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Who Counts in Evaluating the Effects of Air Pollution Policies on Households? Non-Market Valuation in the Presence of Dependencies

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ABSTRACT

Individuals who are likely to realize the largest benefits from improvements in air quality often depend on other members of their households to make time or monetary contributions to their care. The presence of these dependency relationships among household members poses challenges for benefit estimation since it is unlikely that the conditions necessary for recovering the underlying individual preferences from household choices are satisfied in this setting. We propose a conceptual framework that highlights the role of these dependencies in the choice models used to estimate the willingness to pay for environmental quality improvements. We design a complementary stated preference survey that describes hypothetical dependency relationships for household members of different ages to test the implications of our conceptual model. Respondents' choices take into account the care-giving responsibilities for young children and teenagers but not for older adults.

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I. Introduction

When does a child become an economic agent? When do the limitations that arise with advanced age and/or serious health conditions initiate an exit from full economic agency? How do these transitions into and out of economic agency affect dependencies, such as care-giving activities, among family members? Answering these questions requires a model that describes how dependency relationships function among members of a household. This paper begins to develop such a model and evaluates the performance of a strategy for framing stated choice questions to determine how different types of dependency relationships affect willingness to pay for policy changes that alter features of those relationships.

The conventional model of consumer behavior maintains that the observed (or stated) choices of economic agents (either individuals or households) can be described as if they arose from a single, coherent preference function. This framework asserts that choices result from maximizing this function subject to the budget constraint faced by the individual or the household. For example, the unitary model of household decision making assumes that household behavior stems from the preference function of a single member of the household and a household budget constraint that reflects the household income pooled over all sources of income (Becker [1974]). Thus, household choices are independent of the source of income. A number of studies report evidence against the unitary model and income pooling (e.g., Lundberg et al. [1997]). Alternatives to the unitary model, including Nash-bargained (McElroy [1990]), and collective models (Chiappori [1988]) invoke different assumptions regarding the process that underlies household decision making.

In one of the most recent extensions of the theory underlying the collective model, Chiappori and Ekeland [2009] assess the conditions under which aggregate observed behavior (i.e., revealed preferences) provides sufficient information on the structure of preferences and decision making processes for groups of individuals. They model a two-stage group decision making process. Resources are allocated among group (or household) members in the first stage and individuals make choices conditional on that allocation in the second stage. Their analysis suggests two important conditions on the identifiabilty of household preferences: "First, the general version of the [collective] model is not identifiable. A continuum of different models generates the same household demand function. Second, one exclusion condition for each member – for each member there is a commodity this member does not consume – is sufficient to generically guarantee full identifiability of …the welfare-relevant concept that summarizes preferences and the decision processes" (p. 793, bracketed words inserted).[1] Combined with previous results from the literature on collective household models, these results imply that the underlying preferences of all household members can be recovered from observed household behavior when (1) the budget sharing process (and each member's role in it) is well-understood and characterized and (2) each member is an independent economic agent in the sense that she consumes at least one good exclusively and there are well defined access conditions for the other goods of interest based on observed household choices.

In estimating the benefits to improved environmental quality, where household models are especially relevant in informing policy, neither setting is likely. For example,

[1] The presence of distribution factors, variables that influence the group decision making process but do not affect individual utilities directly, eliminates the required exclusion conditions.

most of the benefits from lower ambient concentrations of the criteria air pollutants arise through reductions in the risks of health effects associated with exposure to these pollutants. Young children and older adults are particularly susceptible to these risks.[2] Children and older individuals who experience severe air pollution-related illnesses may require care-giving from other household members. As a result, policies that improve air quality and therefore reduce the incidence of the associated health effect indirectly benefit care-givers and other members of the household through changes in time and income allocations within the household as well as different consumption patterns. In other words, the income sharing rule and the allocation of time and goods among household members may depend on how pollutants affect the health status of specific members. The necessary restrictions to recover the underlying household structure from revealed preference data discussed above are unlikely to apply for these types of applications. Thus, the presence of dependency relationships complicates the identification of individual preferences. Given this challenge, we propose the use of stated preference studies (or a composite of stated and revealed preference information) to examine the tradeoffs individuals are willing to make when environmental externalities affect household dependency relationships.

Our explicit consideration of dependency relationships among household members differs from the focus of other recent stated preference studies (e.g., Bateman and Munro [2009] and Lindhjem and Navrud [2009]) also designed to better understand the nature of household decision making. Bateman and Munro [2009] examine decision making with respect to household food consumption among couples by comparing the

[2] See Chay and Greenstone [2002] and Currie and Neidel [2005] for evidence on the health effects associated with infants and children and Evans and Smith [2005] for older adults.

responses of individual members of couples interviewed separately to the responses couples provided when jointly interviewed. Their results suggest no general rule governing the relationship between the tradeoffs implied by individual and group responses. Focusing on the person in the household responsible for food purchases attenuates the differences but does not offer a viable basis for predicting the group responses. While the results support rejecting the unitary model for the household and are therefore consistent with other studies, the authors conclude that their evaluation does not offer guidance on who within a household should be interviewed for assessing household tradeoffs. The study by Lindhjem and Navrud [2009] asks each respondent to provide responses to household and individual willingness to pay (WTP) questions based on a payment card format. Respondents were randomly assigned to different versions of the survey, which varied the order of the personal and household WTP questions. In a cross-sample comparison of responses from the first question (either individual or household depending on the survey version), the study reports no significant difference between average household and individual WTP measures. The within-sample comparison based on the two responses provided by each respondent finds higher mean values from the responses using the household framing of the willingness to pay question. The authors conclude that respondent understanding of the individual or household perspectives may not align with analysts' assumptions. As a result, they call for research that considers the framing of dependency relationships as part of the structuring of stated choice questions. Our approach is consistent with this appeal.

We consider a new framing for stated choice questions, which involves proposing hypothetical dependency relationships to survey respondents and evaluating whether

these relationships influence choices among air pollution policies. Our results provide direct tests of the effect of different types of dependency relationships on caregivers' choices. A simple non-parametric test and a formal choice model both suggest that, conditional on the level of care-giving time (the commodity of interest), the characterization of household dependency relationships *does influence* an individual's choices. Moreover, they indicate what appears to be an implicit delineation of personal responsibility to different types of household members. Respondents' choices appear to acknowledge the importance of care-giving for young children and teenagers. They do not appear to attach the same importance to older adults.

Section II develops the conceptual basis for our evaluation of how dependency relationships among household members may influence responses to stated preference questions describing policy changes that would affect the intensity of that dependency. The third section describes the Internet-based survey used to test the hypotheses developed in Section II. Section IV presents our findings and the last section discusses their implications for using stated choice surveys to evaluate environmental policies that influence pre-existing dependencies among members of an extended family.

II. Developing choice models that account for dependency relationships

Compared to the unitary framework, a key component of the collective model is the distinction between individual income and household income. In the collective model, the choices of each individual are made conditional on the allocation stage of the household decision process. We abstract from explicitly modeling the allocation stage. However, our analysis acknowledges that the outcome of this process, which defines the

distribution of household income among a household's members, will influence the level of well-being each household member can realize.

We implicitly account for the allocation stage by representing the role of other household members through an income share function, denoted $\theta(\cdot)$, which describes the portion of household income allocated to the respondent of interest. With more than one agent, $\theta_i(\cdot)$ represents the share of household income allocated to member *i* with $\sum_{i=1}^{I} \theta_i(\cdot) = 1$ where *I* is the total number of household members.

From the perspective of interpreting stated choice questions, one basis for distinguishing a unitary and a collective model arises from respondents acknowledging differences between their own individual income and household income. For example, if a respondent answers a question failing to recognize this distinction and the possibility that the proposed change could impact the distribution of income within the household, then his choices provide information that could be used to create a measure of personal or individual WTP. By contrast if an individual's responses reflect an anticipated income reallocation within the household arising from the proposed change, then those responses imply an alternative measure of WTP that is at least potentially consistent with the collective framework. Of course, recognition of income reallocation alone does not guarantee that choices reflect the maximum household willingness to pay for a proposed change.

Ideally, a measure of household WTP for a policy change would be constructed holding constant the levels of well-being realized by each member of the household at their initial levels. A coordinated survey of all household members would be needed to

separate the two stages that describe the decision making process. Without information about household income reallocation and members' wellbeing, we cannot assume a household WTP measure can be recovered from a survey that focuses on a single member.

Our survey is intended to judge the importance of dependency relationships without knowing all the details of the income allocation process within a household. We use a framing that asks respondents to imagine a member of their household has a specific type of dependency. The stated choice question defines a level of care that must be provided to this hypothetical dependent due to a severe health condition. The proposed policy reduces environmental pollution that affects the health condition and, thus, the need for care. By introducing this suggested relationship we attempt to induce the respondent to consider how the presence of the dependency would affect income allocation within the household.

Policy changes can alter $\theta(\cdot)$. To describe the implications of such changes, we contrast how a policy's impacts on the hypothetical dependent would be evaluated relative to the same policy's impacts on the respondent's own health. To develop what can be learned from such linked choice questions (e.g., health impacts on a hypothetical dependent versus on the respondent) our analysis begins by considering different interpretations of how $\theta(\cdot)$ might change in response to that policy. Using a simple linear indirect utility model, we relate the two choices to hypotheses describing what distinguishes a unitary from a collective decision process. This framework provides the

basis for judging whether the nature of dependency is likely to affect the process of eliciting willingness to pay.[3]

Our survey design describes three different types of hypothetical dependent household members, a young child (2-5 years of age), a teen (15-17 years of age), and an older adult (63 years or older). Regardless of age, each hypothetical household member is described as asthmatic. In each case, management of the dependent's asthma requires that the respondent devote a fixed amount of time each week to care-giving. The survey also describes a policy change that would improve air quality and as a result reduce the required weekly care-giving time. Each version of the survey proposes one type of hypothetical dependent (either a young child, teen, or older adult). Versions were randomly assigned to respondents. Each respondent also received a similar question about managing his or her own (hypothetical) asthma condition.

The income available to each respondent is given by $m_R = \theta(\cdot) \cdot m$ where m is household income. If the respondent considers the full household willingness to pay for a proposed policy change, then his or her answers will be based on $HWTP = m^0 - m^*$ where m^0 is the household income under the current or initial conditions and m^* is the income required to realize the initial level of well being for <u>each</u> household member with the proposed policy change.

The alternative WTP measures we construct below motivate two hypotheses. First, we hypothesize that the age of the household member benefiting from an

[3] We assume that the only effect of the policy on the respondent is through changes in care-giving time. In fact, our analysis can consider additional policy effects aside from care-giving without changing our main findings. This ability stems from the linked design of the questions. Additional changes assumed to stem from the policy will contribute to the differences in a respondent's choices for the two questions -- for self versus for a dependent member. Our design does not allow us to separately identify the effects of the policy on each of these aspects (e.g., care-giving time, other policy effects).

environmental health improvement enters the income sharing function. Our choice of three age groups, child, teen, and older adult, is deliberate. We focus on these age groups to exploit variation among these age groups on the basis of the likelihood and intensity of care-giving requirements. Children represent those family members most likely to require care-giving while care-givers may afford teens some level of independence, subject to the limitations associated with their health state. Older adults, on the other hand, represent family members who may be entering a period of uncertainty with respect to dependency, in which the care they require is determined in part by their health. Given this proposed relationship, we derive its implications for the structure of the respondent's choice function. Second, and equally important, we describe several alternative ways each respondent might evaluate the implications of the proposed change for the income sharing process within the household. The analyst does not know whether (and if so, how) each respondent will incorporate income re-allocation into the answers to the policy choice questions.

We derive *three* WTP measures that vary in the way in which they account for possible changes in the household income allocation that arise from the proposed policy.

Equation (1) specifies the indirect utility function

$$V = \alpha_0 + \alpha_1 P + \alpha_2 \pi(L, n, w, c) + \alpha_3 m_R . \quad (1)$$

P is a vector for the prices of all other goods. The respondent's income is given by $m_R = \theta(L, n, c, z)m$ where n denotes the number of household members, L is the quasi-fixed care-giving time required, c designates the age group of the hypothetical family member requiring care, and z represents other covariates that affect the sharing rule. $\pi(L, n, w, c)$ denotes a function representing the implicit cost of care-giving. The effect

of the care-giving requirement depends on a variety of factors that are likely to vary across households; *L*, *n*, and *c* are defined above, *w* is the price of materials for care (e.g., medications, equipment).

Let V^0 represent the respondent's initial (indirect) utility without the reduction in air pollution. Therefore equation (2) defines the benchmark condition.

$$V^0 = \alpha_0 + \alpha_1 P + \alpha_2 \pi\left(L^0, n, w, c\right) + \alpha_3 m_R^0 \tag{2}$$

where $m_R^0 = \theta\left(L^0, n, c, z\right) m^0$. To describe the implications of differences in what the respondent assumes about income reallocation when answering the choice questions, we solve expressions describing the respondent's indirect utility for alternative concepts of respondent and household income. Inverting V^0 in equation (2) yields an expression for m_R^0: in equation (3).

$$\begin{aligned} m_R^0 &= -\frac{\alpha_0}{\alpha_3} + \frac{1}{\alpha_3} V^0 - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right) \\ &= a - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right) \end{aligned} \tag{3}$$

where $a \equiv -\frac{\alpha_0}{\alpha_3} + \frac{1}{\alpha_3} V^0$.

Consider an improvement in environmental quality that reduces the required care-giving time from L^0 to $L^1 < L^0$. The reduction in required care-giving time changes the implied contribution of $\pi(\cdot)$ to the indirect utility function from $\pi\left(L^0, n, w, c\right)$ to $\pi\left(L^1, n, w, c\right)$. For this exposition, we assume $\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right) > 0$.[4] With income sharing, the reduction in *L* can have an additional effect; it may result in a re-

[4] This interpretation is consistent with considering $\pi(\cdot)$ to be a shadow price of care-giving. Of course, if we were to describe $\pi(\cdot)$ as such, it would be a function of all the parameters of the choice problem.

budgeting of household resources such that the individual's share of household income changes.

Define the willingness to pay (WTP) for this change as the difference between the household income required to sustain the respondent's initial utility level at the two shadow prices of care-giving:[5]

$$WTP = \tilde{m}^0 - \tilde{m}^1 . \qquad (4)$$

$\tilde{m}$ denotes the household income that we, as analysts, infer based on responses to the choice questions. If we assume the responses incorporate some revision in the income sharing rule, then conditional on the arguments in the sharing function, we expect one set of factors to influence responses. Alternatively, without budget reallocation, another set of factors would be relevant. Each of these possibilities implies a different distribution of well-being within the household.

To describe the first WTP measure, suppose that the respondent bases his decisions on the initial household income with the initial sharing function describing how income is distributed among members so that $\tilde{m}^0 = m^0 = m_R^0 \frac{1}{\theta\left(L^0, n, c, z\right)}$. This formulation implies that the expenses associated with the proposed policy change must be accommodated with the initial distribution of resources within the household unchanged. Thus choices would be based on this budget. Substituting $m_R^0 = a - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right)$ into $m^0 = m_R^0 \frac{1}{\theta\left(L^0, n, c, z\right)}$ yields an alternative expression for $\tilde{m}^0$:

[5] Note that our definition of WTP only requires that the respondent's level of well-being remain constant. As mentioned above, this need not guarantee that other members' levels of well-being also remain constant.

$$\tilde{m}^0 = \frac{1}{\theta\left(L^0, n, c, z\right)}\left[a - \frac{\alpha_1}{\alpha_3}P - \frac{\alpha_2}{\alpha_3}\pi\left(L^0, n, w, c\right)\right] \tag{5}$$

For consistency with $\tilde{m}^0$, $\tilde{m}^1$ defines the household income necessary for the respondent to achieve his baseline utility given the reduction in required care-giving time. After the change in required care-giving time, the respondent's utility is given by

$$V^1 = \alpha_0 + \alpha_1 P + \alpha_2 \pi\left(L^1, n, w, c\right) + \alpha_3 m_R^1 \tag{6}$$

where we assume the individual accounts for how his share of income will adjust based on the change in *L* so that $m_R^1 = \theta\left(L^1, n, c, z\right)m^0$. Therefore, the following expression implicitly defines $\tilde{m}^1$:

$$V^0 = \alpha_0 + \alpha_1 P + \alpha_2 \pi\left(L^1, n, w, c\right) + \alpha_3 \theta\left(L^1, n, c, z\right)\tilde{m}^1 \tag{7}$$

Solving for $\tilde{m}^1$ yields:

$$\tilde{m}^1 = \frac{1}{\theta\left(L^1, n, c, z\right)}\left[a - \frac{\alpha_1}{\alpha_3}P - \frac{\alpha_2}{\alpha_3}\pi\left(L^1, n, w, c\right)\right]. \tag{8}$$

We can simplify this expression by solving equation (3) for *a* and noting that $m_R^0 = \theta\left(L^0, n, c, z\right)m^0$ which yields:

$$a = \frac{\alpha_1}{\alpha_3}P + \frac{\alpha_2}{\alpha_3}\pi\left(L^0, n, w, c\right) + \theta\left(L^0, n, c, z\right)m^0. \tag{9}$$

Substitution implies:

$$\tilde{m}^1 = \frac{1}{\theta\left(L^1, n, c, z\right)}\left[\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right] + \theta\left(L^0, n, c, z\right)m^0\right] \tag{10}$$

Under these conditions, WTP is the difference between $\tilde{m}^0$ and $\tilde{m}^1$ and is given by:

$$
\begin{aligned}
WTP^* &= \tilde{m}^0 - \tilde{m}^1 \\
&= m^0 - \left\{ \frac{1}{\theta\left(L^1, n, c, z\right)} \left[\frac{\alpha_2}{\alpha_3} \left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right) \right] + \theta\left(L^0, n, c, z\right) m^0 \right] \right\} \qquad (11) \\
&= -\frac{1}{\theta\left(L^1, n, c, z\right)} \frac{\alpha_2}{\alpha_3} \left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right) \right] + \frac{\theta\left(L^1, n, c, z\right) - \theta\left(L^0, n, c, z\right)}{\theta\left(L^1, n, c, z\right)} m^0
\end{aligned}
$$

Thus our first WTP measure, denoted WTP^*, accounts for both the reduction in the implicit cost of required care-giving associated with the reduction in L and the effect of the resulting reallocation of household resources. Although WTP^* reflects the implications of the policy for the distribution of income within the household, it does not assure that all household members remain at their initial levels of well-being. The respondent's choices could reflect a new point in the set of household utility combinations that are feasible with given resources and constraints.

As an alternative to WTP^*, assume the respondent begins his decision making process by accounting for how the change in care-giving time would alter the distribution of resources within the household. In this case, the respondent's initial income level and baseline utility must take account of the anticipated adjustment. The respondent's baseline utility would be given by:[6]

$$
\hat{V}^0 = \alpha_0 + \alpha_1 P + \alpha_2 \pi\left(L^0, n, w, c\right) + \alpha_3 \theta\left(L^1, n, c, z\right) m^0 . \qquad (12)
$$

Assuming the respondent continues to base his decisions on $\tilde{m}^0 = m^0$, substitution implies:

$$
\tilde{m}^0 = \frac{1}{\theta\left(L^1, n, c, z\right)} \left[\hat{a} - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right) \right]. \qquad (13)
$$

[6] Note that $\hat{V}^0 = V^0$ if and only if the reduction in required care-giving time does not alter the allocation of resources within the household so that $\theta\left(L^0, n, c, z\right) = \theta\left(L^1, n, c, z\right)$.

with $\hat{a} = -\frac{\alpha_0}{\alpha_3} + \frac{1}{\alpha_3}\hat{V}^0$.

Now define $\tilde{m}^1$ as the household income necessary for the respondent to achieve his baseline utility (i.e., $\hat{V}^0$) under the new care-giving time recognizing its implications for the allocation of resources within the household. Equation (14) defines $\tilde{m}^1$:

$$\tilde{m}^1 = \frac{1}{\theta\left(L^1, n, c, z\right)}\left[\hat{a} - \frac{\alpha_1}{\alpha_3}P - \frac{\alpha_2}{\alpha_3}\pi\left(L^1, n, w, c\right)\right]. \tag{14}$$

WTP is now given by:

$$\hat{WTP} = -\frac{1}{\theta\left(L^1, n, c, z\right)}\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right] \tag{15}$$

In this case, the respondent acts as if any hypothetical payment would be made after the change in the distribution of household resources associated with the decrease in *L*. In doing so, $\hat{WTP}$ only accounts for the direct benefit of the decrease in *L*, the reduced implicit cost of care-giving. WTP^*, in contrast, reflects the value of the change in the distribution of household resources in addition to the change in $\pi(\cdot)$ due to the change in required care-giving. Comparing equations (11) and (15), we have

$$\begin{aligned} WTP^* &= -\frac{1}{\theta\left(L^1, n, c, z\right)}\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right] + \frac{\theta\left(L^1, n, c, z\right) - \theta\left(L^0, n, c, z\right)}{\theta\left(L^1, n, c, z\right)}m^0 \\ &= \hat{WTP} + \frac{\theta\left(L^1, n, c, z\right) - \theta\left(L^0, n, c, z\right)}{\theta\left(L^1, n, c, z\right)}m^0 \end{aligned} \tag{16}$$

Now consider one final measure of WTP where the respondent's choices reflect no redistribution of resources within the household. The initial indirect utility is given in equation (2), as in our construction of WTP^*, so that

$\tilde{m}^0 = \frac{1}{\theta(L^0, n, c, z)}\left[a - \frac{\alpha_1}{\alpha_3}P - \frac{\alpha_2}{\alpha_3}\pi(L^0, n, w, c)\right]$. However, suppose the respondent considers only the impact of a change in L on $\pi(\cdot)$ and ignores any increase or decrease in his own personal income that results from a reallocation of household resources following the change. In this case, his utility after the change is given by:

$$\tilde{V}^1 = \alpha_0 + \alpha_1 P + \alpha_2 \pi(L^1, n, w, c) + \alpha_3 \theta(L^0, n, c, z) m^0. \tag{17}$$

Define $\tilde{m}^1$ as the household income necessary for the respondent to achieve his baseline utility given the reduction in required care-giving time implicitly defined by:

$$V^0 = \alpha_0 + \alpha_1 P + \alpha_2 \pi(L^1, n, w, c) + \alpha_3 \theta(L^0, n, c, z) \tilde{m}^1 \tag{18}$$

Solving equation (18) for $\tilde{m}^1$ yields:

$$\tilde{m}^1 = \frac{1}{\theta(L^0, n, c, z)}\left[a - \frac{\alpha_1}{\alpha_3}P - \frac{\alpha_2}{\alpha_3}\pi(L^1, n, w, c)\right]. \tag{19}$$

Under this final construction, WTP, the difference between $\tilde{m}^0$ and $\tilde{m}^1$, is given by:

$$\begin{aligned} \tilde{WTP} &= \tilde{m}^0 - \tilde{m}^1 \\ &= -\frac{1}{\theta(L^0, n, c, z)}\frac{\alpha_2}{\alpha_3}\left[\pi(L^0, n, w, c) - \pi(L^1, n, w, c)\right] \end{aligned} \tag{20}$$

Comparisons of equations (11), (15), and (20) highlight how different assumptions about the impact of proposed changes on the distribution of household resources lead to different WTP values.

All three formulations imply the WTP governing choice will be a nonlinear function of the care-giving time. If dependency relationships affect the evaluation of care-giving time then we expect comparisons of our linked choice questions, that hold all other dimensions constant and vary only who is affected, to offer a robust test of the role

of *c*. Under a wide range of specifications for $\pi(\cdot)$, together with different income sharing rules, the research strategy isolates the effects of different types of dependencies. That is, by describing the same policy change for the respondent and for a hypothetical dependent with different characteristics, we are able to isolate how the dependency relationships influence choices.

In addition, with a parameterized model, distinctions among the various WTP measures can be identified through the household income term. Focusing on the household income terms in our estimated WTP functions will also allow us to identify departures from a unitary framework.[7] Given the nonlinearity of the WTP measures, the parametric models we use to describe respondents' choices are best interpreted as linear approximations.

By making assumptions about the budget allocation process and dependency explicit in our model and developing a stated preference strategy that specifies the nature of dependencies, our approach overcomes some of the challenges of recovering underlying household preference structures identified in previous research.

III. Design of the survey

We use a "hypothetical dependency" as a mechanism to evaluate whether choices vary with the nature of dependency relationships among household members.[8] To our

[7] Note that while our three WTP formulations recognize income reallocation albeit in different ways, the WTP measure implied by a similarly structured unitary model would fail to do this. WTP in this case would be given by: $-\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right]$.

[8] We conducted a series of focus groups in August 2005 to explore care-giving. Each individual reported different care-giving experiences, which suggested challenges in successfully developing stated choice questions based on actual care-giving experiences. As a result we developed the hypothetical care-giving

knowledge, hypothetical dependency relationships have not been explored in stated preference research. Our survey evaluates whether respondents comprehend this framing as representing the nature of dependency relationships. We also consider whether this framing successfully conveys the information required to understand household behaviors that reflect the jointness in the allocation of time and money among household members assumed in most household models.

Our sample uses Knowledge Network's (KN) Internet panel. KN's panel is selected from households that are recruited using random digit dialing (RDD). The invitation to participate in our survey was sent to 2,670 panelists aged 18 and over on June 7, 2006. The invitation indicated that the survey was about respondents' health.[9] A reminder email was sent three days later to respondents who had not yet completed the survey. By June 22, 2006, a total of 2,110 panelists (79% of invited panelists) completed interviews. The duration of the interview is measured by KN as the number of minutes between when the survey is begun and when it is completed. Fifty percent of respondents completed the interview within 10 minutes and 92% completed the interview within 30 minutes. Only four percent of the sample took longer than 60 minutes to complete the interview.

KN provided socioeconomic and demographic data on all of the panelists that were invited to take the survey – including both survey respondents and non-respondents.

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scenario and a specific set of time requirements to avoid the possibility of encountering different (and unobservable) understandings of care-giving activities across respondents. Of course, actual care-giving experiences are likely to influence respondent's choices regarding a hypothetical care-giving relationship. Thus, we control for actual care-giving experiences in our regression analysis.

[9] The subject of the email was "Your Health" and the body of the email read: "This week we'd like you to participate in a survey about your health. We believe that you will find the survey very interesting. We'd appreciate your completing the survey at your first convenience. Thank you in advance for your time and participation."

These data on non-respondents permit us to estimate a selection model and implement sample selection correction in the regression analysis described in Section IV.[10]

The survey comprised four main sections: family support, asthma, choice questions, and debriefing. The first section asked respondents whether they provided either financial support and/or spent time providing care for any family members in the following eight age groups: 0-1 years, 2-5 years, 6-11 years, 12-14 years, 15-17 years, 18-55 years, 56-62 years, and 63+ years. To help respondents understand these questions, the survey described examples of these types of support. They were told that financial support includes buying food, paying for housing or healthcare, and paying for education, and that time spent providing care for a family member includes helping a family member run errands or helping them with daily activities such as preparing food or bathing. Respondents were also told that family members include live-in relatives and non-relatives (e.g., step-children), as well as family who live elsewhere.

The second section described asthma[11] and asked respondents whether any of the family members they support (with time or money) had been diagnosed with asthma. These responses were recorded using the age categories that matched the family support questions.

[10] For a more detailed analysis of sample selection in the KN panel, see Cameron and DeShazo [2005].

[11] Asthma was described as follows:

> "Asthma is a disease that affects an individual's airways. When an individual has asthma, the inside walls of the airways are swollen and can be irritated by triggers such as pollen, dust, and air pollution. A person with asthma may have difficulty sleeping. It may be difficult for them to walk or climb stairs, or to be physically active.
>
> When asthma symptoms are worse than usual, it is called an asthma attack. Asthma attacks are not all the same—some are more serious than others. A mild or moderate asthma attack causes symptoms like wheezing, coughing, chest tightness, and trouble breathing. In a severe asthma attack, the airways can close so much that air does not get to vital organs. This condition is a medical emergency."

The third section described a hypothetical dependency relationship as part of a series of two double-bounded contingent valuation questions. The order of the two scenarios was randomly assigned. Respondents were asked to consider each situation independently. One of the scenarios asked the respondent to assume that he personally has asthma and the other scenario asked him to assume that he spends time caring for someone (other than himself) who has asthma. The respondent was told that this other person was in one of three age groups: young child (2-5 years), teenager (15-17 years), or older adult (63+ years). The age groups were randomly assigned as described below. Each respondent saw only one age-specific hypothetical dependency scenario and was unaware of the age groups in other scenarios.

Each scenario has the same structure, beginning with a description of two methods that deliver asthma medicine but take different amounts of time for administration.[12] The slower delivery method is described as using a nebulizer to create a medicated mist that is inhaled through a mask and takes 10 to 20 minutes per dose. The second method proposes that the patient uses an inhaler, which delivers asthma

[12] Asthma treatment was described as follows:

> "Asthma cannot be cured, but doctors help many people with asthma control their symptoms using medications and other treatments. There are two different ways that some asthma medications can be delivered – one that is slower and one that is faster.
>
> The slower delivery method uses a device called a nebulizer. The nebulizer creates a mist out of the asthma drug which makes it easy and pleasant to breathe the drug into the lungs using a mask or mouthpiece. By taking slow, deep breaths, the medicine gets into the lungs.
>
> The faster method uses a device called an inhaler. The inhaler delivers the same medication as the nebulizer in less time. The two ways cost the same and have the same side effects.
>
> A doctor determines which delivery method is appropriate for a person with asthma. Many factors influence the doctor's choice of method, including the presence of uncontrollable asthma triggers. The doctor may recommend changing methods if the conditions that affect a person's asthma change.
>
> The way people take asthma medicine affects the amount of time they spend taking medicine as well as the amount of time they have available to do other things."

medication more quickly (1-2 minutes). Respondents were told that physicians prescribe the delivery method based on several factors including the presence of uncontrollable asthma triggers. Respondents were also told that the medications delivered using the two methods were similar in terms of price, side effects, and effectiveness.

Respondents were told that the asthma was moderately severe, requiring the use of a nebulizer and L^0 hours per week of the respondent's time to assist the person with the nebulizer. L^0 took on a value of 3 hours or 8 hours. One value was randomly assigned to each respondent. "Moderately severe" asthma was described by saying that without medicine the person would frequently experience asthma symptoms that would make it difficult to breathe, sleep, play, or exercise.

Respondents were told that a proposed new policy requiring cleaner industrial technologies in their area would reduce air pollutants and, as a direct result, reduce one important influence on the person's asthma. The improved air quality would allow the asthmatic to switch from the nebulizer to an inhaler, which would reduce the required amount of care-giving time. While the cost of medication would remain the same, the policy would reduce the respondent's weekly time commitment for managing asthma from L^0 (3 hours or 8 hours) to L^1, which was always described as one hour, saving $L^0 - L^1$ (2 hours or 7 hours) hours each week. Each respondent was also told that the policy will lead to higher electricity prices and increased income taxes resulting in increased monthly costs (T) of \$5, \$30, \$70, or \$150. Respondents were reminded that these costs would occur each month for many years and would be in addition to their typical monthly expenditures.

After viewing a table that summarized the key attributes of the choice, the respondents faced a double-bounded discrete choice question. The question was: "Would you support this policy and be willing to pay for it?" If the respondent said "no," then they were asked whether they would support and pay for the policy if the cost were reduced to one half the initially proposed amount per month. If the respondent said "yes" to the initial question, they were asked whether they would support and pay for the policy if the cost was twice their initially proposed amount.

The design involves four different choice attributes with levels as follows: age of the hypothetical dependant (young child, teenager, older adult), time savings due to the program (2 hours or 7 hours), monthly expenditure for the policy ($5, $30, $70, and $150) and the order of the scenarios (self first, self second). These attribute levels were combined to create 48 (=3x2x4x2) different versions of the questionnaire (see Table 1 in the Appendix). Respondents were randomly assigned to one of these versions. Each version of the questionnaire holds the values of L^0, L^1, and T constant across the two scenarios.

IV. Analysis and results

We test the general implications of our conceptual model in two ways. The first involves non-parametric tests that examine the impact of dependency relationships on stated choices for policies that change care-giving time absent a formal structure for the choice model. This approach avoids making more explicit the treatment of the income sharing issues we raised above. The survey design is structured to link the two choice occasions for each respondent, with questions varying only in whose health improves (i.e., the respondent or the dependent) as a result of the policy. Thus the design makes

explicit an issue that often goes unstated in traditional stated preference applications—the nature of dependency relationships among household members. If the nature of these relationships is unimportant, then there will be no differences across responses based merely on a difference in the identity of the hypothetical family member receiving care.

We conduct two types of non-parametric tests. Our first involves testing for differences in the response pattern for the "self" question and the "hypothetical dependent" question. For each such test, we first split the sample according to the hypothetical dependent question received by each respondent (i.e., child, teen, or older adult). Then we create categorical variables based on the sequence of responses, one variable for each choice question. Each categorical variable takes the value of one, two, three, or four based on a response sequence of yes/yes, yes/no, no/yes, or no/no respectively. Because responses to these questions are dependent (each respondent provides two of the categorical variables), we conduct McNemar tests. Separate tests are performed for "self" versus "child", "self" versus "teen", and "self" versus "older adult."

Our second set compares response patterns across all four types of questions, "self," "child," "teen," and "older adult." To do so, the data are pooled so that each respondent is represented twice. We conduct non-parametric χ^2 tests assuming independence of the responses for a given respondent. Features of our survey design including question order, bid levels, and the magnitude of the time savings could impact these findings. However, since all of these attributes are constant *for a given* respondent, they do not impact the McNemar tests.

While the non-parametric tests avoid the need to make specific assumptions about the choice model, they do not control for respondent characteristics, such as family size

and experience with asthma, that may lead to the observed differences in response patterns. Our parametric model, an interval regression model that uses the responses to the choice questions asked of each respondent to form the intervals, allows us to account for this heterogeneity. To illustrate the logic, let WTP_{ic} represent respondent *i*'s latent willingness to pay for the proposed policy change that affects the required care-giving time devoted to individual *c* where *c* denotes child, teen, older adult, or the respondent himself. WTP_{ic} is not observed by the analyst. Instead, the analyst observes two choices. These responses lead to the bounds. Thus if b_{1i} and b_{2i} represent the initial and follow-up bids respectively presented to respondent *i*, then :

(i) $WTP_{ic} \geq b_{2i}$ if respondent chooses yes for both questions;

(ii) $WTP_{ic} < b_{2i}$ if respondent chooses no for both questions;

(iii) $b_{1i} \leq WTP_{ic} < b_{2i}$ if respondent chooses yes for the first question and no for the follow-up;

(iv) $b_{2i} \leq WTP_{ic} < b_{1i}$ if respondent chooses no for the first question and yes for the follow-up.

Initial bids vary randomly across respondents and follow-up bids depend, as we described earlier, on responses to the initial bid such that $b_{2i} = 2b_{1i}$ if the response to the initial bid is yes and $b_{2i} = \frac{1}{2}b_{1i}$ if the initial bid receives a response of no.

The interval-censored (iii and iv), right-censored (i) and left-censored (ii) data that result from our interpretation of the responses suggest likelihood contributions for each

respondent based on his sequence of responses.[13] In estimating our proposed parametric models, we pool all responses so that each respondent makes two contributions to the likelihood function, one based on each double-bounded dichotomous choice question he answers.[14] Our basic empirical model assumes the latent WTP can be represented as follows:

$$WTP_{ic} = \beta_0 + \beta_1 n_i + \beta_2 \Delta L_i + \beta_5 c_i + \beta_6 m_i + \beta_7 x_i + \varepsilon_i \,. \tag{21}$$

where n_i represents the number of household members in respondent *i*'s household, ΔL_i denotes the change in required care-giving time, c_i is the identity of the individual receiving care, m_i is respondent *i*'s household income, and x_i is a vector of other variables hypothesized to affect WTP. The β s are parameters to be estimated and ε_i represents an error term.

Our conceptual model suggests that if respondents' choices are consistent with the underlying WTP described by equation (11), which results from the collective model, and a specific assumption about how respondents account for income reallocation, then we expect household income to be a significant factor in our parametric models. An insignificant coefficient on m_i would be inconsistent with this underlying (collective) WTP measure.[15] Note that in this parsimonious model we do not allow for interactions

[13] We use the intreg command in Stata 10.0SE to estimate these models. See Stewart [1983] for a description of interval regression and the associated maximum likelihood estimator.

[14] This analysis does not account for the correlation among responses that arises because each respondent contributes two responses to the parametric analysis. We use a robust covariance matrix for the estimated standard errors. This estimator corresponds to Stata's implementation of the Huber sandwich estimator for the interval regression model. This procedure offers an asymptotically consistent estimate for the effects of the selection term in the model but it does not fully address the correlation induced by correlation across the two questions asked of each respondent.

[15] Note that an insignificant coefficient on income would not permit us to distinguish between those WTP measures described in equations (15) and (20) and the WTP measure that would arise from a unitary model.

between household income and other factors such as c_i. Variations on this basic specification are discussed below.

The multiple-stage nature of KN's sampling procedures raises concerns of potential sample selection bias. Our data permit us to investigate this possibility for the final stage of the sampling procedure. To be specific, we can distinguish among those individuals who were invited to participate in our survey and chose not to (or failed to complete the survey) and those individuals represented in the final sample used in our parametric model. To formally correct for potential bias resulting from sample selection, we adopt a variant of Heckman's [1979] two-step procedure. First, we estimate a probit selection model where we hypothesize that selection into our sample depends on factors such as gender, race, education, employment status and income. Then, we use predictions from this model to form the inverse Mills ratio for each respondent and include this factor as an independent variable in our interval regression models.

As noted earlier, 2,110 of the 2,670 Knowledge Network panelists invited to participate did so. Thirteen observations had missing values for key variables and were subsequently dropped from the analysis. Table 1 summarizes the sample characteristics of the remaining 2,097 respondents included in the regression analyses described below. Fifty-one percent of respondents were female and the average age of respondents in our sample was 47 years. Almost one-third of respondents (31%) graduated from high school and 17% graduated from college. The majority of respondents (71%) identified themselves as white, while 11% and 12% reported that they were black or Hispanic, respectively.

While household size ranged from one to nine persons, most households were fairly small. Fifty-nine percent had 2 members or less (77% had 3 members or less and 91% had 4 members or less), and the average household size was 2.58 persons. Twenty-three percent of respondents were from households with only one adult aged 18 or older; 55% were from households with 2 adults; and 22% of households had more than 2 adults. One percent of households had at least one child under two years old; ten percent had at least one child aged 2 through 5; fourteen percent had at least one child aged 6-12 years; and twelve percent had at least one child between 13 and 17 years.

Most households represented by respondents in the sample own their own home (68%) and average annual household income was $52,872. Thirty-two percent of households earned $27,500 or less; 35% earned between $27,500 and $55,000; 27% earned between $55,000 and $112,500; and only 5% earned more than $112,500. Fifty-five percent of respondents were from dual income households and the majority worked full-time (60%). Seventeen percent of respondents were retired; 4% were unemployed; and 6% were disabled.

Table 2 indicates the patterns of respondent support for family members. Overall, about 47% of respondents indicated providing support in the form of time or money to at least one child, teen, or older adult; 30% of respondents indicated providing such support to a child, 16% to a teen, and 14% to an older adult. Within a given age category, the percent of respondents providing financial support and providing time support was fairly consistent except for the 18-55 and 63 years plus age categories. Nearly twice as many respondents provided financial support to adults aged 18 to 55 (17.5%) as provided time support (9.5%). Conversely, more respondents provided time support to older adults 63

years or older (9.6%) than provided financial support (6.2%). Of those respondents who indicated providing care for a family member, between 11 and 20 percent of those receiving care had been diagnosed with asthma. Asthma prevalence was slightly higher among adults receiving care.

Table 3 presents the results of one of three McNemar tests. The results presented in the table indicate significant differences between the response pattern for the "self" question and the response pattern for the "child" question (p-value = 0.00).[16] We also find significant differences between the "self" question and the "teen" question (p-value = 0.003; results not shown). However, the tests suggest no significant differences between the "self" question and the "older adult" question (p-value = 0.213; results not shown). Our second set of tests involve pooling the data and forming categorical variables based on the double-bounded responses for the different scenarios. We reject equivalence of the distributions of these variables, which suggests that dependency matters, provided the effect does not vary with the level of the WTP. This is further evidence of the potential importance of different types of dependency relationships.

Table 4 presents the results of our parametric analysis. The second column presents the results of the parsimonious model described in equation (21). First, we discuss the results with respect to measures of household income which, as discussed above permit a test of the collective model as represented in equation (11). We include four household income variables, "income1" through "income4," derived from a categorical household income variable (with 18 categories) provided by KN. Our household income variables allow the marginal effect of income to vary based on

[16] The χ^2 distribution is generally used to evaluate the McNemar test statistic as it provides an approximation of the exact sampling distribution, the binomial distribution [Sheskin, 2000].

household income class. They are created by interacting four dummy variables representing household income classes (less than $27,500; between $27,500 and $55,000; between $55,000 and $112,500; greater than $112,500) with a measure of estimated actual household income. Actual income levels were estimated by taking the midpoint of the 18 income intervals and then using a Pareto tail approximation to assign a point value for the open upper interval. The income classes assign approximately equal numbers of respondents to the first three groups. We investigated the correspondence of the groups to approximate income tax rates using Stata's marginal tax rate computation scheme. The lowest interval would be consistent with two marginal tax rates, the highest of which overlaps with the second income interval. The other two intervals have the same marginal tax rate. Three of the four income variables are positive and significant while "income1" is insignificant. However, the four variables taken as a group are jointly significantly different from zero (p-value = 0.00). These results suggest that respondents' choices are inconsistent with the unitary model.[17]

Other variables suggested by equation (21) include household size, which is negative and significant as expected, and the proposed reduction in care-giving time. Because the change in care-giving time takes only two values, we create a dummy variable, denoted "low time," which equals one if the response was based on the small reduction in care-giving time (from three hours to one hour) and zero if the large reduction (from eight hours to one hour) was assigned. As expected, a smaller reduction in the required care-giving time reduces willingness to pay. However, the effect is not significant at conventional levels (p-value = 0.134). To gauge the effect of familiarity

[17] We also estimated an alternative specification in which we replace our four income measures with a single measure of household income. The coefficient on this variable was positive and highly significant.

with asthma we include a dummy variable indicating whether or not the respondent or a family member had ever been diagnosed with asthma (based on the respondent's self report). As anticipated, the coefficient on this variable is positive and significant.

We use a set of dummy variables, "child question", "teen question", and "older adult question" to indicate the hypothetical household member associated with each response. The excluded category is the respondent himself. Inclusion of this set of dummy variables allows us to further examine the importance of dependency relationships among household members. The coefficients on these terms suggest that estimated WTP is higher for hypothetical changes that affect the dependent child's or teen's health relative to changes that affect the respondent's own health. However, there is no significant difference between responses based on older adult and self questions. Pair-wise hypothesis tests suggest significant differences between child and older adult (p-value = 0.000), and teen and older adult (p-value = 0.014) but no significant differences between child and teen (p-value = 0.253). These results are consistent with our non-parametric results and suggest important effects of different hypothetical dependency relationships.

The variable "current care-giver" allows an examination of the effects of existing dependency relationships on respondents' choices. Its coefficient is positive and (marginally) significant as expected. In order to further explore current relationships among household members that may impact respondents' choices, we include a variable indicating whether or not the respondent indicated belonging to a dual-income household. This variable is negative and (marginally) significant. This result may suggest

differences in the perceived reallocation of income resulting from the policy change between respondents in dual-income households and those in single-income households.

We include two variables in addition to those suggested by (21). The first variable, denoted "question1st," controls for possible ordering effects. This variable takes a value of one if the question associated with an observation came first in the survey and zero if the question came second. The negative and significant coefficient on this term indicates significant ordering effects that reduce WTP estimates for those responses based on first questions. The second variable represents a selection control resulting from the probit model of sample selection described above. Based on the results of this model, we compute the inverse Mills ratio for each respondent and include this as an independent variable in our WTP equations. The results of the selection model suggest that, relative to invited KN panelists who chose not to participate, respondents represented in our sample are older, from lower income households, and are more likely to be white and male.[18] The positive and significant coefficient on the inverse Mills ratio suggests significant selection effects. As we have seen above, neither the ordering nor selection effects confound our ability to test for the importance of different dependency relationships.

While the parsimonious model does not allow for interaction variables, our conceptual model, equation (11) in particular, does not preclude the possibility that interaction variables will be important in explaining differences in respondents' choices. Our second specification explores these effects by augmenting the first specification with various household income interaction terms. To be specific, we investigate whether the effect of differences in the age of the hypothetical household member receiving care on

[18] Full results of the selection model are available by request from the authors.

respondents' choices will vary with income. To do so, we create a set of 12 interaction variables among our household income variables, "income1" through "income4", and our three dummy variables identifying the hypothetical dependent as child, teen, or older adult. We do not report the coefficients on these variables because, taken individually, they are of limited interest. However, using combinations of the estimated coefficients on these interaction terms and non-interacted variables, we can test for differences in WTP estimates for child, teen, older adult, and self within various income classes. The third column of Table 4 reports the results of our second parametric specification. Note that with the inclusion of interaction terms, the interpretation of the coefficients on the income terms as well of those variables indicating question type varies between the two specifications. In the second specification, these coefficients cannot be interpreted independently as in the first specification.

The results of pair-wise hypothesis tests of differences in estimated WTP by hypothetical family member for different income classes are reported in Table 5. The results of these tests suggest estimated WTP is higher for the child question relative to the older adult question for three of the four income classes. We also find differences between estimated WTP for the child and self questions although the results vary with income class. Overall, the tests suggest that WTP estimates based on observed choices of those respondents in the highest income class do not seem to vary with the nature of the hypothesized dependency relationships. However, these distinctions become important at lower income classes.

V. Implications

The protocol used to set ambient standards for the criteria air pollutants focuses on the expected impact of each pollutant on a sensitive group. The standard is selected to protect an average member of that group under the premise that doing so will also protect all other, less sensitive, individuals. To the extent these sensitive individuals are cared for by other household members, benefit estimates should reflect these dependencies and how they might change in response to policies changes.

The recent findings of Bateman and Munro [2009] and Lindhjem and Navrud [2009] confirm that adult decision makers in a given household react differently to the same choice situation. This is true even when they are asked to answer for the household. A framework that accounts for variation in care-giving responsibilities across household members may help to explain these differences. Our analysis takes a first step at exploring how we might learn more about the relationship between dependency and choice.

We derive three expressions for WTP that imply a test for whether respondents consider household budget re-allocations when answering stated choice questions. We design a survey to focus a respondent's attention on a hypothetical dependent. We find that choices display properties that are inconsistent with a unitary model. Moreover, respondent's choices vary with the type of dependency. They also vary with the level of household income. This latter effect would not be present with a unitary model. The stated preference responses also display patterns that are consistent with treating them as situations the respondent took seriously. One indicator supporting this judgment is that a respondent's past experience with asthma and with care-giving influenced the decisions

he made. The observed response patterns also underscore the difficulty in using multiple stated preference questions in a single survey. Our empirical analysis suggests significant ordering effects. We find a significant selection effect for the Internet panel members who agreed to take the survey. However, these effects do not appear to influence our primary conclusions.

While our findings are encouraging, we believe several steps remain before it will be possible to frame stated preference questions that elicit household preferences in ways that allow identification of the budget allocation and choice processes. First, we need to consider the alignment between choices related to hypothetical versus real dependency relationships. Second, we require an improved understanding of how individuals evaluate the effects of policies that influence time or financial resources available to the household and internal reallocation activities. Finally, we need a clear method for asking who among household members participates in these reallocation decisions.

Table 1. Sample characteristics

Variable	Mean	Std. Dev.
Age (years)	46.82	16.88
Education dummy variables		
Did not attend high school	0.14	0.35
High school graduate	0.31	0.46
College graduate	0.17	0.38
Post graduate	0.12	0.33
Race dummy variables		
White	0.71	0.45
Black	0.11	0.32
Hispanic	0.12	0.32
Female dummy variable	0.51	0.50
Own home dummy variable	0.68	0.47
Occupation dummy variables		
Work full-time	0.60	0.49
Unemployed	0.04	0.19
Retired	0.17	0.39
Disabled	0.06	0.25
Homemaker	0.08	0.28
Work part-time	0.001	0.03
Household size	2.58	1.36
Dual income household dummy variable	0.55	0.50
Annual household income ($)	52,872	41,830
Income groups dummy variables		
$0-$27,500	0.32	0.47
>$27,500-$55,000	0.35	0.48
>$55,000-$112,500	0.27	0.46
>$112,500	0.05	0.22
Number of respondents	2097	--

Table 2. Percent of respondents providing support for family members in different age groups and the presence of asthma

Age group	Provide financial support for member in age group	Provide time providing care for member in age group	Household member in age group for whom respondent provides care (time or financial) has asthma
No time or financial support provided	52.5	53.3	N/A
5 years and under	15.8	18.1	11.5
6-11 years	15.5	16.0	17.2
12-14 years	9.0	7.9	17.2
15-17 years	9.0	7.2	18.8
18-55 years	17.5	9.5	20.9
56-62 years	2.1	1.9	19.5
63 years and more	6.2	9.6	13.8

Table 3. Results of McNemar test comparing response patterns for “self” and “child” questions

Responses to child question	Responses to self question				Total
	yes/yes	yes/no	no/yes	no/no	
yes/yes	188	34	10	8	240
yes/no	7	73	19	21	120
no/yes	5	13	54	24	96
no/no	4	6	104	239	217
Total	204	126	104	239	673

Symmetry (asymptotic) chi2(6) = 30.44, Pr = 0.000

Table 4. Interval regression models of willingness to pay for proposed policy change[a]

Variable name	Specification 1	Specification 2
Household size	-4.70* (-2.42)	-4.60* (-2.37)
Asthma	18.62* (3.92)	18.86* (3.98)
Low time	-6.48 (-1.50)	-6.19 (-1.44)
Child question	24.01* (3.73)	57.69* (2.65)
Teen question	14.96* (2.38)	7.16 (0.35)
Older adult question	-3.37 (-0.57)	-19.13 (-0.98)
Current care-giver	7.66 (1.67)	7.19 (1.56)
Dual income	-7.75 (-1.60)	-7.80 (-1.61)
Income1	-0.00016 (-0.37)	-0.00024 (-0.41)
Income2	0.00066* (3.48)	0.00068* (2.68)
Income3	0.00051* (4.97)	0.00050* (3.66)
Income4	0.00040* (5.67)	0.00048* (4.73)
Constant	17.39 (1.27)	16.43 (1.08)
Question1st	-19.83* (-4.54)	-20.30* (-4.65)
Inverse mills ratio	82.84* (3.34)	83.72* (3.37)
Household income interaction terms included?	No	Yes
Number of observations	4193	4193

[a] Numbers in parentheses are *z*-statistics for the null hypothesis of no association based on the robust covariance matrix. * indicates p-value of 0.05 or less.

Table 5: Results of pair-wise hypothesis tests for differences in WTP estimates based on responses to self, child, teen, or older adult questions by household income group[a]

	Self	Child	Teen	Older adult
Income class 1 ($\leq$ \$27,500)				
Self		0.006*	0.124	0.633
Child			0.275	0.066*
Teen				0.417
Older adult				
Income class 2 ($\in$ (\$27,500,\$55,000])				
Self		0.127	0.028*	0.505
Child			0.435	0.068*
Teen				0.016
Older adult				
Income class 3 ($\in$ (\$55,000,\$112,500])				
Self		0.009*	0.296	0.744
Child			0.157	0.012*
Teen				0.255
Older adult				
Income class 4 (> \$112,500)				
Self		0.526	0.200	0.271
Child			0.117	0.155
Teen				0.704
Older adult				

[a] Table reports p-values of hypothesis that estimated WTP based on responses to question in column one equals estimated WTP based on responses to question in row one.
* indicates significant differences at p-value of 0.10 or smaller.

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Appendix. Table of survey versions

Order of scenarios	Age of hypothetical dependent household member	Time savings	Program fee (T)	Version No.
Respondent first, then other household member	Young child (2-5 years)	7 hours	$5	1
			$30	2
			$70	3
			$150	4
		2 hours	$5	5
			$30	6
			$70	7
			$150	8
	Teenager (15-17)	7 hours	$5	9
			$30	10
			$70	11
			$150	12
		2 hours	$5	13
			$30	14
			$70	15
			$150	16
	Older adult (63+ years)	7 hours	$5	17
			$30	18
			$70	19
			$150	20
		2 hours	$5	21
			$30	22
			$70	23
			$150	24
Other household member first, respondent second	Young child (2-5 years)	7 hours	$5	25
			$30	26
			$70	27
			$150	28
		2 hours	$5	29
			$30	30
			$70	31
			$150	32
	Teenager (15-17)	7 hours	$5	33
			$30	34
			$70	35
			$150	36
		2 hours	$5	37
			$30	38
			$70	39
			$150	40
	Older adult (63+ years)	7 hours	$5	41
			$30	42
			$70	43
			$150	44
		2 hours	$5	45
			$30	46
			$70	47
			$150	48