). Like Neumann and Johannesson's private insurance scenario, our study focuses on *ex ante* WTP. Respondents are offered the opportunity to make state-independent payments (i.e., they must pay whether or not they ultimately experience infertility) to improve their chances of conceiving a child in the future. The difference lies in the fact that, through the prevention scenario of our study, respondents also have the opportunity to improve their chances of avoiding the physical, psychological, and pecuniary costs of experiencing and, in many instances, treating infertility. For this reason, the approach taken in our study is more relevant for evaluating the benefits of initiatives that help to prevent conditions or behaviors contributing to infertility.

Private risk reduction commodity. Although this research is motivated by a desire to understand the benefits of public programs to reduce infertility risks, we have developed a contingent valuation scenario that is based on a private good – a hypothetical medication – that helps individuals to avoid infertility problems. This is done to focus specific attention on individuals' WTP to reduce risks only to themselves and only for avoiding infertility.2 In so doing, we are assuming the risk reductions through private and public means are perfect substitutes. One implication of using a private good scenario is that, to make it believable to respondents, they must have some discretion regarding when to use the good. Therefore, we must incorporate into the analysis a timing component to the decision.

Selection and recruitment of study sample. The characteristics of the sample drawn for this study also differ from those of previous studies. Given the resource constraints of the project and the resulting sample size restrictions, our objective was to recruit a demographically diverse set of respondents who were most likely to be in a position to seriously consider an opportunity to reduce their chances of experiencing infertility in the future. In other words, we wished to avoid targeting respondents for whom the decision would be less relevant or would be fundamentally

2 Our primary concern was that a CV scenario based on a public risk reduction program would be "contaminated" by perceived ancillary benefits (such as other health improvements) from such a program or by altruistic considerations on the part of the respondent.

different. For this reason, we wanted to recruit individuals of child-bearing age who were in a long-term relationship with a partner of the opposite sex but who were also uncertain as to whether they would be able to successfully conceive a child. This is clearly a rather small subset of the population; therefore, the results based on this sample cannot be generalized to the US population as a whole. Nonetheless, because of the characteristics of the sample, it may be safe to assume that the implied average WTP for infertility risk reductions in this group represents an upper bound for the broader population's average WTP.

Resource constraints also precluded the recruitment of fully random sample within the criteria described above. Therefore, to recruit respondents for our pilot surveys, we used a mall intercept format. Although this provides what can be best described as a convenience sample, it still provides more of a randomized set of respondents than was used in the previous infertility studies described above3. The convenience nature of the sample again limits the ability to generalize the results of the survey, but we felt that it was appropriate for conducting pilot-scale surveys .

Household decision-making framework. Interviewing women who were in a relationship provided an opportunity to explore how her partner's characteristics and how the potentially joint nature of the decision might affect stated WTP. One important feature of a reduction in infertility risk is that, even within a private good setting, it has public good characteristics. That is, it confers benefits that are non-rival for the two individuals in a couple, provided that they both wish to have children. For this reason, it is important to consider the collective nature of the decision regarding whether to purchase a reduction in risk. The more traditional model of household decisionmaking (e.g., Becker, 1974), sometimes referred to as the "unitary" model, treats the household as if it has a common set of preferences. Households are assumed to maximize a single aggregate utility function subject to a single budget constraint. One implication of a simple unitary model is that households are assumed to pool their income. In other words, purchase decisions are not affected by *which* individual generates the income, only by the *total* income.

More recently, economists (e.g. Chiappori, 1988) have begun to challenge this perspective using "collective" approaches that disaggregate the household utility function and allow individuals' distinct preferences to play a role in household decision processes. Under the collective model, household expenditure patterns can depend on who brings in more of the income and how

3 For a summary of the literature evaluating the properties and implications of mall-intercept surveys, see Boyle et al. (1996).

preferences differ across individuals within the household. In part due to resource constraints of this study, we have only interviewed female partners. Nevertheless, we have collected information from this individual about the characteristics, preferences, and incomes of each partner. We use this to explore whether there is evidence of intrahousehold differences in preferences regarding childbearing and whether the distribution of earned income within the household has an effect on the CV purchase decision.

Computer-based survey instrument. The survey itself was conducted as a self-administered computer interview. The self-administered aspect of the survey was important because of the potentially sensitive nature of some of the questions. Using a computer-based instrument also offered several potential advantages. It allowed the some of the questions in the latter part of the survey to be conditioned on earlier responses (without forcing the respondent to follow complicate skip patterns), it helped to minimize item non-response, and it automatically tabulated responses. It may also have served to increase respondents' interest and involvement in the survey.

5. Background on Survey Development

The survey used in the analysis described below evolved through several stages of development and pretesting.

Clinical interviews. To understand the issues considered and information available to couples facing infertility risk we participated in five clinical interviews with patients at one of Duke Medical Center's Infertility Clinics. These interviews involved an information exchange between the patient (in three cases, couples) and the physician directing the clinic. The primary objectives of these meetings between the patient and the physician were to discuss sexual history, any past medical issues that might be related to infertility, any initial test results, and the treatment options.4 While the set of people in the interviews were a selective sample of all couples who might experience infertility, they nonetheless identified a few generic issues relevant to any effort to elicit household preferences for reducing infertility risks. First, there was wide diversity in these couples' understanding of the clinical definition of infertility and the factors contributing to it. Second, some of the couples (or individual female patients) did identify concerns about individual and joint inconvenience associated with treatments. Finally, when both members of the couple were present for the interviews, both individuals seemed

4 Patients were at different initial stages in determining whether to proceed with infertility treatment.

actively engaged in the decision process even though the treatments (after initial diagnostic evaluations) focused primarily on the female members of each couple.

Focus groups. To evaluate the knowledge of infertility patterns and to investigate the extent of co-ordination in household decisions, a somewhat more random sample of couples was selected for two focus groups.5 Each meeting asked each participant to consider set of questions, and then to discuss their answers openly with the group. Four sets of issues were posed: (a) preferences about starting a family from each individual's perspective and their perceptions of their spouse's desire for children; (b) a series of questions intended to investigate how their households made allocation decisions; (c) knowledge of the factors associated with infertility; and (d) two closed ended contingent valuation questions about programs to reduce infertility risk.

The two meetings were organized somewhat differently for addressing the first two issues. The first focus group had both members of each couple seated beside each other and present for the full meeting. The second meeting (with a different group of couples) split each couple for the first half of the session, asked each member the same questions, evaluated discrepancies in these separately answered queries (during a short break), and then asked couples to discuss how they would resolve differences in their responses. Neither format offered substantive insight into how couples resolved decisions where their preferences seemed quite different. The responses to questions posed at the first focus group would have lead observers to conclude that there was a high degree of agreement in each couple, consistent with the "assortative mating" view of the "marriage market" (Becker [1981]]). While the second was also broadly consistent with this conclusion, there was also more evidence of differences in preferences and in strategies for making expenditure decisions in different households. Most couples did respond in ways that seemed to be consistent with the "income pooling" assumption of the unitary model of household decisionmaking.

Two additional findings emerged from these meetings that influenced the structure of our contingent valuation question. First, there was general agreement in the first group that public programs to reduce naturally occurring infertility risks would not be supported. Participants indicated that infertility was not a public concern. Even though infertility risks could be high for some groups, they indicated that private decisions for treatment were preferred to any public involvement in reducing the risk of infertility. Second, most couples had fairly strong interest in

5 The groups involved married couples who did not have children but were considering having children. They were recruited by a marketing research firm in Raleigh, NC from the Research Triangle area. They were conducted using the firm's focus group facility and video taped for a subsequent content analysis. Our summary is based on that evaluation. The first meeting on February 19, 1997 held six couples. The second on April 17, 1997 had five.

having children. However, the timing of childbearing was also an important consideration in any privately available program or medication that would reduce natural rise in infertility with the female partner's age.

Programming and pretesting of survey instrument. Based on the information from the initial interviews and focus groups, we developed a computer assisted survey. It was designed to be used in a mall intercept survey, where each respondent would answer an interrelated set of questions in private on a PC. The text of the questionnaire was programmed using Visual Basic. This allows the formulation of the stated choice question to be adapted in response to the information provided by each individual. Two sets of pretests were conducted. One involved cognitive interviews with each of nine individuals (four females and five males) after they took the interview. A number of changes in the wording of questions, graphs, size of fonts, and colors used in the screens were made after the first pretest. A second informal pretest was also conducted with RTI employees to evaluate revisions to the questionnaire.

First pilot survey. A preliminary pilot survey was conducted in late 1997 at regional malls in three cities: Charlotte, NC; Seattle, Washington; and Jacksonville, Florida. Following the sample selection criteria described above, we recruited both men and women who met the following specific criteria:

- Currently in a long term relationship with a partner of the opposite sex
- *Female* partner in relationship between 20 and 35 years old
- No children from current relationship.

We completed interviews for 110 men and 73 women. For the purposes of this paper, we do not provide a detailed summary of the data or analysis from this initial pilot6. However, the structure and results of the first pilot are, in many ways, very similar to our second pilot survey, which we do describe in detail below. Also, we do note three fundamental areas of change that were made between the first and second pilots.

First, based on the focus groups and pretests, in both pilots we decided to convey the mechanism by which future infertility risks are reduced by describing a medication that would delay the naturally occurring increase in infertility risks that typically occurs as a woman ages (this is described in more detail below). For this reason, it was a private good that would benefit both

6 For an anlaysis of the first pilot survey data please see Smith and Van Houtven (1998) which can be acquired upon request from the authors.

individuals in a couple, but, to ensure credibility, it had to be a medication that the female partner would take. The results of the first pilot offered support for the conclusion that women were able to report meaningful choices in evaluating options to delay natural increases in infertility. However, the survey instrument did not appear to be effective with male respondents, who were asked to report whether they would be in favor of their *partner* taking the medication (at a specified monthly cost). This probably should not be surprising, given that both the source of the increase in infertility and the mechanism used to convey the delay focused on women. Consequently, we did not include male respondents in our second pilot.

Second, because of the private nature of the risk reduction commodity it was difficult not to allow the respondent some discretion regarding, not only *whether* they would take the medication, but also regarding *when* they would begin to take it. In the first pilot, respondents were presented with a dichotomous choice (yes or no) regarding whether to start taking the medication this year. To more directly address the timing dimension of the choice, in the second pilot respondents were given three fundamental choices – start the medication this year, start the medication in the future, or never start taking the medication. More details of the choice scenario in the second pilot are also described below.

Third, the results of the first pilot offered some evidence that would contradict the "income pooling" hypothesis of the unitary model of household decisionmaking. That is, the individual respondent's income appeared to be significantly more positively correlated than the remainder of total household income with the expressed willingness to purchase the medication. To more carefully test this hypothesis, the second pilot survey included more detailed questions regarding both the respondent's and her partner's earnings.

5. Description of the Second Pilot Survey

The second pilot survey was administered during the summer month of 1998 using mall intercept recruiting at four separate locations in the U.S.—Tampa, FL; Las Vegas, NV; Tulsa, OK; and Freeport, NJ. As shown in Table 1, a total of 188 respondents completed the survey. The mean age of respondents was between 25 and 26 years old, and their partners were on average two to three years older. Average household income was highest in the Freehold sample (almost $70,000) and lowest in the Tulsa sample (about $47,000).

The first section of the survey asked respondents about their (and their partner's) age, their relationship status, and the presence of children in the household to confirm that they met the desired criteria. It also inquired about their and their partners' desire and preferred timing for starting a family. Desire for children was measured using a five-point Likert scale varying from no desire to a "very strong" desire to have children in the future. Over 74 percent of respondents indicated a "strong" or "very strong" desire, and slightly less (71 percent) thought that their partner had a "strong" or "very strong" desire. 73 percent of respondents gave the same response for themselves and their partner. To explore their desired timing for childbearing, respondents were asked how many years into the future they and their partner would ideally wish to start a family. The average desired time until their first child was 2.9 and 2.8 years respectively for respondents and their partners. 72 percent of respondents gave the same response for themselves and their partner. These results are similar to the findings of the focus groups and the first pilot survey, which found a very strong correlation between partners regarding the strength of desire and desired timing of children, consistent with the "assortative mating" view of the "marriage market." With such a strong similarity of preferences between partners, it becomes less likely that one will find observable patterns to distinguish the collective and the unitary models of household decisionmaking.

The second section of the survey provided respondents with fundamental information about infertility and inquired about their perceptions. The meaning of the term "infertility" was described to respondents, and they were then asked to indicate (on a 1 to 7 scale from "not at all likely" to "very likely") their perceived likelihood of experiencing infertility in the next year if they were to try to have a child with their partner. Almost 63 percent of respondents gave values of 1 or 2, indicating that the perceived likelihood of present infertility was relatively low. To explore the determinants of these perceptions, these responses were analyzed using an ordered probit model. The only respondent characteristic that was found to be significant (at a 0.05 level) was the respondent's age, which, as expected, was found to have a positive effect on the perceived risk of infertility7.

Respondents were then shown a series of informational screens describing the prevalence and primary risk factors associated with infertility. They were then asked to revise, if desired, their previous assessment of their perceived infertility risk. About 43% of respondents did revise their stated risk perceptions. Of those who did, more than twice as many increased rather than

7 The results of this regression are not reported in any more detail in this paper, but they are available upon request from the authors.

decreased their stated value; the average perceived rating increased from a score of 2.5 to one of 2.8.

Thereafter, respondents were provided additional information about the treatment of infertility (i.e., types, costs and success rates of treatment). This was followed by a graphical depiction of how average infertility rates increase with the age of the female partner. This is shown in Figure 1. To meet the objectives of the study it was important to carefully distinguish between *ex ante* reductions in future infertility risks and *ex post* treatment of infertility. This was confirmed through focus group discussions and one-on-one interviews that were used to pretest the survey instrument. Because infertility rates are so strongly and positively correlated with the age of a female partner, one way to portray a reduction in future infertility risk is by describing a reduction in the *rate of growth* of infertility risk through time (as opposed to an absolute reduction from the current baseline risk). For this reason we provided the information in Figure 1 to establish a baseline risk scenario.

The third section of the survey described the contingent valuation scenario. Respondents were asked to consider a potential decision; whether to purchase and begin to take a medication (on a weekly basis) that would help to prevent conditions that contribute to infertility and would, in effect, delay the increase in infertility risk for up to five years. Respondents were asked to assume that the medication was completely safe and would not cause adverse side effects. To illustrate the impact of the medication, they were once again shown the graph from Figure 1; however, this time a second trend line was superimposed on the graph to describe how the increase in infertility rates would be lower with the medication if they were to continue taking it indefinitely. Examples are shown in Figures 2a and 2b.

Because the impact of the medication depends on when one starts to take it, the computer-based design offered important advantages. First, it allowed each respondent to initially be shown a "with medication" scenario that corresponded exactly with her age (assuming she started taking the medication "within the next year"). Second, through a simple follow-up query (which could be repeated as often as desired), each respondent could examine the effect of selecting a different age to start the medication. This allowed the respondent to view new graphs, each one depicting a "with medication" scenario that corresponded to a different starting age. Seventy-one (almost 38 percent) respondents took advantage of this option.

The respondent was then asked to assume that the medication would cost a certain amount each month, but that it would not be covered by insurance. Seven monthly payment amounts ($10,

$16, $32, $48, $63, $125, and $300) were randomly assigned to respondents.8 The respondent was then asked to choose between (1) starting to take the medication within the next year, (2) starting to take the medication sometime after next year, or (3) never starting to take the medication. The distribution of responses by bid amount are shown in Table 2. Roughly 20 percent of respondents indicated that they would begin taking the medication within the year and 25 percent indicated they would do so sometime thereafter.

Each of the 46 respondents who stated that they would begin taking the medication at a later date were asked *when* they would ideally begin to take the medication. The median response was to wait two years before starting the medication. Only 7 respondents indicated they would wait four or more years.

In addition to reminding respondents to consider their budget constraint, they were also asked to consider what their partner's role would be in the decision and to account for this in stating their choice. The purpose of this was to replicate as closely as possible what the household's purchase decision would be if indeed it would be a collective decision. As a follow-up to this, they were asked to describe what their partner's role would be in their choice by selecting from one of the following:

- We would make the decision together
- We would discuss the decision, but it is mine to make
- We would not need to discuss it, but I would consider my partner's wishes
- The decision is entirely up to me—my partner would not be involved

Sixty percent indicated they would make the decision together and 30 percent said they would discuss the decision, but it was hers to make. Only 9 percent of respondents indicated that their choice would be different if it were entirely up to them. This indicates that, for the most part, they did view the decision as a collective one involving both individuals in the couple and also that partners' preferences were expected to be consistent with one another.

The remainder of the survey was devoted to collecting socio-demographic information from respondents. Summary statistics for many of these variables have already been provided in Table 1. In addition to information on total household income, particular attention was focused on gathering wage earnings information for both the respondent and her partner. The sum of

8The bid amounts were selected based on focus group discussions and one-on-one pretests of the instrument.

annual wages for 1997 was on average $55,600 (std dev = $44,902). The ratio of the respondent's wage earnings to her partner's varied from 0 to 1 with a mean value of 0.4 (std dev = 0.23).

6. Analysis and Results

To estimate the average WTP that is implied by the discrete choice responses, we use a two-stage probit estimation which is based on a simple conceptual framework.

Conceptual framework for estimating WTP. We assume that a couple's maximum WTP for the risk reduction implied by the medication can be represented by a variation function (McConnell, 1990; Cameron and James, 1987) which includes a deterministic component and a random component:

$$WTP_i = s(\mathbf{X}_i) + e_i$$

The deterministic component s(.) is the mean variation function (the expected WTP) and is assumed to be a function of a vector of exogenous variables, $\mathbf{X}_i$ such as income and other individual or household characteristics. The random component, e_i, is assumed to be normally distributed with a mean of zero and a variance of σ^2.

Respondents are assumed to compare the offered price of the medication to their maximum WTP such that responding NO NEVER implies that price is greater than WTP and responding YES NOW implies that the price is less than WTP. For those who respond YES LATER, the monetary commitment is incurred beginning t years into the future (the number of years that these respondents indicated they would ideally wait before beginning to take the medication), so presumably its cost is discounted to the present (at an annual rate r). This response implies that the *discounted* price is less than WTP.

The probability of responding yes or no can therefore be expressed as

$$\text{Prob(NO)} = \text{Prob}(A_i \geq s_i(\ ) + e_i)$$

$$\text{Prob (YES NOW or YES LATER)} = \text{Prob}\ (A_i < s_i(\ ) + e_i)$$

where $A_i = PRICE_i$ if response is YES NOW or NO NEVER

$= PRICE_i * (1 + r)^{-t}$ if response is YES LATER

Specifying the model in this way implies that there is an endogenous component to A_i ; that is, it depends in part on the yes/no response. To address this endogeneity we estimated a two stage probit model9.

Estimation results. The first stage regression, which is summarized in Table 4, uses ordinary least squares to predict A. To identify the model we need to assume a rate of discount, r. Results are shown for both a 3 percent and 5 percent rate. The explanatory variables include PRICE and a series of socio-demographic variables. As expected, the coefficient for PRICE is positive and very strongly significant. Although PRICE clearly explains a vast majority of the variation in A, two other variables are also significant (at a 0.10 level) are SOMECOLL and WORK. The negative effect of SOMECOLL suggests that those who were more educated would wait longer before starting the medication, thus lowering the present value of payment. WORK has the opposite effect, indicating that those who work more hours during a typical week would wait less. Neither of these variables are significant explanatory variables in a single equation probit model of the YES/NO response10; therefore, they are used as instruments and not included in the second stage probit regression. The R^2 value for both OLS regressions is greater than 0.99.

To test for the endogeneity of PRICE in a single equation probit model of the WTP responses, we included the predicted error from the OLS equation in the probit estimation. Using a t-test on the coefficient of the predicted error, we were unable to reject the null hypothesis of exogeneity.

The results of the first stage OLS regression were therefore used to predict values of A and to replace PRICE in the probit equation. The results of the second stage probit are shown in Table 5 for an assumed discount rate of 3 percent and in Table 6 for an assumed rate of 5 percent11. In support of the internal validity of the instrument, the predicted price variable (A) for the

9 Alternatives to the two-stage probit method are full-information maximum likelihood (FIML) are generalized method of moments (GMM) methods. All three yield consistent estimators; however, the two-stage model is computationally easier and tends to perform well, particularly when the first stage equation has a high R^2 value (Bollen, Guilkey, and Mroz; 1995).

10 A Wald test to test whether SOMECOLL and WORK are jointly equal to zero in a single equation probit (using PRICE as one of the explanatory variables) could not be rejected at a 0.05 level.

11 We have not corrected the standard errors to account for the two-stage approach; however, evidence suggests that such corrections make little practical difference for this type of approach (Bollen, Guilkey, and Mroz; 1995).

medication has a significantly negative effect on the purchase decision and household income HHINC has significantly positive effect. The coefficient on WAGEPART, however, is not significant, indicating that the distribution of income within the household did not affect the decision. That is, the likelihood of purchasing the medication did not increase (or decrease) significantly if the respondent earned relatively more of the household's income. Although it is not included in the specifications reported in Tables 5 and 6, interacting WAGEPART with a measure of the respondent's desire for children (relative to her partner's desire) did not alter this result. This suggested that, even if the respondent had a much stronger preference for children, earning more income relative to her partner did not increase the likelihood of purchasing the medication.

The coefficient for INFPROB is positive and significant -- those who felt they were more likely to experience infertility were more likely to purchase the medication at some point in the future. TIMEINR is also significant, indicating that the longer the respondent had been in the current relationship, the less likely she is to purchase the medication. Because individuals were only surveyed if they did not have children from their current relationship, this result may reflect the fact that those who had been in a childless relationship longer were less likely to want children. Somewhat surprisingly, the effect of CHLDTIM is also negative, indicating that the longer the respondent wanted to wait before having children, the more likely she was to say she would never purchase the medication. Given that the longer a couple waits, the more likely it is that they would experience infertility, it would seem that the medication would be more attractive to those wanting to wait. One explanation for this unexpected result may the that those wanting to wait longer for children also tended to have less of a strong desire for having children; therefore, larger values for CHLDTIM may also reflect a greater ambivalence towards childbearing.

The results summarized in Tables 5 and 6 can be used to estimate mean WTP for the medication and for the reduction in infertility risks that it entails. Because the first specification in the two tables contains a number of explanatory variables that were not significant, a second specification was estimated by dropping eight variables in each case. A likelihood ratio test of the null hypothesis that the coefficients for these variables are jointly zero could not be rejected at a 0.05 level. According to this second specification, the expected value of the variation function (mean WTP) can be expressed as:

$$E(s) = \mathbf{X}\beta$$

$$= \beta 0 + \beta 1*HHINC + \beta 2*WAGEPART + \beta 3*CHLDTIM + \beta 4*TIMEINR + \beta 5*INFPROB + \beta 6*MINORITY$$

Under the assumptions of the probit model,

$$\text{Prob (YES)} = \Phi[A*(1/\sigma) - \mathbf{X}(\boldsymbol{\beta}/\sigma)] = \Phi(A\alpha - \mathbf{X}\boldsymbol{\gamma}).$$

Therefore, using the estimated coefficients, $\hat{\alpha}$ and $\hat{\boldsymbol{\gamma}}$, from the probit model, mean WTP can be approximated by $\mathbf{X}\hat{\boldsymbol{\gamma}}/\hat{\alpha}$. Using sample mean values for the variables in **X**, the estimated mean annual WTP for the medication is $324 ($317) assuming a 3 percent (5 percent) rate of discount.

Based on these results it is possible to develop preliminary estimates of WTP for reductions in infertility risks; however, this requires additional assumptions. The described effect of the medication is to delay the increase in infertility risks for up to five years, as long as one continues to take medication on a regular basis during this period. Therefore, the effect of the medication depends importantly on the age at which one starts to take it and on the number of years it is taken. For a typical couple (as described, for example, in Figures 2a and 2b), after five years of continually using the medication, their probability of experiencing infertility should be between 3 and 9 percent lower than it otherwise would be. After only 2 years the reductions vary between 1 and 4 percent, depending on the female partner's age. Total payments for the medication also depend importantly on how long it is taken for.

Assuming that the medication is purchased and taken for five years and that the discount rate is 3 percent (5 percent), an annual WTP of $324 ($317) for the medication translates to a total discounted WTP value of $1484 ($1371) for infertility risk reductions varying between 3 and 9 percent. This translates to a range of $165 to $494 ($152 to $457) per 1 percent reduction in infertility risk. If the medication is assumed to be taken for just two years, the annual WTP estimates translate to a range of $69 to $207 ($65 to $196) per 1 percent reduction in infertility risk. Finally, assuming that a percentage point reduction in infertility risk is equivalent to a one percent increase in conceiving a child, these values can be further translated into estimates of the value of a "statistical pregnancy." For the five-year scenario, the annual WTP estimates imply a range of values between $16,500 to $49,400 ($15,200 to $45,700) per statistical pregnancy. For the two-year scenario the values imply a range of $6900 to $20,700 ($6500 to $19,600) per statistical pregnancy.

It must be stressed that these values are very preliminary and are based on a relatively small and restricted sample. Furthermore, the implied values for infertility risk reductions are very sensitive to the underlying assumptions regarding the appropriate discount rate and the timing of the medication. However, compared to estimates of WTP for IVF, the implied values per statistical pregnancy are relatively low. Although the *ex ante* risk reduction scenario presented in this survey is most directly comparable to the insurance-based scenario used by Neumann and Johannesson (1994) the implied values are as much as 2 orders of magnitude lower.

7. Conclusions

Infertility issues have been attracting increased nationwide attention, and there is growing recognition that many of the conditions that contribute to infertility may be associated with behavioral and environmental factors that are inherently preventable. As more private and public resources are devoted to combating these factors, it becomes increasingly important to understand household choices related to the risks of infertility and what these choices imply about the value of reducing these risks. We have addressed this through a series of interviews, focus groups, and pilot scale surveys that have elicited individual's and couple's perceptions and preferences regarding future childbearing and the possibility that they may experience infertility problems.

Most of the evidence we have collected supports an assortative mating conclusion regarding childbearing preferences and decisions. That is, perhaps not surprisingly, individuals within couples have similar preferences regarding how strongly and when they wish to have children. and regarding infertility risks. We also found little evidence to contradict the income pooling hypothesis for the infertility decision we presented to respondents. Although household income was a found to be a significant and positive influence on WTP, there was little evidence that one partner's income had a stronger influence than another's. Taken together, these findings suggests that a unitary model of household decisions may be appropriate for analyzing infertility related decisions. However, it is important to stress that, with the exception of our small focus group sample, our evidence is based largely on *individual* reports regarding their own views and how they perceive their partner's views. It should also be noted that we did find some amount of disagreement between partners on these matters, which means that the collective model should by no means be rejected outright. Under ideal circumstances, information would be collected from both partners in a household in order to evaluate which factors influence whether a collective view of the household matters.

Analysis of responses to the CV scenario in our pilot surveys indicates that, with a female sample in particular, respondents provide theoretically consistent responses. This supports our findings from focus groups and pretests that respondents are able to understand the nature of the commodity being offered and to provide meaningful responses to the proposed scenario. These responses can also be used to derive preliminary estimates of mean WTP for the privately purchased medication and, hence, for infertility risk reductions in general. It is important, however, to interpret these results with caution. First, they are based on a relatively small convenience sample that is restricted to include individuals who are relatively likely to be in a position to seriously consider an opportunity to reduce their chances of experiencing infertility in the future. This is appropriate for the purposes of a pilot-scale study to evaluate the CV methodology as a way of eliciting preferences for avoiding infertility; however, it does limit our ability to generalize the results. Second, extrapolating the estimated annual WTP for the proposed private good to a more general WTP for reductions in infertility risks requires a number of assumptions regarding appropriate discount rates, timing of the medication, and the respondent's understanding or perception of how the medication would reduce the likelihood of infertility. With these caveats in mind, we estimate values for a "statistical pregnancy" that are considerably lower those estimated by the most directly comparable study (Neumann and Johannesson, 1994). Although the CV method shows promise as a means of estimating infertility values, more research will be needed to narrow the range of uncertainty regarding WTP for reductions in infertility risks.

Figure 1. Representation of Typical Baseline Infertility Risks

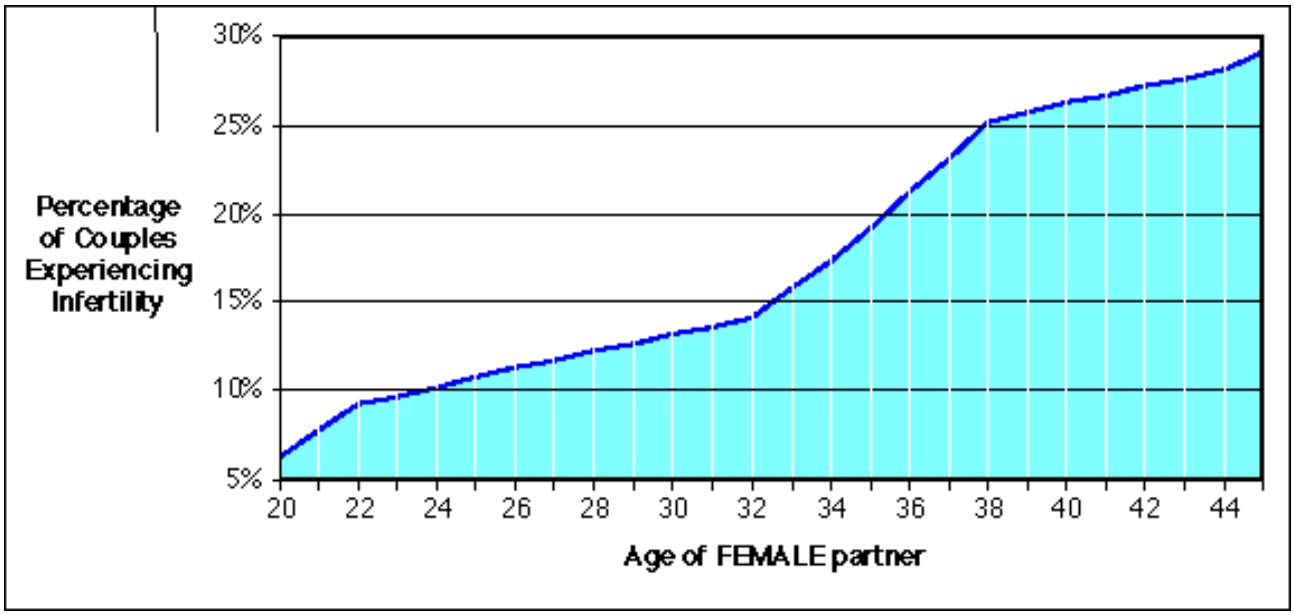

Figure 2a. Representation of Medication's Effect on Infertility Risks (starting at 25 years of age)

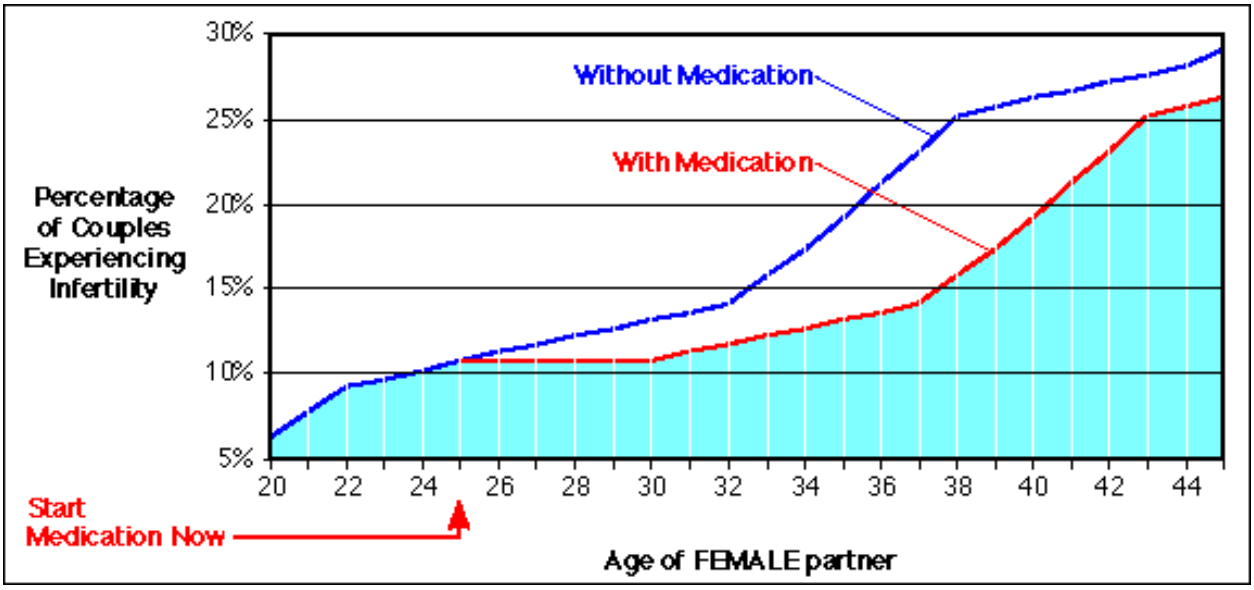

Figure 2b. Representation of Medication's Effect on Infertility Risks (starting at 30 years of age)

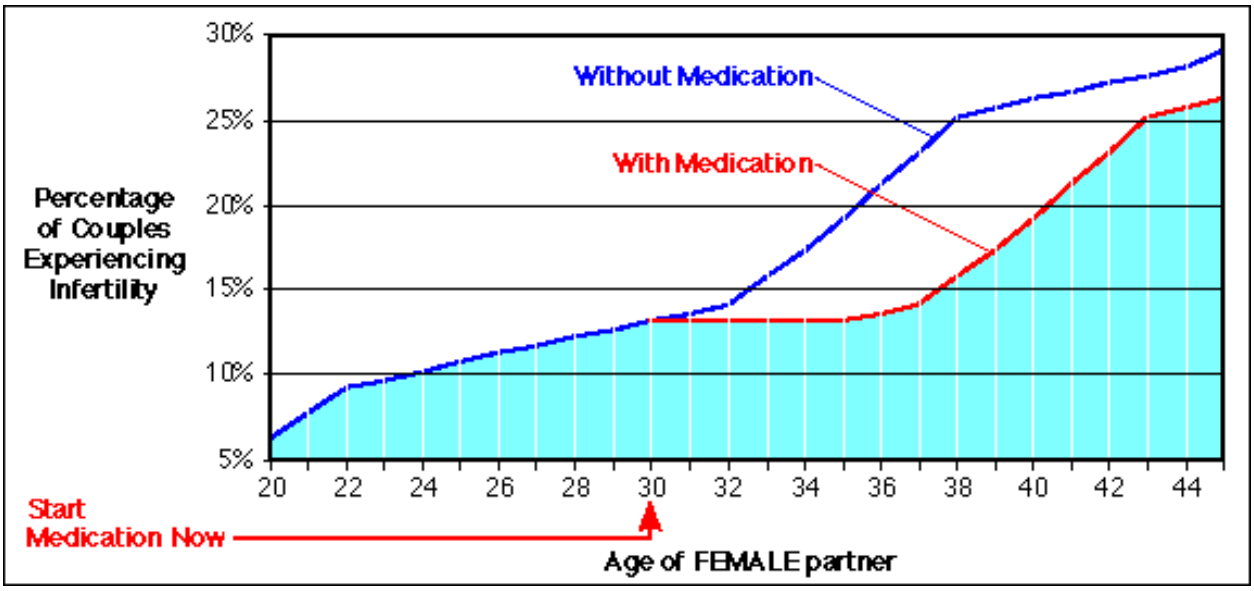

Table 1. Descriptive Statistics for Four Subsamples

Mall Location	Tampa, FL	Tulsa, OK	Las Vegas, NV	Freehold, NJ
Number of Observations	72	50	38	28
Continuous Variables	**Mean (Std Dev)**	**Mean (Std Dev)**	**Mean (Std Dev)**	**Mean (Std Dev)**
Age of respondent	25.53 (5.11)	25.88 (4.54)	26.87 (4.75)	24.64 (3.93)
Age of respondent's partner	27.94 (6.96)	28.64 (5.75)	29.47 (7.09)	26.61 (6.77)
Household income	$58,854 ($48,236)	$47,347 ($34,834)	$54,079 ($38,487)	$69,259 ($42,261)
Dummy Variables	**Percent = 1**	**Percent = 1**	**Percent = 1**	**Percent = 1**
Married	29%	48%	50%	21%
Minority	13%	26%	8%	29%
Beyond highschool education	78%	78%	76%	93%
Employed fulltime	61%	64%	58%	79%
Have health insurance	71%	74%	84%	64%
Ever experienced infertility	11%	14%	24%	11%
Partner ever experienced infertility	3%	4%	0%	4%

Table 2. Description of Variables Used in Analysis

Variable	Description
PRICE	Annual price of hypothetical medication (1998$)
HHINC	Household income in 1997 (1997$)
HHWAGEYR	Sum of respondent and partner's wage earnings in 1997 (1997$)
WAGEPART	Fraction of HHWAGEYR contributed by respondent
WORK	Number of hours of work per week at primary job
FULLTIME	=1 if work fulltime
TIMEINR	Number of years in current relationship
MARRIED	=1 if married
AGE	Age of respondent
CHLDTIM	Preferred number of years until first child
INFPROB	Perceived likelihood of experiencing infertility with partner (1-7 scale)
AUNT	=1 if respondent has nieces and/or nephews
SIBLINGS	Number of siblings
INSURED	=1 if respondent has health insurance
BELIEF	Strength of religious beliefs (1-4 scale)
MINORITY	=1 if respondent is not Caucasian
SOMECOLL	=1 if respondent has more than highschool education but not a bachelor's degree
COLLGRAD	=1 if respondent has bachelor's degree or beyond
TAMPA	=1 if survey location was Tampa, FL
TULSA	=1 if survey location was Tulsa, OK
VEGAS	=1 if survey location was Las Vegas, NV

Table 3. Purchase Decision Responses with Respect to Offered Price

	Number of Respondents in Each Category			
PRICE ($/mth)	**YES NOW**	**YES LATER**	**NO**	**All Responses**
$10	8	6	13	27
$16	12	6	12	30
$32	7	9	15	31
$48	0	8	7	15
$62	6	7	14	27
$125	0	7	25	32
$300	4	3	19	26
Total	37	46	105	188

Table 4. First Stage OLS Regression

	Dependent Variable: A[a]			
	3% Discount Rate		**5% Discount Rate**	
Ind Variable	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
PRICE	0.9928	328.928	0.9884	206.619
HHINC	-3.760E-05	-0.426	-6.170E-05	-0.441
AGE	0.3417	0.422	0.5191	0.404
MARRIED	-5.6490	-0.756	-9.0781	-0.767
MINORITY	-5.5568	-0.603	-9.1625	-0.628
WORK	0.3831	1.838	0.6072	1.838
SOMECOLL	-20.1029	-2.204	-31.8730	-2.205
COLLGRAD	-13.7691	-1.343	-21.7784	-1.341
CONSTANT	-12.0410	-0.600	-18.1500	-0.570
R^2	0.998		0.996	
N	188		188	

[a]equals PRICE/(1+ discount rate)^t where t is the number of years the respondent would wait to start taking the medication (t=0 for respondents who would start this year or never start).

Table 5. Second Stage Probit Analysis of Purchase Decision (assuming a 3 percent discount rate)

	Dependent Variable: whether to start medication 1 = YES NOW or YES LATER 0 = NO NEVER			
Variable	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
A	-2.436E-04	-2.559	-2.446E-04	-2.632
HHINC	6.220E-06	2.394	5.150E-06	2.131
WAGEPART	0.2078	0.402	0.1656	0.392
FULLTIME	-0.0193	-0.075		
CHLDTIM	-0.1418	-2.449	-0.1433	-2.607
TIMEINR	-0.1046	-2.283	-0.0819	-1.924
AUNT	0.2148	0.991		
SIBLINGS	-0.0437	-0.734		
INFPROB	0.1519	2.462	0.1618	2.713
INSURED	0.1768	0.724		
BELIEF	-0.0499	-0.545		
MINORITY	0.5243	1.868	0.4698	1.800
TAMPA	0.0384	0.122		
TULSA	0.4932	1.485		
VEGAS	0.4742	1.295		
CONSTANT	-0.3812	-0.695	-0.1399	-0.374
Log-L	-108.2502		-112.1409	

Table 6. Second Stage Probit Analysis of Purchase Decision (assuming a 5 percent discount rate)

	Dependent Variable: whether to start medication 1 = YES NOW or YES LATER 0 = NO NEVER			
Variable	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
DISCOUNTED PRICE	-2.455E-04	-2.566	-2.464E-04	-2.639
HHINC	6.220E-06	2.392	5.140E-06	2.13
WAGEPART	0.2087	0.404	0.168	0.396
FULLTIME	-0.0183	-0.071		
CHLDTIM	-0.1418	-2.449	-0.143	-2.608
TIMEINR	-0.1046	-2.284	-0.082	-1.925
AUNT	0.2147	0.99		
SIBLINGS	-0.0438	-0.735		
INFPROB	0.1521	2.464	0.162	2.715
INSURED	0.1767	0.723		
BELIEF	-0.0500	-0.545		
MINORITY	0.5236	1.865	0.469	1.796
TAMPA	0.0386	0.123		
TULSA	0.4932	1.485		
VEGAS	0.4747	1.296		
CONSTANT	-0.3825	-0.697	-0.141	-0.377
Log-L	-108.2305			-112.121

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WILLINGNESS TO PAY FOR CHILDREN'S HEALTH: A HOUSEHOLD PRODUCTION APPROACH

--Working Paper*--

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1. Introduction

Children are at greater risk than are adults from environmental hazards such as lead poisoning, pesticides, drinking water contaminants, and overexposure to solar radiation (USEPA 1996). Yet little evidence exists about how families respond to environmental threats to children's health, or about the economic benefits of risk reduction. More generally, significant gaps in knowledge remain about the value of reducing adult morbidity. In *The Benefits and Costs of the Clean Air Act, 1970-1990* (USEPA 1997), for example, many nonfatal health effects of air pollution are monetized using cost-of-illness procedures. The cost of illness includes medical expenses and foregone earnings but does not measure willingness to pay (WTP). One reason for the gaps in knowledge about the value of reduced morbidity is the difficulty of estimating the value with market data. Researchers often use primary data, but the cost of data collection usually results in small samples drawn from narrow geographic locations. Response rates often are low, and replication is relatively rare, raising questions about extrapolation to national benefit estimates.

This paper examines the use of a household production approach together with readily available, nationally representative data sets to estimate the value of reduced morbidity in children. Although joint production and unmeasured input prices hinder estimation of WTP in the household production model, and use of large secondary data sources limits the number of specific health conditions that can be valued, this approach nonetheless represents a cost-effective way to investigate several important questions related to children's health. Depending on the data set used, the approach supports investigation of how parents' choices and family characteristics affect children's health and household WTP for children's health. Also, the approach allows examination of rates of tradeoff between the health of different family members.

The next section of the paper presents a model of family resource allocation in which parents maximize family utility in part by making decisions concerning their own health and the health of their children. Section 3 examines prospects for implementing the household production model with several national data sets. Section 4 dicusses empirical estimation of the model, using preliminary data from the Panel Study in Income Dynamics Child Development Supplement, released in February 1999. Conclusions follow in Section 5.

2. Model

This section presents a model to highlight several key issues in children's environmental health. Concern about environmental health threats to children has arisen in part because, relative to adults, children may have greater exposure or be more sensitive to some pollutants; generally are less able to protect themselves against adverse effects of exposure; and on average have more remaining years of life and thus greater chance to experience delayed effects. Children differ from adults in several other respects that bear on modeling of health. Children are almost always members of multi-person households. Adult caregivers, typically parents, make important economic and health decisions on behalf of children. Previous empirical economic research underlines how important parents' choices are in determining children's health, and how parents' choices are in turn influenced by the inherent "healthiness" of their children (Corman, Joyce and Grossman 1987, Grossman and Joyce 1990, Pitt and Rosenzweig 1990, Rosenzweig and Schultz 1983). In addition to investing in health, parents invest in other forms of human capital, such as schooling, in order to improve their children's future opportunities. Finally, although children's time has no readily observable market price, it has alternative uses.

The model sketched below represents an attempt to illustrate effects of many of these features in a simple way. In the typology of Behrman et al. (1995) it is a "unitary" model with passive children – meaning that children comply with parental decisions, which in turn are made to maximize a single utility function representing the preferences of parents. Children are treated as identical, because the data to be used contain information on only one child, precluding investigation of variation in the characteristics of different children. The model can be generalized to allow for differences among children, however. A three-period version of the model is presented in which parents spend the first two periods raising children. Two-period models are common in the economic analysis of children, but a three-period model makes it easier to separate parents' time preferences from their altruism toward their children.

Parents in the model spend their healthy time working, enjoying consumption/leisure, and investing in their own health and in the health of their children. Children spend their healthy time enjoying leisure or investing in human capital (by attending school, for example). Parents' labor earnings and any asset income is divided between consumption, health investments and other investments in children's human capital, and savings.

Health investments are treated following the general approach of Grossman (1972) and Cropper (1981). Each person's stock of health H_{it} depreciates at an individual and time-specific rate d_{it}, but depreciation is offset by gross investments I_{it}. Thus

$$H_{it} = (1-d_{it})H_{i,t-1} + I_{it}, \qquad t = 0,1,\ i = p,c.$$

In this equation, the subscript *i*=*p*(parent), *c*(children). At time *t*=0, the initial level of health capital is $\overline{H_i}$. Gross investment in turn depends on market goods, time inputs, and exogenous factors $I_{it} = I_{it}(y_{it}, E_{it})$, where y_{it} denotes a vector of inputs chosen by parents and E_{it} denotes a vector of exogenous factors influencing the effective rate of gross investment. A primary reason for investing in health is to increase the flow of healthy time, $h_{it} = \phi_{it} H_{it}$.

Parental utility is determined according to

$$U = U(Z_o, h_{po}, h_{co}, l_{co}; Z_1, h_{p1}, h_{c1}, l_{c1}; Q_2).$$

In the utility function, Z_t denotes parental consumption/leisure at time *t*, l_{ct} denotes children's leisure at time *t*, Q_2 denotes the final period's child "quality," and other symbols are previously defined. Child quality is an index of children's opportunities in life as influenced by parents' investments in children. In empirical applications quality often is measured by children's earnings or wealth, but conceptually it may be viewed as a broader measure of a child's future welfare. Children who are healthier and/or who have more schooling have greater opportunities when adults, and cash transfers or bequests from parents, if any, potentially also may boost child quality. Thus $Q_2 = Q(K_0, K_1, H_{c2}, B)$, where K_t denotes schooling or other human capital investments in period *t*, $H_{c2} = (1-d_{c2})H_{c1}$, and B represents a transfer of cash from parents to children (if any).

Resources available to maximize utility include parental earnings and any initial assets owned by parents. The "full wealth" constraint (see Grossman 1972 or Becker 1991 for details) is

$$R \equiv \sum_{t=0}^{1} (1+r)^{-t} w_t \Omega + A_0 =$$

$$C_p + nC_c + n(1+r)^{-1} B + \sum_{t=0}^{1} (1+r)^{-t} [Z_t q_{zt} + np_{kt} K_t + w_t(\Omega - h_{pt}) + nw_t(\Omega - h_{ct})].$$

In the budget constraint, r denotes the rate of interest at which parents can borrow or lend, and the sources of full wealth are w_t, the wage rate in period *t*, Ω, total time available within the period, and A_0, initial assets. Full wealth is spent partly on consumption Z_t, whose full, or time-inclusive price is $q_{zt} = p_{zt} + w_t t_{zt,}$ where p_{zt} denotes the money price, and t_{zt} denotes the time required to consume a unit of Z. Full wealth also is spent on human capital investments in each of *n* children, purchased at the unit price p_{kt}. Also, C_i denotes the minimum total cost of producing any path of health capital for the parent (*i=p*) or children (*i=c*). Finally, time spent ill detracts from full wealth by reducing time available for market and nonmarket activities, where $(\Omega - h_{pt})$ denotes the time parents spend ill and $n\ (\Omega - h_{ct})$ denotes the total time spent ill by n children. Thus, the parental time constraint assumes that parents must care for sick children, and that no two household members are sick at the same time. (The model is easily modified to allow parent health and child health to have differential effects on parental time loss.)

A final constraint on maximization of household utility concerns children's time. Children's healthy time is divided between leisure and human capital investment: $h_{ct} = l_{ct} + K_t$.

The Value of Health Capital

In the equilibrium of the constrained utility maximization problem, the marginal value of health capital equals its marginal cost or supply price. Thus the value of parental health is

$$[(\partial U / \partial h_{pt}) / \lambda + (1+r)^{-t} w_t]\phi_{pt} = \partial C_p / \partial H_{pt},$$

where λ denotes the marginal utility of full wealth. The term in brackets on the left-hand side of this equation gives the value of a marginal increase in the flow of healthy time, which consists of its value as a pure consumption good plus its value in generating income or additional nonmarket production. For parents, then, the value of health capital equals its effect on healthy time ϕ_{pt} times the value of healthy time; in equilibrium this equals the marginal cost of health capital.

A similar equation gives the value of children's health capital in the initial period, where

$[(\partial U / \partial h_{c0}) / \lambda + nw_0 + \tau_0 / \lambda]\phi_{c0} = n(\partial C_c / \partial H_{c0})$, and where τ_t denotes the marginal value of children's time in period t (which in equilibrium in turn equals

$\partial U / \partial l_{ct} = (\partial U / \partial Q)(\partial Q / \partial K_t) - \lambda(1+r)^{-t} np_{kt}$, or the value of the child's time input in producing future opportunities). The term in brackets measures the value to the family of a marginal increase in the healthy time of children. This value consists of the value of children's health as a pure consumption good, plus its value in reducing parents' time caring for sick children, plus the value of children's own time. Again, the value of health capital equals its effect on healthy time ϕ_{ct} times the value of healthy time; in equilibrium this must equal the marginal cost of health capital. The marginal cost or supply price in turn consists of foregone interest, plus depreciation less any capital gain (see Grossman 1972, equation (13) or Cropper 1981, equation (6)).

$$\partial C_i / \partial H_{i0} = (1+r)^{-1} \pi_{i0} [r + d_{i0} + \pi'_{i1}],$$

where π'_{i1} denotes the proportionate rate of change of π_{i0}, which in turn is the marginal cost of gross investment.

One difference between conditions for optimal investment in health of parents and children can be seen most clearly in the final period of child-rearing. In this period, the marginal cost of children's health capital is not equated to the value of its contribution to children's healthy time alone. Rather, the marginal cost is equated to the value of the contribution of health capital to healthy time, *plus* the value of its contribution to children's future opportunities in life:

$$[(\partial U / \partial h_{c1}) / \lambda + n(1+r)^{-1} w_1 + \tau_1 / \lambda]\phi_{c1} + (\partial Q / \partial H_{c1})(\partial U / \partial Q) / \lambda = n(\partial C_c / \partial H_{c1}).$$

Thus, parents account for the longer future which children have ahead of them, and the impact of health on the quality of that future, when making health investments in children.

Pollution and Willingness to Pay

Pollution can enter this model in several ways. To allow exposure to differ between parents and children, suppose that exposure, $X_{it} = X_{it}(\alpha_t)$, where α denotes ambient pollution. Exposure to some pollutants may cause only acute effects with no long-term health implications. In this case exposure could be viewed as reducing the flow of healthy time for a given stock of health: $\phi_{it} = \phi_{it}(X_{it})$, where $\phi'_{it}(X_{it}) < 0$. Alternatively, pollution may reduce the stock of health by reducing the rate of effective gross investment, $I_{it} = I_{it}(y_{it,} E_{it}, X_{it}(\alpha_t))$, or as in Cropper's model by increasing the rate of decay of health: $d_{it} = d_{it}(X_{it})$, where $d'_{it}(X_{it}) > 0$. Finally, a stock

of pollution may accumulate, reducing health capital in all subsequent periods. Two of these possibilities are illustrated in the present paper: acute effects, and depreciation effects.

Willingness to pay (WTP) for reduced exposure in the initial period, for the case of purely acute effects $\phi_{it} = \phi_{it}(X_{it})$, is

$$[(\partial U / \partial h_{p0}) / \lambda + w_0] H_{p0} \phi_{p0}' = -(\partial C_p / \partial H_{p0}) H_{p0} \phi_{p0}' / \phi_{p0}$$

for parents, or

$$[(\partial U / \partial h_{c0}) / \lambda + n w_0 + \tau_0 / \lambda] H_{c0} \phi_{c0}' = -n(\partial C_c / \partial H_{c0}) H_{c0} \phi_{c0}' / \phi_{c0}$$

for children, where $H_{it}\phi_{it}' = \partial h_{it} / \partial X_{it}$ denotes the effect of exposure on the flow of healthy time, and thus measures how sensitive acute health is to changes in exposure. Thus, WTP equals the marginal value of healthy time, weighted by the sensitivity of healthy time to exposure. As shown in these equations, if all else is equal greater sensitivity implies a higher willingness to pay. Taken by itself, a greater sensitivity among children than among adults would increase WTP for reducing children's exposure relative to WTP for reducing adult's exposure. Likewise a lower ability to convert health capital into health time (ϕ_{it}) raises willingness to pay, as does a lower ability to offset the reduction in health time through greater investment in health capital ($\partial C_i / \partial H_{it}$).

If pollution affects the rate of decay of health, as in Cropper's (1981) model, then the impact of pollution in one period will continue to be felt in subsequent periods because of reductions in the level of health capital carried forward. At $t = 1$, for example, the WTP for a reduction in parental exposure is

$$[(\partial U / \partial h_{p1}) / \lambda + (1+r)^{-1} w_1] \phi_{p1} H_{p0} d_{p1}' = (\partial C_p / \partial H_{p1}) H_{p0} d_{p1}',$$

where $H_{p0}d_{p1}' = \partial H_{p1} / \partial X_{p1}$ denotes the impact of exposure on health capital. Thus, WTP for reduced exposure equals the value of health capital times the effect of exposure on health capital. For children, the corresponding expression is

$$\{[(\partial U / \partial h_{c1}) / \lambda + n(1+r)^{-1} w_1 + \tau_1 / \lambda] \phi_{c1} + (\partial Q / \partial H_{c1})(\partial U / \partial Q) / \lambda\} H_{c0} d_{c1}'$$
$$= n(\partial C_c / \partial H_{c1}) H_{c0} d_{c1}'.$$

Again, the value of reducing exposure equals the impact of exposure on health capital times the value of health capital. In the case of children, however, the value of health capital includes effects on their opportunities or quality extending beyond the years of parental investment.

For both types of effects of pollution on health considered, then, WTP expressions depend on the value of health capital for a given household member. In environmental policy analysis, moreover, effects of exposure on health generally are estimated by health scientists, and economists are asked to provide a value for the resulting change in health. Thus the more important part of the WTP expressions above for economic analysis is the marginal value of health capital for parents or children.

This model supports theoretical and empirical investigation of three broad issues of importance in the analysis of children's environmental health. First, the model focuses on how parents' choices, such as investments in children's health and labor supply affect health outcomes experienced by children. Second, the model can be used to show how family characteristics, including available resources, family size and household composition, affect health outcomes experienced and WTP. Third, the model highlights determinants of any differences in WTP for improved health of various household members.

The last of these issues is analyzed below because it is likely to be the issue of the most immediate policy relevance. The simplest approach to valuation of children's health is benefits transfer, by applying to children existing values previously estimated for adults. Although some environmental hazards such as lead pose a limited threat to adults, many hazards potentially cause similar illnesses in adults and children, such as acute health effects of air pollution exposure, or risk of skin cancer from overexposure to solar radiation. To the extent the value of health is equal for adults and children, there is little need for special economic studies directed at valuing children's health, and the prospects for benefits transfer are improved. More generally, however, differences may exist between health valuations for adult and children, and the WTP expressions presented above indicate the sources of any divergences.

Valuing Health Across Persons and Time

As discussed previously, the key economic element of this model's WTP expressions is the value of health capital. One component of a comparison between the value of health capital for parents and for children is the marginal utility of healthy time. Parental preferences for healthy time of a parent and a child can be summarized by indifference curves showing alternate combinations of healthy time of each individual that would hold parental

utility constant. Figure 1 shows the tradeoffs the parent is willing to make between his or her own healthy time and the healthy time of a child, within a period.

If the (absolute value of the) slope of the indifference curve is unity when the healthy time of the two persons is equal, then the parents' preferences could be described as neutral as between own health and child health. A steeper indifference curve, on the other hand, would indicate "selfish" preferences, or an intrinsic preference for parent over child health. Conversely a flatter indifference curve would indicate greater altruism toward children, or a preference for the child's healthy time over the parent's. Thus, the marginal rate of substitution between parent and child healthy time at the point of equal consumption of healthy time could be used to index the degree of parental selfishness or altruism in health preferences. In any of these cases, movements along an indifference curve which raise the healthy time of one household member while reducing it for another have the effect of boosting the relative marginal valuation of the healthy time of the person incurring the loss in health.

Preferences for current-period healthy time are only one determinant of the amount of health investment and the willingness to pay for health, however. For parental health, the other factors at work are the value of illness-induced losses in time available for market and nonmarket activities, and the marginal cost of health investment. For child health, the other factors at work are the value of time parents spend caring for sick children, the marginal cost of health investments, *and* the marginal value of health-related changes in the child's future opportunities. These health-related changes arise because better health increases the time the child has available for human capital investments (valued at $(\partial U/\partial Q)(\partial Q/\partial K_t)/\lambda$), and because a larger stock of health capital directly increases the child's future opportunities (valued at $(\partial Q/\partial H_{c1})(\partial U/\partial Q)/\lambda$).

Because of the value of children's health includes factors unique to children, even "selfish" parents, with an intrinsic preference for their own healthy time over their children's healthy time, might well prefer that their children enjoy more healthy time than the parents themselves enjoy. Parents with neutral preferences, as defined above, who would lose an equal amount of market and nonmarket time from their own or from a child's illness, would (given equal marginal costs for parental and child health investments), tend to prefer to increase their children's healthy time even at the expense of their own. This possibility is illustrated in Figure 2. The relative preference for child health would be stronger, the greater the value parents place on children's future opportunities

($\partial U / \partial Q$), the greater the productivity of children's time in schooling ($\partial Q / \partial K_t$), and the greater the effect of children's health capital on their future opportunities ($\partial Q / \partial H_{c2}$).

The model does not necessarily imply, however, that parents would value their children's health more highly than their own. If parents prefer consumption of their own healthy time over their children's healthy time, or lose more market or nonmarket time from their own than from a child's illness, of have a lower marginal cost for investing in their own health, then the value of parental health capital may exceed the value of children's health capital. Regardless of whose health capital is valued more highly by parents, the model highlights the determinants of differences in valuations.

A similar analysis can be performed to examine time-preferences for the health of parents or children. Specifically, the indifference curve diagram shown in Figure 1 can be drawn to show utility-constant tradeoffs between the health of a single individual in different periods. The slope of the resulting indifference curve would indicate the rate of time preference for healthy time.

The analysis also can be extended to investigate valuations of health across both periods and persons. In this case, the indifference mapping would be drawn to show utility-constant tradeoffs between, for example, a parent's healthy time now and a child's health time in the future. The slope of the indifference curve would reflect both time-preference and the extent of altruism for child health. Restrictions on the utility function, such as specifying lifetime utility as the sum of discounted within-period utilities, would allow time-preference to be disentangled from altruism.

Data

Ideal data to implement a health production function approach like the one sketched above would have several features. First, the data must include measures of health outcomes or risks experienced by at least one child. More complete data on health of other family members would allow estimation of tradeoffs, particularly between the health of a parent and a child. An economic approach is most easily applied if health outcomes, such as acute or chronic conditions experienced are measured, in addition to variables that measure behavioral responses to health outcomes, such as work loss or restricted activity.

A second requirement to implement the health production approach is measurement of behavioral choices that affect health. Use of medical care is a key input, and other inputs depending on the problem addressed. These would be as varied as time spent outdoors (exposure to ambient air pollution), smoking (especially maternal smoking), alcohol consumption (especially prenatal consumption by mothers), use of sunscreen lotion, actions taken to mitigate radon exposure, and use of water filters or purchase of bottled water. Many of these inputs are sources of joint production, in that they affect household utility in ways other than through their impact on health. Ideally the data would include inputs whose price can be measured and where joint benefits of using the input can be controlled.

A third type of data reflects exogenous factors affecting behavioral choices and health outcomes. These include economic factors like family income, wages, prices, access to medical care, insurance and sick leave coverage, as well as other factors like age, schooling, family size, health attitudes and knowledge, and environmental quality. In addition, a large, nationally representative sample with demographic diversity is helpful. If WTP for reduced pollution is to be estimated, then it must be possible to link households or individuals to measures of pollution or exposure, but this is not necessary to estimate WTP for reduced morbidity.

Few if any data sets have all of these desirable features. For adult morbidity valuation, most researchers have collected primary data. These data offer many advantages, including the ability to measure specific factors of interest, such as health outcomes and behaviors, attitudes, knowledge and beliefs, and exogenous factors. The location of respondents is known, making it possible to match them to measures of local environmental quality. Also, any valuation method can be employed, including stated preference methods.

Collecting survey data is expensive and time-consuming, however, which imposes several limits on the research. The number of studies that can be conducted, and the sample size of any given study are relatively small. Samples typically are drawn from one or two locations, and may have little demographic diversity. Response rates often are quite low. The cost also restricts the ability of other researchers to replicate results. Taken together, these factors limit the confidence that can be placed in extrapolations to national benefit estimates.

Using existing secondary data sets may offer the opportunity for cost-effective morbidity valuation, but these data also suffer from several disadvantages. Although some data sets measure specific acute or chronic conditions, others measure only behavioral responses to underlying conditions, such as work loss or activity restriction. Also, behavioral choices affecting health often are limited to major influences like use of medical care

and smoking, and do not include behaviors that may be important to specific environmental risks like time spent outdoors. Assessments of health knowledge, attitudes and beliefs often are limited, and perceived risks are almost never measured. Confidentiality restrictions severely limit the ability to match survey respondents to local pollution measures. Valuation is limited to cost of illness or health production methods.

Nonetheless these data offer several advantages. The data are readily available at low cost. Replication is straightforward. Usually large, nationally representative samples are drawn, with demographic diversity. The data are extensively validated, response rates typically are high, and some surveys are ongoing, allowing changes to be tracked over time. Table 1 summarizes advantages and disadvantages of using primary data and secondary data from national surveys.

This section of the paper reviews prospects for estimating a household production model to value children's health using four large, national data sets. The three data sets most useful for applying the approach to children beyond infancy are (1) the National Health Interview Survey, (2) the Panel Study in Income Dynamics, and (3) the Medical Expenditure Panel Survey. The fourth data set discussed pertains to pregnancy outcomes and infant health. Brief descriptions of these and dozens of other public health data sources can be found in a recent compendium (US Public Health Service 1993).

National Health Interview Survey

The National Health Interview Survey (NHIS) is an ongoing survey of the health of the US resident, civilian, non-institutionalized population, in continuous operation since 1957. The NHIS is a nationwide survey with oversampling of blacks. A representative sample is drawn each week, and weekly samples are combined to form an annual sample. The 1994 NHIS includes 45,705 households consisting of 116,179 persons. The response rate was 94.1 percent.

The survey is a personal interview with adult household members who also report data on children living in the home. A core survey is administered to all respondents, and supplemental surveys on current health topics are administered to representative subsamples.

The core survey is repeated each year and collects basic health and demographic data. Health data collected include the presence of acute and chronic conditions, and disability days, including restricted activity, work loss, school loss, and bed days. The use of medical services, and the acute or chronic conditions responsible for the medical services, are recorded. Also measured are long term limits on activity from chronic conditions, and

hospitalization experiences. Health data are collected for a two-week recall period, with an annual recall for more severe episodes of illness. Demographic data include age, sex, race and family income. Supplemental surveys in 1994 include access to care, and health insurance. The health insurance supplement includes premiums paid, as well as family annual medical spending.

The NHIS is useful for assessing the health status of the population or subgroups, epidemiological investigations, and the impact of some behavioral variables such as smoking and medical care on the health of family members. But it contains relatively little economic information. Family income is not measured by person or by source in the main survey, and has a high item non-response rate. Medical prices or time spent obtaining medical care is not measured, and the measure of annual household medical spending is not broken down by family member.

Medical Expenditure Panel Survey

The Medical Expenditure Panel Survey (MEPS) is the third in a series of national probability samples of health care use and expenditure. Its predecessors are the National Medical Care Expenditure Survey of 1977 and the National Medical Expenditure Survey of 1987. The MEPS substantially improves on the earlier intermittent surveys; it is a continuous survey of overlapping panels. Each year a nationally representative sample is drawn from respondents to the NHIS. Sampled households are interviewed six times to collect data over two calendar years. The first panel of 23,230 individuals living in 10,639 households was drawn from the 1995 NHIS, with data collection in 1996-1997. The overall response rate to the first wave of the MEPS was 77.7 percent (93.9 percent to the 1995 NHIS x 82.8 percent to the MEPS). Partial data collected for 1996 now are available.

The MEPS fills in the missing economic information from the NHIS: employment and earnings, and an hourly wage, are included. Health insurance data are collected, along with expenditures, and utilization. The survey includes four components. The Household Component is the subsample of the NHIS, with oversampling of blacks and Hispanics. The Medical Provider Component supplements and validates the utilization and expenditure information reported by respondents by collecting data from providers and pharmacies. The Insurance Component collects data from employers and unions and other establishments providing insurance to sample members, including data on insurance plans not chosen. Finally, the Nursing Home Component is a separate survey of nursing homes and residents.

The MEPS is likely to be the best source of data to implement the household production function, and a key source of cost of illness data as well. The data currently available are limited however. For example, data on health care use, health care expenditure, and household characteristics cannot yet be merged (until fall 1999).

Panel Study in Income Dynamics Child Development Supplement

In 1997 the Panel Study in Income Dynamics included a detailed supplement on children's well-being and development. The PSID is an ongoing panel started in 1968, with 6792 families in the core sample as of 1997. The data are widely used in economics. The Child Development Supplement was administered to 2394 PSID families, and data were collected on 3586 children 12 years of age and younger. The response rate was 88.2 percent. Data were collected on children's social and emotional well-being, their cognitive and behavioral development, and their health. Economic and demographic characteristics of families include income and wealth, the schooling, employment, hours and earnings of caregivers, and household size and composition. A cognitive assessment was administered to children, and surveys were administered to caregivers and to a teacher and school administrator.

Health status measures collected for children include a lifetime history of health, including birth weight, prematurity, immunization, and hospitalization experiences. Medical care expenditures and school loss days for the year preceding the survey were collected, along with data on health insurance coverage.

The PSID-CDS does not include as much specific detail on health status, presence of conditions, use of care, expenditures and insurance as does the MEPS or NHIS. But it does include the typical work loss and medical care variables, a great deal of economic information, and data on broader issues of children's development. Also, the data can be linked to family data in the larger PSID (although not yet to concurrent data from the 1997 PSID).

National Maternal and Infant Health Survey and Longitudinal Follow-up

Health production function models have had their most frequent successful application to children with respect to pregnancy outcomes – fetal death, gestational age, birth weight, and infant death (Corman, Joyce and Grossman 1987, Grossman and Joyce 1990, Rosenzweig and Schultz 1983) in part because the links between maternal behavior and infant health is clear. Micro data at the national level for studying infant health outcomes include the 1988 National Maternal and Infant Health Survey, and its 1991 Longitudinal Follow-up.

The 1988 data collection began with a sample of national records of live births, fetal deaths and infant deaths. Questionnaires were mailed to each mother named in the vital records. Over 18,000 mothers responded (54 percent of them in the live birth sample, 29 percent in the infant death sample, and 18 percent in the fetal death

sample). The survey data are linked to the vital records. Data were collected on use of prenatal care, maternal smoking and alcohol and drug use before and during pregnancy, a history of pregnancies and outcomes for the mother, family income, and schooling and employment of the mother and father. For the live birth sample, additional data were collected on health inputs (medical care, vaccines) and illnesses during the first six months of life.

The 1991 Longitudinal Follow-up re-interviewed women from the 1988 survey, including all women with live births and samples of women with fetal or infant deaths. Response rates ranged from 82 to 89 percent, with over 8000 women in the live birth follow-up sample, and 1000 in each of the fetal and infant death samples. The fetal death and infant death surveys collected data on maternal health and any pregnancies since 1988. The live birth survey collected data on childhood injury, acute and chronic illness, and health inputs including smoking, use of alcohol and drugs in the household, immunizations, and pediatric care. Family income, sources of income, and health insurance data also were collected.

The 1988 NMIHS and 1991 LFU provide a rich source of data for infant and early childhood health. Effects of low birth weight on early childhood health, and more generally links between pregnancy inputs and outcomes to early childhood, can be investigated using these data.

4. Empirical Analysis

Empirical estimation of a household production model for children's health has been undertaken using preliminary data from the PSID-CDS released last month. The data have not been validated for final release, however, and cannot yet be matched to concurrent data on PSID families, current estimates are preliminary at best and inaccurate at worst. Therefore empirical results are not presented in this version of the paper.

5. Conclusions

Although children are at greater risk than are adults from several environmental hazards, little is known about how families respond to these hazards, or about the economic benefits of reducing hazards. There remain significant gaps in knowledge about adult health valuation as well, but the gaps are wider for children.

This paper has examined use of the household production approach together with data from large, nationally representative data sets to address some issues of children's health valuation. Although availability of only preliminary data precludes presentation of empirical results, the approach taken will support investigation of a

number of key issues. These issues include: effects of family resources, size and composition on the value of children's health; effects of parental resource allocations on children's health; and estimation the relative value of children'sand parents health.

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Figure 1: Neutral Parental Preferences.
$(\partial U / \partial h_{ct}) / (\partial U / \partial h_{pt}) = -1$, when $h_{ct} = h_{pt}$.

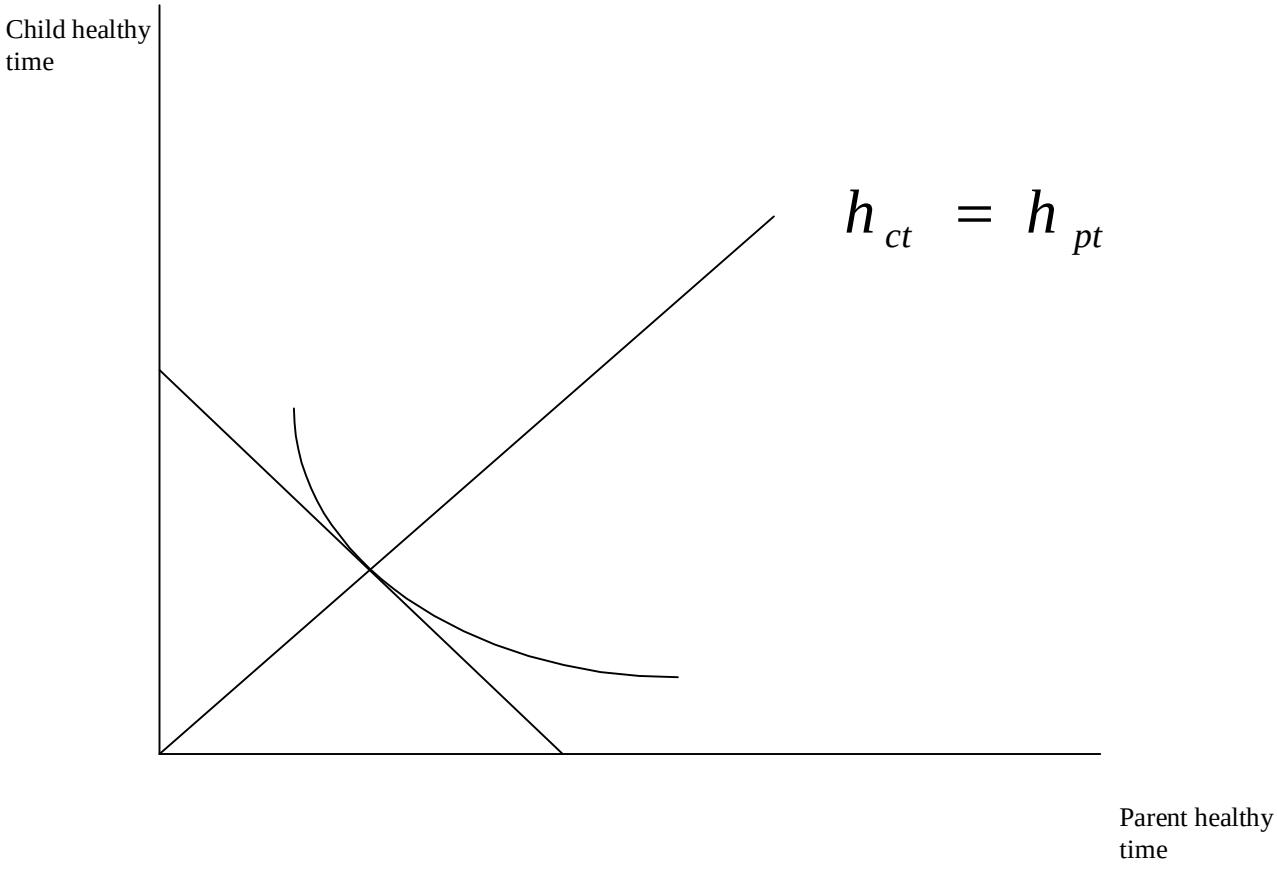

Figure 2: A Potential Health Investment Allocation, with Neutral Parental Preferences. The child consumes OC healthy days, which exceeds the parent's OP healthy days.

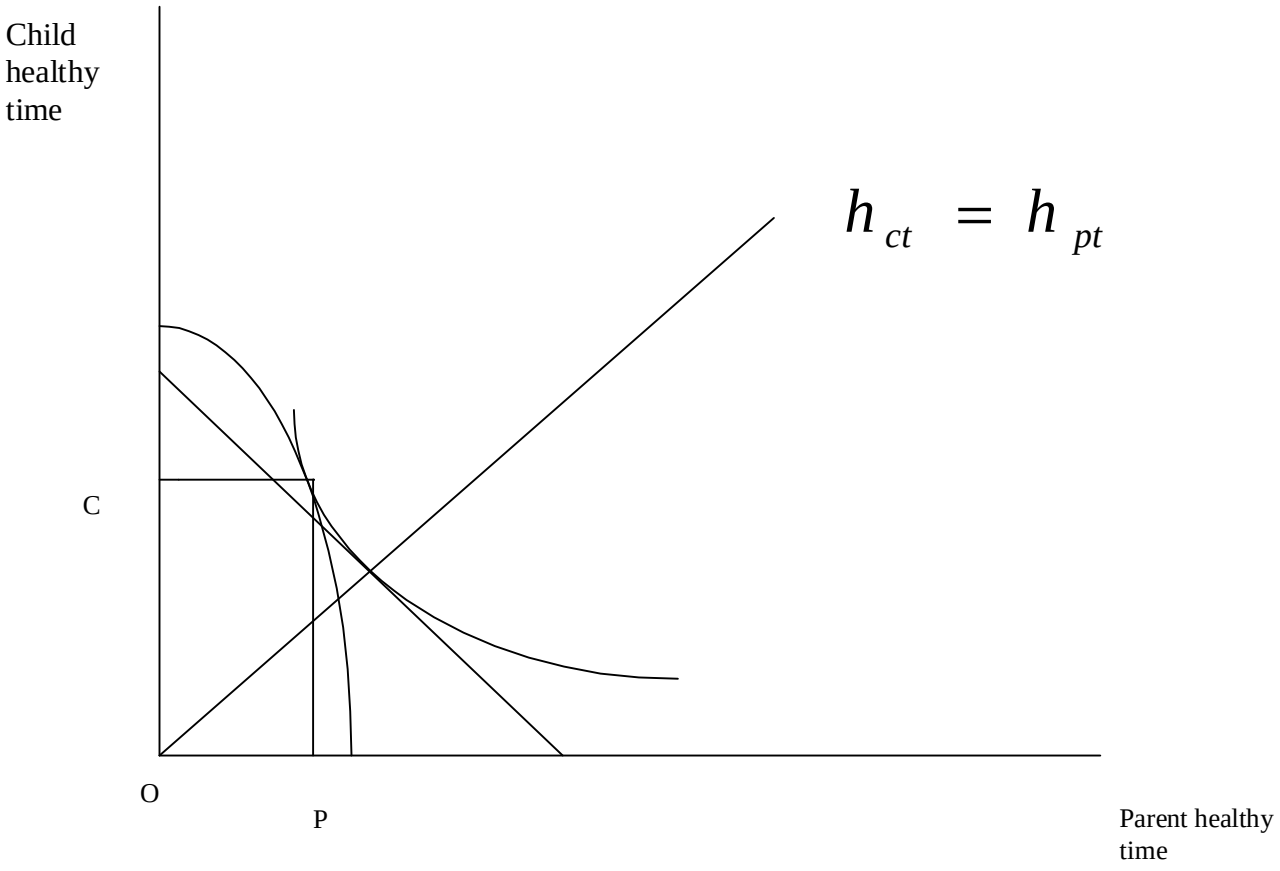

Table 1. Comparing Primary Data Collection and Use of National, Micro Data for Children's Health Valuation.

Attribute	**Primary Data Collection**	**Large National Data Sets**
Health Effects	Specific effects of interest	Broad measures of health or mixtures of health/behavior
Health-related behavior	Behaviors linked to specific effects of interest	Only most important health-related behaviors
Attitudes, information, beliefs	Can account for these	Little information on these
Location	Known	Confidential
Valuation Method	Any	Only COI or HPF
Cost	Expensive	Cheap
Sample Size	Small	Large
Geographic representation	Limited	National
Demographic diversity	Often limited	Diverse, minorities often over-sampled
Response rates	Typically low	High
Replication	Little opportunity	Available for replication
Repetition of survey	One-time	Sometimes ongoing

Discussion of Crocker and Agee Paper

by Jane Hall, California State University, Fullerton

Dr. Hall was unable to attend the conference.

Discussion of Van Houtven and Smith Paper

by John Horowitz, University of Maryland -- Summarization

Dr. Horowitz began his discussion by emphasizing the need to keep in mind the relevant policy question. That is, allowing people to abstain from voting or indicating that they would be willing to pay the stated amount but *later*, is a complicating issue because people are not afforded these options in real life. This is problematic because it is giving respondents an option that is not part of the underlying welfare model. EPA is considering implementing costly regulations now, and people will have to pay for it now. Although the authors of this paper dealt with this issue, their analysis was made more difficult by this issue.

Dr. Horowitz queried whether the bid responses were sensitive to the change in probability hypothesized in the survey, or whether they were sensitive to the description of the underlying problem contained in the survey. Dr. Horowitz noted that we usually have suspicions regarding the lack of sensitivity to the amount of change in probability, but there is not much that can be done to remedy that. Nevertheless, CV researchers should remain sensitive to the issue.

Dr. Horowitz's third point was a more general one regarding differences in baseline risks. The problem with fertility is that baseline risks change much more dramatically over time than mortality risks. A couple can be attempting to have children for a long time, and only after several unsuccessful attempts do they realize that they are in a higher risk group, in which case their willingness to pay can be expected to be much higher. The very large difference over time and cross-sectionally will have a very large effect on willingness to pay.

Dr. Horowitz also remarked that although Mr. Van Houtven's presentation did not reveal this, Mr. Van Houtven and Mr. Smith have spent a great deal of time thinking about the household decision-making process, and considering whether this is a collective decision-making process or a unitary decision, a matter that is at the crux of the work in this area.

Finally, Dr. Horowitz drew a parallel between the Van Houtven/Smith paper and the Crocker/Agee paper, in that they both deal with household production situations in which there is a public good substitution for a private good, which economic theory clearly predicts will result in some undersupply. This will make welfare calculations substantially more difficult.

Discussion of Dickie Paper

by Jason Shogren, University of Wyoming – Summarization

Dr. Shogren complemented Dr. Dickie on the groundwork that he had laid thus far, and commented that Dr. Dickie's model raises some interesting issues not yet addressed by the literature. Firstly, little is known about intra-household allocations, which differs a great deal from family to family, and inter-culturally. In some cases, the family attempts to balance out the opportunity sets for all the children, so that resources are allocated away from healthy children and towards needy children. Some cultures allocate resources to the first-born child. Knowing more about how these processes work is important for purposes of model specification. A related issue is how families mitigate against and adapt to problems. This is a separate question from the question of risk management.

A second point Dr. Shogren made was to suggest that state-dependent preferences may be important here, but not in the sense that it usually comes into play. It is possible that when one's children actually become sick, the marginal utility of money may change.

Thirdly, Dr. Shogren wondered what is known about the markets that currently exist, such as markets for health insurance and life insurance. Yet application of valuations obtained from these markets to valuation of children's health is not straightforward, because some parents wish to raise their children in a challenging environment, and limit their dependence upon inherited resources. This is a different kind of preference, which may also be important.

Fourthly, Dr. Shogren remarked that often economists attempt to decompose total values, while in the end, it is probably the total value that we are interested in. Thus, the effort to ascertain a special value for children may be misplaced, in that it is simply embedded in our own adult willingness to pay.

Finally, Dr. Shogren posed the question of what we know about the retrospective views of respondents? Does it indeed matter what children think about the opportunity set that they were given? Should their views matter in a retrospective sense? If the answer is yes, then perhaps children should indeed be entitled to value the opportunity sets that they are given prospectively.

Policy Discussion of Session IV

by Robin Jenkins, US EPA Office of Economy and Environment – Summarization

Dr.. Jenkins commented that all three of the papers asked relevant policy questions as far as EPA's Office of Policy and Office of Children's Health was concerned. With respect to the Agee and Crocker paper, the primary conclusion appeared to be that there may be a vicious cycle whereby children who grow up in a poor environment with many health risks grow up to become adults who tend to place a lower value on improving environmental conditions for their own children. The cycle is perpetuated by the passing down of a low discount rate. There are thus two possible policy options to break the cycle: (1) improving the environment for children, such as removing lead poisoning threats and decreasing second-hand smoke and even improving education, and (2) manipulate parents' discount rate, particularly by lowering the discount rates of parents who as children were exposed to high environmental risk. This may be particularly important in our culture, where the link between a child's adult development and the parent's utility is a weak one, at least more so than in developing countries. So, specific policy suggestions might be to provide parents with a tax rebate for enrolling their children in college, or perhaps as they progress through high school. Agee and Crocker themselves referred Dr. Jenkins to a paper that suggested reducing parents' opportunity costs of time in spending necessary time with their children, particularly caring for them when they are sick.

Another interesting implication of the paper is that parents' discount rate for themselves is not necessarily different from that applied to their children. In other words, those parents who undertake high risk behaviors themselves such as smoking of eating a high fat diet are more likely not to protect their children from environmental hazards such as lead poisoning. This suggests that the federal government may have a role to play to attempt to lower discount rates, perhaps by advertising campaigns discouraging smoking, encouraging radon mitigation, etc.

Thus, the larger question is whether or not society has a grand discount rate that we believe ought to apply to children, such that child-rearing which reflects a rate higher than such a grand discount rate might be considered neglectful or abusive. It is very difficult to think of the problem in this way, which is probably why we try to regulate in terms of the minimum quality environment. Government has recognized its limits in attempting to control childrens' environments, making sure that *schools* are smoke-free, lead-free and radon-free, implying that out of respect for individual rights, government is stopping short of imposing specific trade-offs upon everyone. In short, it is not surprising that when children grow up to be adults and have their own children, they mimic the trade-offs that their parents made. The larger policy solution is to attempt to remedy the growing income gap between rich and poor, because the discount rate gap will probably track the income gap.

Regarding the Van Houtven and Smith paper, Dr. Jenkins noted that the infertility risk issue was an issue of growing importance. Dr. Jenkins was surprised to hear that *true* infertility has not increased, in light of popular evidence that sperm counts are reported to be lower, and that there are more biological threats to fertility than previously. As a valuation issue, it seems that the value of a reduction in infertility risk is somewhere in between valuing a reduction of a risk in death and valuing ecosystem services, in terms of depth of study. But this is probably more difficult a task to value a reduction in risk of infertility than it is to value a human life. For example, the abortion debate suggests that we may not even be sure that a fetus is a human life. Nevertheless, it should not be surprising to find that the value of a statistical conception is worth less than the value of a statistical life. For example, there is probably some societal agreement that in cases where a choice must be made between an unborn baby and the mother, the choice is typically to save the life of the mother.

Dr. Jenkins wondered why the hypothetical medication scenario seemed to make it difficult for men to respond; could it have been because only women were hypothesized to be taking the drug? Perhaps if medication were hypothesized for the man, it would alleviate the respondent problems with men. Nevertheless, Dr. Jenkins complemented the medication scenario because it presents infertility in a fashion similar to what an EPA policy would implement. On the other hand, this does miss the "outrage" costs of environmental contamination. Dr. Jenkins indicated that as a respondent she would be willing to pay more first to do away with the associated injustice and second, to perhaps deal with broader concerns about what the implications are for other species and other natural processes.

With respect to the Dickie paper, Dr. Jenkins noted that Dr. Dickie is pointing out the advantages of large national data sets in estimating the value of health benefits, in that the researcher has better representation of the public, reproducible results and lower costs. From the policymakers' standpoint, there are more benefits. There are some surveys that are repetitive, so that one can track, over time, how specific health effects are valued, and observe trends. Also, national data sets better enable the researcher to make demographic delineations such as age. A third benefit is that we would avoid the "trained seal" problem that was referred to in an earlier session, in that people are not responding to very specific scenarios that are unnatural reaction.

Dr. Dickie's theoretical model points out two differences between children and adults. When a child becomes ill, a child not only loses her own time, but also the parents lose time caring for them. A second difference is that a child's illness may affect the child's opportunity set as an adult, as it robs the child of the opportunity to make choices regarding what her adult life might look like.

In conclusion, Dr. Jenkins complemented the relevance and quality of all three papers.

Question and Answer Period for Session IV

George Van Houtven, Research Triangle Institute, opened the session by acknowledging a comment made by Ms. Jenkins in noting that the terminology "value of a statistical life" was somewhat inaccurate with respect to his paper. As Ms. Jenkins pointed out, since their paper dealt with infertility risk instead of mortality risk, a more appropriate term might be "value of a statistical conception."

George Tolley, University of Chicago, commented that contingent valuation does not deal well with endogenous risk. Household production function models make strong assumptions about preferences in that risk-adjusting behavior is not accounted for. A second point made by Mr. Tolley was that the emphasis in this workshop thus far on soliciting values from *private* goods was problematic, in that it ignores the value of mortality risk reduction to society as a whole. That is, there is legitimately a public good aspect to mortality risk policy that should be measured as well.

Kerry Smith, Duke University, posed a philosophical question to the workshop participants regarding contingent valuation: is it more important to make certain that the question elicits a response to the precise policy question, or to make sure that the respondent understands the question clearly? There is a fundamental trade-off in that either a value is obtained for a specific policy, but at the cost of imposing strong assumptions, or a value is obtained for a commodity that the respondents understand but is not matched to a specific policy. This is true in the context of a production function, from which values are obtained but need to be identified back to a policy value of interest by imposing assumptions. Al McGartland, US EPA Office of Policy, suggested that one alternative may be to do a survey in the context of a household production function approach.

Thomas Crocker, University of Wyoming, expounded upon Mr. Smith's comment, pointing out that a deeper philosophical question pertains to the usefulness of economics in valuing non-market goods. If there is a well-established market basis for a commodity, then all standard economic axioms hold up well; if there is no market, however, the axioms are violated. When axioms are violated, we no longer know what "value" means, as there is no body of theory to deal with that situation.

Kim Thompson, Harvard School for Public Health, pointed out that environmental issues affect not only children's issues, but also ecosystem services. What would be useful is a single metric that combines the valuation of children and adults. For example, there may be some literature from the medical profession that combines valuations of children and adults, and the transferance of qualitative measures of risk.

Christina McLaughlin, US FDA Center for Food Safety and Applied Nutrition, commented that the Needleman estimate of the effects of lead exposure on IQ utilized by Mr. Crocker is unreliable because it added effects in a manner that led to double-counting, and hence probably over-estimated the effect of lead exposure on IQ. Also, Ms. McLaughlin questioned whether it was appropriate to use IQ as a measure of damages, which is itself of questionable accuracy. Mr. Crocker responded that he was aware of the controversy of the Needleman data, as he conducted a review of the study. Mr. Crocker and a colleague found that there were some coding errors, missing data and some questionable data analysis. These omissions might have led to an underestimation of the biomedical consequences of lead poisoning because it failed to take into account the opportunity cost of the mother's time (which was invested in inverse proportion to the opportunity costs), and also neglected to account for the improvement in the child's cognitive development problems resulting from the time invested by the mother. Using a Bayesian diagnostic analysis, Mr. Crocker and his colleague were able to show that the Needleman data was very accurate, once the omissions had been corrected. This is an example of how difficult it is to conduct this kind of analysis because of the need to account for how people adjust to adverse developments. On a second point, Mr. Crocker, acknowledged that while IQ is not a perfect measure, it is widely-accepted in the psychological community, and in fact is fairly accurate when used to evaluate young subjects.

Amalm Mahfouz, US EPA Office of Water opined that it was spurious to survey respondents on their willingness to pay for a reduction of risk outcomes that have not yet occurred, and apply these measures as if they had, giving rise to a general and inherent inconsistency in using ex post measures for ex ante situations. John Horowitz, University of Maryland, replied that the discounting literature addresses this issue to some extent. Mr. Smith further replied

that even if the measures are not perfect, it is necessary to build a structure for things that we cannot observe and link them to things that we can observe. As is the case with social science generally, the only time we can conduct a perfect study is the situation where we do not need it, that is when the outcome is already known.

Ms. Thompson opined that benefit-cost analysis has not historically been very good at accounting for individual variability, and that researchers need to do a better job of dealing with variability on the individual level, and with violations of basic assumptions.

Richard Belzer, Washington University, expressed concern that very specific policy prescriptions were being made on the basis of very weak evidence. Mr. Tolley and others replied that "policy won't wait" for overwhelming evidence.

Concluding Remarks

by Jane Hall, California State University, Fullerton

Ms. Hall was unable to attend the conference.

Concluding Remarks

by Trudy Ann Cameron, University of California at Los Angeles

The conference organizers have asked me to distill some of the key issues from this conference, from my perspective, and to wrap up these two days of presentations and discussion by academics and policy-makers with a few summary remarks. I am both flattered and intimidated to be assigned this task.

It seems the most useful to organize my observations by issue, rather than to review individual papers in any formal order. The assigned discussants have already done an excellent job of raising important questions about the papers, and many helpful comments have cropped up in the discussion from the floor. I have noted names of speakers and commenters where I was able to identify them, but I also offer my apologies and my sincere gratitude to all those whom I have failed to credit explicitly.

• Subjective Individual Probabilities vs. Objective Actuarial Probabilities

I think the strongest general theme that cuts across almost all of the papers in this conference, either recognized or not, has been the problem of **subjective individual probabilities** versus **objective actuarial probabilities**. The former is what drives people's choices under uncertainty; the latter is what we can hope to affect via environmental policies.

The issue of subjective versus objective probability was raised explicitly by Robin Jenkins, who explained that their project (on valuing a statistical child's life based on bicycle helmet prices) assumed the two were identical. Subjective probabilities were also mentioned by George Van Houtven in his discussion of "private baselines" for respondents in his and Kerry Smith's survey study of willingness to pay for reductions in the risks of infertility.

We might wish to make policy based on science (objective probabilities), but individual people are going to make choices based on perceptions (subjective probabilities), and these choices are the only kind we can observe ex ante in order to infer the likely benefits from policy measures. Try as we might, via information provision, to get people to internalize our scientific objective probabilities, we can never know for sure that they have adopted these probabilities (we rarely even check). If we assume that they have, and model their WTP for risk reduction assuming that our objective probabilities are being used when they are not, we will be deriving biased estimates of willingness to pay for risk reduction.

• What They Don't Know Won't Hurt Them?

We need to know a lot more about people's **cognitive processes**. Perceived "risk" can be interpreted as the subjective probability of some adverse future outcome, in this case, some health endpoint. Subjective risks might be correct; sometimes, however, they are vastly out of line with reality, being either too high, or too low.

We also do not know enough about the **potential for manipulation** of individual subjective probabilities by information provision. What types of consumers are susceptible to having their individual subjective probabilities manipulated by authorities such as government scientists, the Surgeon General, environmental groups, or industry advertising? Does the **nature of the information source** matter? Does **the degree of susceptibility** vary across sociodemographic types? I've been exploring this on a pilot survey concerning expectations about climate change. The answer to both questions seems to be "yes."

In most applications, we have no way of knowing how individuals combine their own **priors** on risks with the information we provide on our surveys to generate a **posterior distribution** on risks that forms the basis of their response to our valuation questions. We usually assume, blithely, that their choices are based exclusively on what we have told them--that they completely discard their subjective priors and fully subscribe to the scenario we provide. The **credibility** of an information source seems to be a key determinant of how closely people attend to our scenarios in formulating their own conception of the good we are asking them to value. (Cameron, 1998). If we are

less than credible, they will down-weight what we tell them and value some other "good" (consisting of health effect and probability), the precise identity of which is beyond our control.

• Risks are Not Point-Valued--They Are Distributions

Individual subjective mortality risks are probably not point-valued. Even if you inform respondents that the probability of death from a certain environmental hazard is 23 in 100,000, it is their prerogative to disbelieve you, and to instead formulate a response to your valuation question by using their *subjective* assessment of this probability. Their subjective assessment might possibly have an expectation of 23 in 100,000. But it might also be, say, normally distributed with 95% of the probability density falling between 3 in 100,000 and 43 in 100,000.

• Information Provision: Can We "Explain" some Problems Away?

In the Wednesday morning question period, the possibility was raised that manipulation of preferences by providing information about risks might increase utility by as much as the elimination of the risk. People's risk *perceptions* are presumably what matter to utility, not actual scientifically measured risks. Thus *subjective* risks are what drive choices in our WTP questions, yet *actual* risks are what can be manipulated by policy. If actual risks are "acceptable," whereas perceived risks are "unacceptable," then an information campaign may indeed do more to improve utility than eliminating the actual risk, particularly if the populace would remain unconvinced that the risk has been eliminated.

This leads us to the insight that there are tradeoffs between spending scarce environmental management resources on information programs as opposed to hazard mitigation programs. The tradeoffs will be a bigger issue in cases where the public has a uniformly poor understanding of actual risks. Willingness to pay to reduce environmental risks is a function not only of *expected* health endpoints (such as a 22/100,000 chance of an adverse outcome), but also of the degree of *uncertainty* about those endpoints. If willingness to pay for the same underlying reduction of threat could be reduced by 50% if people understood the scientific risks and believed them, then providing the information will result in an increase in social benefits of this amount. There may be some cases where an information program may represent the "highest and best" social use of management resources.

• Risk Communication vs. Risk Elicitation

A common thread in several papers was the challenge of communicating risk to survey respondents. Phaedra Corso's visual aids, Alan Krupnick's work, and George Tolley's "Wheel of Death" are good examples, as is the Van Houtven and Smith graphical profile of fertility risk. This is still too much of a "one-way street." Risk *communication* (i.e. the researcher explaining environmental health risks to the respondent) was the dominant concern. There was relatively little discussion of risk *elicitation* (i.e. the respondent conveying to the researcher the perceived environmental health risks upon which their choice behavior is based). The majority of papers in this conference did not address the possibility of empirical "slippage" between subjective and objective probabilities, and I believe that this problem is very important.

However, elicitation of subjective probabilities is a tough problem. Even many college sophomores at a prestigious public university cannot comprehend a relative frequency histogram at first, let alone draw one that summarizes their subjective probabilities regarding some event in a way that is consistent with their verbal description of these probabilities. This illustrates what survey researchers are up against with the general public. As researchers, most of us could express a probability distribution, but this is not an innate skill, it is learned form of expression.

It is worth noting that researchers who have studied the economics of aging have begun to address the problem of eliciting probabilities from subjects in their studies. Michael Hurd and Kathleen McGarry, for example, have had some success in asking samples of elderly people about the probabilities that they will live to age 70 or to

age 80 (as opposed to asking them to specify their expected age at death). Facilitating the two-way flow of risk (probability distribution) information between researcher and subject is a vitally important part of the agenda in environmental health valuation research.

• Misguided Pursuit of a Single, Handy, One-Size-Fits-All VSL

Much of the discussion at the conference seemed to orbit around the problem of identifying "the" value of a statistical life. The observation that different studies have produced different values for this elusive quantity appears to be the source of some discomfiture. Admittedly, there is policy-making demand for a single number, like $5.8 million. One number could be remembered easily and universally applied. And it would be democratically appealing if everybody's life were to be valued identically. But I submit that there is no one number that can be universally applied.

Here, there are parallels to the discussion of "benefits transfer" versus "benefits function" transfer. We *do* want to explore how the choices that individual people make belie the values they place on marginal reductions in their own morbidity or mortality (and upon the morbidity and mortality of family members or broader society). But individual choices are constrained by income and prices. We need to estimate a VSL function that allows sociodemographic heterogeneity *and* controls for the nature of each chooser's constraints. Having estimated such a function, one could then counterfactually simulate the choices the individuals in the sample *might* have made, had everyone's constraints instead looked like those faced by the middle class (the median voter?). If the respondent's subjective understanding of the probabilities associated with health risks is part of the information set driving their choices from which we deduce the VSL, then we might also counterfactually simulate their VSL if these subjective probabilities were modified to reflect the objective facts about health risks.

• VSL *Functions* and Environmental Justice

Ellen Post asked how we could attribute a social value to the life of a "crack baby" based on its mother's observed choices relative to the child's health risks. Addictive behavior is an extreme case that has challenged economists for some time. Nevertheless, the question in a similar form can be applied to socioeconomically disadvantaged children in general.

Remember that **different choices** can stem from **different preferences** or from **different constraints**. Most basic economic theory also assumes full information (and zero transactions costs, etc., etc.). If it is *only* preferences that differ across individuals (perhaps according to sociodemographic groups), then economists are prepared to allow consumer sovereignty to prevail. If *constraints* differ across groups, however, an equity (distributional) issue arises. A persuasive social justice argument can sometimes be made that the amount of risk reduction that should be provided to everyone (as a public good) is the amount they would, on average, be "free to choose" if they all had comparable resources and perfect information.

• Diminishing Marginal Utility?

Phaedra Corso's paper went a bit too far in its demands that WTP be *proportional* to the size of the risk reduction that the survey stipulates. All that the economics requires (assuming perfect information—namely that respondents are answering the same question that you believe you are asking) is that "more should be better" if we are talking about a good, as opposed to a bad. There is no requirement of affine linearity. In fact, diminishing marginal utility is probably expected to be the norm, rather than constant marginal utility.

• Half-empty vs. half-full?

I'm sure it has come up before whether people respond to the absolute magnitude of two different levels of scope in risk analysis, or whether they interpret the information we give them in other ways. For example, some people who might worry about mortality risks might look at a reduction in risk due to a side-impact airbag from 20 in 100,000 to 10 in 100,000 as a 50% decrease in risk of **death**. But others, of a more optimistic bent, might think instead of the probability of ***NOT* being killed**, with or without a side-impact airbag. This probability will go from 99,980 in 100,000 to 99,990 in 100,000, which is a (10/99,980) *100%, or a 0.01000% (1/100%) increase in the probability of NOT being killed—a barely detectable improvement. We need to know more about what goes on inside people's heads as we feed them information. This takes us dangerously into the realm of cognitive psychology…but the detour is essential.

• **Non-response "Responsibilities"** (my current crusade)

Phaedra Corso is rightly pleased with her 76% response rate among households who were successfully recruited in the initial telephone contact of the phone-mail-phone survey. However, it is important to report how many valid residential telephones were simply not answered (e.g. answering machine used to screen calls; no reply). What are their characteristics? How many of those households with which voice contact could be established were not interested in participating in the sequence of surveys. What were their characteristics? Of the 24% who dropped out after the initial phone contact, what were their characteristics, and are they systematically different from the respondent group? If the individual's decision not to participate in your survey is in any way correlated with their WTP for risk reductions, then non-response bias can compromise your ability to scale your sample estimates to the general population.

The all-to-common strategy for dealing for non-response in this literature is to calculate and display marginal means of the distributions of sociodemographic variables in the sample and in the population. If these marginal means are not "too" different, it is presumed that non-response is "not a problem." But just because two groups of people (respondents and non-respondents) appear to be similar based on their observable characteristics does not mean they are similar based on their unobservables. Crucial unobservables such as "concern for the environment" (the salience of the survey's subject matter) can be what distinguishes a respondent from a non-respondent, even if their observable characteristics are identical. If the estimating sample vastly over-represents people with a high level of concern about the environment, WTP estimates from the sample will be misleading as a measure of mean WTP in the population.

All is not lost--provided the researcher retains some information about the numbers that were dialed randomly that were unsuccessful contacts, or about the zip codes to which unreturned questionnaires were sent. With luck it will be possible to map these telephone numbers back to geocoded information such as zip codes or census tracts. If this is the case, it will soon be possible (over the next year or so) to implement sample selection models based on zip code moment matrices for individual Census data by zip code (calculated from the 1-in-6 sample). One can approximate these models, using just the means, right now. We are working on preparing the necessary covariance matrices right now, with a proposal to the Bureau of the Census to process these data at UCLA's California Census Research Data Center. The local team seems enthusiastic; it will not take long to implement once approval has been gained.

• **Survey Experimental "Treatments" and Precision of Value Estimates**

"Treatments," such as alternative visual aids for risk communication, need not affect *only* the mean values of WTP. They can also systematically affect the precision (or variance) of WTP. Why do we want to pay attention to precsion? Precision is an important issue because it relates to how much data you need to collect before you can narrow to an acceptable width the confidence bounds on whatever unknown quantity you are trying to estimate. I believe it was Melonie Williams' point that "stated preference methods will be required; they are expensive, and we need to identify cost-effective survey modes."

Over the last few years, stated preference (conjoint) researchers have been devoting a lot of attention to the so-called "scale" issue in their random utility models. Value elicitation methods which provide for lesser error variances are preferred. However, these survey "treatments" may also have different effects on the point values of the utility parameters, not just on error dispersions. There may be tradeoffs. While experimentation with elicitation methods continues, we do not yet understand completely the nature of these tradeoffs. Phaedra Corso's study concerning alternative risk-communication methods (different visual aids), for example, looked only at the effects of these different treatments on point estimates of willingness to pay. Many researchers (and presumably funding agencies) will be intrigued about the effects of these alternative treatments on dispersions.

The decision of Alan Krupnick and his co-authors to use an abstract rather than a specific commodity stems from a comparison of the apparent consequences of using relatively more- or less-specific descriptions. In their experiments with commodity definitions, they had to trade off the problem of assumptions associated with specific "named" diseases against the problem of scenario rejection based on inadequate detail. A formal experimental design to quantify the exact nature of these tradeoffs would be very useful. It may or may not generalize to other applications, of course.

DeShazo and Fermo (1998) have conducted an assessment of complexity effects on the precision of WTP estimates from an assortment of conjoint instruments. They identify five different dimensions of complexity (including number of alternatives, number of attributes, within and across alternative measures of correlation among attributes, and so on). Each of these complexity measures is demonstrated to have statistically significant effects on the dispersion parameter in their random utility model. This research will be informative to researchers dealing with complexity in the description of mortality and morbidity risks.

• "Informed Consent" and WTP Questions; or, the Question of Trained Seals

Alan Krupnick pointed out that he wasn't too sure *how much* people should know about the good being valued before they are allowed to inform the government on policy. Do we want to consult the "person on the street"? Or should we insist that informants have at least some level of expertise with respect to the issue in question? Reed Johnson talked about the potential hazards of using "trained seals" to assess the typical behavior of seals in general.

George Tolley noted in his presentation that experience should matter to values. In work with Jeff Englin, I have certainly found that a respondent's past experience with the good to be valued has a systematic effect not only on *mean* WTP, but also on the *dispersion* in their WTP (e.g. values appear to be heteroscedastic with respect to past experience). Others have found, not surprisingly, that experience with food poisoning affects people's WTP to avoid it, as I recall. (Ready and Buzby? Kerry Smith? Hensen (in the UK).) With respect to the study reported by Phaedra Corso, did they think to ask if the respondent, personally, had ever been in an auto accident where they were injured? not injured? Had anyone in their immediate family been seriously injured or killed in an auto accident in the last 20 years? (This might of course be an omitted variable that is correlated with gender or with risk perception, that could be muddying the apparent coefficients of your models.)

• Endogenous and Exogenous Experience

In survey research, there are also two kinds of "experience" with the good to be valued. One is the kind that respondents have accrued on their own. The extent of their natural experience with an issue is an endogenous variable—it is a product of the same sorts of processes that contribute to the respondent's value of the good in question. Suppose we are talking about food poisoning. Whether or not you *have* experienced food poisoning in the past may have quite a bit to do with *how much you care* about avoiding food poisoning. The other kind of experience is the kind that survey researchers provide artificially on their questionnaires, for example, in the form of information or context for the respondents stated choices. Variations across individuals in the amount of this sort of experience can be randomly assigned, and is therefore exogenous. It is likely that BOTH types of experience will affect WTP distributions (not just means, but also dispersions).

• **Now Tell Me Just Exactly *How* Willing Are You to Pay?**

Just as people are likely to be uncertain about health risks, and to place greater or lesser faith in the information being provided to them by the government or by survey researchers, many people will be uncertain about their likely behavior in the hypothetical markets we employ in stated preference surveys. We need to capture this contingent choice uncertainty when we elicit valuation information.

Laurie Chestnut's discussion of Phaedra Corso's presentation brought up the issue of inviting respondents to indicate how confident they are in their answers. This can be done as a follow-up question, with the response modeled jointly and/or used as a control for the expected WTP (although with caution, because there are some econometric problems in "program evaluation models" employing two discrete variables).

There appears to be some promise in employing "multiple-bounded" contingent valuation questions, where "probability of being WTP," in several categories, can be employed in lieu of a simple yes/no response (which would be just two categories). The responses can then be modeled as an ordered logit or probit instead of a binary choice model. These responses can also be elicited at each of several bid values, providing a broader picture of preferences. Of course, "going back to the well" may times with each respondent invites the same sorts of problems faced by stated preference researchers (conjoint analyses) that require several choices from each respondent (e.g. fatigue, etc.)

• **Nice Survey Research. Real Expensive… But We Have to Do Benefits Transfer Around Here?**

It was valuable to have Melonie Williams remind us of the perennial government need to do benefits transfer. Mark Dickie raised the issue again on the second day. I believe that the method-of-moments ideas devised and demonstrated by Kerry Smith and his co-authors have great potential for helping us think rigorously and systematically about benefits transfer. This is the freshest "benefits transfer" insight in quite some time. It is going to be an essential strategy when we are trying to merge empirical evidence regarding different types of value estimates, all of which can be characterized as a different items on the menu of alternative utility-theoretic welfare concepts. The approach has much in common with the "calibration" strategy employed by one camp of modern macroeconomists.

• **Oh, No! Have I Been Driving the Wrong Car for 18 Years?**

Bill Schulze reported on a barely-off-the-presses pilot study concerning hedonic prices for auto safety as a function of family composition. The sample is 4000 single-car (unusual?) households in three classes: (a) with neither kids nor retired people present, (b) with kids, but no retired people, and (c) with retired people but no kids.

What Bill characterizes as a simultaneous equations problem is in fact a severe multicollinearity problem in the revealed preference data (which is quite a different kettle of fish). There is also an endogeneity problem in the *proxy data* he uses for the individual household's expected mortality rates by vehicle make/model/year. I am fundamentally troubled by the use of statistical fatality rates by vehicle type, even when controlling for the marginal means of driver characteristics and driving conditions within the sample of fatal accidents. I still don't think this gets around the fundamental endogeneity of vehicle choice.

Is there a better way to control for endogenous vehicle choices using Bill's current data? Observed average mortality rates by vehicle make/model/year are *not* the same mortality rates that would result if we randomly assigned people to different cars and observed fatality rates by make/model/year. People self-select their vehicles. Suppose everybody drove the same way, dealt with frustration the same way, had the same reaction times, the same visual acuity, the same driving experience and the same number of distractions while driving. Only then would the observed fatality rates per 1000 cars sold, for each make/model/year, be a good measure of the fatality risk of that vehicle type for a *randomly selected* driver.

I assume there exists a data set for the 1100 distinct types of automobile that includes total number sold, as well as another data set that records information pertinent to every traffic fatality of someone driving or riding in one of these vehicles. These fatality data are then grouped according to model/make/year, and marginal means are generated for the circumstances of the accident (including the characteristics of driver). To measure what he wants, however, Bill needs a random sample of vehicles and drivers, observed over a certain period. What he wants to model is the *probability* of a fatal accident as a function of the type of vehicle, controlling for the type of driver, etc.

The observable dependent variable would be a zero-one variable for each driver or driver-year that takes a value of zero if there is no fatality, and a value of 1 if there is. The explanatory variables would be type of vehicle, V (a very long list of dummy variables) , driver characteristics, D (age, gender, ability to deal with frustration, etc.) and behavior, B (e.g. drinking habits, seatbelt habits, night driving habits, etc.) and typical driving conditions, W (e.g. traffic, rainfall, storms, ice, etc.)

$$(0,1) = \beta_1 V + \beta_2 D + \beta_3 B + \beta_4 W + \varepsilon$$

But even this individual data would not get us around the problem of the fundamental endogeneity of vehicle type choice. Bill is in need of an unbiased estimate of the parameter(s) β_1. Even if these individual data were available, he would have to figure out how to instrument for vehicle type choice, perhaps by using other econometric vehicle choice models to construct a predicted choice probability to use as an instrument (that would be purged of correlation with the error term).

Surely vehicle manufacturers have attempted to discern consumer choices among vehicle makes and models as a function of vehicle attributes (possibly even safety) and sociodemographic characteristics of consumers. Consider Berry, Levinsohn, and Pakes' work. There is almost certainly something there that can be transferred to this study. Their random utility multiple choice models might even allow them to infer a marginal value of mortality risks at least as well as you can do with your data.

But again it comes down to whether actual science matters, or whether perceptions of risk matter…. Consider an alternative "take" on the problem of mortality risk data. Perhaps demand for vehicle safety is not based on *actual* safety, but on *perceptions* of safety, which might be drawn from just the sorts of data that I have just complained were problematic. People *think* they are buying safety when they purchase a Volvo. However, suppose the apparent safety of a Volvo is just an artifact of the unusually fastidious driving habits of the typical person who drives a Volvo—suppose the car itself is fundamentally no safer than a Corvette. The consumer is still paying a safety premium when they buy the car, even though the perceived safety is a figment of their imaginations.

But suppose a clean objective Mortality Risk variable could be obtained for each car, how should systematic variations in WTP for mortality risk be modeled as a function of family composition? The regression coefficient on the mortality risk variable is the quantity of interest. Render it a systematic varying parameter that depends upon a whole menu of family characteristics. And don't forget diminishing marginal utility—WTP for risk reduction should be *allowed* to vary with the amount of risk reduction if the data dictate this.

For the primary data collection, Bill might want to ask respondents directly about "what do you look for in a car?" People could be allowed to rank all the usual attributes of interest, including safety, speed, legroom, headroom, trunk space, style, reliability, color, warranty terms, proximity of dealership/service, and whatever other "important" features come out of focus groups. This might help us understand why some people value a car for its safety features, while others value the same car more for its size and comfort.

The key insight for Bill's team to keep in mind is that when the problem is one of multicollinearity—lack of sufficient orthogonal variation in the values of the regressor variables—then sometimes there is *absolutely nothing* that can be done to discern a precise estimate of the slope on one of the collinear variables. Even with 1100 different vehicles in the choice set, attribute space for cars is pretty sparsely populated. The available attribute combinations simply do not span all of attribute space. Suppose what we seek to know is the difference in WTP for a vehicle as a function of mortality risk, *ceteris paribus* (everything else held constant). If mortality risk never

varies without other desirable or undesirable features being different as well, then the non-experimental data on vehicle attributes provided by the real market is not up to the task we require.

In these circumstances, however, additional data can sometimes be brought to bear on the problem. In this case, there will be an opportunity break the chronic multicollinearities in the actual data by resorting to contingent choice data. Create a hypothetical vehicle similar to the one a family chose, but different in just one key dimension; ask if they would have preferred that alternative. We had a similar problem with revealed preference valuation of water levels at Federal projects along the Columbia River system (Cameron, Shaw, Callaway, Ragland, and O'Keefe, 1996). Insufficient orthogonal variation across waters and over time led us to introduce contingent behavior components into our survey to identify crucial parameters.

There is one class of circumstances wherein multicollinearity in the observed data might not matter as much. That is when there *will never be* any independent variation among the multicollinear variables. Suppose it is technologically impossible to provide safety without also providing a heavier car, and that safety is a perfect linear function of vehicle weight. If nobody can ever consume more safety without also consuming more weight, then a change in vehicle safety will always produce a change in WTP that captures *both* the higher value of more safety and the higher value of more weight. This is a lucky thing if all we are trying to do is to predict WTP for different vehicles. Unfortunately, it does not get us anywhere if we are trying to isolate just the value of additional safety.

- **The Aggravations of Relying on Non-Experimental Data**

Most economists would agree that revealed preferences, as a source of information about environmental or health values, dominate stated preferences as an indicator of these same things. However, one insufficiently appreciated shortcoming of revealed preference data is that the conditions under which choices are observed were not established by orthogonal experimental design.

Consider the child IQ production function described by Tom Crocker and Mark Agee. Lead policy will pretty much affect ONLY lead levels in children, not their overall socioeconomic and physical circumstances. For valid ex ante predictions about the effect of lead reduction on child IQ levels, however, the correct "experiment" would have been to first remove all sources of lead from the environments of all children in a representative sample. Then, the researcher would have to randomly assign different amounts of lead to different children, so that lead exposure had no correlation with anything else about the child. Obviously, such a field experiment would be impossible (and unethical).

The consequence is that even with the best field data, it is ultimately the case that child IQ levels and body lead burden are jointly determined by the same vast and complex set of processes that have led to this child living in this place at this time. As an aside, I often explain to my econometrics students that since the world is a closed system, everything is endogenous…it is only a matter of degree. For each empirical problem we somewhat arbitrarily partition the continuum of variables into two groups and label one group (sometimes just one variable) as endogenous, and consider all the rest to be "exogenous."

It is worth remembering that despite the desirability of using revealed preference data for inferring health values, most revealed preference data from sources outside the laboratory are non-experimental and therefore vulnerable to this problem.

- **Finessing Subjective/Objective Probability by Assuming it is 1.**

Reed Johnson reported on a conjoint choice study of 400 Toronto respondents, inferring WTP to avoid for outcomes that would otherwise occur with certainty. There was not much about Reed's project that I would disagree with, at least based on his verbal description, since I have not yet had the opportunity to study the paper. I remain concerned, however, about the *ex post* nature of the values this study elicits. Individuals' subjective WTP amounts are often "option prices," in the sense of Daniel Graham's exposition about cost-benefit analysis under uncertainty. Individual option prices for uncertain future outcomes are fundamentally based upon subjective probabilities, and

these option prices can be manipulated by manipulation of subjective probabilities. If you can alter someone's probability distribution over the health consequences that are being valued, you can alter their ex ante willingness to incur costs to avoid that particular consequence. Some of the remarks of both George Tolley and Jay Shogren kept me thinking about this option price issue.

Daniel Graham's original development of the theory of cost-benefit analysis under uncertainty (AER, 1982?) was in terms of **community risk** (i.e. objective actual probabilities, common to the entire community), rather than individual uncertainty. This is analogous to our dilemma about whether we should force people to acknowledge objective actuarial probabilities about an assortment of health endpoints, or whether we should allow them to employ (or just acknowledge that they *will* employ) their own subjective revisions to these "official" probabilities. Even if we choose to do the latter, there is an opportunity to counterfactually simulate what *would have been* their option price had their perceived subjective probabilities matched scientifically measured objective actual probabilities.

The policy question is emphatically NOT about health endpoints that occur with certainty. It is about uncertain future events. Reed has avoided the uncertainty problem in his study, but we cannot avoid it in policy-making. Thus his study is half of the answer to a policy question. A very important half, to be sure. But without an understanding of the subjective probability formation process, we do not yet have enough for determining ex ante willingness to pay for environmental health protection.

• Kids—And Example of the Economic Behavior of Other Species

In the late 1970's, I was greatly amused by demonstrations by Ray Battaglio of the economically rational behavior displayed by rats in the laboratory. It was somehow very satisfying to learn of the universality of the problem of making oneself as happy as possible when facing constraints, such as finite resources. Thus it is not surprising that Bill Harbaugh finds that any child old enough to recognize that candy and toys confer positive utility might be able to make rational economic choices. I am also greatly relieved to have my suspicions confirmed that even while some children can be observed to make apparently irrational choices some of the time, so will some adults, even Ph.D. economists (although the prevalence of errors declines in that order).

It occurred to me while listening to Bill's presentation that it would be intriguing to observe interpersonal variations in the frequency of economically irrational choices, perhaps over time, as well, and to see if there are any systematic determinants of this sort of economically anomalous behavior. Are the axioms of revealed preference violated more frequently when the individual is tired, or hungry, or distracted? Are there any traces of systematic sociodemographic differences? Clearly age and/or education seem to matter. What about other attributes? How about experience with the decision-making context? The types of goods being valued? Assumptions about the presence or absence of close substitutes? This inquiry would not, of course, immediately inform child environmental health valuation, but it appears to be a regression begging to be run, nevertheless.

• Opportunities for Combination of Data

I was greatly intrigued to learn from Mark Dickie that the Panel Study of Income Dynamics (PSID) Child Development Supplement (1997) data released last month might finally provide a reason for me to invest in learning how to work with the PSID. Over the last 15 years, dozens and dozens of labor economists have passed through UCLA giving seminars based on PSID data, yet I could never discern how this monstrous government panel data set might be of use to me and my research interests.

One thing that sparks my interest most is the possibility of linking these data, via internal-use geo-coding, to environmental quality data sets such as the Toxics Release Inventory or ozone attainment data, or other physical environmental data that might have a systematic effect on these children. Creation of such a data set would be immensely valuable. In particular, I have been trying to think of ways we might be able to seduce conventional labor economists into becoming interesting in children's environmental health issues. This PSID module might be a great opportunity. If economists primarily concerned with the valuation of environmental health could initiate a

dialog with conventional labor economists by making creative use of special editions of the labor economists's own data sets, we might successfully expand the scope of interest in these topics. I will definitely be exploring this further!

- **Remembering that Other Groups Have Useful Ideas, Too.**

Near the close of the general question period at the end of the conference, Kimberly Thompson of the Harvard School of Public health suggested that economists should beware of re-inventing the wheel and should pay more attention to the large and growing inventory of medical research pertaining to child health effects. This is certainly a good idea. In the post-conference discussion, however, Jay Shogren noted that it would be immensely helpful if more researchers in the epidemiological community could be persuaded to include crucial economic variables in their studies. He brought up the point that public health researchers sometimes collect large national data sets on environmentally related disease, but fail to collect information about the degree of heterogeneity in indicators of socioeconomic status. This oversight can mean that a data set that would be of immense value is rendered almost useless for inferences about environmental health values. The omission of this key variable can mean that it is impossible to rule out "omitted variables bias" in the relationship between environmental conditions and health outcomes. The reason is that socioeconomic status is a key determinant of people's abilities to engage in averting behaviors with respect to poor environmental quality (e.g. to use air conditioners with filters, or to have bottled water delivered).

We can all learn from each other. That is what a conference like this one is for.

• Overall?

I found the presentations and discussions at this conference to be both interesting and provocative. It is invigorating to have so many researchers and policy folks, with common interests, engaged in discussion of critical basic research and its relevance for policy-making. It is cannot fail to be helpful to bring together both the producers and consumers of academic research to ensure that product development is on target with respect to its eventual uses. And it does not bother me at all that the presented papers span the entire spectrum of completeness. When a study is all finished, it is too late to make helpful suggestions for how it might have been done better.

It is misguided to think that "pure" academic research can proceed without reference to the value of the knowledge it creates from the point of view of society. As environmental and health economists, we have a moral responsibility to ensure that what we produce is useful—in the sense that it contributes to better decisions. Due regard for the policy implications of our work may not be the most highly rewarded dimension of our research when we are evaluated for promotion or salary increases, but it is what matters "in the real world."

The format and organization of this series of conferences is a great idea. I hope the policy folks will continue to make their voices heard. The two constituencies should be co-equal in this particular venue. Academics are accustomed to telling audiences how things work (we have had years of practice on our students). In this context, however, the policy folks have a responsibility to assert their views, *especially* when they conflict with what is being presented by researchers.

I would like to thank the conference organizers for inviting me to participate in this capacity. It is especially nice to have a really good reason to pay meticulously close attention to a complete set of conference papers. I learned a remarkable amount from my colleagues and from the policy-oriented participants. For me, a conference is always a success if I come away with new research ideas, which I have!