Designing contingent valuation scenarios for environmental health: The case of childhood asthma

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Designing contingent valuation scenarios for environmental health: The case of childhood asthma[*][†]

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September 29, 2008

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Valuation of morbidity associated with childhood asthma is significant both to policy and to non-market valuation methodologies. Our results show that household perceptions and beliefs, such as belief in one's ability to predict and control asthma attacks, and relative perceptions of the overall burden asthma places on a family, have a larger impact on valuation than traditional measures of asthma severity. More generally, our approach can be applied to other chronic illnesses as well, such as diabetes or chronic pain.

1 Introduction

Valuation plays an important and increasingly visible role in the public health arena. Valuations of health states are required under many current policies, ranging from cost-benefit analyses of air quality regulations to evaluations of health program. In this context, developing the most accurate and efficient tools for health valuation is a high priority for the field of health economics.

It would be convenient if there were a single valuation approach and survey instrument that could be used to estimate the willingness to pay (WTP) for a wide range of conditions that are associated with human morbidity and mortality risks. If all human morbidity could be reduced to a set of attributes that can be varied independently, then this flexibility would allow a researcher to describe a large set of outcomes and the typical WTP associated with any condition that could be described by those attributes. Conjoint analysis of health states has been suggested as a methodology that could provide this level of comprehensiveness for health valuation (Johnson et al., 2000).

[*]The authors thank the lead researchers of the Fresno Asthmatic Children's Environment Study, Drs. Ira Tager and Kathleen Mortimer for their valuable input. Without their collaboration this research would not have been possible. This research was funded through the US EPA-STAR Valuation of Human Health Program (R-82966501, Valuing Reduced Asthma Morbidity in Children). This article has not been formally reviewed by the EPA. The views expressed in this document are solely those of the authors and the EPA does not endorse any product or commercial services mentioned in the publication.

[†]Paper presented in the Summer Workshop, **Health and the Environment**, Association of Environmental and Resource Economists, University of California, Berkeley, June 21-23, 2008. www.aere.org

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Despite the conceptual appeal of such a tool, however, there are substantial practical difficulties in using a single valuation instrument across a range of health conditions. Most fundamentally, all stated preference approaches rely on participants to make informed choices in the context of their real-life experiences; however, this means that the choices that are presented to them must be grounded in those experiences, and in the specifics of the health condition in question.

We set out to develop a health valuation methodology that accurately values the true impact of a health condition on the affected population by taking into account the subjective perceptions and experiences of that population. We chose to focus on childhood asthma because of its health policy significance and because it raises important methodological issues for non-market valuation. Asthma is a critical policy issue because of its large individual and social costs: in the U.S., 31.3 million people reported a positive diagnosis for asthma during their lifetimes (CDC, 2001) and the direct health care cost for treating asthma is almost $13 billion per year (Weiss and Sullivan, 2003). In addition, there is strong evidence that asthma is exacerbated by high levels of EPA's criteria air pollutants. Therefore, valuing welfare losses from asthma morbidity is critical for allocating funding to health programs and for evaluating air quality policies.

From a methodological point of view, asthma shares four important characteristics with a wide range of chronic illnesses. First, symptom frequency and severity are not constant and typically fluctuate over time. Second, health outcomes are dependent on both exogenous factors (e.g., ambient air pollution) and individual behaviors (e.g., preventative medication use). Third, except in extreme cases, asthma's overall impact on quality of life is determined less by physiological severity than by the family's experience and perceptions of the disease. Fourth, the burden of the disease is not evenly distributed over the population, and there can be great variation in the value placed on disease prevention or mitigation by different socio-economic groups. The heterogeneity of preferences makes it important and also challenging to value reductions in morbidity from these types of chronic illnesses, and particularly important to develop "best practice" guidelines similar to those established in environmental economics (see Arrow et al. 1993; Mitchell, 2002; Carson et al., 2001). Health valuations currently do not benefit from such guidelines (Hanley et al., 2003), and generally fail to adhere to the guidelines standard in environmental economics (Smith, 2003 and Diener et al., 1998).

In valuing reductions in morbidity from childhood asthma, we take heterogeneity of preferences into account by developing three components that are essential to a credible health valuation study: a strategy for identifying and sampling the population of interest, a realistic and relevant scenario, and a method to elicit measures of households' health beliefs and attitudes. In Section 2, we describe our overall approach to ground our valuation study in the relevant context. We describe our contingent valuation survey in Section 3. The econometric approach is described in Section 4, and results are in Section 5.

2 Grounding the contingent valuation survey in the health context

Any contingent valuation (CV) survey must be grounded in the context of the phenomena it intends to study. In the field of public health, this requires locating the research project in an appropriately representative population, adapting the survey to the attitudes and beliefs of that population, and designing a survey instrument that effectively isolates the benefits to be valued from confounding factors.

2.1 Population of interest

The first issue in conducting a valuation study is to identify the population whose valuations are of interest. The general consensus in the literature is that it is preferred to sample individuals who are personally familiar with the health outcome (Alberini et al., 1997; Ratcliffe et al., 2007). This is essential for a chronic disease, because it is difficult for one who is unaffected to appreciate the range of impacts that the disease has on the quality of personal and family life. For a reliable estimate of aggregate value, it is desirable that the characteristics of the people surveyed should reflect the distribution of these characteristics in the affected population. If empirical studies identify higher concentrations of specific health conditions or their associated morbidity, those differences in prevalence and morbidity are likely to be correlated with other unobserved factors that influence behavior.

Asthma does not affect the population evenly; indeed, it is routinely used as an indicator of health disparities. Previous studies have shown substantial disparities in the hospitalization rates for asthma by race/ethnicity and by income group (Claudio et al., 1999; Lin et al., 1999 and Koren, 1995). Even after controlling for socio-demographic variables within a Medicaid population, black and Hispanic children had worse asthma status—higher rates of hospitalizations, emergency room use, and school absences—than did white children (Lieu et al., 2002; Lask, 2003; Christiansen and Zuraw, 2002). These disparities in morbidity can be partially explained by differences in treatment - empirically, non-whites are less likely to be on appropriate preventative medications (Akinbami et al., 2002; Shapiro and Stout, 2002) and to have other asthma resources dictated by national asthma guidelines (de Vries et al., 2005) - but there is a poor understanding of why these differences persist.

Consider childhood asthma in California, the site of our study. Table 1 reports the distribution over race/ethnic groups of children ages 1-17 in the state (column two), children with active asthma (column three), and children who have had at least one asthma-related emergency department (ED) visit (column four). These statistics illustrate the relatively greater burden of active asthma and asthma morbidity on the non-white population (Meng et al., 2007).

Table 1. Distribution of childhood asthma over race/ ethnic groups in California

	General population (%)	**Active asthma** (%)	**One or more ED visit(s) for asthma** (%)
White/ non-Hispanic	43.1	48.0	41.0
Hispanic/ Latino	35.9	28.0	47.0
African American/ Black	6.7	13.0	11.0
Asian/ Asian American	12.8	10.0	NA
American Indian/ Alaskan	1.2	1.0	NA
Other/ missing	0.3	NA	NA

Source: Population data are from the U.S. Census. Data for rates of active asthma and ED visits are derived from estimates in Meng et al. (2007).

NA --- The statistic for emergency department visits for American Indian/Alaskan Native children was reported to be statistically unreliable. The statistic for Asian/Asian American children was not statistically significant.

Similarly, while the prevalence of active asthma varies inversely with income, the differences in morbidity are even greater: the rate of ED visits for the population below the federal poverty line is twice that of the rate for the population at 300% or more of the poverty line (Babey et al., 2007). This pattern is troublesome, as 18.8% of children ages 5-17 live in families below the poverty line (U.S. Census, 2003). A third relevant demographic characteristic is gender: childhood asthma is more common in boys than girls, whereas after puberty this switches and the prevalence is higher in women (Babey et al., 2006).

Previous researchers have suggested that greater attention needs to be given to heterogeneity in socio-economic characteristics of valuation samples. However, current literature does not reflect this need, for instance, Johnson et al. (2000) provide little demographic information about their sample. In Mansfield et al. (2006) and Rowe and Chestnut (1986) there is not enough information to compare the distribution of survey participants to the overall population. In Chestnut et al. (2006) the sample is on average more highly educated than the state as a whole, less likely to have children at home, and substantially more white. In O'Conor and Blomquist (1997) the sample is "predominantly healthy, white and female." Samples that are more educated or more white than the entire affected population provide information about WTP in one segment of society, but they do inform the full distribution of WTP across the population. However, it is typically very difficult in practice to put together a completely representative sample across the various population segments affected by these chronic illnesses. For research studies in general, recruiting has become increasingly difficult, with some participation rates dropping approximately twenty percentage points over the past two decades (Galea and Tracy, 2007). Recruiting in populations with the highest asthma morbidity is even more difficult due to barriers such as mistrust of outsiders (Corbie-Smith et al., 1999). One possible approach is to administer an economic survey to current participants in an existing asthma epidemiology study (as in Rowe and Chestnut, 1986 and Dickie and Gerking, 1991). This lowers the potential sample size because these epidemiology studies typically have relatively limited enrollments. But, it allows for richer access to the population of greatest interest. This is the approach adopted in our study.

2.2 Households' health beliefs and attitudes

Because participants' reactions to a CV survey are based on their existing beliefs and attitudes, the survey design must take into account those beliefs and attitudes. In the case of asthma, these vary widely across households. Households vary in whether they perceive asthma as a chronic disease or as a recurring acute condition (Halm et al., 2006) and in the degree to which asthma affects their quality of life (Fiese et al., 2008). Families also vary in their level of acceptance that a child actually has asthma, in their level of understanding that asthma is a serious health condition that can be treated (Zimmerman et al., 1999), and in their self-efficacy - their perception that their behaviors can make a difference in outcomes (Campbell et al., 2006 and van der Palen et al., 1997). Other sources of heterogeneity are the level of trust individuals have in doctors and the health care sector (Saha et al., 2003 and LaVeist and Nuru-Jeter, 2002) and perceptions of risk from environmental pollution (Johnson, 2002)[1].

There is a very low correlation between objective measures of severity and perceived severity (Rabe et al., 2004). Therefore, beliefs about disease severity cannot be inferred from objective data on symptom frequency: they must be measured directly. The case is similar for household understanding, acceptance, and perception of risk.

This finding has several important consequences for survey design and empirical estimation in health valuation studies. First, if researchers want to value asthma morbidity, they need to sample within households who recognize that their child's respiratory symptoms are related to asthma. This goal is facilitated by incorporating a valuation study into an existing epidemiological or health science study, because participants are more likely to be familiar with asthma symptoms. Second, in order to value quality of life impacts, those impacts should be measured directly from the household rather than inferred from symptom reports. Statistical tests can then be conducted to empirically evaluate the relative contribution to heterogeneity in WTP of symptom measures and quality of life impacts.

To create a CV scenario that elicits preferences over health outcomes and avoids the confounding effects of unobserved sources of heterogeneity, it is important to understand what attributes are consistent with households' pre-existing beliefs. Consider, for example, a valuation scenario that depends on improving air quality. If respondents vary in their perception of the risk of poor air quality, or in their preferences for public versus private tools to change asthma risks, it will be difficult to infer WTP for changes in health based on measured WTP for a government program to improve air quality. Similarly, scenarios that depend on a medical intervention or on a household's ability to implement new behaviors will evoke responses that reflect participants' levels of self-efficacy and trust in the medical system as well as preferences over health outcomes. Disentangling

[1] Surveys suggest that reported satisfaction with patient-physician relationships vary across race/ethnic groups and are positively associated with probability of high quality health care (Saha et al., 2003 and LaVeist and Nuru-Jeter, 2002). Johnson (2002) presents respondents with environmental related risks and replicates previous studies that found differences in generic perceived risks by gender and race/ethnicity. Self-efficacy, the perceived ability that one can take effective action, has been shown to be associated with both degree of asthma management (van der Palen et al., 1997) and physiological effects (Campbell et al., 2006).

the pure valuation of health is not easy. An alternative approach is to find a valuation vehicle that does not depend on factors such as self-efficacy. In addition, scenarios that value a change in a specific symptom may miss the attribute that is most important for the household — the overall impact on the family's quality of life.

While economists regularly discuss the importance of beliefs for determining behaviors, making these beliefs an integral part of data collection and scenario design is less common. The valuation studies of asthma-specific and general respiratory symptoms mentioned above do include health status and standard socio-economic indicators that are likely to be associated with preferences (age, income and education), but they do not incorporate perceptions of health behaviors or outcomes.[2]

2.3 Scenario development

A common concern in the health valuation literature is the validity of responses to hypothetical scenarios (see Smith, 2003; Diener et al., 1998; Van Den Berg et al., 2007; Lloyd, 2003[3]), but this concern is not unique to the field of health. The credibility of the scenario is essential to any contingent valuation study. Hanemann (1994) and Bishop (2003) provide insight into the development of CV methodology in the context of environmental economics, while Mitchell (2002) and Bateman et al. (2002) provide thorough discussions of essential development and implementation considerations. Bateman et al. (2005) consider the case of reducing the risk of skin cancer and advise that any valuation approach should describe the health impact in a manner that is realistic to the respondent and derive its sample from a population of individuals who are aware of or have experienced symptoms. Executing these design criteria remains the real challenge, and requires researchers to understand the physiological attributes of the condition being studied and how the condition is actually experienced in the household.

A key step in constructing a valuation scenario is to identify the relevant outcome. The environmental economics literature includes six published studies of asthma morbidity and/or respiratory outcomes. These studies vary both in how they define the outcomes and in their scenario design.[4] Asthma is a multifaceted disease that causes a variety of symptoms, such as coughing or wheezing, that vary over individuals. Rather than valuing individual symptoms, two studies use a contingent valuation question to value days with asthma symptoms. O'Conor and Blomquist (1997) present respondents with a detailed description of alternative asthma inhalers, which are consistent with actual inhalers that arrived on the market after the study. Their rich descriptions make this an almost ideal CV scenario, with the limitation being the difficulty of using a similar scenario in a population that may have unmeasured bias against using this type of medication. In contrast, Rowe

[2] The importance of health beliefs has been addressed in other health contexts. Alberini et al. (1997) noted that there is no reason to presume that the preferences that shape WTP for health outcomes are consistent across developed and developing countries and Krupnick et al. (2002) show that determinants of willingness to pay may vary over age.

[3] Both Smith (2003) and Diener et al (1998) conclude that most CV studies in health economics do not conform to guidelines for a robust CV study. Smith reviews 111 papers published in the period 1985-2000 and finds that the hypothetical devices in these studies were poorly constructed and described.

[4] None of the studies we discuss here were reviewed in Smith (2003).

and Chestnut (1986) use a broad scenario asking willingness to increase taxes to pay for "federal, state or local governments to set up programs that could reduce pollens, dusts, air pollutants, and other factors throughout this area that might reduce your (and your household's) bad asthma days by half." One difficulty with inferring WTP from this scenario is disentangling preferences for air quality improvement, reductions in asthma morbidity, and the payment vehicle (increased taxes). Both of these studies look at one aspect of asthma, the number of days with symptoms. To the degree that reducing symptoms reduces the psychological stress or worry caused by asthma, they do address overall quality of life, but neither scenario specifically values the broader psycho-social burden of the uncertainty and daily management associated with asthma.

Two studies value asthma-related impacts using conjoint analysis. Mansfield et al. (2006) focus on parents keeping a child indoors on high smog days as a type of averting behavior and estimate the willingness to pay to decrease this averting behavior. They use a choice experiment where respondents are asked to choose between two drugs that vary in their length of treatment, degree to which they change the length of safe sun exposure, and price. The trade-off presented in this scenario is consistent with that of using antibiotics and is likely to be familiar. The WTP estimates from this study capture one aspect of household behavior but not the full range of ways in which families are affected. Chestnut et al. (2006) estimate the WTP to avoid a hospital stay, which is one possible consequence of an extreme asthma attack, but not the only one. They start by explaining that new programs (including physical treatments, reduced exposure to environmental pollution and preventative care) may change the attributes of future hospitalizations. Then they present respondents with four pairs of choice alternatives that vary in the length of hospital stay, the days spent at home in recovery and the additional cost to the individual. Following these choices, an open-ended question is used to ask their WTP to avoid a future ten-day hospital stay with one day of recovery at home. This scenario has some credibility issues; there was a 17% non-response rate for the WTP question, and 36% of the sample agreed with the statement that they did not believe such programs existed.

Two other studies examine general respiratory symptoms. Alberini et al. (1997) ask a discrete choice WTP to avoid a future illness similar to the most recent illness experienced by the individual; however, they do not provide a description of the mechanism that would generate or eliminate the symptoms. Furthermore, it is difficult to compare the WTP for acute symptoms which a person may not expect to reoccur regularly to the stress and uncertainty associated with the knowledge that symptoms could reappear. Johnson et al. (2000) use the most flexible approach of all these papers. They present respondents with four attributes: symptoms (stuffy nose, eye irritation, fluttering in chest, coughing, coughing with fever, shortness of breath and swelling, pain in chest or arm), length of time with symptoms, activity restrictions and costs. Like Alberini et al. (1997), Johnson et al. (2000), do not provide an explanation as to why these attributes would vary or a context where people would be expected to make these types of trade-offs.

Furthermore, in the case of a chronic disease such as asthma, it is difficult to imagine these attributes varying independently. Indeed, people tend to describe a bad asthma day in terms of symptoms and changes in activity level. In our first survey of families with asthmatic children, the typical respondent used six to seven distinct impacts to describe an asthma exacerbation. The most common characteristics that parents used to define an asthma exacerbation were: wheezing, shortness of breath, excessive phlegm, fatigue, reducing the child's activity level, restricting the child's time outside, and child awakening at night. This set of physical and social impacts best described the impacts of asthma from the parents' perspectives. Even if asthma is defined only as physical symptoms, rarely does a single symptom present itself during an asthma exacerbation. The Fresno Asthmatic Children's Environment Study recorded 1,410 daily observations on asthma symptoms. Of those observations that reported a cough, 70% reported at least one other symptom. Typically these simultaneous symptoms were shortness of breath or congestion but they also included runny/stuffed nose or head cold. Only 8% ever reported shortness of breath without reporting additional symptoms, and only 1% ever reported congestion in isolation from other symptoms[5]. Existing quality of life indexes for asthma reflect the fact that people perceive asthma impacts as a clustering of effects (see Juniper et al., 2001).

In this study, our objective was to design a contingent valuation scenario that would be realistic and familiar to participants, and would accurately quantify the specific benefits that were important to them. This required an understanding of the attitudes and beliefs, behaviors, and risk and benefit perceptions of the affected population. We chose to use a household behavior survey to elicit this information, which we then analyzed to develop our criteria for designing the CV scenario. Without careful scenario design, heterogeneity in preferences over the health outcome of interest will be confounded by unmeasured heterogeneity for the preferences over the attributes of the scenario.

3 Study design

Our approach was designed to account for heterogeneity of beliefs and preferences mentioned above, and to be rooted in the reality of the respondents' actual experiences.

3.1 Population of interest

In order to identify a representative sample of the affected population, we combined our economic study of risk-reducing and -averting behavior with epidemiological and demographic data collected as part of the Fresno Asthmatic Children's Environment Study (FACES). FACES is a five-year epidemiological study of approximately 250 households with children ages 5-11 with clinically diagnosed asthma, funded by the California Air Resources Board. The primary focus of FACES is to evaluate the impact of environmental factors such as air pollution on the natural history of childhood asthma. FACES follows households over multiple years and incorporates the most detailed socio-demographic, indoor air quality and pollution monitoring data collection effort to date. Detailed health measures, utilization of health services, levels of antigens in the household and exposure to criteria air pollutants were collected as part of the study.

[5] These surveys are described in more detail in section 3.

Our sample of households who eventually participated in the contingent valuation scenario includes 152 observations. Descriptive statistics for Fresno County (U.S. Census, 2006 and Tager et al., 2006) and for the participants in the CV survey are in Table 2. The prevalence of asthma among children aged 1-17 in Fresno, CA is 16.4% (Meng et al., 2003), but by design all of our households include children with asthma. The slightly higher representation of boys relative to girls (58% boys) reflects the difference in prevalence by gender for this age group. The relatively larger proportion of black/African-American participants and relatively smaller proportion of white participants reflect the difference in prevalence and morbidity in the California population (Meng et al., 2007). It is difficult to compare the statistics for the Hispanic group because of differences in the format of data collection.

Although we would expect that the median participant to have a lower income than the population of Fresno County because of the inverse relationship between income and asthma morbidity (Babey et al., 2007), the income of our participants is distributed more towards higher income categories. However, the lower level of home ownership may reflect a lower level of total wealth. One area in which our sample may not be representative is the percentage of mothers/ maternal caregivers with a high school education. It is not clear to what degree this difference is due to sample selection or to differences in rates of positive asthma diagnoses by family education level. Given the empirical difficulties of recruiting in non-white, lower-income populations, we feel our sample is reasonably close to our population of interest — families with children with active asthma.

Table 2. Descriptive statistics for Fresno county and the sample

	Fresno County Population (%)	**CV Sample** (%)
Race/ Ethnicity		
White	62.6	53
Hispanic*	47.6	30
Black/ African American	4.9	12
Own home	56.6	35
Maternal caregiver has high school degree or higher	69	93
Income		
Less than $30,000	43.2	34
$31,000-50,000	23.1	28
$51,000 and above	33.7	38

Source: U.S. Census and authors' data.

* This category includes self-identified Hispanic, any race for the US Census data, whereas the FACES survey used mutually exclusive categories.

The majority of children with asthma do not suffer from the most severe cases; only a minority will ever have an incident extreme enough to necessitate a visit to the emergency room or hospitalization. 54% of the children in our sample fall into the classification of "persistent but mild" asthma, 30% are "mild intermittent," 15% are "moderate," and only 1% are "severe." (These classifications are based on the Global Initiative on Asthma (GINA).) Therefore, we are primarily interested in measuring and valuing the quality of life impact of asthma, not its most extreme consequences.

3.2 Scenario development

A central element in a CV study must be the construction of a credible valuation scenario that takes into account the beliefs and preferences of participants. As a first step in this process, we conducted a household behaviors survey that covered four domains: health status (description of symptoms including frequency and severity, quantity of health care utilization and activity limitations), attitudes and beliefs (perception of asthma triggers and risks, conception of asthma as chronic or acute disease, beliefs about local air quality), averting and mitigating behaviors (including preventative medical care, environmental modifications, changes in activities and any associated costs) and perceived risks and benefits of these behaviors, and household socioeconomic characteristics.

In addition, we conducted five focus groups (each with 4-6 participants) between July 2002 and May 2003. The goals of the focus groups were to understand the relevant health behaviors from the perspective of the household and to understand what influences the household's choices. As an introduction, we asked families to describe the history of the child's asthma. Questions and discussion topics were drawn from three models of health behaviors - the Health Belief Model, the Theory of Reasoned Action and the Theory of Social Cognition - and covered the following topics: perceived susceptibility and vulnerability to asthma; perceived severity of the disease; perceived benefits from taking action; perceived barriers preventing action; attitudes about health behaviors; subjective norms concerning behaviors; and self-efficacy (Glanz, Rimer and Lewis, 2002).

From the household behavior survey and the focus groups, we derived three key criteria for our CV scenario.

a) The scenario is not dependent on medication.

The households in our population had clear preferences over different health inputs: most notably, they had negative views of medications and strong opinions about their side-effects. Although a majority of households (87%, n=195) reported that their children took medications to treat asthma, 30% of all households had concerns about those medications. Although not statistically significant (p=0.11), minorities were more likely to express concern over asthma prescription medications than non-minorities (39% versus 26%); minorities were also slightly more likely to report that asthma medication either did not improve asthma symptoms or made them worse (20% versus 13%). A surprisingly common concern was that taking asthma medication as prescribed could lead to addiction or dependency on asthma medication (49% agree or strongly agree, n=187; 41% for non-minorities and 51% for minorities). Some households reported that they believed that having to take medications regularly was embarrassing to children (23% agree or strongly agree, n=189).

Second, there are likely to be unmeasured factors that determine how households evaluate the information they receive about medications. Within our sample, 17% of those prescribed a control medication were not taking the medication in the manner intended; of those prescribed a rescue medication, 43% were not taking the medication as intended. Minorities were less likely to take all medications correctly than whites (40% for minorities versus 57% for non-minorities). While the causes for non-compliance are complex and not well understood, it does suggest that using new medications for a hypothetical market may be affected by factors other than pure preference for health states.

These negative attitudes toward medication use are evident in many other health studies, reviewed in Hanemann and Brandt (2006) For these reasons, we determined that any CV scenario based on medication would be compromised by these negative attitudes and preferences.

b) The scenario responds to an asthma episode.

There was a clear indication in the focus groups that caregivers do not see a direct relationship between individual risk-averting or -mitigating behaviors and individual asthma triggers. Instead, an asthma episode is thought of as being a cluster of symptoms (e.g., sleeplessness, coughing, and wheezing) and sets of responses (e.g., giving medication, staying indoors, reducing activity). In the CV survey we included both an open-ended question and a prompted question asking participants to describe an asthma day. The descriptions fall into three broad groups: symptoms, prescriptions, and changes in activity. All respondents who used symptoms to describe asthma (38% of the sample) described at least two symptoms. This is consistent with findings in the public health literature in which families describe groups of symptoms (Young et al., 2002) and impacts on quality of life (Jones et al., 2002) rather than individual symptoms.

Because of the difficulty of isolating individual symptoms or responses, we needed to design a CV scenario that benefited participants by reducing the number of asthma days rather than the individual symptoms. The responses to the CV survey demonstrate that any proposal to vary symptoms independently would likely reduce the acceptance of the scenario.

c) The scenario addresses the impact on quality of life.

We found that the single most frequently stated behavior and the greatest family burden was the need to monitor the asthmatic child's health and environment. Many caregivers felt they had a better understanding of the relevant asthma triggers than did their child's medical care provider. For these reasons, families expressed little interest in a program for improved access to medical care providers or coverage for new pharmaceuticals. Based on these discussions, we knew that we needed to offer a commodity that would help monitor the child's health and environment, reduce asthma morbidity, and be acceptable to families.

These three criteria led us to construct a CV scenario different from those used previously in health valuations. Rather than presenting the respondent with a hypothetical policy change that would affect pollution or provision of health services and consequently the child's health, we decided to follow a more direct approach and present a health product that would be used by the family. We took this approach to avoid two sources of unobserved heterogeneity — the household's perception of the effectiveness of the policy and of the child's responsiveness to the desired change (either reduction of pollution or increase in health services). To avoid confounding the WTP response with pre-existing preferences over health inputs, we decided not to depend on any type of medication. Finally, we decided that our scenario should target not only the dominant asthma impact (pain to child) by reducing the number of asthma days, but also the second most important impact (parental stress from uncertainty).

We used the focus groups to refine our ideas and develop a specific health product to be used in the CV scenario. Parents were asked to assess the health products they currently used and their effect on their quality of life. A recurring theme was that uncertainty concerning their child's asthma status made it difficult to manage his symptoms. Many families described how a simple cold would lead to very bad asthma symptoms. A small subset of families had a daily peak flow meter to measure lung function, but the hassle involved with using the meter prevented them from using it regularly. We then asked parents to think about what type of information they would like to have about their child's asthma status. Two products that were mentioned were the pulmonary function tests that the children underwent as participants in the epidemiological study and the fingertip oxygen monitor used in medical offices. From these discussions, we concluded that we should offer a device that provided objective status information to households effectively and without additional effort.

To meet this need, we "designed" an oxygen monitor that could be worn as a watch and that would provide immediate, objective information about the child's asthma status (blood oxygen level). We chose the asthma watch in part because it was similar to a device with which our population was already familiar - the fingertip oxygen monitor - and about which people generally had objective factual information. Few people, if any, are confused about what a fingertip oxygen monitor does, or about what the information it produces means; of course, they can differ on how much they value that information. Another major benefit was that the asthma watch addresses not the medical symptoms themselves, but the uncertainty and stress that had a major impact on households' quality of life. While some caregivers believed there was no way to reduce the number or severity of asthma attacks, they still valued the information the watch could give them to reduce the uncertainty in their lives. Because the CV approach uses a synthetic trade-off for estimation purposes, it is only required that the scenario itself avoid the problem of constrained choice sets; the fact that participants may feel constrained in other aspects of dealing with asthma is no longer crucial.

We used the focus groups to elicit questions or concerns (no substantial concerns were raised) and to test different versions of the watch in order to ensure that it offered as direct a benefit as possible without raising complicating issues. (For example, if respondents had said they didn't want their children to know what time it is, we would have had to remove the time-telling feature of the device.)

In the final survey, individuals were presented with a brochure describing the hypothetical watch. The description specifically compared the watch to the actual oxygen monitor used in emergency rooms in order to provide a meaningful reference to the participant. The brochure explained that the watch would decrease the number of asthma days by 50%. The respondent was reminded of the number of days with asthma symptoms they reported in a previous section of the survey and the number of asthma days the watch would be expected to prevent. In our sample the mean number of days per week with symptoms was 2.64 and the mean number of bad days per week was 1.26. A 50% reduction thus translates to avoiding 69 days of symptoms per year, 33 of which are bad days, on average. The respondent was then asked whether he or she would be willing to pay certain specific amounts for the watch; each discrete willingness-to-pay question was followed by a certainty follow-up question. After a set of filler questions on whether they would like any free options, we concluded the survey with two open-ended questions to ensure the reliability of responses: "Do you think this watch could have other benefits aside from helping [child's name]'s asthma?" and "Is there anything else you would like to tell me about your child's asthma or the asthma watch we discussed today?"[6]

These final questions demonstrated that the scenario avoids any hidden utility effects that could bias WTP estimates. The only non-asthma benefit given was telling time (n=7 out of 152); the most common criticism was that the watch needed to be more stylish and available in more feminine styles (n=5 out of 152). The paucity of non-asthma benefits or concerns shows that extraneous factors did not play a significant role in the participant's willingness to pay for the watch. In addition, the scenario did not depend on any potentially problematic assumptions about changes in household behavior. The product description specified that no change in behavior was needed, and no respondent raised concerns about needing to change behavior. The description also explained how the information provided by the watch could make management easier by helping caregivers monitor asthma status and treat inflammation early, particularly when their child had a cold or flu (the trigger for the greatest proportion of the sample in the household behaviors survey). Because we knew about the specific concerns raised by households, we were able to design the product and the accompanying description to conform to their busy lifestyles and alleviate their concerns.

Careful attention to design of the CV scenario and information from the household behaviors survey and from focus groups led to a more realistic valuation commodity than previous studies have used for valuing respiratory outcomes. Respondents were very familiar with similar oxygen monitors in common usage (95% reported being familiar with a finger-clip style oxygen monitor), and 87% of respondents were interested in more information prior to being presented a price for the hypothetical product. Furthermore, at the end of each survey the interviewer evaluated the respondent on comprehension and thoughtfulness of response. The interviewers reported that 93% of the sample understood all questions and 96% responded thoughtfully to all questions. These

[6] In addition to being provided detailed instructions on administering the survey, the interviewers for the CV survey had a one-day training session conducted by the researchers in September 2005. The CV survey was then administered in person at the FACES office to the same sample that completed the prior household preference survey from October 2005 through June 2006. From February 2007 to April 2007 we attempted to contact any households that had not completed either the first household behaviors survey or the CV survey. An additional 20 households completed the CV survey in person, but no additional household behaviors surveys were completed.

high-quality responses are likely due in part to the design of the scenario itself.

3.3 Household health beliefs and attitudes

The public health literature on asthma beliefs suggests five ways in which beliefs may lead to heterogeneity in preferences. Two sources of heterogeneity that are not specific to asthma are trust in and satisfaction with the medical sector, and perceived risk of pollution. Based on the initial household behaviors survey we concluded that our sample did vary in these respects; therefore, we decided to avoid these sources of heterogeneity by offering a device that did not require interacting with the health care sector and that was not related to environmental quality. There are three potential sources of heterogeneity that are specific to asthma: beliefs that asthma is either chronic or acute; self-efficacy in controlling asthma; and perceived severity of the disease. Because these sources could not be directly minimized by the design of the scenario, we opted to explicitly measure these beliefs within our sample.

First we verified the extent to which households conceptualize asthma as a chronic condition. Our sample was very familiar with asthma, as 43% of the households had at least one parent/guardian with asthma, and 73% of the children have had asthma since before five years of age. We were reassured that a scenario that prevented symptoms was a good that would provide a perceived benefit to a family managing a chronic disease. We found that 59% of our sample characterized asthma as a condition that is always present, and 33% think of asthma as an illness that occurs in conjunction with another illness (e.g., colds, flu, allergies) or time of year. A smaller proportion falls into the "no symptoms, no asthma" mindset — 8% think of asthma as a condition that comes and goes.

Next we modified self-efficacy scales (Bandura, 2006) for our context, including measures of perceived effectiveness to both prevent episodes and treat an episode once it began. In our sample, 62% reported a high level of effectiveness in preventing symptoms and 39% reported a high level of effectiveness in treating episodes. Interestingly, those individuals who felt they could prevent an attack effectively were not substantially more likely to feel that they could control an attack once it started. The difference between self-efficacy to prevent versus control an ongoing attack may be partly explained by the difference between the perceived severity of asthma overall and the perceived severity of an attack. When asked to describe the severity of their child's asthma in general, 37% reported a score of mild to less than moderate and 67% reported a score of moderate to severe; of the former group, 80% rated an actual attack as moderate to severe. This finding is consistent with the fact that asthma, while chronic, has episodic symptoms; as a result, individuals may describe the overall status as relatively less severe than an actual attack because there are periods without symptoms. The number of episodes in any given month is a better measure of overall status over that month than the intensity of any one of those episodes. However, it may be the experience during these episodes that is actually relevant to household choice.

We asked multiple questions to characterize the experience of asthma by the household, such as whether or not the household worried between asthma episodes and how asthma ranks relative to other common stressors faced by families. We then compared the distribution of the responses to these questions to standard questions on symptom frequency. The households reporting that asthma is a primary stressor and the households reporting that they worry between asthma episodes had a higher median number of days with symptoms (4-12 versus 0-4 days) than those that did not rank asthma as the primary household stress or did not report worrying between episodes (chi-squared statistics of 0.08 and 0.004, respectively). Likewise those households that reported worry between episodes had a greater median number of days with bad symptoms (4-6 versus 1-4, chi-squared statistic of 0.08). There was no statistically significant difference in the number of days with bad symptoms by the rank of asthma as a stressor. Out interpretation is that although the experience, as reflected by the stress and worry due to asthma, is related to the frequency of symptoms, the magnitude of that relationship is not substantial. Put differently, the "quantity" of asthma morbidity is related to household's perception of asthma severity but does not fully reflect the qualitative effects. Instead the variation in these perception variables is because households differ in the intensity of their experience.

A standardized asthma severity measure was available from the epidemiology data for 106 out of 152 individuals (GINA, 2007). Table 3 directly compares our subjective measures of asthma with this standardized measure. In our sample 55% reported a severity level that was consistent with the objective measure. The remaining 45% either believe their asthma was less severe than the objective measure (11%) or believe that the asthma was more severe than indicated by the clinical measure (34%).

The inconsistencies between subjective and standardized measures of severity can be explained using the two variables describing the household's experience of asthma. The proportion of children who have a GINA classification of mild is approximately 84%; regardless of whether the household ranks asthma as a primary stressor or the household worries about asthma between episodes (chi-square statistics are 0.90 for asthma rank and 0.68 for worry). In other words, we cannot predict how the household perceives the significance or magnitude of asthma morbidity by asking symptom frequency or using clinical classifications. Therefore if we want to explain the variation in willingness to pay we need to elicit the household's perception directly.

Table 3. Subjective and standardized measures of severity

Clinical classification (%)	Self-defined classification (%)	
	Mild	Moderate to severe
Mild	50	34
Moderate to severe	11	5

We show below that these broader measures of the quality of life impacts do a better job at explaining the probability that a respondent is willing to purchase the hypothetical device than the more traditional measures such as frequency of symptoms.

3.4 Econometric approaches

We use the one-and-one-half-bounded dichotomous choice contingent valuation approach (Cooper et al., 2002) in which participants are presented with a range of possible prices for the watch $(\$A_l, \$A_u)$ with $\$A_l$ being the lower bound and $\$A_u$ the upper bound. Then, one of these two value is randomly selected and the respondent have to decide whether or not he is willing to pay this amount of money. If we start with the lower value ($\$A_l$) and the individual is willing to pay this amount, then he is asked whether he would pay the higher value $\$A_u$. If the individual is willing to pay the higher price, then we deduce that his maximum WTP is in the interval (A_u, ∞). On the contrary, if he refused to pay $\$A_u$, then his WTP is in the interval (A_l, A_u). If the person rejects paying the lower price, $\$A_l$, then the interview proceeds to the debriefing questions. In this case his WTP is in the interval $(0, A_l)$. In our application, we know that the WTP is greater than zero because only people with a positive WTP faced a willingness to pay question. We will exploit this property a little further in the Spike model below.

Similar intervals can be obtained for the surveys that started with an upper bound, and these intervals are $(0, A_l)$ for two consecutive negative answers, (A_u, ∞) for a positive answer and (A_l, A_u) for a negative answer followed by a positive answer.

For our analysis we use both a nonparametric Turnbull estimator and a parametric model to estimate a survival function and the mean WTP in the sample.

3.4.1 Turnbull's nonparametric estimator of interval-censored data

Following Carson et al. (2004), in the nonparametric framework we order the different bids presented in the survey as order statistics, i.e.

$$0 = A_{(0)} < A_{(1)} < A_{(2)} < \cdots < A_{(M)} < A_{(M+1)} = \infty,$$

where $A_{(1)}$ is the lowest bid presented in the survey, $A_{(2)}$ is the second lowest value, and so on. In our surveys this set of values is $\mathbf{A} = \{5, 15, 20, 30, 55, 60, 65, 80, 90, 100, 125\}$. By the properties of a distribution function we know that

$$0 < F(A_{(1)}) < F(A_{(2)}) < \cdots < F(A_{(m)}) < 1,$$

where F is a distribution function. The probabilities associated with each value are given by

$$p_1 = F(A_{(1)}),\ p_2 = F(A_{(2)}) - F(A_{(1)}), \ldots,\ p_m = F(A_{(m)}) - F(A_{(m-1)}),$$

where the regularity condition is $F(A_{(j)}) \leq F(A_{(j+1)})$.

In the context of the survey, people do not face these bounds in a sequential order, that is the interval (A_l, A_u) faced by each individual could be any combination of the values in $\mathbf{A}$ with the condition that $A_l < A_u$, therefore, several subintervals of $\mathbf{A}$ can be included in (A_l, A_u). For example, the combination $(A_l = 20, A_u = 65)$ contains the subintervals $(20, 30), (30, 55)$ and

$(55, 65)$. To account for this issue we define an indicator $\alpha_{ij} = \mathbf{1}\left\{A_l < A_{(m)}\right\} \cdot \mathbf{1}\left\{A_l \geq A_{(m)}\right\}$ that takes the value 1 if the subinterval $\left(A_{(j-1)}, A_{(j)}\right) \subseteq (A_l, A_u)$. This indicator function will tell us whether the actual intervals we use in the survey contain some of the intervals defined by the order statistics.

The likelihood function depends only on the M parameters defined by $p_1, ..., p_m$. Given these definitions the log-likelihood function can be written as (Gentleman and Geyer, 1994)

$$\log L = \sum_{i}^{n} \log \left(\sum_{j=1}^{m+1} \alpha_{ij} p_j \right).$$

We maximize this likelihood function subject to the constraints

$$\sum_{j=1}^{m+1} p_j = 1 \text{ and } p_j \geq 0 \quad \forall j.$$

Maximization of the likelihood function given these constraints produces the following Kuhn-Tucker conditions

$$\begin{aligned} \lambda_j p_j &\geq 0 \quad \forall j \\ \lambda_j &\geq 0 \quad \forall j \end{aligned}$$

$$\sum_{i}^{n} \frac{\alpha_{ij}}{\sum_{j=1}^{m+1} \alpha_{ij} p_j} + \lambda_j - \lambda_0 = 0 \quad \forall j,$$

the matrix of variance and covariance of these estimators is

$$Var(\hat{p}) = \left[\sum_{n=1}^{n} \frac{\alpha_{ij} \alpha'_{ij}}{\left(\sum_{j=1}^{m+1} \alpha_{ij} p_j \right)^2} \right]^{-1}. \tag{1}$$

Carson et al. (2004) suggest the following lower-bound WTP

$$WTP_L = \sum_{m=1}^{M+1} A_{(m-1)} p_m = A'_L p$$

and its variance is

$$var(WTP_L) = A'_L var(p) A_L = A'_L \left[\sum_{n=1}^{n} \frac{\alpha_{ij} \alpha'_{ij}}{\left(\sum_{j=1}^{m+1} \alpha_{ij} p_j \right)^2} \right]^{-1} A_L$$

Turnbull (1976) also suggests a self-consistent algorithm to estimate the probabilities p_j. The ML estimator is consistent, unique and equivalent to the self-consistent estimators. The self-consistent estimator could provide a solution of self-consistent points that are not the ML estimators (see Gentleman and Geyer (1994) for proofs of these properties). We estimated the coefficients using both approaches and they became indistinguishable as we reduced the level of convergence tolerance in the self-consistent estimator.

3.4.2 Parametric models

Traditional parametric model The nonparametric estimation is appealing since it does not require any assumption about the distribution of the willingness to pay. However, it does not allow for explanatory variables in the determination of the survival function or in the calculation of the willingness to pay. The only manner to evaluate the effect of covariates in the mean WTP is to estimate separate nonparametric models for subsamples of the data.

Parametric models for discrete choice models have been commonly used in CV, following either Hanemann's indirect utility function approach (Hanemann, 1984) or Cameron's valuation function (Cameron, 1988). We follow the first approach using the simplest indirect utility function given by $v_j = \alpha_j + \beta y + \varepsilon_j$, where $j = 1$ for the alternative when people buy the watch and $j = 0$ otherwise, y is the income of the individual and ε_j is an error term. It can be shown that the probability of a positive answer to the question "would you be willing to pay A_j" is given by

$$\Pr\{\text{ "}yes\text{"}\} = \Pr\left(\Delta v > \eta_j\right) = \Pr\left(C_j > A_j\right) = 1 - F_{wtp}(A_j)$$

where C_j is the true WTP, $\Delta v = \alpha - \beta A_j$, $\eta_j = \varepsilon_1 - \varepsilon_0$ and $F_{wtp}(A_j)$ is the cumulative distribution of C_j[7]. The mean WTP for this model is given by

$$E(C_j) = \int_0^{\infty}(1 - F_{wtp}(A))dA - \int_{-\infty}^{0} F_{wtp}(A)dA = \frac{\alpha}{\beta}$$

Other explanatory factors could be incorporated in the model through modification of α, say $\tilde{\alpha} = \alpha + \delta' Z_1$ and the welfare measure would be $\frac{\tilde{\alpha}}{\beta} = \frac{\alpha + \delta' Z_1}{\beta}$.

For the elicitation format used in our survey there are three possible results. Let A represent the design where the lower bid is presented first and B the design where the upper bid is presented first. Then a negative answer for design A is analogous to two negative answers in the design B, since they provide exactly the same information about the interval where C_j lies, that is, C_j is between zero and the lower bound in the survey. A *yes/no* combination in design A is analogous to a *no/yes* combination in design B. Finally two positive answers in design A are analogous to a positive answer in design B. These possible combinations and their probabilities are given by

$$\begin{aligned}
\overset{A}{\Pr}(no) &= \overset{B}{\Pr}(no, no) = \Pr(C_j < A_l) = F_{wtp}(A_l) - F_{wtp}(0) \\
\overset{A}{\Pr}(yes, no) &= \overset{B}{\Pr}(no, yes) = \Pr(A_l < C_j < A_u) = F_{wtp}(A_u) - F_{wtp}(A_l) \\
\overset{B}{\Pr}(yes) &= \overset{A}{\Pr}(yes, yes) = \Pr(C_j > A_u) = 1 - F_{wtp}(A_u)
\end{aligned}$$

[7] See Hanemann (1984) or Hanemann and Kanninen (1999) for details.

Let $nn_i = 1\{C_j < A_l\}$, $ny_i = 1\{A_l < C_j < A_u\}$ and $yy_i = 1\{C_j > A_u\}$ be the indicators for these three cases. The likelihood function for this model is given by

$$
\begin{aligned}
l &= \sum_i^N nn_i(1-ny_i)(1-yy_i)\ln(F_{wtp}(A_l)) + (1-nn_i)ny_i(1-yy_i)\ln(F_{wtp}(A_u) - F_{wtp}(A_l)) \\
&\quad +(1-nn_i)(1-ny_i)yy_i\ln(1-F_{wtp}(A_u)).
\end{aligned}
$$

Spike model Our survey design includes a question that classified people between those that are in the market, that is, people that would like to have the watch, and those that are not in the market, i.e. people that do not want to buy it. After we divide the sample into these two subsets, only people in the first group are presented with a question about their WTP. Had we asked people in this group the question about their WTP, the most likely result would have been a negative answer (no or no-no combinations), since their true WTP is equal to zero.

Given we can infer that their WTP is equal to zero, we could use this information to increase our understanding of the distribution of the willingness to pay. Kriström (1997) suggests a model that assigns a spike to the probability of having a WTP equal to zero. This probability is given by

$$
\Pr(WTP = 0) = F_{wtp}(0),
$$

let $S_i = 1\{C_j = 0\}$ be the indicator for this case, then the likelihood function is

$$
\begin{aligned}
l &= \sum_i^N S_i(1-nn_i)(1-ny_i)(1-yy_i)\ln(F_{wtp}(0)) \\
&\quad + (1-S_i)\, nn_i(1-ny_i)(1-yy_i)\ln(F_{wtp}(A_l) - F_{wtp}(0)) + \\
&\quad (1-S_i)\,(1-nn_i)ny_i(1-yy_i)\ln(F_{wtp}(A_u) - F_{wtp}(A_l)) \\
&\quad + (1-S_i)\,(1-nn_i)(1-ny_i)yy_i\ln(1-F_{wtp}(A_u))
\end{aligned}
$$

The welfare measure associated to the spike model is $E(C_j) = \ln(1+\exp(\alpha))/\beta$.

4 Results

In this study we have a rich amount of data on a limited number of respondents coming from a single geographical area. Furthermore there is a high degree of correlation among many of the explanatory variables, which limits the size of the models that we can estimate. Consequently, it is difficult to draw strong conclusions from the parametric and nonparametric statistical estimates. However, the results suggest some important factors that govern the distribution of willingness to pay. We discuss a subset of the potential explanatory variables that were particularly relevant.

Our first objective was to confirm that the scenario elicited household preferences for reducing asthma morbidity and was not systematically confounded by other beliefs about the device. After the valuation section of the survey, respondents were asked both closed-ended and open-ended questions on why they reported that they would or would not be willing to pay for the watch, how the product would benefit their family, and if they had any concerns. The overwhelming majority reported only asthma-related benefits (preventing an asthma episode or improved information); only seven respondents reported non-asthma benefits (the watch would also tell time). Only three respondents reported any concerns about accuracy and four reported that they were uncertain their child would wear the watch out of the total 152 completed surveys. The primary reason families gave for not buying the watch at the offered price was that the child's asthma was not significant enough to warrant the purchase (30 out of the 78 respondents who were interested said "no" to one or both prices), followed by budget constraints (29 out of the same group of 78). Of those who declined the watch, 63% would have bought the watch at another time when the child's asthma was worse than at the time of the survey. These responses provide assurance that participants saw the watch as a useful and relevant device and valued it based on its health impacts, not any other benefits or concerns.

Of those who were willing to buy the watch, there was one major theme: the benefit of improved information was cited 132 times out of 134 who were interested in the device. Improved information was valuable because it reduced anxiety about the child's health; the phrase "peace of mind" was used 17 times out of those 132 explanations. Other benefits of the information included educating the child to manage his asthma, enabling him to be more physically active, and verifying the child's asthma for school officials and other child care providers. Reduction of symptoms was cited only 5 times, and reduction in health care encounters and costs only 5 times out of the 132 comments of those interested in the device. The watch was described as "amazing" and "a good investment."

In all the models we estimated, the bid variable is of the expected sign and statistically significant. We therefore proceeded to use the information on household characteristics and beliefs to explain the probability that a household would be willing to pay the price offered for the device.

4.1 Comparison of groups by WTP

The definitions, means and standard deviations of the explanatory variables are in Table 4. After presenting the CV scenario, we asked the respondents if they would be interested in the device if it were available. Of the 152 respondents, 18 said "no" and their interview proceeded to the debriefing section[8]; for this group, their WTP is equal to zero ($WTP = 0$). The remaining 134 respondents were then presented a price using a one-and-one-half bounded dichotomous choice. 29 were not willing to buy the device at any price given, so $WTP < A_l$; 49 were willing to buy at the minumum price offered but not at the maximum, so $A_l \leq WTP < A_u$; and 56 were willing to buy at the highest price, so $WTP \geq A_u$. We compare the characteristics of these four groups.

Compared to the $WTP = 0$ group, the other three groups together ($WTP > 0$) had: a lower

[8] The rationale behind the screening question was two-fold. First, we hypothesized that some individuals are not interested in participating in the market, as is the case for some environmental amenities. Second this question addresses a request from study leaders that we provide a way for respondents to "opt out" of the CV scenario.

proportion of respondents reporting that their children were overall in excellent health (50% versus 19%, p-value 0.003); a higher proportion reporting that less than three months had passed since the most recent bad attack (28% versus 54%, p-value 0.039); a lower proportion reporting having mild asthma (72% versus 32%, p-value 0.001); a higher proportion reporting worrying about asthma between episodes (17% versus 43%, p-value 0.045); and a higher proportion ranking asthma as their primary family stressor (11% versus 35%, p-value 0.041). All of these indicate that, for the $WTP = 0$ group, asthma was less of a household concern than for other participants.

Next we compare the three groups where WTP was higher than zero ($WTP > 0$). Compared to the $0 < WTP < A_l$ group, the $A_l \leq WTP < A_u$ group had: a higher proportion reporting they were able to control an asthma attack once it started (25% versus 55%, p-value 0.006), and a lower proportion reporting physical activity as a trigger (47% versus 24%, p-value 0.045). Compared to the $A_l \leq WTP < A_u$ group, the $WTP > A_u$ group had: a higher proportion reporting being able to control an asthma attack (25% versus 48%, p-value 0.012); and statistically significant only at 10%, a lower proportion reporting mild asthma (41% versus 25%, p-value 0.09); and, again statistically significant at 10%, a higher proportion reporting worry between asthma attacks (37% versus 54%, p-value 0.084). These initial statistics indicate that the degree to which asthma dominates the household life influences the WTP.

Of particular interest is the contrast between the explanatory variables that have significance and those that do not, most remarkably measures of symptom frequency. In the health economics literature, severity or health status is typically measured using variables such as the frequency of symptoms over a defined period (e.g. number of days with symptoms) or a measure of health care utilization (hospitalizations, unscheduled visits to ER, wheezing, among others), which attempt to measure the objective nature of the asthma – frequency and possibly intensity of symptoms. However, these variables do not reflect how those symptoms are experienced by the family. Our results show that WTP depends less on objective measures of asthma severity and more on attitudes and beliefs - primarily perceived ability to control an attack, but also degree of worrying between attacks and importance of asthma as a family stressor.

This contrast reflects a phenomenon referred to in the health literature as "benchmarking" a person who experiences any type of morbidity regularly can become desensitized to those symptoms (Halm et al, 2006; Groot, 2000). In this case, a family whose child has symptoms on a regular basis may start to accept those exacerbations as a normal part of childhood. Indeed, a significant component of asthma education interventions is devoted to convincing families that frequent symptoms are not normal and should not be expected. This phenomenon is likely to be reinforced in communities where asthma is common and commonly under-treated.

Table 4. Descriptive statistics and definitions of explanatory variables

Name	Definition	Mean s.d.
Health Status		
Overall health	Overall health of child: 1 for excellent.	0.222 (0.417)
Bad days	Number of bad days with asthma: 1 for less than two a month.	0.556 (0.499)
Length	Term of length of time since last bad day: 1 for less than three months.	0.510 (0.502)
Severity of asthma	Severity of asthma in general: 1 for the lowest level.	0.366 (0.483)
Severity of attacks	Severity of an attack: 1 for the lowest value.	0.078 (0.270)
Symptom frequency	Number of days with symptoms: 1 for up to one symptom a week.	0.497 (0.502)
Attitudes and Beliefs		
Prevent attack	Do they think they can prevent an attack? 1 for yes.	0.621 (0.487)
Control attack	Do they think they can control an attack once started? 1 for yes	0.392 (0.490)
Worry	Do they worry about asthma between episodes? 1 for often or sometimes.	0.399 (0.491)
Typical	Are current symptoms typical for child? 1 for yes.	0.248 (0.433)
Asthma rank	Do they rank asthma as the primary stressor? 1 for yes.	0.320 (0.468)
Asthma parents	Has a parent been diagnosed with asthma? 1 for yes.	0.431 (0.497)
Triggers	Do parents report that physical activity is a trigger for asthma? 1 for yes.	0.399 (0.491)
Demographics		
Income	Is income<$40,000/yr? 1 for yes	0.458 (0.500)
No Rx	Has child foregone a RX because of price? 1 for yes.	0.255 (0.437)
Financial stress	Do they rank family finances as primary stressor? 1 for yes	0.229 (0.421)
Race	Does parent report white/Caucasian as child's race/ethnicity? 1 for yes	0.118 (0.323)
Mom's Education	Does mother have less than average education? 1 for yes	0.438 (0.498)
Gender	Is child male? 1 for yes	0.588 (0.494)
Parents' overall health	Is parent in excellent health? 1 for yes	0.183 (0.388)

Our results suggest that measures of attitudes, beliefs and self-efficacy play an important role in preferences and WTP. Furthermore, the differences in standard socio-economic indicators (income, education and race) do not appear to be statistically significant across responses. With these data we cannot discern whether this result is an artifact of the small sample size and collinearity in explanatory variables, or an actual property of the underlying preferences.

4.2 Parametric models

Table 5 presents the estimates of the parametric models. We took three approaches to the segmentation introduced by asking if the respondent was interested in the device. First, we excluded these 18 observations and estimated the discrete choice models only for those individuals who were presented prices (Model One). Second, we coded these 18 responses as saying "no" to the lower bid or to both the higher bid and the lower bid, depending on which survey version they received (Model Two). Third, we used these individuals to define a spike at zero (Model 3). For each model, we compared two specifications: (a) a simple model with only the bid as an explanatory variable; (b) a full model which adds health status and beliefs to the bid. The sign and statistical significance of the bid variable are as expected. Models 2 and 3 are essentially equivalent in terms of the sign, magnitude and statistical significance of the bid, health status and beliefs variables. If respondents who said they were not interested in the device at any price either are coded as "no-no" responses in a parametric model or are modeled using a spike; the variables for health status and beliefs are statistically significant. If those observations are excluded, these variables are not statistically significant. This pattern suggests that these factors explain the segmentation of the sample between those with zero WTP and those with a positive WTP. Overall, the results of the parametric models are consistent with the comparisons across groups by WTP discussed above: the probability of being willing to pay for the device is higher if the child has a lower level of overall health, asthma is ranked as a primary stressor, the respondent feels he or she can control an asthma attack once it started, or the respondent reports worrying about the child's asthma between episodes.

Table 5. Parametric models

	Model (1) Excluding WTP=0		**Model (2) WTP=0 are no-no**		**Model (3) Spike Model**	
Variable	**Simple**	**Full**	**Simple**	**Full**	**Simple**	**Full**
CONSTANT	2.802**	2.552**	2.309**	1.904**	1.793**	1.334**
t-value	(9.380)	(5.851)	(6.020)	(6.318)	(7.636)	(4.655)
Bid	-4.39**	-4.719**	-4.140**	-4.651**	-3.240**	-3.624**
t-value	(-10.00)	(-9.999)	(-7.856)	(-11.242)	(-10.077)	(-10.150)
Overall health	-	-0.425	-	-0.642**	-	-0.741*
t-value	-	(-1.116)	-	(-1.651)	-	(-1.899)
Control attack	-	0.4659	-	0.597*	-	0.662**
t-value	-	(1.264)	-	(1.766)	-	(2.006)
Worry	-	0.441	-	0.623*	-	0.590*
t-value	-	(1.152)	-	(1.730)	-	(1.709)
Asthma rank	-	0.912**	-	1.136**	-	1.044**
t-value	-	(2.248)	-	2.915	-	(2.804)
Estimated spike	-	-	-	-	0.143	0.119
N	134	134	152	152	152	152
Log-likelihood	-151.70	-144.57	-199.26	-186.79	-193.78	-181.27

*** and ** significant at a 10% and 5% respectively.**

The valuation scenario implies that the device reduces morbidity by providing information on which the family can then act. Those people who have the need for such information and believe they can put this information to use to reduce symptoms naturally have a greater WTP than those who believe there is nothing they can do about an attack. Note that the latter is a statement about the person's belief regarding the effectiveness of her own action, not her belief about the effectiveness of the device itself.

These results are suggestive of the complicated role that beliefs play in forming preferences. The child's overall health does affect the choice, but indicators of the burden of asthma on the family are of equal if not greater importance.

4.3 Estimated WTP

The estimated mean WTP derived from the parametric and nonparametric models and the marginal effects of the explanatory variables on the WTP are reported in Table 6. The mean WTP ranges from \$55.77 (assuming $WTP = 0$ are a no-no combination with the simplest explanatory variable formulation) to \$64.20 (excluding $WTP = 0$ with other explanatory variables). The comparable mean WTP from the nonparametric Turnbull model is \$65.50 with an standard deviation of 5.33.

The differences in the parametric models' willingness to pay by the explanatory variables are at the bottom of Table 6. To assess the relative influence of a binary explanatory variables on the mean WTP we calculated the difference in WTP when $Z_i = 1$ and $Z_i = 0$. For Models 1 and 2, this difference simplifies to $E(WTP_1 - WTP_0) = \delta_i/\beta$. In the standard models, regardless of how the $WTP = 0$ observations are treated, the dominant factor is whether or not asthma is ranked as the most important household stressor. Those households that rank asthma as the primary stressor are on average willing to pay approximately \$20 more than those who do not. If those households with $WTP = 0$ are excluded, then difference in expected WTP is roughly the same magnitude across the remaining explanatory variables (recall that overall health, control and worry were not statistically significant). If households that have $WTP = 0$ are coded as answering "no-no" to the bids then the magnitude of the difference in mean WTP is roughly \$10 (report worrying between episodes) to \$16.76 (report excellent health). These results most likely reflect the importance of those variables beyond the rank of asthma in differentiating those households with $WTP = 0$ from those with non-zero WTP. In the case of the spike model, the difference in WTP for the binary explanatory variables, say Z_1, simplifies to $E(WTP_1) - E(WTP_0) = \beta^{-1} \ln \left(\frac{1+\exp(\alpha+\delta_1 Z_1+\delta_2 Z_2+\delta_3 Z_3+\delta_4 Z_4)}{1+\exp(\alpha+\delta_2 Z_2+\delta_3 Z_3+\delta_4 Z_4)} \right)$. Consequentially the magnitude of the difference is smaller for all variables, but the pattern is similar to that for the case where $WTP = 0$ are coded as "no-no" replies.

Table 6. WTP estimates and marginal effects of explanatory variables

	Model (1) Excluding WTP=0		Model (2) WTP=0 are no-no		Model (3) Spike Model		Model (4) Turnbull Model
	Simple	Full	Simple	Full	Simple	Full	
Mean WTP	63.82	64.20	55.77	56.09	60.10	59.60	65.5
(s.d.)	(3.90)	(3.78)	(3.84)	(3.51)	(3.87)	(4.15)	(5.33)
				Changes in WTP			
Overall health		-9.01		-16.76		-10.69	-9.61
Control attack		9.87		14.25		6.58	13.42
Worry		9.34		10.67		4.69	22.62
Asthma rank		19.34		21.55		7.43	25.6

The last column in Table 6 presents nonparametric WTP estimates by subgroups, splitting the sample according to the four explanatory variables that were significant in the parametric models. The survival functions are Figures 1 to 4 in the appendix. The directions of the differences are as expected and consistent with the differences by the binary variables for the parametric models. In the nonparametric case, there is not an equivalent to testing the significance of individual parameters. Therefore we use a simple t-test for each pair of means defined by the binary variables. There is a statistically significant difference in the means for two explanatory variables, asthma rank and worry. Households that rank asthma as a primary stressor are willing on average to pay \$80.98 (s.d.=\$7.73) whereas families that do not rank asthma first are willing to pay only \$55.38 (s.d.= \$6.25). Similarly, households that worry more about asthma between episodes are willing to pay \$74.64 (s.d.=\$7.14) and those that do not worry are willing to pay \$52.05 (s.d.=\$6.73).

These results further substantiate our hypothesis that the overall importance of the child's asthma in the household critically affects the WTP for the contingent valuation scenario. It is possible that once the issues surrounding asthma morbidity and/or management reach a threshold of prominence the willingness to pay function is shifted upwards. This has a larger impact on WTP than the other explanatory factors such as price, income, and health status. Our small sample size makes it difficult to statistically test whether the two groups are structurally different and whether the data should be pooled across the groups. However, Figure 2 shows that the survival function for those who rank asthma as a primary stressor is always above the survival function for the other households, possibly suggesting that there may be two corresponding groups of preference functions. The same is true for those who worry about asthma between episodes.

An unusual case is the estimated survival functions for the respondent's belief that he or she can control an attack once it begins. Below a bid of \$60, those who believe that they cannot control an attack have a higher probability of saying "yes," whereas the opposite is true above a bid of \$60. This switch may be due to a small sample size, or it may reflect a more complicated relationship between individuals' self-efficacy and the perceived value of the device. Recall that the device works by enabling parents to be pre-emptive. One interpretation of this survival function is that, at a lower price, those who do not feel they can control an asthma attack are still willing to buy the device solely for the information it could provide. At a higher price the value of information alone is not sufficient because those with low self-efficacy do not derive the health benefit. In other words, if I currently cannot control an attack the benefit of the information alone may be worth less than \$60, but because I do not think I can effectively use the information I am not willing to pay more than \$60.

As discussed in Section 2, we paid particular attention to designing a CV scenario that would not confound WTP for reduced morbidity with unobserved factors that are correlated with socio-economic variables, most importantly race/ethnicity. Race was not statistically significant in the parametric models, and income falls out of the WTP expression. Therefore we calculated the difference in mean WTP using the Turnbull model by race and income. The difference in mean WTP between white versus non-white groups is \$7.07 and was not statistically significant (t-value=0.75). The difference between households making more than \$40,000 from those making less than that amount is \$5.94 (t-value=0.59). The survival functions by income and race are consistent over the bids, and the curves are very close to one another. Taken with the careful review of the comments and responses to open-ended questions, we feel that we met our objective of a relatively neutral CV tool.

4.4 Willingness to pay of zero

In asking the screening question, before presenting a price, we could separate out those individuals who would not want to participate in the market. In retrospect, child's health is likely to always be considered a valuable good (indeed others have found that parents are willing to pay more for children's health than own health. See Dickie and Gerking, 2007) and this question could obscure the difference between those who say "no" because they are rejecting the scenario and those who have a true zero willingness to pay because the scenario does not offer a benefit to them. To differentiate between these two motivations, we looked at the replies to every open-ended question about the scenario and the child's asthma severity. Of the 18, only two mentioned they had concerns about the effectiveness of the design: one parent doubted their child would wear such an unstylish watch and one parent rejected the concept. The remaining 16 all explained their "not interested" response by describing their child's asthma as mild or under control. Our interpretation of these 16 observations is that they have a true WTP of zero because the level of uncertainty they have regarding the child's asthma was sufficiently limited that they had no value for additional information. Note that this does not imply they have a zero WTP for an actual reduction in morbidity.

4.5 Comparison to Previous Literature

This scenario differs from previous CV scenarios used in health valuations in three dimensions. First, rather than presenting the respondent with a hypothetical policy change that would affect pollution or provision of health services and subsequently the child's health, our scenario presents a health product that would be directly used by the family. We took this approach to avoid two sources of unobserved heterogeneity — household perceptions of the effectiveness of the policy and of the child's responsiveness to pollution. Second, to avoid confounding the willingness-to-pay (WTP) response with pre-existing preferences for health inputs, our scenario does not depend on any type of medication. Third, our hypothetical scenario targets both the obvious asthma impact (pain to child) by reducing the number of asthma attacks and a dominant quality of life impact (parental stress from uncertainty) by providing objective information.

The two most comparable studies are Rowe & Chestnut (1986) and O'Conor & Blomquist (1997). We find that the mean willingness to pay to avoid a single day with symptoms is $9.75-$11.39, and the mean willingness to pay to avoid a single day with bad symptoms is $20.40-$23.82. Our estimates are consistent with the Rowe and Chestnut estimates of a willingness to pay of $22 to avoid a single day of bad asthma symptoms (all estimates from prior literature are converted to 2007 dollars using the CPI) .

We had expected our estimates would differ because Rowe and Chestnut study used a general scenario in which a government (local, state or federal) would reduce pollen, dust, air pollution and other asthma triggers by an undetermined mechanism. While our scenario was designed to focus the households only on asthma symptoms, the Rowe and Chestnut scenario elicited preferences for environmental amenities and a range of symptoms that are often related and confounded with asthma, such as allergies. The similarity may be due in part to the fact that both scenarios reduced symptoms by the same amount (50%) and that the samples were similar in their reported frequency of symptoms — the Rowe and Chestnut had a mean reduction of 37 bad days whereas our mean reduction in bad days was about 33.

Using two alternative hypothetical drugs to treat symptoms, O'Conor & Blomquist estimate a willingness to pay for a 100% reduction in symptoms. Based on the results they report, their sample is on average willing to pay $36-47 per day of symptoms avoided and $67-89 per bad symptom day avoided. We expected a difference between the two estimates because our sample differs markedly on socioeconomic variables. The O'Conor and Blomquist sample was predominately white, well-educated females with a higher mean income than the US mean and without children with asthma. Unlike their sample, households in our study all had with children with asthma, were racially mixed, had a wide range of education, varied in the language spoken at home, and had a mean household income lower than the US mean. It is reasonable to believe that our sample's mean WTP would lie below the O'Conor and Blomquist range due to a lower mean ability to pay relative to households in their sample. The explanation for the magnitude of the difference is less clear. One conjecture that is consistent with our findings is that the marginal utility from morbidity reduction is not constant. Our study evaluates a 50% reduction whereas O'Conor and Blomquist evaluate a 100% reduction. Households may be willing to pay a premium to move to a state of 100% control, thus eliminating asthma from being a household concern.

5 Conclusions

Valuation of health states and morbidity is always challenging, but this is especially true of chronic, poorly understood conditions. Consider, as an alternative to asthma, the more common phenomenon of occasional back pain. Two people with the same income and socio-demographic variables could experience the same number of "symptom days" of back pain but may have very different perceptions of their ability to predict what triggers will cause episodes of pain, and of their ability to manage the pain once it occurs. These people will probably have very different overall assessments of their back pain, and may place different monetary values on a day free of symptoms. To take the analogy further, they might have very different expectations for different treatment routines (pills, injections, acupuncture, deep tissue massage, etc.), and therefore the value one would elicit in a contingent valuation scenario could depend heavily on which type of treatment one suggested in the valuation scenario.

In short, chronic medical conditions reveal considerable heterogeneity of preferences across their affected populations, and this heterogeneity creates complications for valuation studies. Our valuation of asthma morbidity in this study confronts this problem by explicitly measuring and accounting for these variances across households suffering from the same disease. First, because both morbidity and perceptions of a disease may be unevenly distributed across the population, we use a sampling design to ensure that groups with the highest morbidity are covered. Second, we measure those health beliefs and behaviors that may produce differences in prevalence or in morbidity. And third, we use household perceptions of health states and of the factors that affect health states to inform our CV scenario to ensure that it is credible to survey participants and that participants' choices are not unduly affected by unintended attributes of the scenario.

Our results show that household perceptions and beliefs, such as belief in one's ability to predict and control asthma attacks, and relative perceptions of the overall burden asthma places on a family, have a larger impact on valuation than traditional measures of asthma severity. More generally, our approach can be applied to other chronic illnesses as well, such as diabetes or chronic pain. By improving the tools available to health economists, we hope to contribute to establishing a sounder basis for policy decisions in the field of public health.

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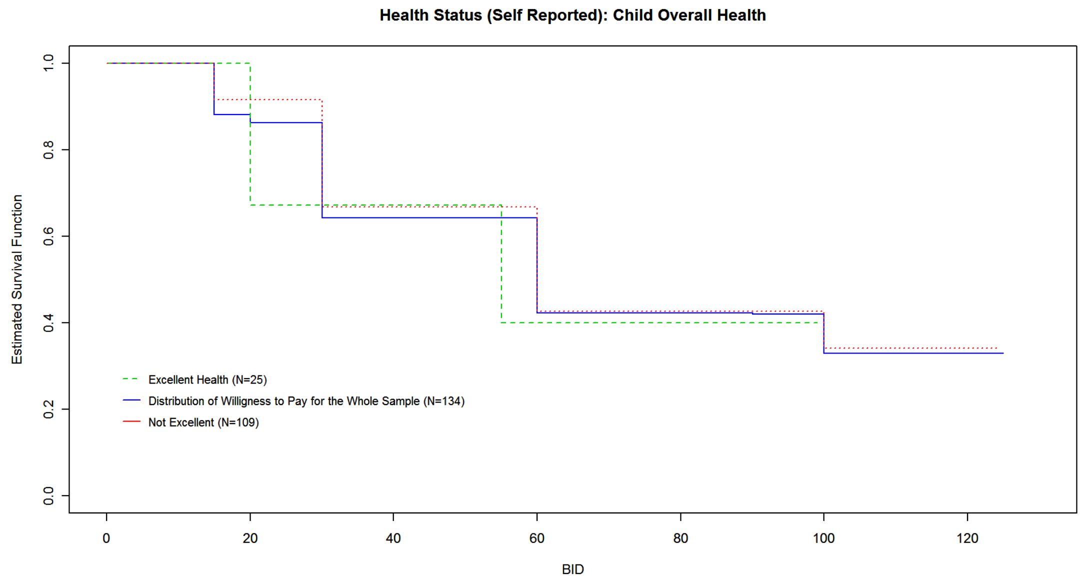

Figure 1

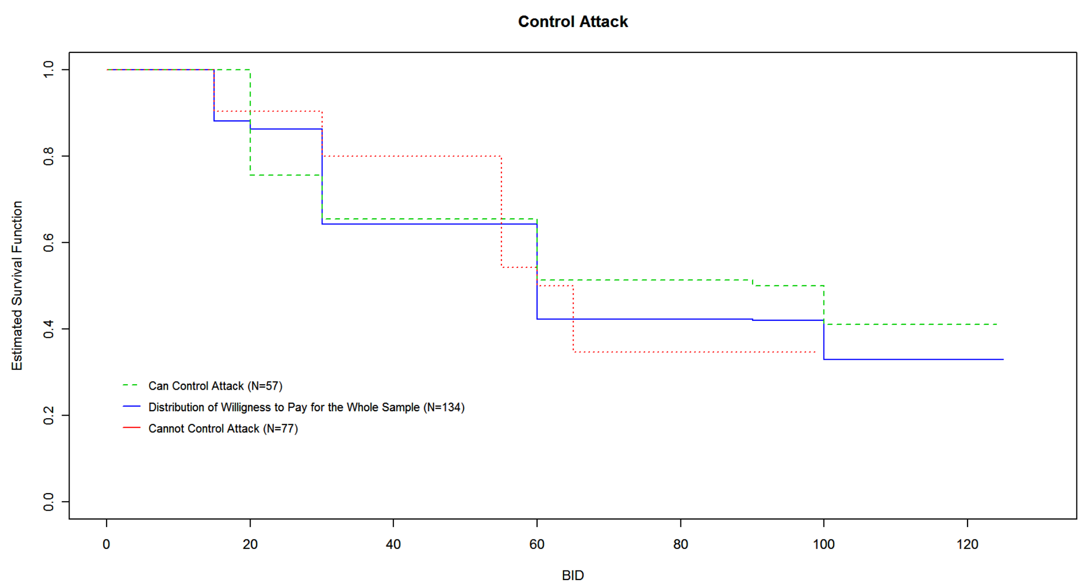

Figure 2

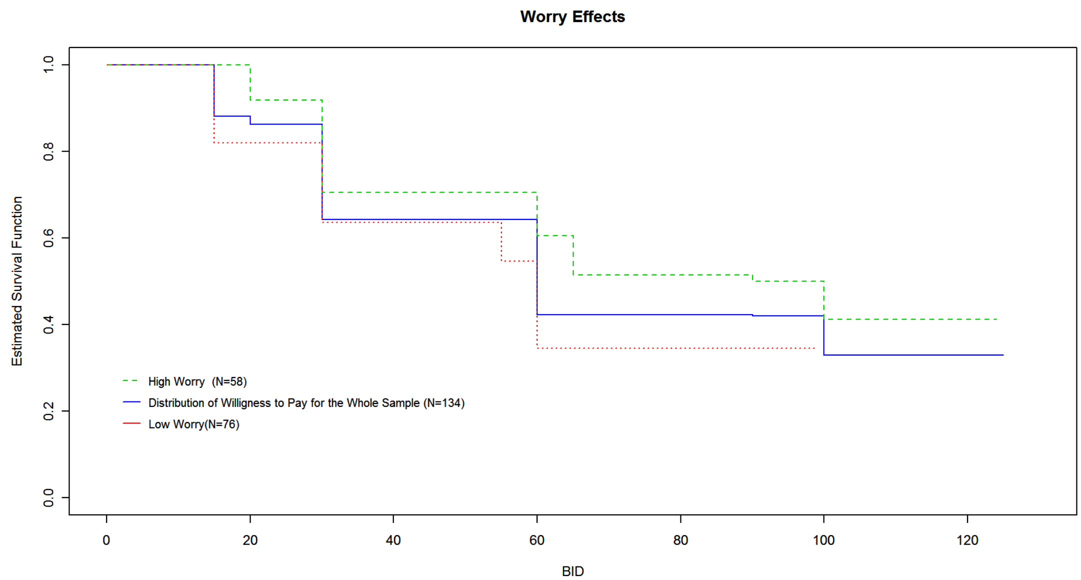

Figure 3

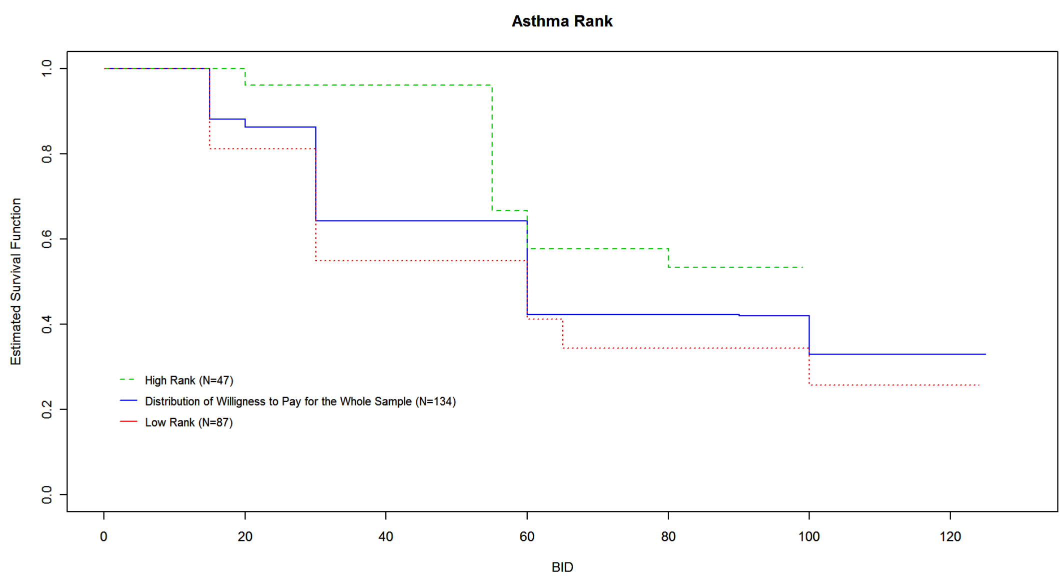

Figure 4