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ARTICLE

Valuing a Reduction in the Risk and Severity of Asthma: A Large Scale Multi-Country Stated Preference Approach

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Abstract
Asthma is a non-communicable and non-curable lung disease that affects 10% of children and 4% of adults worldwide and is associated with an array of environmental contaminants and chemicals. This article offers values suitable for use in cost–benefit analyses of the willingness to pay (WTP) for reduced severity of asthma in adults and children and in reduced probability of getting asthma for these two population groups, all in the context of reducing chemical exposures. To this end, an online survey was administered between November 2021 and May 2022 to 12 727 respondents from seven countries of the Organisation for Economic Co-operation and Development (OECD). This article applies two stated preference methods for eliciting WTP: the contingent valuation method for reduced asthma severity and choice experiments for reduced probability of getting asthma of various severities. The context for such elicitations was a set of household products that contain fewer hazardous chemicals than what is currently available in supermarkets but are more expensive. The study finds that the WTP for reducing asthma severity in adults by one step, e.g. from "moderate plus" to "moderate", is USD_{2022} 529 per year on average. The parental WTP for reducing asthma severity in their children is USD_{2022} PPP 948 per year and is on average 1.8 times higher than their WTP for themselves. The mean value of a statistical case (VSC) of adult asthma which would be applied to predictions of new cases of asthma avoided by a regulation equals USD_{2022} 280 000, while the mean VSC of childhood asthma equals USD_{2022} 430 000.

1. Introduction

OECD countries have laws and regulations to manage the risks of chemicals by eliminating or reducing exposure. Examples include the European Union under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation and the United States under the Lautenberg Chemical Safety Act. As part of these laws and regulations,

governments are often required to perform cost–benefit analyses to inform the design of chemical management options to maximize social welfare. To inform benefit estimates, governments need studies that value the suite of health effects that chemical exposure can cause or exacerbate. Current socio-economic analyses of chemical regulations use values for morbidity impacts that are often incomplete, and in most cases, cover only lost productivity or cost-of-illness (COI)[1] and disregard the disutility costs of pain and suffering from the illnesses (Navrud, 2018). Therefore, the benefits of reducing morbidity impacts due to chemical exposures are potentially underestimated in socio-economic analyses. The only way to capture the full willingness-to-pay (WTP) to avoid illness is to conduct a stated-preference study, i.e. surveys where individuals are asked to report their WTP to reduce chemical pollution or risk or avoid the illness associated with exposure. Contingent valuation methods and discrete choice experiments do just that, and WTP figures based on these methods have been used in assessment efforts (irrespective of the payment vehicle used) (Alberini, 2017). To improve the basis of doing cost–benefit analyses of chemical management options, the OECD coordinated a multi-country project to elicit internationally comparable willingness-to-pay values to avoid negative health endpoints due to chemical exposure, known as the SWACHE project.

This article provides results on the endpoints related to asthma. Asthma affects people of all ages and has an estimated prevalence of around 4% in adults and 10% in children worldwide, but these figures are probably underestimated due to poor diagnosis in many countries (Global Burden of Disease Collaborative Network, 2021; The Global Asthma Network, 2022). Asthma prevalence is higher in OECD countries where data are more reliable. For example, asthma prevalence in the United Kingdom and in the United States was around 10% in 2019 (Global Burden of Disease Collaborative Network, 2021). Asthma is a lung disease with both genetic predisposition and environmental causes and exacerbations, such as from allergens, tobacco smoke, chemicals, and more conventional air pollutants. Asthma attacks can be mild to severe, characterized by coughing, shortness of breath, wheezing, and other respiratory symptoms, and in rare cases can lead to death. The severity and frequency of asthma attacks can be mitigated with medication and avoiding triggers, while the probability of getting asthma can be lowered by avoiding lung sensitization agents. It cannot be cured.

Epidemiological studies link air pollutants, such as fine particulates (PM2.5) to asthma attacks and an increased likelihood of developing asthma. Several studies relevant to this article suggest that chemicals in cleaning products can increase the risk of an asthma diagnosis and asthma attacks (Rosenman *et al.,* 2003; Medina-Ramon *et al.,* 2005; Jaakkola & Jaakkola, 2006; Nielsen *et al.,* 2007; Quirce & Barranco, 2010; Zock *et al.,* 2010). These studies, in turn, are used by governments around the world to estimate the effect of reduced air pollution and chemical exposure through policy interventions on reduced asthma prevalence and attacks. A relatively thin literature (discussed in Section 2) provides monetary values for avoiding asthma attacks and cases. This article adds significantly to the literature by offering WTP values for asthma suitable for use in cost–benefit analyses in the context of reducing chemical exposures and covering populations in seven OECD countries (Canada, Czech Republic, France, Poland, Sweden, the United Kingdom, and the United States). More specifically, the study provides, on the one hand, values of the WTP

[1] Cost-of-illness usually refers to direct medical cost and to indirect cost such as lost earning due to partial incapacity to work normally.

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for reduced severity and frequency of asthma attacks in adults and children (called here reduced severity or RS) by using the contingent valuation method and, on the other hand, values of the WTP for reduced probability of getting asthma (called here reduced probability or RP) for these two population groups (using the discrete choice experiment (DCE) approach).

This article is organized as follows. Section 2 presents the literature review. Section 3 details the survey design. Section 4 shows data sources, sample representativeness, screening strategy, and key descriptive statistics. The econometric strategy is presented in Section 5 and results are provided in Section 6. Finally, Section 7 provides recommended values for asthma severity and asthma risk to use in policy analysis and Section 8 concludes.

2. Literature review

2.1. Reduced probability (RP) valuation studies

Several studies that have estimated WTP to avoid similar symptoms such as chronic bronchitis are also worth reviewing. Hence, Viscusi *et al.* (1991) valued chronic bronchitis but they used a risk–risk trade-off technique. By combining the observed risk–risk trade-offs with a statistical value of life, the annual value of a case of chronic bronchitis can be derived. Of course, this indirect approach depends on the chosen value of a statistical life (VSL). Their median value was USD_{1991} 457 000 per case avoided. In a similar vein, Krupnick and Cropper (1992) surveyed relatives of persons with chronic bronchitis and estimated an average statistical case of chronic lung disease of USD_{1992} 1 438 000.[2] Priez and Jeanrenaud (1999) employed a risk-based contingent valuation (CV) method to estimate the value of disutility of chronic bronchitis. They surveyed 757 people representative of the population of Switzerland and elicited WTP using two methods: a payment card and a bidding game. Using a semi-logarithmic model, they found a mean WTP of (Swiss Franc) CHF 38.5 cents (in CHF 1999) for a reduction of the risk equal to 1 in 100 000 over 1 year, which results in a value of the statistical case of chronic bronchitis equal to CHF1999 38 500.

It is instructive to consider the studies used to provide asthma values in government regulatory cost–benefit analyses. For the US Environmental Protection Agency's (EPA) regulatory impact analyses (RIAs), the values appear in the BENMAP model and originate with Belova *et al.* (2020). These are labeled "New Onset Asthma" and are based on the COI over a lifetime of asthma, including productivity loss at work, all discounted at 3%. While these values vary by age, as they should, the differences are insignificant (children showing a lower value per year but have more years with asthma), averaging around USD_{2015} 17 000.

There are some issues with these previous studies. First, COI estimates represent only medical expenses, not pain and suffering, anxiety, and other health outcomes associated with asthma. Even if some of these studies use stated preferences, they also generally use small sample sizes and focus solely on adults. In contrast to these studies, this article improves the approach by also valuing reduction in the probability of getting asthma (similar to Priez & Jeanrenaud, 1999 for chronic bronchitis) as well as for different levels of asthma severity. Moreover, after proper screening, this article analyses responses from 769 non-asthmatics

[2] According to the national cancer institute, chronic lung disease is a type of disorder that affects the lungs and other parts of the respiratory system. Types of chronic lung disease include asthma, chronic obstructive pulmonary disease, pulmonary fibrosis, asbestosis, pneumonitis, and other lung conditions.

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per surveyed country who are representative of the general population adults and derives a value of a statistical case (VSC) of adult asthma. In addition, the article derives a VSC of childhood asthma based on the responses of 222 parents of a non-asthmatic child obtained in each country.

2.2. Reduced asthma severity and frequency (RS) valuation studies

Because VSC was previously not available, estimates from asthma COI studies have tended to be the ones used in government cost–benefit analyses. For example, the US EPA's RIAs rely on the BENMAP model for valuation. This model features values for several different types of RS endpoints. Two studies are cited for emergency visit costs: one is from Smith *et al.* (1997) with a cost per visit of USD_{2015} 534 on average and the other is from Stanford *et al.* (1999) who find average cost of USD_{2015} 447. Belova *et al.* (2020) find that asthma-related annual healthcare expenditures equal USD_{2010} 2 000 for asthmatic adults and USD_{2010} 1 200 for asthmatic children. They find that lost annual earnings of adult asthma equals USD_{2010} 2 000 on average across age groups and that lost annual earnings for parents of childhood asthma equals USD_{2010} 3 000 on average. Finally, Table H-10 from BENMAP Documentation (2022) provides the values available to EPA analysts for their RIAs. For instance, it provides the value of USD_{2015} 70 for a day with minor restricted activity, which is known as a consequence of mild asthma symptoms.

Other studies use stated preference surveys. Hence, O'Conor and Blomquist (1997) estimated the WTP of asthmatic adults for a set of drugs that have various effectiveness and involved different death risks and found a WTP equal to USD_{1997} 1 500 per year for a certain relief from asthma symptoms. Dickie and Messman (2004) used a DCE approach based on 16 illness profiles and asked parents about their WTP for themselves and for their children. They found that people are willing to pay USD_{2004} 125 to avoid 24 symptom days of mild adult asthma, USD_{2004} 238 to avoid 24 symptom days of mild childhood asthma, USD_{2004} 212 to avoid 24 symptom days of severe adult asthma, and USD_{2004} 404 to avoid 24 symptom days of severe childhood asthma. Using a DCE approach as well, Lloyd *et al.* (2007) surveyed 479 patients (in the Netherlands, Spain, and the United Kingdom) for their WTP to avoid asthma attacks and for days without symptoms. They found that asthma patients are willing to pay EUR2007 94 per month for an asthma cure and EUR2007 78 per month for a fully controlled asthma. These previous studies focus on specific symptoms and frequencies, while the study presented here elicits WTP to reduce the suite of symptoms associated with a severity level to the next less severe level. Two other studies compare the current situation of asthma patients with a cure, even though no cure is possible and certainly not from a reduction in chemical exposure. Still, the approaches they used are closest to the present study. Blumenschein and Johannesson (1998) used two different CV elicitation formats, the dichotomous choice method, and a bidding game, to estimate the mean willingness to pay for a cure for asthma from interviewing 69 patients. The mean WTP elicited from the bidding game was USD_{1996} 189 per month, or USD_{1996} 2 268 per year. The mean WTP elicited from the dichotomous choice approach was USD 343 per month, or USD_{1996} 4 116 per year. The second study of this type, Zillich *et al.* (2002), estimated the WTP for a cure from 100 asthmatic patients answering a double-bounded dichotomous choice (DBDC) question in the United States. Patients were asked whether they would pay an extra amount per month for a new treatment that would cure their asthma. They found mean monthly WTP of USD_{2002} 90 for curing mild asthma, USD 131 for curing moderate asthma, and USD 331 for curing severe asthma.

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3. Survey design

3.1. Definition and description of asthma relevant to survey design

The population is divided into children and adults and asthmatics and non-asthmatics. Non-asthmatic adults and children are given the same baseline probabilities of getting asthma of different severity levels.

3.1.1. Incidence versus prevalence

Incidence is the number of new cases in a given time period and prevalence is the frequency of the disease in the population. Prevalence is reduced by reducing incidence. As an example, in the United States, the incidence of childhood asthma in children at risk is 12.5 in 1 000 and the incidence of adult asthma in adults at risk is 4 in 1 000 (Winer *et al.,* 2012). The prevalence of asthma is about 80 in 1 000 in the US population and approximately the same in children and adults. Because the aim of the study is to elicit the value of a statistical case of asthma, the baseline risk presented to respondents in the survey was based on adult asthma incidence of at-risk adults. This ensures that the presented baseline risk, although overestimated, is a realistic approximation and is therefore credible. However, smaller risk values such as 4 in 1 000 are generally more difficult to grasp for most respondents. Therefore, it was decided to present a baseline risk over 10 years equal to 40 in 1 000 or 4.0% and to ask respondents what they are willing to pay per year over 10 years to reduce this risk. The baseline "total" risk is broken down into severity groups (mild, moderate, and severe) in the population. Mild asthma is more prevalent than moderate asthma, which is more prevalent than severe asthma.

3.1.2. Duration

As noted, there is no cure for asthma although childhood asthma may become asymptomatic over time and asthma may develop in an adult, even though they were never asthmatic as a child. In the survey, the baseline risk of developing asthma over a period of 10 years was presented to non-asthmatic adults and parents of non-asthmatic children, and in scenarios, small reductions to that probability if the non-asthmatic uses safer home cleaning and other "SAFETYFIRST" products. Asthma was presented as a non-curable lifetime disease. In the survey, asthmatic adults and parents of an asthmatic child were asked about their willingness to pay to reduce the severity of their asthma during a period of 10 years after, which their severity would go back to its previous severity if they stopped using SAFETYFIRST products (Figure 1).

3.1.3. Risk factors

The survey language recognizes that chemicals in household products are risk factors for asthma onset and for asthma attacks. People who buy and use reformulated products are told that these products can reduce their probability of getting the disease or, if they have the disease, reduce its severity. In line with expert views, no scenarios take risks to zero or eliminate attacks for those with asthma, in contrast to some of the literature reviewed earlier.

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Figure 1. *Picture used to present original vs SAFETYFIRST household products. Note: Labels on products were translated in each country.* Source: *Authors' own elaboration.*

3.2. Survey structure

The first section of the survey includes an introduction to welcome respondents, provides information on the purpose of the survey, confidentiality of responses, voluntary nature of their participation, contact information, and respondent's informed consent. The second section asks the respondent to describe themselves and their household. Additional questions were added to determine the sequence of six branches of the survey that the respondents would take. The questions were about whether the respondent had been diagnosed with asthma, whether the respondent had children, and whether any of those children had been diagnosed with asthma. The branches are shown in Figure 2.

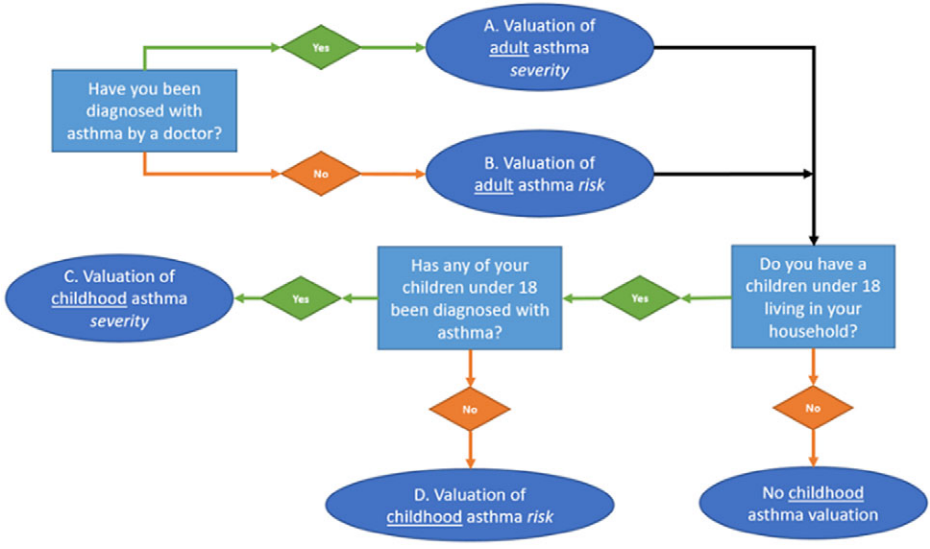

Figure 2. *Branching of the asthma survey.*
Source: *Authors' own elaboration.*

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Adults without children receive either the adult asthma section of the survey (A) or the adult non-asthmatic section (B). Adults with children receive A or B, as appropriate, and also receive one of two child sections of the survey – (C) if they had a child with asthma, (D) if they did not. All other things being equal, respondents were asked to focus on the youngest child when questions were asked about their children.

3.2.1. Asthmatic adults

Starting with the asthmatic adult branch, the survey defines how severity varies, as in Figure 3, and asks respondents to rate their own asthma severity. Although only three levels are provided in the figure, respondents can also rate their asthma as very mild, mild plus (between mild and moderate), and moderate plus (between moderate and severe) to better capture their own severity.

The severity reduction mechanism and payment vehicle are introduced next as a new line of household products specially formulated to contain fewer and safer chemicals, called SAFETYFIRST products. To avoid environmental and other health co-benefits identified in one-on-one interviews, the language specifies that SAFETYFIRST products are as effective as the original products, that both sets of products have the same amount and composition of packaging and that the only difference is in the reduction of attack severity and frequency.

The valuation questions are formulated as DBDCs (Figure 4). For the sake of clarity, the follow-up bid questions and open-ended questions about reasons behind their choices are not presented below, even though they were asked to the respondents.

There are several elements that need to be pointed out. First, the language used throughout the survey aims to focus people away from valuations for their household and towards valuation for only themselves and (separately) for their youngest child. Thus the $12 per

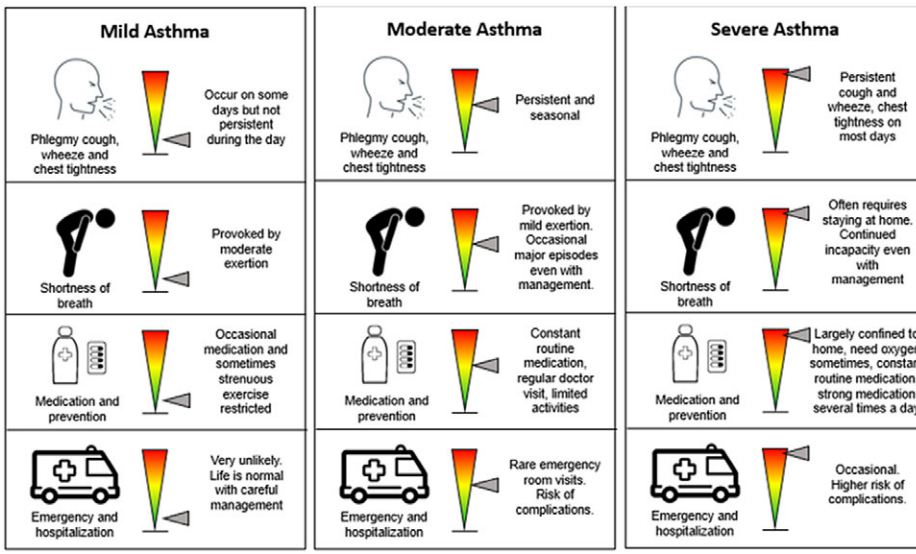

Figure 3. *Visual description of asthma severity levels.*
Source*: Authors' own elaboration.*

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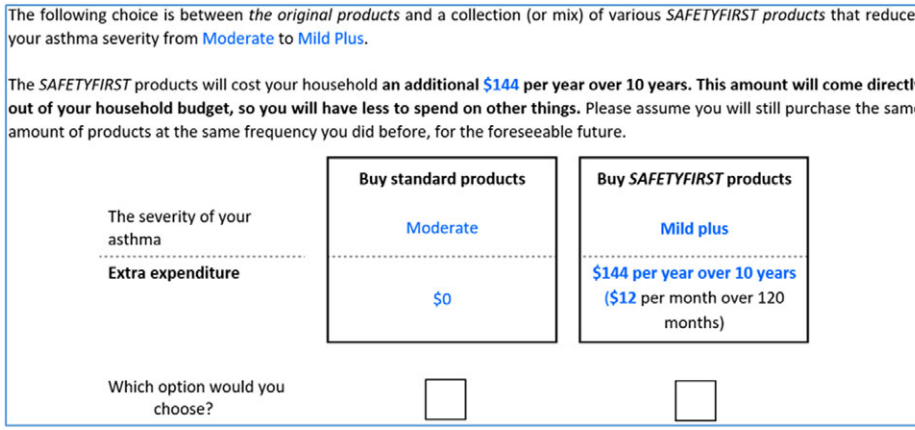

Figure 4. *Double-bounded dichotomous choice to elicit WTP to reduce asthma severity.* Source*: Authors' own elaboration.*

month in Figure 4 is the WTP of the respondent out of their household budget for reducing their asthma severity. The second issue is to focus the respondent away from any savings in medical expenditures from their asthma being less severe so that the estimated WTP will capture the utility associated with a reduced severity. This is easier to assume for European respondents as most do not pay out-of-pocket costs and thus would not think about these savings. However, in countries where patients pay for medical care out of pocket, respondents would think about the savings from reduced asthma severity. Thus, the language telling the respondent to think only of their non-monetary benefits from less severe asthma allows the estimates to be comparable between European countries and other countries. Third, the language stresses the importance that respondents assume they would still buy the same amount of products whether SAFETYFIRST or original products. This type of thinking would bias WTP estimates downward. This problem was checked by using a debriefing question and respondents could also signal their thinking using the open-ended question following their choice.

Respondents were presented with a first bid randomly chosen among five potential values. Table 1 shows the first bid values presented to respondents by country. To enable

Table 1. *Bid values for the first dichotomous choice*

Canada	Czech Republic	France	Poland	Sweden	UK	US
$ 44	444 Kč	25 €	61 zł	kr. 348	£ 26	$ 36
$ 89	888 Kč	52 €	120 zł	kr. 696	£ 54	$ 72
$ 180	1 776 Kč	103 €	240 zł	kr. 1 380	£ 108	$ 144
$ 360	3 552 Kč	204 €	492 zł	kr. 2 772	£ 216	$ 288
$ 720	7 116 Kč	408 €	984 zł	kr. 5 544	£ 432	$ 576

Note: Bid values as seen by respondents. They were later converted into USD PPP using Purchasing Power Parities for actual individual consumption data for 2019 from the PPPs and exchange rates OECD database. The PPP data was extracted on 22 Feb 2021 at 08:44 UTC (GMT) from OECD.Stat, but has subsequently been revised. The exact series can be provided upon request.
Source: Authors' own elaboration.

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the comparison of WTP across countries, these values are the same across countries but they were shown in local currencies. Bid values were converted using Purchasing Power Parity (PPP) for actual individual consumption provided by the OECD. The first bid values were tested and updated during survey piloting to aim towards achieving an average yes responses of 50% to the first dichotomous choice. There is a factor of two steps between each first bid value to avoid getting too many "yes"-"yes" responses that do not allow pin down individual WTP. For example, respondents in the United States were presented with first bid values ranging from USD 36 per year to USD 576 per year. Bid values were purposely not rounded to give the impression to respondents that the added costs for SAFETYFIRST products were more realistic.

To avoid too many "no"-"no" and "yes"-"yes" responses and tend towards a balance across the four potential outcomes of the dichotomous choice questions, follow-up bids were multiplied by 3 when people responded "yes" to the first dichotomous question and multiplied by 1/3 when people responded "no" to the first dichotomous question. Table 2 provides the bid values that were presented to respondents in the United States.

3.2.2. Parents of an asthmatic child

The branch of the parents of an asthmatic child (Figure 2) was identical to the adult asthmatic branch except for minor changes such as replacing the language so that respondents would think about the non-monetary benefits for their asthmatic child and not for themselves.

3.2.3. Non-asthmatic adults

This branch was different from the asthmatic adults' branch in two main ways. First, the setup was a choice experiment where the respondent was asked to choose among the baseline scenario and two alternatives, lower-risk scenarios. Because asthma can be mild, moderate, or severe, and the expected probabilities of getting asthma with different severities would likely influence WTP, the risks for the different severity levels were included as attributes. Specifically, the observed incidence rates over 10 years in the United States were used to define these three levels of severity for the baseline and reduce those probabilities for the scenarios. The questions were preceded by a practice choice screen, which made it clear, after working extensively with one-on-one interviewees, that the sum of the probabilities across severity levels is equal to the total probability of developing asthma. The choice

Table 2. *Bids presented to respondents in the United States, in USD per year*

First bid value	Follow-up bid if respondent chose "No"	Follow-up bid if respondent chose "Yes"
36	12	108
72	24	216
144	48	432
288	96	864
576	192	1 728

Source: Authors' own elaboration.

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Table 3. Example of choice in the discrete choice experiment to elicit WTP to avoid developing asthma

Over the next 10 years, risk of getting	Using original products	Using SAFETYFIRST products (Mix B)	Using SAFETYFIRST products (Mix C)
Mild asthma	25 in 1 000	13 in 1 000	23 in 1 000
Moderate asthma	10 in 1 000	9 in 1 000	7 in 1 000
Severe asthma	5 in 1 000	3 in 1 000	3 in 1 000
Total risk of getting adult asthma over the next 10 years	40 in 1 000	25 in 1 000	33 in 1 000
Added costs of SAFETYFIRST products you use for the next 10 years	$ 0	$ 252 per year over 10 years ($ 21 per month over 120 months)	$ 36 per year over 10 years ($ 3 per month over 120 months)
Your choice? (check one box on this row)			

If the respondent chooses Mix B (resp. Mix C), he will have to pay added annual costs of 252 (resp.36). *Source*: Authors' own elaboration.

screen is reproduced in Table 3. Five consecutive choice screens were presented to respondents. Two sets of five choices were developed. One of two choice sets was randomly attributed to each non-asthmatic adult.

Because of the use of probabilities, the standard approach to teaching respondents about this concept was introduced at the beginning of this branch using a coin flip, a die-cast, a grid with 100 and then 1 000 people in it colored orange and blue, followed by two probability tests. The first test question showed two grids, each with 100 persons, with most colored in blue and a few colored in orange indicating the probability of getting asthma. The two grids had different numbers of "orange people" and respondents were asked which grid showed the highest number of asthmatics. Figure 5 shows the probability test taken by respondents.

The second test question was formulated as follows: "Which of these two probabilities (risk) of developing asthma is higher? 40 in 1 000 or 30 in 1 000".

The first test measures the ability to understand the concept of probability, while the second test measures the ability to read a probability as it is then used in the DCE tables.

3.2.4. Non asthmatic child

If non-asthmatic adults have children who are not asthmatic, they responded to the discrete choice set that was not attributed to them when they had responded as adults.

3.2.5. Debriefing questions and final questions and information

The debriefing section was identical for all pathways through the survey. It contained questions on the respondent: (i) attitudes towards the information provided in the survey e.g. did they believe it or act as if they did, was there enough information to make a choice;

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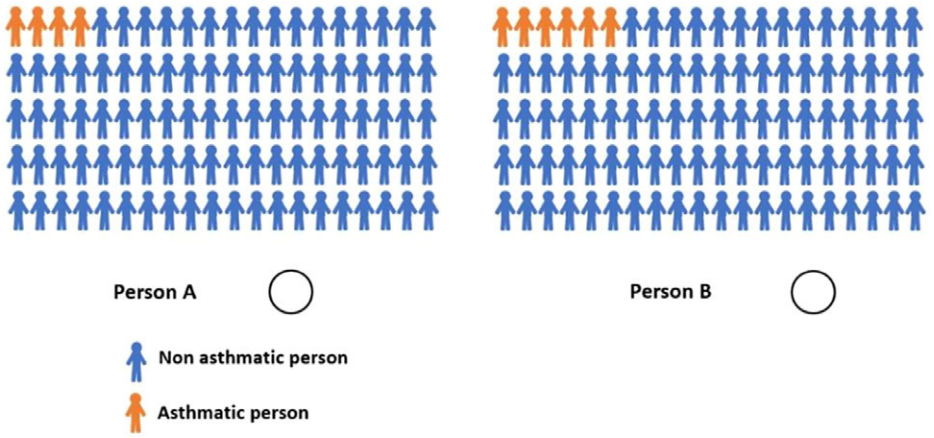

Figure 5. *Question to test respondents' understanding of probability using visuals.* Source*: Authors' own elaboration, following Krupnick* et al. *(2002).*

(ii) behavior in answering the choice questions e.g. did the respondent consider the probabilities and the cost, (iii) considerations when answering the choice questions e.g. did the respondent think about financial consequences to his or her wages or medical bills, understand that the payments for SAFETYFIRST products carried indefinitely into the future to gain the added protection; (iv) yea-saying and protests, and (v) attitudes towards chemicals, e.g. frequency of exposure and adequacy of government regulation.

The final questions covered the respondent's health status, their socioeconomic characteristics, and their experience with COVID-19 following Mourato and Shreedhar (2021). These questions were followed by a statement correcting any wrong impressions the survey may have caused and giving all the facts about the ideas in the survey, e.g. there is actually a high degree of uncertainty about the role of chemicals in asthma.

3.3. Testing and piloting

All the language, concepts, and visual aids were tested in one-on-one interviews administered to non-technical staff members at Resources for the Future (RFF)[3] in the US, then translated into French and piloted via an online survey to 52 adults (and their relatives) affiliated to either the University of Angers or the University of Nantes. Additional one-on-ones were conducted in both countries. Late-stage piloting was used to set final cut-points for bids in the survey seeking approximate equality in the proportion responding to the DBDC questions ("No-No", "No-Yes", "Yes-No", "No-No") and minimizing "serial status quo responses" to the choice experiment (e.g. respondents making all status quo choices over the five-choice questions). More precisely, the first pilot of 150 completed interviews was conducted in the United States and in France, followed by a second pilot in the United Kingdom and in Canada (150 interviews), and then a third pilot in Poland, the Czech

[3] RFF is an independent, non-profit research institution based in Washington, DC, USA, which mission is to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement.

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Republic, and Sweden (225 interviews in total). Each pilot included a minimum number of asthmatic respondents to set final cut-points for bids in the survey. The questionnaire was submitted to an institutional review board, the French Inserm Ethics Evaluation Committee (CEEI), for an external, independent ethics review.[4]

4. Survey data

4.1. Data sources and samples representativeness

The survey was administered to a sample drawn from a large panel of individuals, maintained by Ipsos European Public Affairs, who volunteer to participate in research surveys. The survey was conducted via Computer-Assisted Web Interviewing (CAWI) and was carried out in seven countries: Canada, the Czech Republic, France, Poland, Sweden, the United Kingdom, and the United States. Fieldwork took place between 11 November 2021 and 4 May 2022 (pilot and main stage fieldwork). The selection of respondents was based on quotas matching four key demographic characteristics: gender, age group, level of education, and geographic region to help ensure representativeness.

The target population for the asthma survey was males and females aged 18 or older. However, asthmatic adults and parents of an asthmatic child were oversampled because the prevalence rate of asthma is low. Oversampling allowed for a sufficiently high number of observations to get satisfactory statistical power for the econometric estimation of the WTP for a reduction in asthma severity in adults and children. Therefore, hard quotas were set for the number of adults who have been diagnosed with asthma by a healthcare professional (n = 300) and for the number of parents who have asthmatic children (n = 200) for each country.

A total of 17 526 individuals started the survey and 12 727 finished the survey. This is a break-off rate of 27.4%, with a substantial amount of break-off occurring at the probability test questions and less importantly at the various valuation questions. The online survey data were evaluated by Ipsos using automated checks. After these checks, an additional 79 interviews were suspected as unreliable due to having duplicate answers to the open-ended questions or specifying unrealistic numbers of children. In total 601 interviews were removed from the online survey data. A total of 12 126 interviews were complete and valid, with a minimum of 1 600 in each of the countries surveyed. The target of 1 600 was exceeded due to oversampling to meet the hard quota for the number of parents with asthmatic children.

To verify the representativeness of the sample, the achieved quotas were compared to target quotas set for the four groups of interest: (i) asthmatic adults, (ii) parents with an asthmatic child, (iii) non-asthmatic adults and (iv) parents with a non-asthmatic child. Target quotas for non-asthmatic adults were set based on statistics from the general population of each country surveyed. Gender ratios were taken from World Bank (2019). The distribution of ages across four categories (18–29 year old, 30–44 year old, 45–60 year old, and greater than 60 year old were taken from UN data (United Nations Statistics Division, 2021). Data on education come from the OECD data from "Education at a Glance: Educational Attainment and Labor-Force Status" (OECD, 2020). Target quotas for asthmatic adults

[4] See https://www.inserm.fr/en/ethics/ethics-evaluation-committee-ceei-irb/.

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Table 4. *Average deviation from target quotas across surveyed countries*

	Asthmatic adults (%)	Parents of an asthmatic child (%)	Non-asthmatic adults (%)	Parents of non-asthmatic child (%)
Age				
18–29	2.4	13.2	−2.2	5.7
30–44	12.0	−6.8	1.1	−8.8
45–60	−4.8	−6.7	−0.8	0.8
60+	−9.6	0.3	1.9	2.3
Gender				
Female	−5.3	−4.3	0.0	1.3
Male	5.3	4.3	0.0	−1.3
Education				
Low + Medium	−7.6	−13.2	−3.5	−9.1
High	7.6	13.2	3.5	9.1

Source: Authors' own elaboration.

were set using various data on the key demographics of people diagnosed with asthma. For example, 63% of asthmatic adults in the United States are female according to the most recent national asthma data from the Centers for Disease Control and Prevention (CDC) (2020) drawing from the 2020 National Health Interview Survey (NHIS) Data. The CDC also provides the distribution by age and educational attainment. For all countries, data were available on the gender ratio of asthmatics. For 5 countries, the distribution across age categories was also available.[5] The distribution across educational attainment was only available for the United States. However, there is no significant difference between asthmatic and non-asthmatic adults in terms of education. Missing target quotas for asthmatic adults were imputed by the target quotas used for the general population. Target quotas for parents of an asthmatic or non-asthmatic child were set based on statistics on the age of parents at birth from Eurostat (2022) and the United Nations Statistics Division (2022). The target quotas for gender ratio and education used for the parents were the same as the general population.

The difference between achieved quotas and target quotas varies across key demographics and groups of respondents. Table 4 shows the average deviation from target quotas across surveyed countries for each demographic and group of respondents. For non-asthmatic adults, there is little deviation from the target quota meaning that the sample is representative of the general population overall. For other groups of respondents, the deviation is larger but is never very high.

[5] Various sources were used to set target quotas for asthmatic adults: Statistics Canada. Table 13-10-0096-08 Asthma, by age group, DOI: https://doi.org/10.25318/1310009601-eng; Institute of Health Information and Statistics of the Czech Republic. 6.2.21 Prevalence of asthma (J45–J46); Santé Publique France citing the study of Śliwczyński *et al.* (2015); Delmas *et al.* (2021); Folkhälsomyndigheten, National public health, national and regional results, diseases and disorders (self-reported) by age, sex and year. Percentage; British Lung Foundation, asthma statistics; Centers for Disease Control and Prevention, national asthma data.

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Average deviation from target quotas set for age categories varies from −9.6% to 13.2%. In the sample of asthmatic adults, people aged 30–44 tend to be slightly overrepresented, while people aged above 45 tend to be slightly underrepresented. For parents of an asthmatic child, young respondents aged 18–29 tend to be somewhat overrepresented, while people aged 30–60 are slightly underrepresented. For parents of a non-asthmatic child, people aged 18–29 are marginally overrepresented at the expense of people aged 30–44.

Regarding education quotas, people with low or medium education tend to be somewhat underrepresented in all groups of respondents. This deviation is relatively more important for surveyed parents. This underrepresentation of people with lower education is not specific to this survey. It is notoriously harder to survey people with lower education for several reasons. First, the asthma survey is long due to its complexity and ambition, especially for parents who not only have to provide their own WTP but also their WTP for their child. It took between 15 and 23 min on average for respondents to complete the survey depending on which group they were assigned to. The longer the survey, the more likely respondents will leave before finishing the survey. People with lower education tend to leave more often than people with higher education for different reasons. The deviation for gender quotas is less important than the one observed for age or education overall. The largest deviation equals 4.3% for parents of an asthmatic child and 5.3% for asthmatic adults.

Table 5 shows the average absolute deviation from target quotas across key demographics by country and by group of respondents. The deviation from target quotas is higher for asthmatic adults and parents of an asthmatic child. This is explained by the smaller sample size of these two groups but also by the fact that it's more difficult to recruit asthmatic respondents and even more difficult to recruit parents of an asthmatic child. The deviation from target quotas is highest for the United States, France, and Poland. Post-stratification weights are used in the estimation of WTP to take these deviations into account.

4.2. Screening strategy

The survey builds in a variety of checks that can flag problematic responses for possible deletion or treatment econometrically. Some of these are common to the two types of

Table 5. *Average absolute deviation from target quotas across key demographics*

Country	Asthmatic adults (%)	Parents of an asthmatic child (%)	Non-asthmatic adults (%)	Parents of non-asthmatic child (%)	Average (%)
Canada	7.6	6.7	6.5	5.3	6.5
Czech Republic	7.6	11.7	1.6	4.2	6.3
France	10.6	11.4	6.6	8.1	9.2
Poland	5.8	12.9	6.8	7.1	8.2
Sweden	7.0	8.4	3.2	4.1	5.7
United States	19.3	17.8	7.9	6.3	12.8
United Kingdom	5.7	5.5	2.0	7.4	5.2
Average	9.1	10.6	4.9	6.1	

Source: Authors' own elaboration.

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valuation: the estimation of WTP for reduced asthma severity and the WTP for a reduced risk of getting asthma. These checks include very slow respondents and speeders. For the groups of respondents who were asked for their WTP for a reduced risk of getting asthma, three additional screening criteria were applied. First, respondents who were part of the pilot are excluded because the parameters of the DCE in the pilot are too different from the final parameters. Second, non-attendant respondents who indicated that they did not take into account any attributes while making their five consecutive choices for the DCE are also screened out. Third, respondents who failed to respond correctly to the "understanding probabilities" tests were screened out. For the groups of respondents who were asked their WTP for reduced asthma severity, debriefing questions were analyzed as well.

4.2.1. Very slow respondents

Very slow respondents were identified as taking an inordinately long time to finish the survey and therefore may forget part of it and lose the logic presented. Sometimes, respondents leave the survey to do other things. In the extreme, they may start one day and finish the next. There is no consensus on the definition of a very slow responder. A definition was agreed to be a respondent taking more than 12 h to complete the survey. 2.0% of the non-asthmatic adults (182) and 2.3% of non-asthmatic children (61) were screened out as a result of eliminating parents who were determined to be very slow responders. None of the asthmatic adults or parents of an asthmatic child had to be eliminated from the sample.

4.2.2. Speeders

Speeders are respondents who run through the survey so quickly that they could not possibly be reading the questions. Speeders cannot provide informed responses so they need to be screened out. Two types of speeders were defined in this analysis. First were speeders who completed the entire survey too quickly. Second were speeders who completed the valuation questions too quickly. Respondents who belong to either of these categories were screened out. A standard recommendation from Survey Sampling International (2013) and Mitchell (2014) is to filter out respondents that took 48% less time than the median respondent. However, depending on their circumstances, some respondents answered only one section of the survey rather than two – one for themselves and one for their child. Therefore, respondents' completion time was re-computed and the median was taken for each of the four-valued health effects based on similar sets of survey items. This allows, for example, for the comparison of completion time for childhood asthma risk of non-asthmatic adults to the completion time for childhood asthma risk of asthmatic adults. A unique median per group was computed for each country to take into account differences in language, IT proficiency, and other cross-country differences. The median values were computed based on the sample that excludes very slow respondents.

The speeder criteria screened out 12.3% of non-asthmatic adults (1 123), 10.2% of non-asthmatic children (270), 15.6% of asthmatic adults (406) and 5.3% of parents of an asthmatic child (75). In an informal literature search of speeding in online surveys, 10% was a common finding (Rao *et al.,* 2014).

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4.2.3. Non-attendance of all the attributes of DCE

Following the five consecutive choices in the DCE, non-asthmatic respondents were asked whether they took into account or neglected some of the attributes during their choices. Respondents who indicated they never considered any attribute during their 5 choices were removed from the sample. This criterion screens out 4.5% of non-asthmatic adults (407) and 3.4% of non-asthmatic children (90).

4.2.4. Not understanding probability

The selection criteria used consists of keeping only respondents who passed both probability tests. This rather strict screening strategy can be justified because the initial test measures the ability to understand the concept of probability, while the second test measures the ability to read a probability as it is then used in the DCE tables. Since a random response could result in a correct answer, this aimed to minimize risks of falsely accepting responses from an individual that really did not understand probabilities. This screening criteria excludes 31.6% (2 882) of non-asthmatic adults and 33.0% (872) of parents of non-asthmatic children. Most of them failed the first test, which was more difficult. For example, in the case of non-asthmatic adults, 25.6% failed this first test, while 11.2% of them failed the second test. As a consequence, only 5.3% of non-asthmatic adults failed both tests. There is a significant difference at the 1% level of risk in the average probability test failure rate between countries for non-asthmatic adults and for parents of non-asthmatic children. Table 6 summarises the difference between the full and screened samples in terms of the number of survey responses.

4.2.5. Debriefing questions

Open-ended responses: Respondents had multiple opportunities to give open-ended (OE) answers to explain why they chose to pay for a reduction in asthma severity. The responses to open-ended questions in English and in French from the screened sample were analyzed in two steps for Canada, France, the United Kingdom, and the United States. First, the number of characters of OE responses was computed to get a sense of how seriously

Table 6. *Full and screened sample composition*

	Provided by Ipsos	Very slow responders	Speeders	Failed probability	Full non-attendance	Final sample
Asthmatic adults	2 600	0	406			2 194
Parents of an asthmatic child	1 414	0	75			1 339
Non-asthmatic adults*	9 132	182	1 123	2 882	407	5 384
Parents of a non-asthmatic child*	2 645	61	270	872	90	1 556

Note: *Observations from the pilot were not used because the DCE varied too significantly between the pilot and the main stage. Asthmatic adults and parents of an asthmatic child were not presented with a probability test and did not participate in the DCE.
Source: Authors' own elaboration.

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respondents were taking this opportunity. A minimal number of characters typically indicates that the respondent did not care much about providing an open-ended answer. Second, all of the open-ended responses for adult and childhood asthma severity in English and in French were analyzed to find a set of keywords that could indicate a problematic response, such as protest, altruism, people who thought they could save on their current medication and people who would pay anything to reduce their risk even by a small amount. Table 7 provides examples of responses for the different categories for asthmatic adults and parents of an asthmatic child.

Table 7. *Examples of responses to open-ended from English speaking asthmatic adults and parent of asthmatic child*

Type of OE responses	Asthmatic adult	Parent of an asthmatic child
Excellent	I would gladly reduce other "pleasure" spending to spend more on products that would reduce my asthma and give me better health. My health is much more important to me than dining out several time a week	I would like to try the products but I also cannot afford to pay that price every year due to financial issues I have incurred recently
Altruism	I prefer things that work and are also good for me, my kids, and the environment	Very important to reduce the number of people suffering whit this disease
Protest	Because I would rather reduce chemical usage and find natural ways to alleviate symptoms of asthma	I can buy items that are natural DIY cleaning solutions that would be cheaper
Reduce med	If these products are not going to affect me like the regular products do, I will spend less on medications and suffer much less, so it would make sense to try the new products	$6 per month would be worth the cost of the peace of mind of knowing she is well and possibly can be on less medicine for her asthma. In the long run this will actually save me money because her medicine is more than $6 per month
Would pay anything	Health is wealth and money is nothing	I would go broke if it meant keeping my children much more healthy

Source: Authors' own elaboration.

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Table 8. *Share of problematic responses to open-ended for asthmatic adults and children*

	Altruism (%)	Protest (%)	Reduce medical cost (%)	Would pay anything (%)
Asthmatic adult	4.3	0.8	2.4	0.6
Parent of an asthmatic child	1.1	4.3	0.3	1.0

Note: Computed on all responses from Canada, France, the United States, and the United Kingdom after the screen out.
Source: Authors' own elaboration.

For asthmatic adults, 4.3% of responses were related to altruism, 0.8% to protest, 2.4% to people who thought that they would save on asthma medication, and 0.6% related to people saying they would pay anything (Table 8). The remaining 91.8% were short, normal, or excellent responses.[6] For parents of an asthmatic child, 4.3% of responses were protest, 1.1% related to altruism, 1.0% related to people saying they would pay anything, and 0.3% thought they could save on asthma medication by choosing reduced asthma severity. The remaining 93.3% were short, normal, or well-aligned responses. Overall, there were very few problematic responses to open-ended questions. Therefore, respondents were not screened out on this basis.

Closed-ended debriefing questions: The questionnaire included 14 debriefing questions at the end of the survey. Table 9 illustrates the questions for asthmatic adults and parents of an asthmatic child. No respondents were dropped based on their responses to close-ended debriefing questions. This avoids being too conservative by preserving degrees of freedom. It also allows keeping a representative sample since responses to these debriefing questions could be correlated with gender, age, and education. However, responses to these questions were analyzed to check if the results were sensitive to this methodological choice. Debriefing questions are grouped into three groups – those whose problematic response would lead to an overestimation of WTP e.g. "I would pay anything"… (8 questions), those that would lead to an underestimation, e.g. "I thought the probabilities were lower than those presented" (4 questions), and those that were neutral or with an undetermined directional bias, e.g. "I did not have enough information to make an informed choice" (4 questions). The number of overestimating, underestimating, and non-directional problematic responses was computed for each respondent.

The utilization of these variables is illustrated with asthmatic adults and parents of an asthmatic child. For asthmatic adults, 13 debriefing questions were analyzed: 4 can indicate poor non-directional responses, 7 help the identification of potential overestimation of WTP, and 4 help the identification of potential underestimation of WTP. The frequencies of poor answers to these debriefing questions from asthmatic adults are included in Table 10.

It was found that 20.0% of asthmatic adults respond "poorly" at least once to the non-directional debriefs. 66.6% of asthmatic adults have at least one response that could indicate overestimation of WTP and 79.4% have at least one response that could indicate underestimation of WTP. However, these high percentages are not necessarily problematic considering the large number of debriefing questions. For example, 826 asthmatic adults responded poorly to only 1 out of the 7 debriefing questions, which can help identify overestimation of WTP.

[6] In this context, an excellent response is a response presenting a logical argumentation that proves that the respondent completely understood the trade-off between lower risk and higher cost.

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Table 9. *Bias direction of problematic responses to debriefing questions for asthma severity*

Debriefing questions	Bias direction of poor responses
Do you understand that to continue to get the benefits you have to keep using the SAFETYFIRST products?	Overestimation if responded "no"
Do you understand that to continue to get the benefits for your child, you have to keep using the SAFETYFIRST products?	Overestimation if responded "no"
I responded to the survey as I would have done in real life. :	Non-directional if responded "disagree"
…think that by reducing your (your child's) risk of getting asthma (asthma severity) you also reduced your medical bills.	Overestimation if responded "yes"
…think that by reducing your (your child's) risk of getting asthma (asthma severity) you also reduced the risk that your wages decrease because of being sick with asthma.	Overestimation if responded "yes"
Did you understand that your household would be required to pay an additional amount every month for 10 years if you chose to buy SAFETYFIRST products to reduce the severity of asthma or the risk to develop asthma?	Overestimation if responded "no"
When you chose between the original and SAFETYFIRST products, were you thinking you could just lower the consumption of these products to reduce your costs?	Underestimation if responded "yes"
Do you already purchase household products that you feel reduce risks of asthma or its severity?	Underestimation if responded "yes"
Please consider the statement: "I would pay almost anything necessary to improve my children's health even a small amount". Do you…*	Overestimation if responded "agree"
The survey provided me with enough information to make informed choices.	Non-directional if "disagree"
Do you think the survey tried to PUSH you to choose one answer or another, or did it let you freely make up your own mind?	Overestimation if responded "pushed me to choose spend more" Underestimation if responded "pushed me to choose spend less or nothing"
How confident are you that the information that has been provided in this survey is correct?	Non-directional if "not confident"

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Table 9. *Continued*

Debriefing questions	Bias direction of poor responses
How confident are you in the ability of experts to provide reliable information?	Non-directional if "not confident"
Regarding the reduction of asthma risks and severity, did you think using the SAFETYFIRST products would…	Overestimation if responded "be more effective than described in the survey" Underestimation if responded "be less effective than described in the survey" or "have no effect on asthma risks or its severity"

Note: *Only parents of an asthmatic child were asked this question.
Source: Authors' own elaboration.

For parents of an asthmatic child, 14 debriefing questions were analyzed: 4 can indicate poor non-directional responses, 8 help the identification of potential overestimation of WTP, and 4 help the identification of potential underestimation of WTP. The frequencies of poor answers to these debriefing questions from parents of an asthmatic child are included in Table 11. It was found that 24.0% of parents of an asthmatic child respond "poorly" at least once to the non-directional debriefs. However, 91.3% of them have at least one response that could indicate overestimation of WTP and 83.7% have at least one response that could indicate underestimation of WTP. Similar to the asthmatic adults, it is not necessarily problematic considering the large number of debriefing questions considered. For example, 61.7% of parents of an asthmatic child responded poorly to less than 3 out of the 8 debriefing questions that can help identifying overestimation of WTP. Comparing with the frequencies reported in Table 11 for asthmatic adults, it was found that there are slightly more poor responses for parents of an asthmatic child.

To make sure that these "poor" answers do not unduly influence the results, robustness checks were performed, where the model was augmented to include the number of poor responses in these three categories: non-directional, overestimation, underestimation as additional control variables.

4.3. Key descriptive statistics

4.3.1. Composition of the final sample

After screening, there are 2 194 asthmatic respondents, between 288 and 343 per country (Table 12). There are fewer parents of an asthmatic child, 1 339 in total, between 188 and 194 per country. The final sample includes 5 384 non-asthmatic adults, between 620 and 849 per country, and 1 556 parents of non-asthmatic children, from 168 to 321 per country.

4.3.2. Asthmatic respondents

After applying the screening criteria described in the previous section, the number of asthmatic adults is 2 194, i.e. 85% of the initial sample and the number of parents of an

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Table 10. *Frequency of poor answers to debriefing questions, asthmatic adults*

	Poor non-directional answers to debrief		Answers potentially indicating overestimation of WTP		Answers potentially indicating underestimation of WTP	
Number of poor responses	Number of respondents	Share of respondents (%)	Number of respondents	Share of respondents (%)	Number of respondents	Share of respondents (%)
0	1 755	80.0	733	33.4	453	20.6
1	289	13.2	826	37.6	889	40.5
2	116	5.3	420	19.1	758	34.5
3	22	1.0	171	7.8	92	4.2
4	12	0.5	42	1.9	2	0.1
5	0	0.0	2	0.1	0	0.0

Source: Authors' own elaboration.

Table 11. *Frequency of poor answers to debriefing questions, parents of an asthmatic child*

	Poor non-directional answers to debrief		Answers potentially indicating overestimation of WTP		Answers potentially indicating underestimation of WTP	
Number of poor responses	Number of respondents	Share of respondents (%)	Number of respondents	Share of respondents (%)	Number of respondents	Share of respondents (%)
0	1 018	76.0	117	8.7	218	16.3
1	199	14.9	324	24.2	493	36.8
2	84	6.3	385	28.8	563	42.0
3	23	1.7	300	22.4	63	4.7
4	15	1.1	158	11.8	2	0.1
5	0	0.0	55	4.1	0	0.0

Source: Authors' own elaboration.

Table 12. *Number of respondents in the screened sample by country and by group*

	Asthmatic adults	Parents of an asthmatic child	Non-asthmatic adults	Parents of non-asthmatic children
Canada	288	188	849	168
Czech Republic	343	192	620	248
France	294	192	818	227
Poland	293	188	783	321
Sweden	334	193	793	190
United Kingdom	323	194	819	205
United States	319	192	702	197
All countries	2 194	1 339	5 384	1 556

Source: Authors' own elaboration.

asthmatic child is 1 339, i.e. 95% of the initial database. Supplementary materials A.1 and A.2 show the respective descriptive statistics for the key demographics by country.

4.3.3. Non-asthmatic respondents

After applying the screening criteria described in the previous section, the number of non-asthmatic adults is 5 384, i.e. 59% of the initial sample without the pilot surveys, and the number of parents of non-asthmatic children is 1 556, i.e. 58.8% of the initial sample excluding respondents included in the pilot surveys. A large majority of non-asthmatic adults (70.5%) do not have children under 18 living with them (Supplementary material A.3). Respondents from the Czech Republic account for the lowest share of respondents (11.5%) because many are screened out due to the probability tests criterion. The percentage of adults aged between 18 and 29 is higher in Poland reflecting a younger population. The percentage of non-asthmatic adults surveyed with a low level of education is much higher in the Czech Republic than in other countries (Supplementary material A.4). This difference is only due to the way education achievement has been classified for the Czech Republic and not due to lower education achievement in the Czech Republic.

A very large majority of parents of non-asthmatic children are themselves non-asthmatic (86.4%) (Supplementary material A.5). Regarding the parents of non-asthmatic children, the proportion of people over 60 is (as expected) much lower compared to that of non-asthmatic adults (Supplementary material A.6).

Finally, the issue of serial status quo is explored for choice experiments. A serial status quo respondent is defined as a respondent who for their five discrete choices systematically chooses the status quo, i.e. the original products. While such responses may be legitimate, there is reason to question them. The share of serial status quo respondents is on average 21.5% for adults and 17.8% for children (Supplementary material A.7). These magnitudes are close to those observed in the literature. In terms of countries, important differences emerge, especially between respondents from the United Kingdom and those from the Czech Republic There are 11.6% of serial status quo adults in the Czech Republic sample and 33.1% for the United Kingdom. There are 13.3% of serial status quo respondents for parents of non-asthmatic children in the Czech Republic sample against 24.9% in the United Kingdom.

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5. Empirical strategy

5.1. Valuing a reduction in asthma severity

5.1.1. Baseline estimation strategy

Estimating WTP using contingent valuation. The first aim of this article is to derive mean and median WTP for a reduction in asthma severity from severity s_0 to s_1 where s_0 denotes baseline asthma severity using standard products and s_1 the reduced asthma severity level using SAFETYFIRST products, such that $s_1 \succ s_0$, other things equal. Denote y the income and $V(s,y)$ the indirect utility. Assuming a Random Utility Model, one can write indirect utility of individual i as follows:

$$v(s,y_i)+\epsilon_i,$$

where ϵ_i is the idiosyncratic error term. The WTP corresponds to the maximum monetary amount that a person is willing to spend in order to have at least the same utility level as the situation with the baseline severity and unchanged disposable income.

$$V(s_1,y-WTP)=V(s_0,y)$$

To estimate WTP, it is possible to ask a sample of the population if they would pay a certain amount of money to reduce their asthma severity. This contingent valuation method is called a single-bounded dichotomous choice approach. An individual who responds yes when asked if he is willing to pay the amount b for reducing asthma severity from s_0 to s_1 implies that

$$v(s_1,y_i-b)+\epsilon_{i1}\geq v(s_0,y_i)+\epsilon_{i0}$$

and that $b\leq WTP_i$. Therefore, the probability that individual i chooses yes when presented b can be written as follows:

$$\begin{aligned}Pr\{Yes_i|b\}&=Pr\{b\leq WTP_i\}\\&=Pr\{\epsilon_{i0}-\epsilon_{i1}\leq v(s_0,y_i)-v(s_1,y_i-b)\}\\&=Pr\{\epsilon_{i0}-\epsilon_{i1}\leq g(b,y_i,s_0,s_1,\theta)\}=1-F(b,y_i,s_0,s_1,\theta),\end{aligned}$$

where F is the cumulative distribution function of the error term $\epsilon_{i1}-\epsilon_{i0}$ and θ the parameter of the distribution. Assuming that the n observations are independent and identically distributed, θ can be estimated by finding the maximum likelihood, which is the joint probability that respondents choose the reduced risk option.

$$L(b,y,s_0,s_1,\theta)=Pr\{Yes_1,\ldots,Yes_i,\ldots,Yes_n|b\}=\prod_{i=1}^{n}Pr\{Yes_i|b\}$$

The mean WTP can then be estimated by integrating the probability of choosing the reduced severity option over the interval from 0 to infinite cost.

$$E(WTP)=\int_0^{\infty}Pr\{\text{Yes}|b\}db$$

The median WTP is the bid level for which the $Pr\{\text{Yes}|b\}$ equals 50%.

DBDC estimation. In this questionnaire, people were asked if they were willing to pay for a reduced asthma severity using a DBDC. This elicitation method allows several of the estimated individual WTP to be bounded between two values, which is not possible using a

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single-bounded dichotomous choice. Denote b_i as the first bid level proposed to respondent i. Denote $b_i^U = 3b_i$ the follow-up bid level proposed to respondent i if he responded yes to the first valuation question. $b_i^L = \frac{b_i}{3}$ is the follow-up bid level proposed to respondent i if he responded no to the first valuation question.[7] This elicitation provides four outcomes per respondent: d_i^{YY}, d_i^{YN}, d_i^{NY}, and d_i^{NN}. Denote d_i^{YY} a dummy variable equal to one when respondent i chooses yes to both valuation questions. When d_i^{YY} equals 1, $WTP_i \geq b_i^U > b_i$ where b_i is the first bid level proposed to respondent i and b_i^U is the higher follow up bid level proposed to respondent i. Denote d_i^{YN} a dummy variable equal to one when respondent i chooses yes to the first valuation question and no to the follow-up valuation question. When d_i^{YN} equals 1, $b_i \leq WTP_i < b_i^U$. Denote d_i^{NY} a dummy variable equal to one when respondent i chooses no to the first valuation question and yes to the follow-up valuation question. When d_i^{NY} equals 1, $b_i^L \leq WTP_i < b_i$. Finally, denote d_i^{NN} a dummy variable equal to one when respondent i chooses no for both valuation questions. When d_i^{NN} equals 1, $WTP_i < b_i^L$.

Based on the previous section, the probability of these four outcomes can be written as follows:

$$\begin{aligned} Pr\{YesYes|b^u\} &= Pr\{b^u \leq WTP\} = 1 - F(b^u, \theta), \\ Pr\{YesNo|b, b^u\} &= Pr\{b \leq WTP < b^u\} = F(b^u, \theta) - F(b, \theta), \\ Pr\{NoYes|b^L, b\} &= Pr\{b^L \leq WTP < b\} = F(b, \theta) - F(b^L, \theta) \\ Pr\{NoNo|b^L\} &= Pr\{WTP < b^L\} = F(b^L, \theta). \end{aligned}$$

In this setting, the log-likelihood function for the sample of n respondents can be written as follows:

$$\begin{aligned} \ln L(b, \theta) = \sum_{i=1}^{n} \big[& d^{YY} Pr\{YesYes|b^u\} + d^{YN} Pr\{YesNo|b, b^u\} + d^{NY} Pr\{NoYes|b^L, b\} \\ & + d^{NN} Pr\{NoNo|b^u\}\big]. \end{aligned}$$

Maximizing $\ln L(b, \theta)$ permits an estimate θ and derives the mean WTP and median WTP more efficiently than with a single-bounded dichotomous choice approach, although the professional literature debates the incentive compatibility of the double-bounded approach and its empirical significance (Bateman *et al.,* 2001).

Spike configuration with Weibull distribution of the error. So far, it has been assumed that people will always choose the reduced severity option when it costs them nothing or almost nothing. In other words that $Pr\{Yes|b = 0\} = 1$. In reality, a small share of the population might still choose the status quo because they do not care enough about reducing their asthma severity. This creates a spike near zero that could be significant in the case of people having mild asthma that can be more easily controlled. Carson and Hanemann (2005) argue that failing to include a spike parameter can in some cases lead to an overestimate of WTP. This spike near zero can be measured using the responses to the open-ended question that followed the DBDC: "What would be the most you would be willing to pay, for the SAFETYFIRST products?". Denote d_i^{NNY} a dummy variable equal to one when respondent i chooses no to both valuation questions but provides a positive value to the open-ended questions and d_i^{NNN} a dummy variable equal to one when respondent i chooses no to both

[7] See Section 3.2.1 for more details about the bid levels.

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valuation questions and responded 0 to the open-ended questions. The probability of these two events are

$$Pr\{NoNoYes|b^L\} = Pr\{0 < WTP < b^L\} = F(b^L,\theta) - F(0,\theta),$$
$$Pr\{NoNoNo|0\} = Pr\{WTP \leq 0\} = F(0,\theta).$$

These two events can be added to the likelihood function to improve information as follows:

$$\ln L(b,\theta) = \sum_{i=1}^{n} [d^{YY} Pr\{YesYes|b^u\} + d^{YN} Pr\{YesNo|b,b^u\} + d^{NY} Pr\{NoYes|b^L,b\} + d^{NN} Pr\{NoNo|b^u\} + d^{NNY} Pr\{NoNoYes|b^L\} + d^{NNN} Pr\{NoNoNo|0\}].$$

To derive the mean WTP and median WTP, it is necessary to estimate θ and therefore to be able to compute the log-likelihood for various values of θ. Hence, it is necessary to assume a distribution F for the utility error. In this article, a Weibull distribution is assumed as the baseline because it generally has a shorter right tail than the log-normal and, in its "spike" configuration, usually performs well (Kriström, 1997; Carson & Hanemann, 2005).

Control variables and use of post-stratification weights. A Weibull distribution $\theta = \{k,\lambda\}$ is characterized by a shape parameter k that measures the slope of the function and a scale parameter λ that measures the spread of the distribution. All estimations assume a shape parameter equal to 1. In the baseline, specification of the scale parameter when $b > 0$ is

$$\lambda_{ic}(b) = \alpha_0 + \alpha_1 MediumSev_i + \alpha_2 HighSev_i + \alpha_3 \ln b_i + \sum_c \delta_c (d_{ic} \times \omega_i) \quad (1)$$

and the spike parameter when $b = 0$ is

$$\eta_{ic} = \alpha_0 + \alpha_1 MediumSev_i + \alpha_2 HighSev_i + \sum_c \delta_c (d_{ic} \times \omega_i), \quad (2)$$

where $MediumSev_i$ is a dummy variable equal to 1 when respondent i has mild plus or moderate asthma, $HighSev_i$ is a dummy variable equal to 1 when respondent i has moderate plus or severe asthma, $\ln b_i$ is the logged cost or bid proposed to respondent i, d_{ic} is a country dummy equal to 1 when respondent i lives in country c and ω_i is the post-stratification weight of respondent i. Including ω_i as a control captures the fact that some categories of people were slightly under or over represented in the sample compared to the actual population. The greater respondent i is underrepresented in the sample, the higher their weight ω_i. It is necessary to interact country dummies with the weight because weights are defined at the country level.

The model is also estimated when the scale parameter includes additional explanatory variables as follows:

$$\lambda_{ic}(b) = \alpha_0 + \alpha_1 MediumSev_i + \alpha_2 HighSev_i + \alpha_3 \ln b_i + \sum_c \delta_c (d_{ic} \times \omega_i) + \alpha_4 Female_i + \sum_a \tau_a Age_{ia} + \alpha_5 \ln y_i + \alpha_6 HighEduc_i \quad (3)$$

where $Female_i$ is a dummy variable equal to 1 when respondent i identifies as a female, Age_{ia} is a country dummy equal to 1 when respondent i belongs to age category a, $\ln y_i$ is the logged monthly income for the household of respondent i and $HighEduc_i$ is a dummy variable equal to 1 when respondent i achieved a high education outcome.

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The model is also estimated when the scale parameters include information on whether respondents have to pay health costs out of pocket, whether they perceive their health below or above average people of their gender and age, whether they are diagnosed with any other chronic disease and whether they or a relative was diagnosed with COVID-19.

Deriving mean and median WTP based on individual WTP. The mean WTP for a one-step reduction in asthma severity is computed as a simple average of the individual mean WTP as follows:

$$\widehat{WTP} = \frac{1}{n}\sum_{i=1}^{n} \widehat{WTP}_i.$$

The individual mean WTP is computed by integrating the probability of responding yes to the valuation question over the interval from 0 to maximum bid with adjustment:

$$\widehat{WTP}_i = \int_0^{b_{max}} \frac{f(\lambda_{ic}(b),k)}{1-f(\lambda_{ic}(b_{max}),k)} db,$$

where f is the density function of the Weibull distribution. Truncation at maximum bid level b_{max} is necessary since the right tail is not null when the cost goes to infinity. The adjustment of the denominator compensates for the fact that the support of $f(\lambda_{ic}(b),k)$ does not stop at b_{max}. The median WTP is also computed as a simple average of individual median WTP, computed as follows:

$$\tilde{WTP}_i = \frac{\ln 2}{|\alpha_3|} e^{\eta_{ic}\left(\frac{1}{|\alpha_3|}\right)},$$

where α_3 is the parameter for the logged bid value as indicated in Equation (1).

5.1.2. Robustness checks

Several robustness checks were performed. Overall, the baseline estimation results are robust to various methodological choices. First, the model was estimated assuming different distributions for the utility error including lognormal or log-logistic. Second, the model was estimated without allowing for a spike. Third, the model was estimated without post-stratification weights to see if rare respondents have an outsized impact on the estimates. Finally, the model was augmented with counts of problematic responses to debriefing questions to examine the sensitivity of the estimated coefficients to respondents who likely underestimated or overestimated their WTP.

5.2. Valuing a reduction in the risk of developing asthma

In addition to deriving WTP values for a reduction in asthma severity, this article also derives mean and median marginal WTP for a reduction in the risk of developing asthma, based on the choices of respondents in the context of a DCE.

Due to the structure of the choices, two types of specifications were estimated. For the first specification, the risk of having asthma is broken down into 3 levels of severity: mild, moderate, and severe.

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$$U\left(Alternative_j\right) = ASC + \beta_1 MildRisk_j + \beta_2 ModerateRisk_j + \beta_3 SevereRisk_j + \beta_4 AddedCost_j \quad (4)$$

where $Alternative_j$ is using original products or using SAFETYFIRST products (Mix B) or using SAFETYFIRST products (Mix C); ASC is the Alternative Specific Constant that is the coefficient associated with the Status Quo which corresponds to not choosing the SAFETYFIRST products; $MildRisk_j$ ($ModerateRisk_j$, $SevereRisk_j$) are the respective risks of getting mild, moderate, severe asthma under $Alternative_j$ and $AddedCost_j$ is the additional cost that the respondent chooses to pay to reduce its risks under $Alternative_j$.

The second specification estimates the reduction in the total probability of getting asthma which is the sum of risk for mild, moderate, and severe asthma and the added cost.

$$U\left(Alternative_j\right) = ASC + \beta_5 TotalRisk_j + \beta_6 AddedCost_j. \quad (5)$$

For these two specifications, estimates are made separately for non-asthmatic adults and for parents of non-asthmatic children and analyses are conducted from data for all countries. Three types of econometric estimation techniques are used: the Multinomial Logit model (MNL), the Random Parameter Logit model (RPL), and the Latent Class model (LCM).

5.2.1. Overview of the different econometric models

Regarding the Multinomial Logit (MNL) model, individuals are assumed to assign the same value to an attribute entering into their utility function. The coefficient associated with this attribute is considered to be identical for all individuals (McFadden, 1974), which is a very strong assumption.

The Random Parameter Logit model (RPL) makes it possible to take into account the heterogeneity of individuals' preferences by allowing coefficients associated with the different attributes to vary randomly according to a specified distribution $f(\beta|\Omega)$. The coefficient associated with the status quo is assumed to be normally distributed and therefore it can be positive or negative depending on whether the individual has utility or disutility from not using SAFETYFIRST products. The non-monetary attributes associated with reductions in the risk of developing asthma follow an exponential Weibull distribution because their coefficients would naturally be positive. The coefficient associated with the added cost is assumed to be deterministic. In the case where individual i makes T choices,[8] it is assumed that their preferences for a given attribute do not vary over their choices. The probability for an individual i choosing alternative j for choice t is then calculated as follows:

$$P_i(y_{it} = j|\Omega) = \int_{\beta} P_i(y_{it} = j|\beta) f(\beta|\Omega) d\beta, \quad (6)$$

where $y_{it} = j$ corresponds to the alternative chosen by individual i for the choice t and where

$$P_i(y_{it} = j|\beta) = \frac{exp\left(\alpha_i + \beta_i' X_{ijt}\right)}{\sum_{j=1}^{J} exp\left(\alpha_i + \beta_i' X_{ijt}\right)}, \quad (7)$$

[8] Here, the number of choices by individual is 5.

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where α is the constant associated with the status quo and X corresponds to the different attributes. Consequently, the log-likelihood function associated with the various coefficients to be estimated is defined as follows:

$$\ln L(\Omega) = \sum_{i=1}^{N} \ln \left(\int_{\beta} \left(\prod_{t=1}^{T} P_i(y_{it} = j|\beta) \right) f(\beta|\Omega) d\beta \right). \tag{8}$$

Since the integral of the log-likelihood must be approximated through simulations, the different parameters of the estimate are calculated from different random samples.[9]

Nevertheless, in the model presented above, the sources of heterogeneity are assumed to be random. A refinement of this model following Hensher and Greene (2003) is to allow the means of the parameter distributions to be heterogeneous according to the country of individuals. Alternatively, the heterogeneity of individuals' preferences can be modeled through a discrete distribution using the Latent Class model. This type of model assumes that each individual belongs to a class c, and his membership can be linked to his geographic origin. This model simultaneously divides individuals into classes and estimates the different coefficients β_c of the utility function conditional on class membership (Greene & Hensher, 2003). The probability that individual i chooses alternative j for choice t is then calculated as follows:

$$P(y_{it} = j) = \sum_{c=1}^{C} (P(class = c) \times P(y_{it} = j|class = c)), \tag{9}$$

where $P(y_{it} = j|class = c)$ is the probability for the individual i to choose the choice t, the alternative j conditional on their membership to the class c. This probability is calculated as follows:

$$P(y_{it} = j|\text{class} = \text{c}) = \frac{exp\left(\alpha_c + \beta_c' X_{ijt}\right)}{\sum_{j=1}^{J} exp\left(\alpha_c + \beta_c' X_{ijt}\right)}. \tag{10}$$

$P(class = c)$ is the probability of belonging to class c, calculated as follows:

$$P(\text{class} = \text{c}) = \frac{exp\left(\theta_c' z_i\right)}{\sum_{c=1}^{C} exp\left(\theta_c' z_i\right)}, \tag{11}$$

where z_i corresponds to the choice-invariant characteristics having a potential effect on the probability of belonging to class c (e.g. geographical origin) and θ_c corresponds to the coefficients associated with the variables z_i, specific to class c. Since each individual makes a series of T choices, the probability of choosing alternative j by individual i is

$$P(y_i = j) = \sum_{c=1}^{C} P(\text{class} = \text{c}) \underbrace{\prod_{t=1}^{T} (P(y_{it} = j|\text{class} = \text{c}))}_{P_i(j|c)}. \tag{12}$$

[9] The RPL model is estimated using 500 draws.

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The log-likelihood function associated with the various parameters to be estimated is then defined as follows:

$$\ln L = \sum_{i=1}^{N} \ln \left(\sum_{c=1}^{C} P(\text{class} = \text{c}) \prod_{t=1}^{T} (P(y_{it} = j \,|\, \text{class} = \text{c})) \right). \tag{13}$$

Due to its structure, the Latent Class model is generally considered to be an easier model to implement and to understand by decision makers, as it allows for the identification of different classes of marginal willingness-to-pay, defined according to the individual's profile as well as their respective weights in the surveyed population.

5.2.2. Deriving mean and median marginal WTP

The individual marginal Willingness to Pay for each non-monetary attribute is then calculated as follows in the case of an RPL model:

$$MWTP_{i,non\ monetary\ attribute} = -\frac{\hat{\beta}_{i,non\ monetary\ attribute}}{\hat{\beta}_{i,added\ cost}}. \tag{14}$$

In the case of a Latent Class model, the calculation of the individual marginal willingness to pay for each non-monetary attribute is calculated in the same way after calculating the coefficients of the different attributes $\hat{\beta}_i$, as follows:

$$\hat{\beta}_i = \sum_{c=1}^{C} \hat{\pi}^*_{ic} \hat{\beta}_c, \tag{15}$$

with

$$\hat{\pi}^*_{ic} = \frac{\hat{\pi}_{ic} \hat{P}_i(j|c)}{\sum_{c=1}^{C} \hat{\pi}_{ic} \hat{P}_i(j|c)}. \tag{16}$$

The unweighted individual marginal willingness to pay ($MWTP_i$) for the non-monetary attributes are calculated via Equation (14). They are then weighted to compute willingness-to-pay statistics that are representative of the population. The weighted mean marginal WTP is calculated as follows:

$$\overline{MWTP} = \frac{1}{N} \sum_{i=1}^{N} \omega_i MWTP_i, \tag{17}$$

where ω_i is the post-stratification weight for individual i derived from a raking algorithm that corrects for differences between target population quotas and achieved sample quotas. The mean marginal WTP (and the median marginal WTP) by country are calculated from pooled data according to the respondents belonging to the different countries.

6. Results

6.1. Valuing a reduction in asthma severity in adults and children

This section presents the results of the estimation of the mean and median willingness to pay of asthmatic adults and parents of asthmatic children for a reduction in asthma severity in the

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context of a DBDC. The econometric methods associated with these estimates are presented in detail in Section 5.1.

6.1.1. Main results

The parametric estimation results of model 1 for asthmatic adults are presented in Table 13. Column 1 shows the baseline estimation results. Baseline asthma severity has a positive and statistically significant effect on the joint probabilities of choosing the reduced severity options. Asthmatics who have a mild plus or moderate form of asthma are willing to pay more than those who have a very mild or mild asthma. Moreover, asthmatics who have moderate plus or severe asthma are willing to pay even more for a reduced severity than those having a mild plus or moderate asthma. Consistent with expectations, the additional cost of choosing the reduced severity option has a negative and statistically significant effect. The spike variable equals 0.04 and is statistically different from zero. In other words, the average probability that people are indifferent to the valued item is 4% for the estimation sample.

For an average reduction (one step) in asthma severity, the mean WTP equals USD PPP[10] 529 per year over 10 years and the median WTP equals USD 200 per year over 10 years. For adults with mild asthma, mean WTP equals USD 382 per year and median WTP equals USD 127 per year. For adults with mild plus or moderate asthma, mean WTP equals USD 594 per year and median WTP equals USD 227 per year. Finally, for adults with moderate plus or severe asthma, mean WTP equals USD 895 per year and median WTP equals USD 408 per year. Supplementary material B.1 provides the estimation results where all baseline severity levels are included as regressors. Results are consistent with the baseline model. However, given the small number of respondents with severe asthma, there is not enough statistical power to properly test the influence of severe asthma on WTP responses. These results are robust to alternative methodological choices. Column 2 shows the estimation results when a log-logistic distribution of the errors is assumed, while column 3 assumes a log-normal distribution. Column 4 shows the estimation results when country dummies interacted with post-stratification weights are not included as regressors. Column 5 excludes the possibility of a spike at zero. All columns show a positive impact of baseline asthma severity and a negative impact of cost on the joint probabilities to choose the reduced severity option that is statistically different from zero. All columns report similar WTP estimates. The mean WTP varies from USD 529 to USD 615 per year and the median WTP varies from USD 175 to USD 205. The largest deviation from the baseline is when a log-normal distribution is assumed but this deviation is not economically large. Dropping the spike variable reduces the absolute value of all coefficients.

The parametric estimation results of model 1 for parents of an asthmatic child are presented in Table 14. Column 1 shows the baseline estimation results, which are very similar to what is found for asthmatic adults. Overall, for an average reduction in child asthma severity, the mean WTP equals USD 948 per year over 10 years and the median WTP equals USD 416 per year over 10 years. The mean WTP for a reduction in child asthma severity is 1.8 times the mean WTP for a reduction in adult asthma severity, while the median WTP is twice as high for child asthma severity as for adult asthma severity. This difference

[10] All the dollar amount mentioned in this paper are PPP adjusted. For simplicity, USD PPP will be written as USD.

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Table 13. *Main parametric estimations of WTP to reduce asthma severity in adults*

	Spike				No spike
	Weibull	Log-logistic	Log-normal	Without weight	Weibull
	1	2	3	4	5
Has mild plus or moderate asthma (0/1)	0.308***	0.462***	0.298***	0.308***	0.297***
	(0.054)	(0.082)	(0.049)	(0.054)	(0.054)
Has moderate plus or severe asthma (0/1)	0.619***	0.811***	0.470***	0.622***	0.612***
	(0.116)	(0.164)	(0.095)	(0.116)	(0.116)
Log(cost)	−0.530***	−0.706***	−0.404***	−0.531***	−0.513***
	(0.012)	(0.017)	(0.009)	(0.012)	(0.014)
Spike	0.043***	0.028***	0.022***	0.043***	
	(0.003)	(0.002)	(0.002)	(0.003)	
Observations	2 194	2 194	2 194	2 194	2 194
Country dummies	No	No	No	Yes	No
Country dummies × weights	Yes	Yes	Yes	No	Yes
Log-likelihood	−3 218	−3 222	−3 231	−3 210	−2 979
LR statistics	81	76	83	96	77
AIC	6 457	6 466	6 484	6 440	5 981
BIC	6 520	6 529	6 547	6 497	6 044
WTP (USD per year over 10 years)					
Mean WTP (truncated at the maximum bid with adjustment)	529	601	615	535	538
Median WTP (mean of median)	200	175	169	205	196

Note: Significance codes: "***" 0.001 "**" 0.01 "*" 0.05 "+" 0.1 " " 1. The baseline estimation corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution with a spike configuration. All columns exclude very slow respondents as well as speeders. Base group: mild asthmatic, American, aged 18–29, male with low and medium education. The intercept, country dummies, and country dummies interacted with the sampling weight are included as regressors but not reported in the table for clarity.
Source: Authors' own elaboration.

Table 14. *Main parametric estimations of WTP to reduce asthma severity in children*

	Spike				No spike
	Weibull	Log-logistic	Log-normal	Without weight	Weibull
	1	2	3	4	5
Child has a mild plus or moderate asthma (0/1)	0.302***	0.346**	0.202**	0.320***	0.292***
	(0.078)	(0.109)	(0.065)	(0.077)	(0.078)
Child has a moderate plus or severe asthma (0/1)	0.486**	0.616**	0.346**	0.518**	0.473**
	(0.174)	(0.227)	(0.134)	(0.173)	(0.174)
Log(cost)	−0.447***	−0.569***	−0.330***	−0.445***	−0.395***
	(0.015)	(0.020)	(0.010)	(0.015)	(0.017)
Spike	0.050***	0.038***	0.030***	0.051***	
	(0.005)	(0.004)	(0.004)	(0.005)	
Observations	1 339	1 339	1 339	1 339	1 339
Country dummies	No	No	No	Yes	No
Country dummies × sample weights	Yes	Yes	Yes	No	Yes
Log-likelihood	−1 808	−1 794	−1 791	−1 817	−1 660
LR statistics	65	63	63	48	62
AIC	3 637	3 610	3 604	3 653	3 343
BIC	3 695	3 668	3 661	3 705	3 400
WTP (USD per year over 10 years)					
Mean WTP (truncated at the maximum bid with adjustment)	948	991	1 024	939	1 005
Median WTP (mean of median)	416	374	380	404	424

Note: Significanse codes: 0 "***" 0.001 "**" 0.01 "*" 0.05 "+" 0.1 " " 1. The baseline estimation corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution with a spike configuration. All columns exclude very slow respondents as well as speeders. Base group: mild asthmatic child, American, male with non-asthmatic parent. Country dummies and country dummies that interacted with the sampling weight are included as regressors but not reported in the table for clarity.
Source: Authors' own elaboration.

between children and adults is similar to what is found in the VSL literature (OECD, 2012), where results from the United States and Europe indicate that VSL for children can be as high as a factor of 2 greater than that of their parents/adults (US EPA, 2003; OECD, 2010).

For parents of a child with mild asthma, mean WTP equals USD 707 per year and median WTP equals USD 245 per year (Figure 6). For parents of a child with mild plus or moderate asthma, mean WTP equals USD 1 056 per year and median WTP equals USD 481 per year. Finally, for parents of a child with moderate plus or severe asthma, mean WTP equals USD 1 330 per year and median WTP equals USD 726 per year.

Supplementary material B.1 provides the estimation results where all baseline severity levels are included as regressors. Results are consistent with the baseline model. However, given the small number of respondents with children with severe asthma, there is not enough

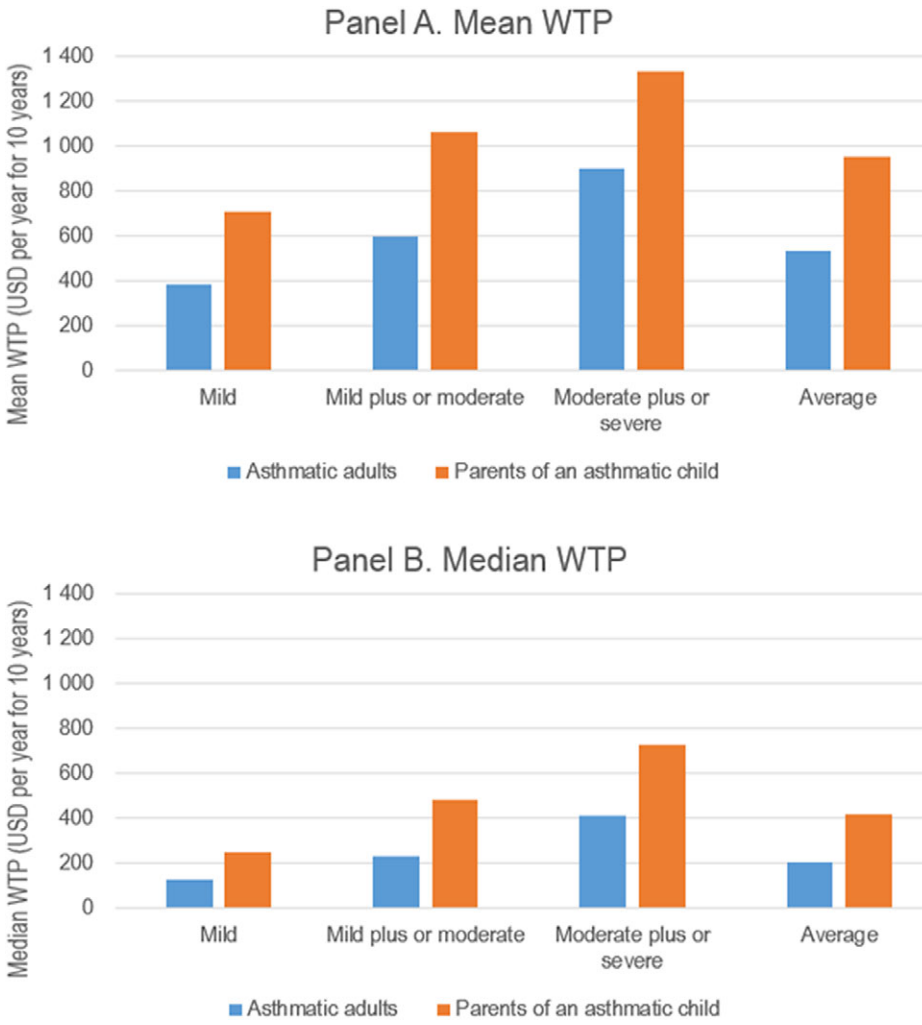

Figure 6. *Mean and median WTP for a reduction in asthma severity in adults and children.*
Source*: Authors' own elaboration.*

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statistical power to properly test the influence of severe childhood asthma on WTP responses.

Figure 6 compares the mean (panel A) and median (panel B) WTP responses for adults and parents of their asthmatic child by severity level. Both mean and median show that WTP of adults for themselves is consistently less than their WTP for their asthmatic child at all three severity categories and WTP is greater for reducing severity by one step the more severe the baseline asthma is. As also found for adults, these results for children are robust to alternative methodological choices, as shown in Table 14. The mean WTP to reduce childhood asthma severity varies from USD 939 to USD 1 024 per year and the median WTP varies from USD 374 to USD 424. The largest deviation from the baseline is when a log-normal distribution is assumed but this deviation is not economically large.

To analyze the different determinants of WTP, model 3 includes additional control variables and model 4 includes health-related controls are estimated (Table 15). Column 1 reports the baseline model estimated on the same sample for comparison. The main determinants of WTP to reduce asthma severity are in order of importance: having more severe asthma, having to pay medical costs out of pocket, having another chronic disease, income, being aged 30 or more, and gender. Having to pay medical costs out of pocket has a positive and statistically significant effect on the probability of choosing the reduced severity option. Therefore, some respondents did consider medical costs when choosing between baseline severity and reduced severity even if they were instructed to not think about saving these costs through using SAFETYFIRST products and to only think about the non-monetary benefits to them and the rest of their family from them having less severe asthma. The impact of this anticipation is explored in more detail in Section 6.1.4.

WTP is correlated with other factors. Asthmatics who are diagnosed with other chronic diseases state a higher willingness to pay than asthmatics who have no other chronic disease. This is consistent with expectations. Asthmatics aged 30 or above stated a lower WTP than asthmatics aged 18–29. This could be related to the quality-of-life impact of asthma which can be less important at different stages of life. For example, asthmatics aged 30 might be less physically active than asthmatics aged 18–29. Female respondents stated a lower willingness to pay than male respondents, conditional on income level. Asthmatics with higher income and higher education stated higher WTP, other things equal. Respondents who did not provide income stated lower WTP. This could be either because they did not report their low income or they had less interest in the survey and in the proposed risk reduction.[11] Finally, perceived health status, having had a positive diagnosis of COVID-19 and having a relative who had COVID-19 have no statistically significant impact on WTP.

To illustrate the relative magnitude of the impact of these different factors, marginal effects on mean WTP are provided in column 4 in Table 15. These marginal effects are based on the results of the estimated odds ratios reported in column 3 by changing at the margin the different determinants one by one. The mean WTP for asthmatics with moderate plus or severe asthma is USD 480 per year more than what it is for adults with mild asthma. The mean WTP for adults with mild plus or moderate asthma is UDS 148 per year more than what it is for adults with mild asthma. Asthmatics who have to pay their medical costs out of their pocket are willing to pay USD 161 per year more than those who have any form of insurance

[11] Including the missing income dummy has no impact on the estimated parameters as shown by Supplementary material B.2. even if it is negative and statistically significant.

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Table 15. *The determinants of WTP to reduce asthma severity in adults*

	Basic	Basic + controls	Basic + controls + health	
	Odds ratios	Odds ratios	Odds ratios	Marginal effect (USD per year)
	1	2	3	4
Has mild plus or moderate asthma (0/1)	0.308*** (0.054)	0.253*** (0.055)	0.210*** (0.056)	+148
Has moderate plus or severe asthma (0/1)	0.619*** (0.116)	0.634*** (0.117)	0.555*** (0.120)	+480
Female (0/1)		−0.154** (0.054)	−0.154** (0.055)	−116
Aged 30–44 (0/1)		−0.176* (0.076)	−0.183* (0.077)	−152
Aged 45–59 (0/1)		−0.290*** (0.077)	−0.287*** (0.078)	−225
Aged 60+ (0/1)		−0.218* (0.089)	−0.229* (0.090)	−185
Log(Income)		0.245*** (0.040)	0.244*** (0.041)	+28[a]
Missing income (0/1)		−0.327*** (0.092)	−0.323*** (0.091)	−208
High education (0/1)		0.123* (0.057)	0.127* (0.058)	+96
Health expenditure out of my pocket (0/1)			0.195* (0.095)	+161
Health perceived below average (0/1)			−0.037 (0.067)	−27
Health perceived above average (0/1)			0.049 (0.064)	+38
Not diagnosed with chronic diseases (0/1)			−0.220*** (0.060)	−157
Was diagnosed with COVID-19 (0/1)			0.068 (0.060)	+52
Relative was diagnosed with COVID-19 (0/1)			0.065 (0.053)	+49
Log(Cost)	−0.530*** (0.012)	−0.538*** (0.012)	−0.541*** (0.013)	
Spike	0.043*** (0.003)	0.041*** (0.003)	0.041*** (0.003)	
Observations	2 194	2 194	2 194	
Country dummies × sample weights	Yes	Yes	Yes	
Log-likelihood	−3 218	−3 170	−3 159	

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Table 15. *Continued*

	Basic	Basic + controls	Basic + controls + health	
	Odds ratios	Odds ratios	Odds ratios	Marginal effect (USD per year)
	1	2	3	4
LR statistics	81	177	198	
AIC	6 457	6 376	6 366	
BIC	6 520	6 478	6 503	
Mean WTP truncated at the maximum bid with adjustment (USD per year over 10 years)	529	551	555	
Median WTP (USD per year over 10 years)	200	225	230	

Note: Signif. codes: 0 "***" 0.001 "**" 0.01 "*" 0.05 "+" 0.1 " " 1. The baseline estimation corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution with a spike configuration. All columns exclude very slow respondents as well as speeders. Base group: mild asthmatic, American, aged 18–29, male with low and medium education, health perceived as average compared to other people of the same age and gender. Country dummies and country dummies interacted with the sampling weight are included as regressors but not reported in the table for clarity.

[a]For income, the marginal effect equals the increase in mean WTP due to an increase of average income by USD 500 per month.

Source: Authors' own elaboration.

(public or/and private). Asthmatics who have another chronic disease are willing to pay USD 157 per year more on average. Asthmatics aged 45–59 are willing to pay USD 225 per year less than asthmatics aged 18–29. Women are willing to pay USD 116 per year less than men on average. Finally, income has a rather small impact. When income increases by USD 500 per month, mean WTP only increases by USD 28 per year. The income elasticity equals 0.3.[12]

To analyze the different determinants of WTP for reduction in childhood asthma severity, models that include additional control variables and health related controls are estimated in columns 2 and 3 in Table 16. Column 1 reports the baseline model estimated on the same sample for comparison. The main determinants of WTP to reduce childhood asthma severity are in order of importance: severity, presence of another chronic disease, degree of asthma control, child gender, income and child age. To illustrate the relative magnitude of the impact of these different factors, marginal effects on mean WTP are computed in column 4 in Table 16 using the estimates reported in column 3. If their child has moderate plus or severe asthma, parents are willing to pay USD 325 per year more than if their child has mild asthma. If their child has mild plus or moderate asthma, parents are willing to pay USD 128 more per year than if their child has mild asthma.[13] It is found that parents are willing to pay USD 335 per year more if their child has another chronic disease. Finally, as would be expected, if the asthma of their child is completely controlled, parents are willing to pay USD 227 per

[12] The income elasticity is obtained by computing the % difference between the mean WTP when average income increases by 1% and the baseline mean WTP.

[13] Baseline severity is not statistically significant in this extended model because of the smaller statistical power.

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Table 16. *The determinants of WTP to reduce asthma severity in children*

	Basic	Basic + controls	Basic + controls + health	
	Odd ratios	Odd ratios	Odd ratios	Marginal effect (USD per year)
	1	2	3	4
Child has mild plus or moderate asthma (0/1)	0.302*** (0.078)	0.178* (0.084)	0.104+ (0.087)	+128
Child has moderate plus or severe asthma (0/1)	0.486** (0.174)	0.359* (0.177)	0.244 (0.182)	+325
Child asthma is completely controlled (0/1)		−0.187* (0.080)	−0.177** (0.081)	−227
Female child (0/1)		−0.182* (0.076)	−0.168* (0.076)	−210
Child age		−0.021** (0.008)	−0.022** (0.008)	−28
Asthmatic parent (0/1)		0.000 (0.078)	−0.042 (0.079)	−53
Log(Income)		0.337*** (0.058)	0.339*** (0.058)	+52[a]
Missing income (0/1)		−0.505*** (0.158)	−0.493** (0.158)	−496
Health expenditure out of my pocket (0/1)			−0.057 (0.141)	−70
Child health perceived below average (0/1)			0.174 (0.112)	+234
Child health perceived above average (0/1)			−0.028 (0.084)	−35
Child diagnosed with other chronic diseases (0/1)			0.290*** (0.095)	+335
Log(Cost)	−0.447*** (0.015)	−0.457*** (0.015)	−0.459*** (0.016)	
Spike	0.050*** (0.005)	0.047*** (0.005)	0.046*** (0.005)	
Observations	1 339	1 339	1 339	
Country dummies × sample weights	Yes	Yes	Yes	
Log-likelihood	−1 808	−1 780	−1 770	
LR statistics	65	121	134	
AIC	3 637	3 594	3 588	

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Table 16. *Continued*

	Basic	Basic + controls	Basic + controls + health	
	Odd ratios	Odd ratios	Odd ratios	Marginal effect (USD per year)
	1	2	3	4
BIC	3 695	3 682	3 698	
Mean WTP truncated at the maximum bid with adjustment (USD per year over 10 years)	948	994	1 001	
Median WTP (USD per year over 10 years)	416	501	513	

Note: Signif. codes: 0 "***" 0.001 "**" 0.01 "*" 0.05 "+" 0.1 " " 1. The baseline estimation corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution with a spike configuration. All columns exclude very slow respondents as well as speeders. Base group: mild asthmatic child, American, male with non-asthmatic parent, child health perceived as average compared to other children of the same age and gender. Country dummies interacted with the sampling weight are included as regressors but not reported in the table for clarity.

[a]For income, the marginal effect equals the increase in mean WTP due to an increase of average income by USD 500 per month.

Source: Authors' own elaboration.

year less than if it's partially or not controlled at all. If their child is female, parents are willing to pay USD 210 per year less than if their child is male. This apparent preference for boys health can be surprising considering that there does not seem to be any major difference in the severity of symptoms in asthmatic males when compared to asthmatic females in childhood (Almqvist *et al.,* 2008) and that baseline severity and asthma control are both explicitly controlled for in the model. When income increases by USD 500 per month, mean WTP for a reduction in childhood asthma increases by USD 52 per year. The income elasticity equals 0.4 and is obtained by computing the percentage difference between the mean WTP when average income increases by 1% and the baseline mean WTP.[14] It is 0.1 higher than the estimated income elasticity for adults. Finally, mean WTP to reduce childhood asthma severity decreases by USD 28 per year when the age of the child increases by 1 year. This is not surprising as parents generally consider young children to be more fragile as their lungs have not yet fully developed.

6.1.2. Country-level estimates

Mean and median WTP at the country level are reported in Table 17. They are computed from individual WTP derived from the estimation of model 1 reported in column 1 in Table 13 for adult asthma severity and column 1 in Table 14 for childhood asthma severity. The mean WTP for a one-step reduction in adult asthma severity varies from USD 429 per

[14] Including the missing income dummy has no impact on the estimated parameters as shown by Supplementary material B.3 even if it is negative and statistically significant.

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Table 17. *Country-level estimates of WTP to reduce asthma severity*

USD per year over 10 years for	Mean WTP		Median WTP	
	Reduction in *adult* asthma severity	Reduction in *childhood* asthma severity	Reduction in *adult* asthma severity	Reduction in *childhood* asthma severity
Canada	429	840	150	331
Czech Republic	685	1 080	280	495
France	438	775	153	302
Poland	632	1 130	252	534
Sweden	471	756	168	294
United Kingdom	445	743	158	267
United States	587	1 317	227	694

Note: Mean and median WTP at the country level are computed from individual WTP derived from the estimations of model 1 reported in column 1 in Table 13 for adult asthma severity and column 1 in Table 14 for childhood asthma severity. Mean WTP is truncated at the maximum bid with adjustment and median WTP is computed as the mean of individual medians.
Source: Authors' own elaboration.

year in Canada to USD 685 per year in Czech Republic. The median WTP varies from USD 150 per year in the Canada to USD 280 in Czech Republic.

As a robustness check, model 1 is estimated for each country taken separately. Results are provided in Supplementary material B.4. for adult asthma severity. For all countries, adults having mild plus or moderate asthma are more likely to choose the reduced severity option. However, the coefficient is not statistically significant in the Czech Republic, Sweden, and Poland. For all countries, adults having a moderate plus or severe asthma have the highest WTP to reduced asthma severity though the coefficient is not statistically different from zero for the Czech Republic and Poland. The largest difference in WTP from mild asthma and WTP from mild plus or moderate asthma is found for the United Kingdom, Canada, and the United States. The largest difference in WTP from mild asthma and WTP from moderate plus or severe asthma is found for Canada, Sweden, and the United Kingdom. In all countries, the cost for the reduced risk option has a negative effect on the probability of choosing the reduced severity option that is statistically different from zero. Cost sensitivity is smallest in the United Kingdom and highest in the Czech Republic. The spike at zero varies from 2.3% in the Czech Republic to 6.9% in the United Kingdom. The small median WTP value compared to the mean WTP value for the United Kingdom, France, and Sweden is consistent with the high share of respondents who are indifferent to the valued item, the spike at zero.

The mean and median WTP derived from these separate regressions are highly similar to the values obtained via the estimation of the pooled model showing the high robustness of the baseline results presented in Table 17. The largest difference compared to the baseline is USD 55 per year less for Canada and USD 61 per year more for the United States. The mean WTP for a one-step reduction in childhood asthma severity varies from USD 743 per year in the United Kingdom to USD 1 130 per year in Poland. The median WTP varies from USD 267 per year in the United Kingdom to USD 694 in the United States.

As a robustness check, model 1 is estimated for each country taken separately for childhood asthma severity. Results are provided in Supplementary material B.5. Overall,

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WTP increases with baseline asthma severity. However, the corresponding coefficients are not always statistically different from zero because of the few numbers of parents of an asthmatic child surveyed in each country. In all countries, the cost for the reduced childhood asthma severity option has a statistically significant negative effect on the probability of choosing the reduced risk option. Cost sensitivity is smallest in the United States and highest in the Czech Republic. The spike at zero varies from 3.4% in the Czech Republic to 6% in Sweden and the United Kingdom. The mean and median WTP derived from these separate regressions are very similar to the values obtained via the estimation of the pooled model, which is evidence for the robustness of the results. The largest difference compared to the baseline is USD 172 per year less for the United States and USD 95 per year more for Poland.

Unsurprisingly, the mean WTP to reduce childhood asthma severity is positively correlated with the mean WTP to reduce adult asthma severity as illustrated in Figure 7. Compared to other countries, parents of an asthmatic child in the United States exhibit a relatively higher premium for reduced asthma severity than adults for a reduction of their own asthma severity. Figure 7 reveals two groups of countries. The first group consists of Canada, France, the United Kingdom, and Sweden which exhibit lower WTP values. The second group consists of the United States, Poland, and the Czech Republic where respondents' choices led to higher WTP values.

The potential drivers of cross-country differences in WTP are illustrated using only WTP for a reduction in adult asthma severity since it is highly correlated with WTP for a reduction in childhood asthma severity. At the country level, mean WTP to reduce asthma severity is positively correlated with the effectiveness of health systems, which are proxied by the rates

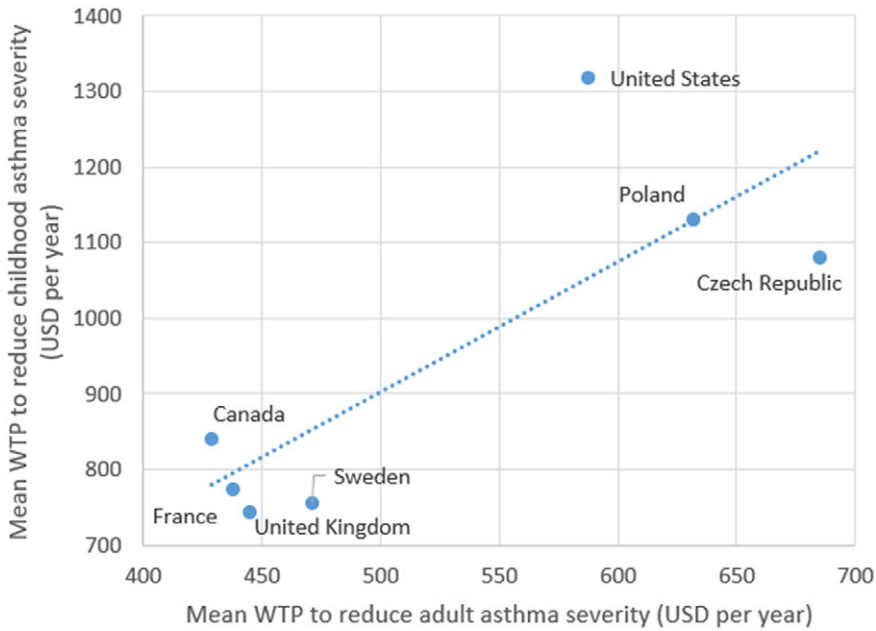

Figure 7. *WTP to reduce adult and childhood asthma severity by country.* Note*: Mean WTP derived from the parametric estimations reported in Table 17.*
Source: *Authors' own elaboration.*

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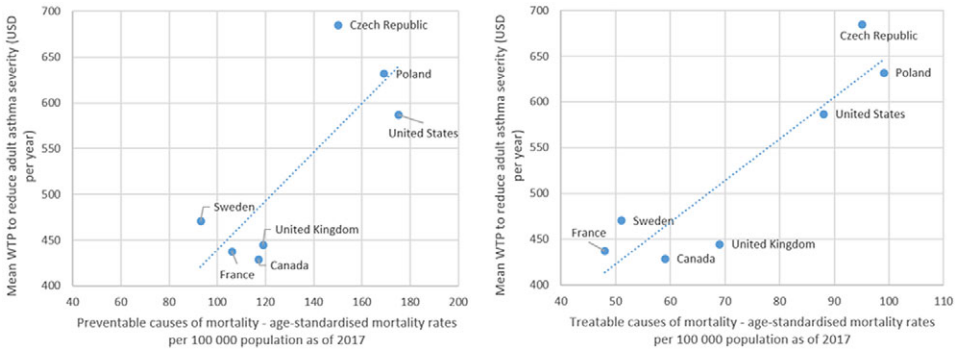

Figure 8. *WTP to reduce adult asthma severity and effectiveness of health system.*
Note: Mean WTP derived from the parametric estimations reported in Table 17.
Source: *Data on preventable and treatable causes of mortality come from OECD (2019), "Avoidable mortality (preventable and treatable)," in Health at a Glance 2019: OECD Indicators, OECD Publishing, Paris, https://doi.org/10.1787/3b4fdbf2-en.*

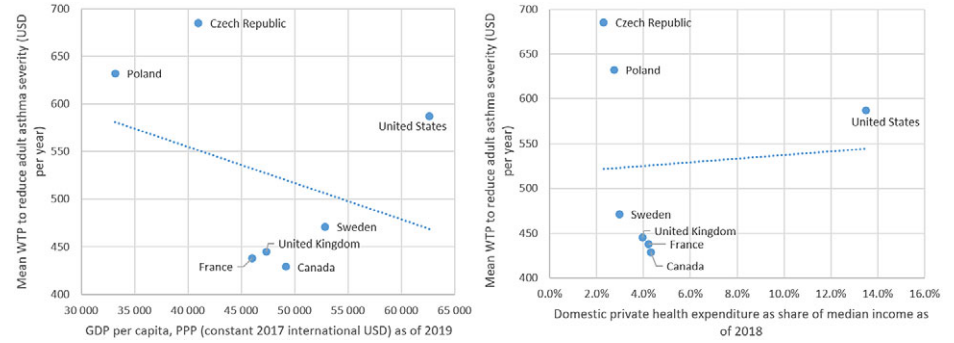

Figure 9. *WTP to reduce adult asthma severity, GDP per capita, and medical cost burden.*
Note: Mean WTP derived from the parametric estimations reported in Table 17.
Source: *GDP per capita in 2019, PPP (constant 2017 international USD) comes from the World Bank. Data on domestic private health expenditure per capita comes from the World Health Organization Global Health Expenditure database. Data on equivalized income are taken from OECD Income Distribution Database.*

of preventable and treatable causes of mortality[15] (Figure 8), while is it weakly negatively correlated with GDP per capita and uncorrelated with medical cost burden (Figure 9). Medical cost burden is measured by the ratio between domestic private health expenditure per capita (including prepayment to voluntary health insurance and direct payment to healthcare providers) and median income. That WTP is mostly correlated with the efficiency of the health system in the country of residence of respondents is consistent with the strong impact of having another chronic disease on WTP at the level of individuals.

[15] These indicators are used notably by OECD and European Union (OECD and European Union, 2022).

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6.1.3. Additional robustness checks

The baseline estimation results for adult asthma severity are also highly robust to different screening choices as shown in Table 18. Basically, problematic (termed "poor" in the text and Table 18) answers to debriefing questions leading to underestimates of WTP are balanced by poor responses leading to overestimates. Thus, when adding the number of poor answers to debriefing questions that are non-directional, overestimating and underestimating in column 2, the mean WTP to reduce adult asthma severity is only USD 65 per year less than the baseline, while the median WTP is only USD 26 per year more than the baseline. The number of poor non-directional debriefs has a negative and statistically significant impact on WTP. The number of poor overestimating debriefs has a statistically positive impact on WTP, as expected. However, the number of poor underestimating debriefs also has a positive impact (though not highly statistically significant). When removing asthmatics who responded poorly to more than two non-directional debriefs in column 3 (1.5%), the mean WTP is USD 3 per year less than the baseline, while the median WTP is the same as the baseline. When removing asthmatics who responded poorly to more than 3 overestimation debriefs in column 4 (2%), the mean WTP is USD 10 per year less than the baseline, while the median WTP is USD 5 per year less than the baseline. Finally, when removing asthmatics who responded poorly to more than two underestimation debriefs in column 5 (4.3%), the mean WTP is USD 67 less than the baseline, while the median WTP is USD 2 per year more than the baseline. In columns 4 and 5, the signs of the deviation from the baseline are consistent with the expected direction due to the poor responses with the exception of the mean WTP when removing respondents with more than 3 underestimation debriefs. This could be explained by the mean WTP being more sensitive than the median WTP to outliers that are high values of individual WTP.

The baseline estimation results for childhood asthma severity are also highly robust to different screening choices as shown in Table 19. However, estimates of WTP for childhood asthma severity are more sensitive to screening choice in absolute terms than the corresponding estimates for adult asthma. This might be due to the lower number of observations (1 339) for childhood asthma severity compared to the 2 194 observations for adult asthma severity. When adding the number of poor answers to debriefing questions that are non-directional, overestimating and underestimating in column 2, the mean WTP to reduce adult asthma severity is USD 49 per year more than the baseline, while the median WTP is USD 90 per year more than the baseline. Similar to the results for adult asthma severity, the number of poor non-directional debriefs has a negative and statistically significant impact on WTP whereas the number of poor overestimating debriefs and the number of poor underestimating debriefs both have a statistically positive impact on WTP.

When removing parents of an asthmatic child (2.8%) who responded poorly to more than two non-directional debriefs in column 3, the mean WTP is USD 1 per year more than the baseline, while the median WTP is USD 1 per year more than the baseline. When removing parents of an asthmatic child (15.9%) who responded poorly to more than three overestimation debriefs in column 4, the mean WTP is USD 83 per year less than the baseline, while the median WTP is USD 50 per year less than the baseline. Finally, when removing parents of an asthmatic child (4.9%) who responded poorly to more than two underestimation debriefs in column 5, the mean WTP is USD 10 per year more than the baseline, while the median WTP is USD 9 per year more than the baseline. In columns 4 and 5, the signs of the deviation from the baseline are consistent with the expected direction due to the poor

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Table 18. *Estimations of WTP to reduce asthma severity in adults including debriefing controls*

	Basic	Basic + debrief counts	Only respondents with less than 3 non-directional	Only respondents with less than 4 overestimations	Only respondents with less than 3 underestimations
	1	2	3	4	5
Has mild plus or moderate asthma (0/1)	0.308***	0.211***	0.317***	0.296***	0.294***
	(0.054)	(0.055)	(0.054)	(0.054)	(0.055)
Has moderate plus or severe asthma (0/1)	0.619***	0.502***	0.638***	0.568***	0.646***
	(0.116)	(0.117)	(0.118)	(0.117)	(0.119)
Number of poor non-directional debriefs		−0.146***			
		(0.037)			
Number of poor overestimating debriefs		0.233***			
		(0.029)			
Number of poor underestimating debriefs		0.074*			
		(0.034)			
Log(Cost)	−0.530***	−0.541***	−0.533***	−0.533***	−0.523***
	(0.012)	(0.013)	(0.012)	(0.012)	(0.013)
Spike	0.043***	0.041***	0.043***	0.043***	0.043***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	2 194	2 194	2 160	2 150	2 100
Country dummies × sample weights	Yes	Yes	Yes	Yes	Yes
Log-likelihood	−3 218	−3 175	−3 165	−3 155	−3 074
LR statistics	81	166	85	77	78
AIC	6 457	6 378	6 351	6 332	6 171
BIC	6 520	6 458	6 414	6 395	6 233

Table 18. *Continued*

	Basic	Basic + debrief counts	Only respondents with less than 3 non-directional	Only respondents with less than 4 overestimations	Only respondents with less than 3 underestimations
	1	2	3	4	5
WTP (USD per year over 10 years)					
Mean WTP (truncated at the maximum bid with adjustment)	529	464	526	519	462
Median WTP (mean of median)	200	226	200	195	202

Note: Signif. codes: "***" 0.001 "**" 0.01 "*" 0.05 "+" 0.1 " " 1. The baseline estimation corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution with a spike configuration. All columns exclude very slow respondents as well as speeders. Base group: mild asthmatic, American, aged 18–29, male with low and medium education. Country dummies and country dummies interacted with the sampling weight are included as regressors but not reported in the table for clarity.
Source: Authors' own elaboration.

Table 19. *Estimations of WTP to reduce asthma severity in children including debriefing controls*

	Basic	Basic + debrief counts	Only respondents with less than 3 non-directional	Only respondents with less than 4 overestimations	Only respondents with less than 3 underestimations
	1	2	3	4	5
Child has mild plus or moderate asthma (0/1)	0.302***	0.236**	0.307***	0.350***	0.313***
	(0.078)	(0.079)	(0.078)	(0.083)	(0.080)
Child has moderate plus or severe asthma (0/1)	0.486**	0.357*	0.539**	0.400*	0.495**
	(0.174)	(0.176)	(0.178)	(0.196)	(0.181)
Number of poor non directional debriefs		−0.197***			
		(0.043)			
Number of poor overestimating debriefs		0.178***			
		(0.034)			
Number of poor underestimating debriefs		0.105*			
		(0.048)			
Log(Cost)	−0.447***	−0.456***	−0.446***	−0.462***	−0.446***
	(0.015)	(0.016)	(0.015)	(0.017)	(0.016)
Spike	0.050***	0.047***	0.050***	0.048***	0.050***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Observations	1 339	1 339	1 301	1 126	1 274
Country dummies × sample weights	Yes	Yes	Yes	Yes	Yes
Log-likelihood	−1 808	−1 782	−1 760	−1 533	−1 711
LR statistics	65	116	65	60	62
AIC	3 637	3 593	3 542	3 088	3 444
BIC	3 695	3 666	3 599	3 144	3 501

Table 19. *Continued*

	Basic	Basic + debrief counts	Only respondents with less than 3 non-directional	Only respondents with less than 4 overestimations	Only respondents with less than 3 underestimations
	1	2	3	4	5
WTP (USD per year over 10 years)					
Mean WTP (truncated at the maximum bid with adjustment)	948	997	949	865	958
Median WTP (mean of median)	416	506	417	366	425

Note: Signif. codes: "***" 0.001 "**" 0.01 "*" 0.05 "+" 0.1 "" 1. The baseline estimation corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution with a spike configuration. All columns exclude very slow respondents as well as speeders. Base group: mild asthmatic child, American, male with non-asthmatic parent. Country dummies and country dummies interacted with the sampling weight are included as regressors but not reported in the table for clarity.
Source: Authors' own elaboration.

responses. Overall, mean and median WTP obtained with these different screening approaches have the same order of magnitude as the baseline approach both for adult and childhood asthma severity. Furthermore, the estimated coefficients are highly similar to the corresponding baseline regression results.

6.1.4. The impact of anticipated medical cost savings

Despite asking respondents to focus only on non-monetary benefits, around 35% of the asthmatic adult respondents and 39% of parents of an asthmatic child thought they could save on medical costs by choosing the reduced severity option. This share is highest in the United States (53% and 59%) where the share of income dedicated to domestic private health expenditure is also the highest (Supplementary material A.8).

To investigate the impact of such anticipations on WTP, a model 1 with an additional dummy variable equal to 1 if the respondent thought he or she could save on medical costs was estimated. Results are presented in Supplementary material B.6 for adult asthma and in Supplementary material B.7 for childhood asthma. The coefficients of the dummy variable are high and statistically different from zero. They are also positive, indicating that people who thought they could save on medical costs also state a higher WTP.

For adult asthma, mean WTP equals USD 397 per year if it is assumed that no respondent thought they could save on medical costs when choosing the SAFETYFIRST products, while mean WTP equals USD 845 per year if it is assumed that all respondents thought they could save on medical cost. This difference of USD 448 per year is economically significant. Mean WTP values by country depending on respondents' assumption on medical costs are provided in Table 20. In all countries, mean WTP is twice as much if it is assumed that all respondents thought they could save on medical costs. For childhood asthma, mean WTP equals USD 758 per year if it is assumed that no respondent thought they could save on medical costs when choosing the SAFETYFIRST products, while mean WTP equals USD 1 293 per year if it is assumed that all respondents thought they could save on medical cost. This difference of USD 535 per year is also economically significant. Mean WTP values by country depending on respondents' assumption on medical cost are provided in Table 20. In all countries, mean WTP is 1.7 times higher if it is assumed that all respondents thought they could save on medical costs.

Table 20. *Mean WTP by country depending on anticipation of medical cost savings*

USD PPP per year	Adult asthma			Childhood asthma		
	No saving	Saving	Difference	No saving	Saving	Difference
Canada	320	703	383	659	1 141	482
Czech Republic	557	1 136	579	893	1 502	609
France	318	697	379	604	1 052	448
Poland	466	972	506	899	1 511	612
Sweden	365	787	422	617	1 074	457
United Kingdom	340	739	399	618	1 078	460
United States	399	849	450	1 019	1 695	676

Source: Authors' own elaboration.

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6.2. Valuing a reduction in the risk of developing asthma

This section presents the results of the estimation of the mean and median willingness to pay of non-asthmatic adults and parents of non-asthmatic children for a marginal reduction in the probability of developing asthma in the context of a DCE. The econometric methods associated with these estimates are presented in detail in Section 5.2.

6.2.1. Non-asthmatic adults

Estimates are first conducted for all countries (Canada, Czech Republic, France, Poland, Sweden, United Kingdom, and United States) for two alternative specifications. The first specification includes mild, moderate, and severe asthma risks as attributes (see. Equation (4) in Section 5.2) and the second specification includes total risk (see Equation (5) in Section 5.2[16]). Following the recommendations of Scarpa and Thiene (2005), the data indicates that the optimal number of classes is 3 for the LCM estimates for these two specifications. The heterogeneity of preferences for RPL and LCM estimates is explained via the countries where the respondents live.

The estimations are conducted using various models including MNL, RPL, and LCM. For the two specifications, the highest goodness of fit across the various models, measured by McFadden's pseudo-R^2, is obtained using the 3-class latent class model. For specification 1, McFadden's pseudo-R^2 is equal to 0.048 for the MNL model, 0.233 for the RPL model, and 0.365 for the 3-class LCM model. For specification 2, McFadden's pseudo-R^2 is equal to 0.044 for the MNL model, 0.188 for the RPL model, and 0.363 for the 3-class LCM model. Therefore, this article presents the estimation results for the 3-class latent class model (Table 21).

In the case of specification 1 with the three levels of severity, the coefficient associated with a risk reduction of 1 in 1 000 of moderate asthma for the first class does not have the expected positive sign, which could be linked to difficulties in responding to the different choices presented during the DCE. Among the respondents who indicated that it was very difficult for them to make their choices for the DCE, the proportion of people with a low level of education is higher. Notably, many Czech respondents reported that making these choices was difficult. Therefore, a second analysis was performed from the previous data excluding non-asthmatic Czech adults to obtain more reliable estimates (Table 22).

Respondents belonging to the first class, for the two specifications, give a positive and significant value to the ASC (*Alternative Specific Constant*) indicating that on average the individuals of this class prefer the status quo (keep using standard products instead of SAFETYFIRST products). Respondents from the United Kingdom have a higher probability of belonging to this class than respondents from other countries. Conversely, the Poles have a smaller probability of belonging to this class.[17]

Individuals belonging to the 2nd and 3rd classes state a negative value to the ASC that is they get positive utility from the use of SAFETYFIRST products. For these two classes,

[16] After dropping people who are very slow respondents, speeders, who failed the 2 probability tests and who did not take any of the attributes into account during the DCE.

[17] This result is consistent with the fact that British respondents have the highest percentage of people who consistently chose the status quo that is not choosing SAFETYFIST products in their 5 choices (33.1% for adults, 24.9% for the parents of non-asthmatic children). The Polish respondents are the ones with the lowest percentage of status quo after respondents from the Czech Republic (14% for adults, 15% for the parents of non-asthmatic children) (Supplementary material A.7).

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Table 21. *Estimates of the LCM model for the two specifications for all countries*

	Specification 1			Specification 2		
Attribute	Class 1 (28.8% of sample)	Class 2 (37.1% of sample)	Class 3 (34.1% of sample)	Class 1 (28.6% of sample)	Class 2 (38.0% of sample)	Class 3 (33.4% of sample)
ASC	2.3032***	−3.6319***	−1.9945***	2.9951***	−3.7526***	−1.6984***
	(0.2347)	(0.1537)	(0.1135)	(0.1818)	(0.0858)	(0.0777)
Mild asthma risk	0.1097***	0.0515***	0.1151***			
	(0.0193)	(0.0132)	(0.0058)			
Moderate asthma risk	−0.0542*	0.0528*	0.0964***			
	(0.0315)	(0.0309)	(0.0151)			
Severe asthma risk	−0.0639	0.1690***	−0.0082			
	(0.0580)	(0.0337)	(0.0172)			
Total risk of asthma				0.0922***	0.0503***	0.1239***
				(0.0185)	(0.0094)	(0.0044)
Added cost	−0.0131***	−0.0308***	−0.0005	−0.0130***	−0.0299***	−0.0016***
	(0.0012)	(0.0010)	(0.0004)	(0.0009)	(0.0007)	(0.0003)
θ_c in class probability model						
United States	−0.2290**	−0.0388	Ref.	−0.2230**	0.0116	Ref.
	(0.0982)	(0.1012)		(0.0982)	(0.0984)	
Canada	0.4260***	0.2973**	Ref.	0.4317***	0.2898**	Ref.
	(0.1326)	(0.1350)		(0.1334)	(0.1349)	
Czech Republic	−0.8206***	−0.8083***	Ref.	−0.8188***	−0.7932***	Ref.
	(0.1522)	(0.1475)		(0.1483)	(0.1452)	
France	0.0861	0.4558***	Ref.	0.0966	0.4560***	Ref.
	(0.1383)	(0.1329)		(0.1392)	(0.1330)	
Poland	−0.6697***	0.0021	Ref.	−0.6594***	−0.0081	Ref.

Table 21. *Continued*

	Specification 1			Specification 2		
Attribute	Class 1 (28.8% of sample)	Class 2 (37.1% of sample)	Class 3 (34.1% of sample)	Class 1 (28.6% of sample)	Class 2 (38.0% of sample)	Class 3 (33.4% of sample)
	(0.1436)	(0.1298)		(0.1440)	(0.1298)	
Sweden	0.1753	0.2207	Ref.	(0.1813)	0.2198	Ref.
	(0.1352)	(0.1353)		(0.1361)	(0.1351)	
United Kingdom	0.9734***	0.6312***	Ref.	0.9787***	0.6188***	Ref.
	(0.1384)	(0.1436)		(0.1395)	(0.1439)	
Pseudo-R^2	0.365			0.363		
AIC/N	1.398			1.401		
Number of observations (N)	5 384			5 384		

Notes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Standard errors in parentheses.
Source: Authors' own elaboration.

Table 22. *Estimates of the LCM model excluding non-asthmatic adults from the Czech Republic*

	Specification 1				Specification 2	
Attribute	Class 1 (30.1% of sample)	Class 2 (40.3% of sample)	Class 3 (29.7% of sample)	Class 1 (29.7% of sample)	Class 2 (41.0% of sample)	Class 3 (29.3% of sample)
ASC	2.5024***	−3.3327***	−1.3637***	2.9701***	−3.6035***	−1.2957***
	(0.2711)	(0.1388)	(0.1280)	(0.1758)	(0.1191)	(0.1165)
Mild asthma risk	0.1354***	0.0735***	0.1449***			
	(0.0225)	(0.0124)	(0.0069)			
Moderate asthma risk	0.0183	0.1118***	0.1728***			
	(0.0354)	(0.0292)	(0.0175)			
Severe asthma risk	0.0396	0.2070***	0.0597***			
	(0.0676)	(0.0324)	(0.0204)			
Total risk of asthma				0.1180***	0.0558***	0.1453***
				(0.0171)	(0.0010)	(0.0064)
Added cost	−0.0187***	−0.0309***	−0.0012**	−0.0180***	−0.0289***	−0.0013***
	(0.0015)	(0.0010)	(0.0005)	(0.0014)	(0.0008)	(0.0004)
θ_c in class probability model						
United States	−0.1888*	0.0431	Ref.	−0.1935*	0.0826	Ref.
	(0.0988)	(0.1007)		(0.0990)	(0.1009)	
Canada	0.4358***	0.3099**	Ref.	0.4395***	0.2943**	Ref.
	(0.1341)	(0.1348)		(0.1348)	(0.1346)	
France	0.1092	0.4667***	Ref.	0.1136	0.4606***	Ref.
	(0.1398)	(0.1333)		(0.1410)	(0.1334)	
Poland	−0.6640***	0.0178	Ref.	−0.6554***	0.0012	Ref.
	(0.1449)	(0.1297)		(0.1457)	(0.1298)	
Sweden	0.1930	0.2308*	Ref.	0.1951	0.2274*	Ref.

Table 22. *Continued*

	Specification 1			Specification 2		
Attribute	Class 1 (30.1% of sample)	Class 2 (40.3% of sample)	Class 3 (29.7% of sample)	Class 1 (29.7% of sample)	Class 2 (41.0% of sample)	Class 3 (29.3% of sample)
	(0.1369)	(0.1357)		(0.1377)	(0.1354)	
United Kingdom	0.9884***	0.6267***	Ref.	0.9933***	0.6163***	Ref.
	(0.1401)	(0.1443)		(0.1412)	(0.1447)	
Pseudo-R^2	0.379			0.378		
AIC/N	1.367			1 369		
Number of observations (N)	4 764			4 764		

Notes: *p < 0.1; **p < 0.05; ***p < 0.01. Standard errors in parentheses.
Source: Authors' own elaboration.

individuals give a positive and significant value (at the 1% level of risk) to all probability reductions. The disutility associated with the additional cost is less important in the 3rd class. In the case of the first specification, the utility associated with a reduction in the risk varies depending on whether the individuals belong to the 2nd or the 3rd class. It is found that individuals in the 2nd class get a greater utility from a marginal reduction in the probability of developing severe asthma compared to moderate or mild asthma. Conversely, individuals in the 3rd class get a greater utility from a marginal reduction in the probability of developing moderate asthma compared to mild or severe asthma. From a theoretical point of view, there is no reason that the coefficient associated with severe asthma must be higher than the coefficient associated with moderate asthma (and that this latter one must be higher than the coefficient for mild asthma). Indeed, these asthma outcomes are not certain but can occur with different probabilities ordered as follows: Probability(severe asthma) < Probability (moderate asthma) < Probability(mild asthma). When making their choices respondents combine the probabilities and the levels of asthma. Consequently, the respondents can value and rank the probability reductions differently, depending on how they consider these two dimensions of the risk. Finally, there is not a "right" and a "wrong" class.

6.2.2. Parents of non-asthmatic children

Regarding parents of non-asthmatic children, the model is estimated for all countries excluding respondents from the Czech Republic, as above. Three classes of respondents emerge from the estimation (Table 23). Nevertheless, compared to non-asthmatic adults, the distribution of the parents of non-asthmatic children is different over the 3 groups: their proportion is lower in the class with a positive ASC (−8 points) and higher in the class which the ASC is negative and with the highest disutility for additional costs for the non-asthmatic adults (+6.9 points). As in the case of non-asthmatic adults, parents in the 3rd class get greater utility from a marginal reduction in the probability of developing moderate asthma compared to mild or severe asthma. Moreover, the values of these different coefficients are higher in the case of parents choosing for their children relative to choosing for themselves. Interestingly, parents belonging to the 2nd class focus, at the 5% level of risk, only on the marginal reduction in the probability of developing mild asthma.

6.2.3. Mean and median marginal willingness to pay (mean and median MWTP)

The mean marginal WTPs are calculated starting from Equation (17) (see Section 5.2) for the 3-class latent class model using the estimates displayed in Tables 22 and 23 and the sampling weights. The mean WTP for a risk reduction of 1 in 1 000 over 10 years equals USD 28 per year for non-asthmatic adults and USD 43 for non-asthmatic children (Figure 10). The mean marginal WTP for a reduction in moderate asthma risk (USD 37 per year, for non-asthmatic adults) is greater than the mean marginal WTP for a reduction in mild asthma risk (USD 32 per year, for non-asthmatic adults), which is greater than the mean marginal WTP for a reduction in severe asthma risk (USD 16 per year, for non-asthmatic adults).

The median WTP for a risk reduction of 1 in 1 000 over 10 years equals USD 5.2 per year for adult asthma and USD 7.4 for childhood asthma (Figure 11). The median marginal WTP for a reduction in severe asthma (USD 6.2 per year, for non-asthmatic adults) is greater than the median marginal WTP for a reduction in mild asthma risk (USD 5.9 per year, for non-asthmatic adults), which is greater than the median marginal WTP for a reduction in

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Table 23. *Estimates of the LCM model excluding parents of non-asthmatic children from the Czech Republic*

	Specification 1			Specification 2		
Attributes	Class 1 (22.1% of sample)	Class 2 (41.2% of sample)	Class 3 (36.6% of sample)	Class 1 (22.1% of sample)	Class 2 (42.9% of sample)	Class 3 (35.1% of sample)
ASC	3.1328***	−2.7699***	−1.2444***	3.7227***	−2.6135***	−1.3536***
	(0.6620)	(0.1793)	(0.3261)	(0.4665)	(0.1351)	(0.3433)
Mild asthma risk	0.0863*	0.0769***	0.1917***			
	(0.0510)	(0.0146)	(0.0143)			
Moderate asthma risk	0.0190	0.0674*	0.3071***			
	(0.0907)	(0.0372)	(0.0399)			
Severe asthma risk	−0.0950	0.0582	0.1015**			
	(0.1671)	(0.0456)	(0.0411)			
Total risk of asthma				0.0950**	0.0805***	0.1862***
				(0.0432)	(0.0126)	(0.0122)
Added cost	−0.0097***	−0.0211***	0.0004	−0.0110***	−0.0204***	0.0021***
	(0.0032)	(0.0015)	(0.0009)	(0.0031)	(0.0011)	(0.0006)
θ_c in class probability model						
United States	−0.3447*	Ref.	0.3063	−0.3747*	Ref.	0.2584
	(0.2044)		(0.1870)	(0.2015)		(0.1791)
Canada	−0.3987	Ref.	−0.9441***	−0.3871	Ref.	−0.9408***
	(0.2841)		(0.2628)	(0.2820)		(0.2619)
France	−0.3681	Ref.	−0.4230*	−0.4560	Ref.	−0.6194**
	(0.2832)		(0.2555)	(0.2786)		(0.2488)
Poland	−0.0637**	Ref.	−0.4169*	−0.6338**	Ref.	−0.4254**
	(0.2599)		(0.2182)	(0.2579)		(0.2165)
Sweden	−0.1851	Ref.	−0.3278	−0.1828	Ref.	−0.3319

Table 23. *Continued*

	Specification 1			Specification 2		
Attributes	Class 1 (22.1% of sample)	Class 2 (41.2% of sample)	Class 3 (36.6% of sample)	Class 1 (22.1% of sample)	Class 2 (42.9% of sample)	Class 3 (35.1% of sample)
	(0.2841)		(0.2491)	(0.2816)		(0.2466)
United Kingdom	0.0572	Ref.	−0.5397**	0.0724	Ref.	−0.5311**
	(0.2681)		(0.2510)	(0.2660)		(0.2494)
Pseudo-R^2	0.357			0.355		
AIC/N	1.422			1.423		
Number of observations (N)	1 308			1 308		

Notes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Standard errors in parentheses.
Source: Authors' own elaboration.

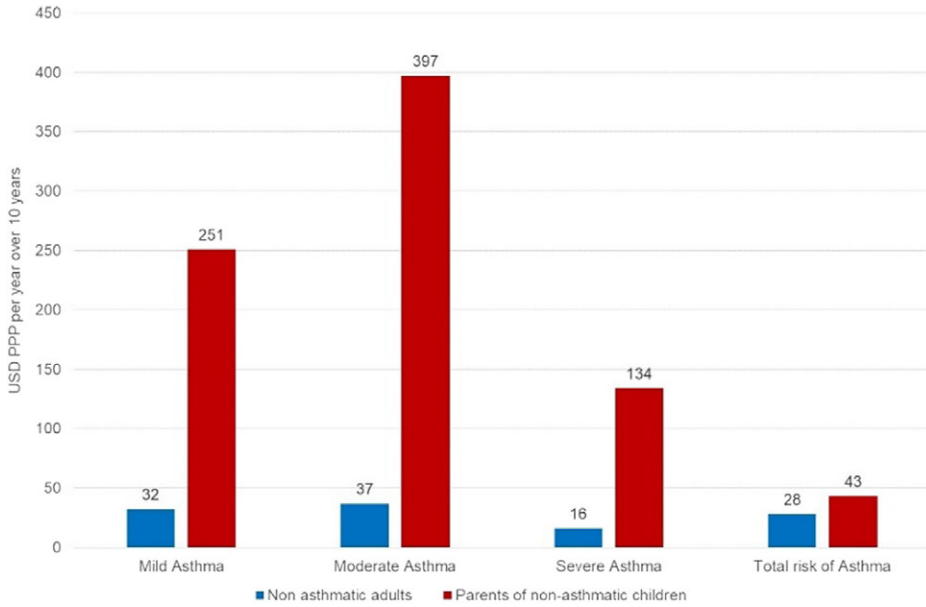

Figure 10. *Mean marginal willingness to pay for 1 in 1 000 reduction in the risk to develop adult and childhood asthma.* Note*: Mean WTP is the weighted average of individual WTP where the weight equals to the sampling weight used to correct for the differences between the sample and the target population. Parents of non-asthmatic children were asked their WTP for a reduction in the risk that their youngest non-asthmatic child develops asthma.*
Source: *Authors' own elaboration.*

moderate asthma risk (USD 3.5 per year, for non-asthmatic adults). The important difference between mean and median values is due to the fact that the distribution of the individual MWTP is asymmetric with high maximum values.

The marginal WTPs for a risk reduction of 1 in 1000 for the parents of non-asthmatic children are systematically greater than those of non-asthmatic adults, in terms of mean and median values (Figures 10 and 11). That the valuation of health risk reduction in children exceeds the valuation of health risk reduction in adults is also observed for asthma severity and also in the VSL literature. The same is observed of median marginal WTP for a reduction in asthma risk, although the differences between adults and children are smaller than for mean WTPs. For the mean values, the very high MWTP is due to the existence of very high values for the parents of non-asthmatic children compared to the sample of non-asthmatic adults. Therefore, the median is more robust than the mean to extreme values.

Finally, to measure how WTP varies with income, the income elasticity is estimated as follows. Logged unweighted individual WTPs are regressed on logged income, a dummy for missing income, and interactions between country dummies and the sampling weight. For non-asthmatic adults, the income elasticity equals 0.08 for mild asthma, 0.18 for moderate asthma, 0.12 for severe asthma, and 0.07 for total risk. For parents of

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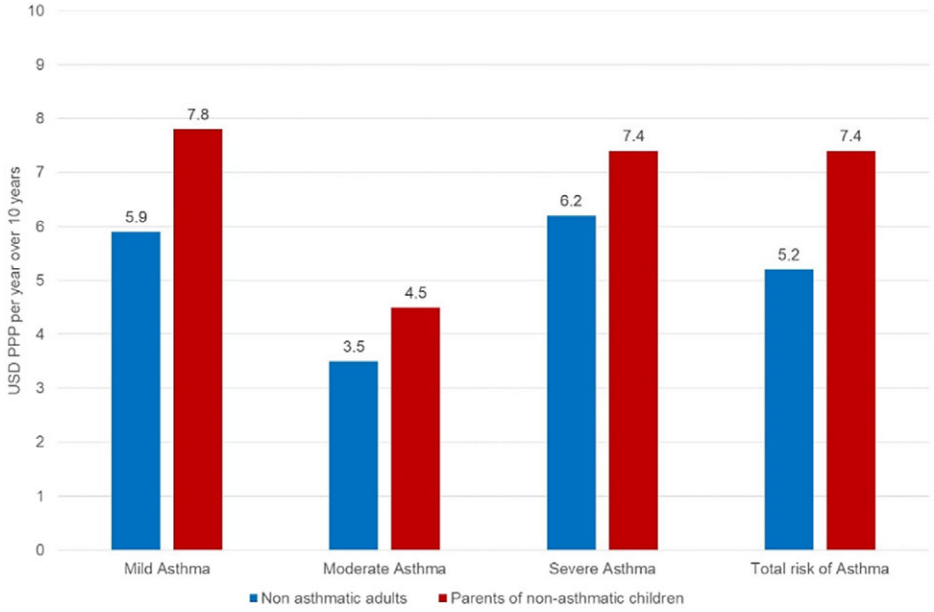

Figure 11. *Median marginal willingness to pay for 1 in 1 000 reduction in the risk to develop adult and childhood asthma.* Note*: Median WTP is the median of individual WTP multiplied with the sampling weight used to correct for the differences between the sample and the target population. Parents of non-asthmatic children were asked their WTP for a reduction in the risk that their youngest non-asthmatic child develops asthma.*
Source: *Authors' own elaboration.*

non-asthmatic children, the income elasticity equals 0.10 for mild asthma, 0.14 for moderate asthma, 0.08 for severe asthma, and 0.06 for total risk. These income elasticities are much lower than those estimated for reducing severity in asthmatics.

6.2.4. Country-level estimates

Mean marginal WTPs for adult asthma risk are provided for each country in Figure 12 The mean WTP for reduction in total adult asthma risk by 1 in 1 000 varies between USD 20 and USD 37 per year. The analysis by country shows that adults without asthma from Canada, France, and Sweden have very similar mean marginal WTP for each level of severity. Respondents from the United Kingdom stated the lowest mean values as opposed to respondents from Poland. One plausible explanation for the high value found in Poland is that it is the country with the largest share of young respondents aged 18–29 (23.4% vs 15.3% for the average surveyed country). An analysis of mean marginal WTP by age group indicates a higher value for non-asthmatic adults aged from 18 to 29, regardless of the severity considered. Another potential explanation could be that Poles are willing to pay relatively more to avoid asthma because they have a relatively less efficient health system as measured by treatable causes of mortality per 100 000 population compared to the other countries of the sample. However, this hypothesis is not tested in the article. For all

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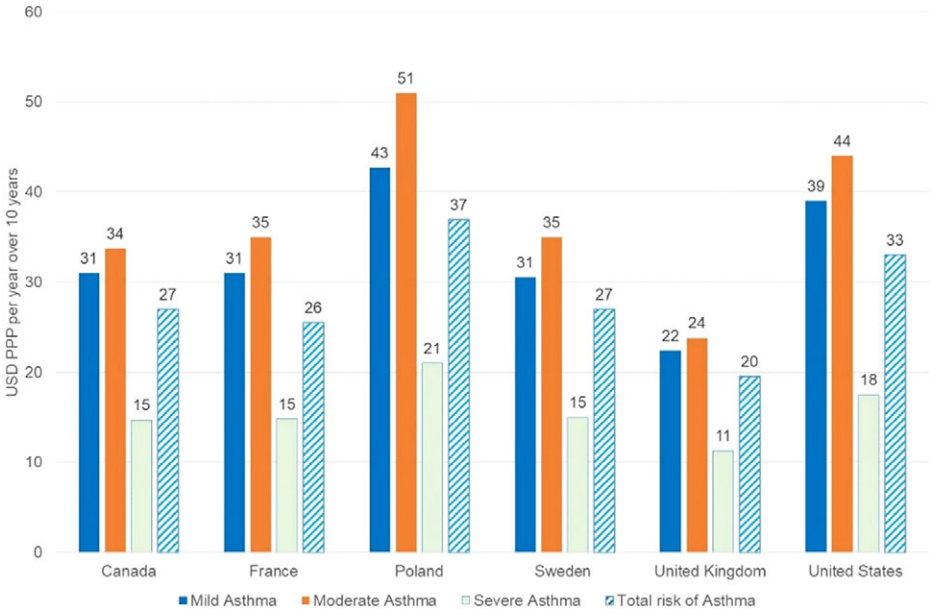

Figure 12. *Mean marginal willingness to pay for non-asthmatic adults by country.* Source: *Authors' own elaboration.*

countries, the marginal WTPs for a reduced risk of moderate asthma are higher than for a reduced risk of severe asthma.

Mean marginal WTPs for childhood asthma risk by country are shown in Figure 13. The mean WTP for reduction in total childhood asthma risk by 1 in 1 000 varies between USD 35 and USD 61. Respondents from Canada stated the lowest mean values. The largest mean WTP for childhood asthma risk is found in the United States followed by Poland.

For non-asthmatic adults, median WTP for a reduction of 1 in 1 000 in total asthma risk per year over 10 years is very similar across countries ranging from USD 5.2 for Canada to USD 5.4 for the United States, Poland, and the United Kingdom (Figure 14). The exception is France with a lower median value equal to USD 3.9 per year.

For parents of non-asthmatic children, Canada has the lowest median marginal WTP for the total risk (USD 5.9 per year), while the United States has the highest one (USD 9.4 per year) (Figure 15). In contrast to the mean WTP, the median WTP to reduce the risk of moderate asthma is smaller than the median WTP to reduce the risk of severe asthma in all countries for both non-asthmatic adults and parents of non-asthmatic children. These differences are explained by high values driving the mean WTP up.

6.2.5. Additional robustness checks

Some respondents indicated that they thought they would save on medical bills by choosing SAFETYFIRST products, while others did not. The impact of such

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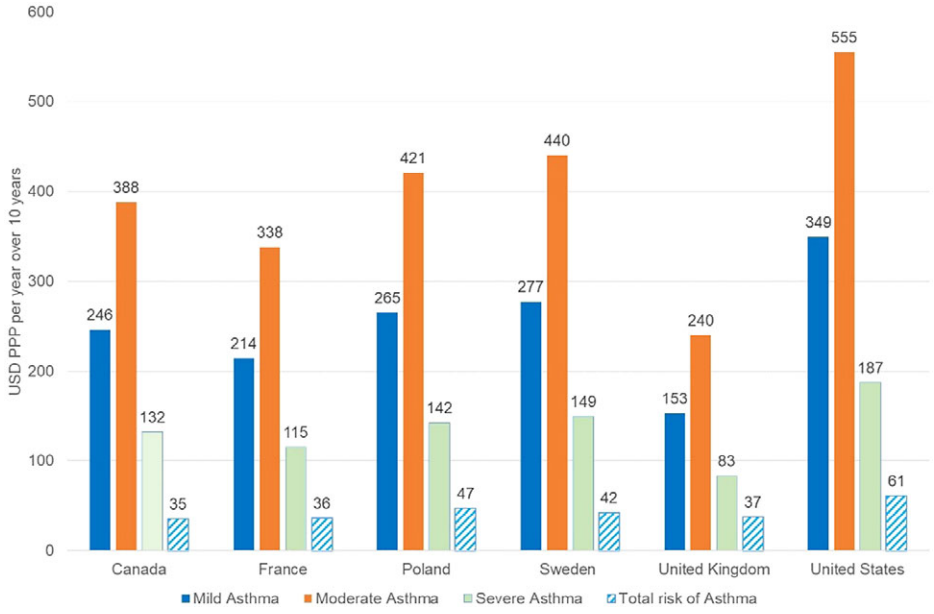

Figure 13. *Mean marginal willingness to pay of parents of non-asthmatic children for a 1 in 1 000 risk reduction in the risk that their child develops asthma.*
Source: *Authors' own elaboration.*

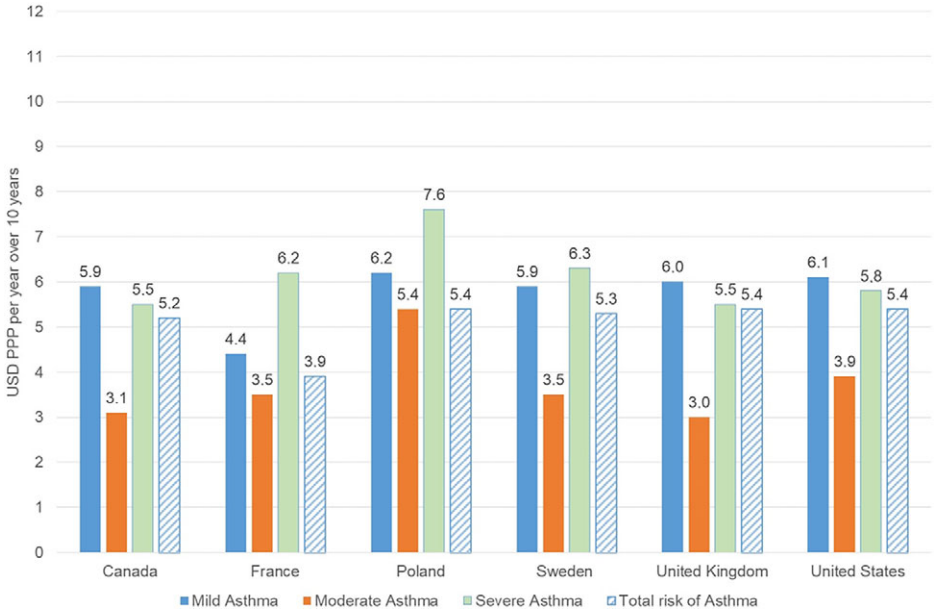

Figure 14. *Median marginal willingness to pay for non-asthmatic adults by country.*
Source: *Authors' own elaboration.*

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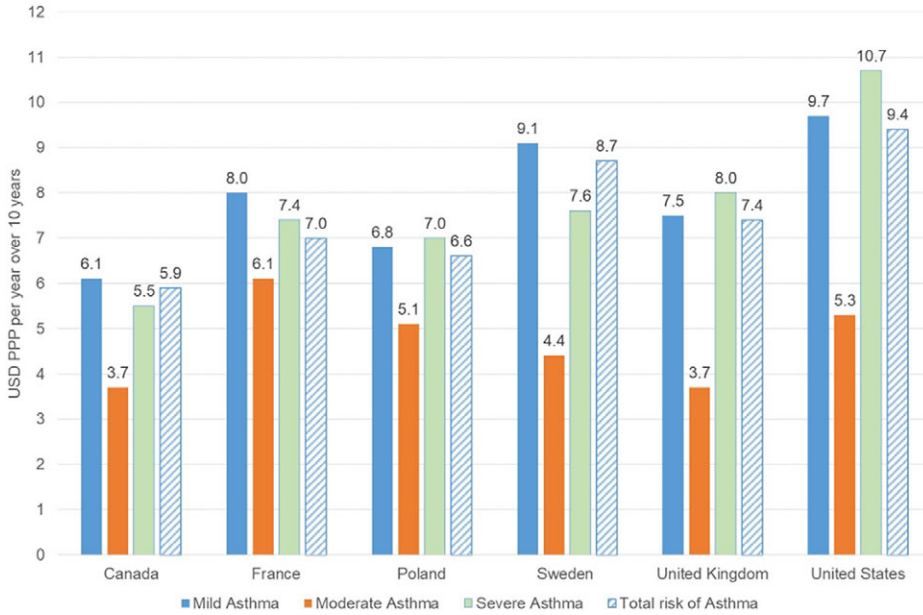

Figure 15. *Median marginal willingness to pay of parents of non-asthmatic children for a 1 in 1,000 risk reduction in the risk that their child develops asthma.*
Source: *Authors' own elaboration.*

consideration is analyzed here. Despite the instruction provided in the questionnaire to not take into account medical cost savings, about 25.3% of the adult respondents (resp. 31.4% of parents) declared that they considered this effect when making their choices. This proportion ranges from 13.9% in the United Kingdom to 35.8% in the United States. In the case of parents, it ranges from 19.5% in Sweden to 42.6% in the United States (Supplementary material A.9.). Thinking about saving on medical bills has a significant effect on the WTP estimates. If a respondent considered that buying SAFETYFIRST products would reduce their medical bills, their probability of being in the class of people who want to pay the most is higher, while their probability of belonging to the class of people who do not want to pay is lower. Consequently, the mean and median values for the marginal WTP vary in a significant way between respondents considering or not these effects during their choices (Table 24). Respondents who thought they would save on their medical bills are willing to pay USD 20 per year more on average than respondents who did not think they would for a 1 in 1 000 reduction in total asthma risk.

Regarding the WTP of non-asthmatic adults, the effect of having an asthmatic child, having a non-asthmatic child, or having no child was tested for the LCM model based on the 3 classes for the 2 specifications (3 levels of severity or total risk) (Table 25). The results indicate that adults without children have a higher probability of belonging to the class of people who do not want to pay and to the class of people who want to pay a small amount. Conversely, having a child decreases these respective probabilities and this phenomenon is more pronounced for adults with asthmatic children.

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Table 24. *Marginal WTP for reduced asthma risk by stance on medical cost saving for asthmatic adults*

Did you think that by reducing the risk of getting asthma you also reduced your medical bills?				
	Mean		Median	
MWTP (USD PPP per year)	No	Yes	No	Yes
Mild	27.4	50.1	5.7	6.7
Moderate	30.2	59.5	3.2	6.7
Severe	14.1	24.4	5.5	9.6
Total	23.7	43.4	5.0	5.6

Note: Non-asthmatic adults, all countries without the Czech Republic.
Source: Authors' own elaboration.

7. Recommended values for asthma severity and risk for policy analysis

7.1. Recommended WTP values for a one-step reduction in asthma severity

Recommend mean WTP values for a one-step reduction in adult asthma severity and childhood asthma severity by country in both USD PPP and local currencies are provided in Table 26. These values are based on the baseline estimation strategy presented in Section 6.1.1, which is robust to various sensitivity tests. Recommended WTP values are also provided by baseline severity level. Recommend median WTP values for a one-step reduction in adult asthma severity and childhood asthma severity by country in both USD PPP and local currencies are provided in Supplementary material C.1.

7.2. Recommended values of a statistical case of asthma

Recommended mean values of a statistical case of adult and childhood asthma by country in both USD PPP and national currencies are provided in Table 27. VSC is obtained by dividing mean marginal willingness to pay values per year provided in Figures 12 and 13 by 1 in 1 000 and multiplying the result by 10 which corresponds to the number of years of payment and reduced risk of developing asthma. Estimates for Czech Republic cannot be provided given the high share of respondents who could not provide informed preferences. Recommended median values of a statistical case of adult and childhood asthma by country in both USD PPP and national currencies are provided in Supplementary material C.2.

7.3. Comparison with previously stated preference and cost of illness studies

It is worth comparing the results of the present analysis with previously stated preferences and COI studies. Comparing the results of the present study valuing WTP for one-step reduction in asthma severity and previous studies that most exclusively focus on WTP for an asthma cure is not straightforward. Nevertheless, there are two ways to compare the results of the present studies with findings in the literature. First, WTP estimates for an asthma cure can be compared to WTP for a very mild asthma, which is the asthma severity level closest to a

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Table 25. *Estimates of the LCM model taking into account child status*

	Specification 1			Specification 2		
Attributes	Class 1 (30.0% of sample)	Class 2 (40.3% of sample)	Class 3 (29.7% of sample)	Class 1 (29.6% of sample)	Class 2 (41.0% of sample)	Class 3 (29.4% of sample)
ASC	2.5467***	−3.3307***	−1.3684***	2.9892***	−3.5942***	−1.2992 ***
	(0.2759)	(0.1404)	(0.1278)	(0.1787)	(0.1207)	(0.1157)
Mild asthma risk	0.1361***	0.0732***	0.1447***			
	(0.0229)	(0.0124)	(0.0069)			
Moderate asthma risk	0.0168	0.1093***	0.1721***			
	(0.0356)	(0.0293)	(0.0174)			
Severe asthma risk	0.0475	0.2022***	0.0597***			
	(0.0683)	(0.0325)	(0.0205)			
Total risk of asthma				0.1171***	0.0562***	0.1453***
				(0.0172)	(0.0100)	(0.0063)
Added cost	−0.0185***	- 0.0308***	−0.0012**	−0.0178***	−0.0290***	−0.0014***
	(0.0015)	(0.0010)	(0.0005)	(0.0014)	(0.0008)	(0.0004)
θ_c in class probability model						
No child	0.1418***	0.4099***	Ref.	0.1402***	0.4368***	Ref.
	(0.0497)	(0.0560)		(0.0501)	(0.0570)	
Asthmatic child	−0.6539***	−0.3687**	Ref.	−0.6560***	−0.3410**	Ref.
	(0.1788)	(0.1657)		(0.1807)	(0.1659)	
No asthmatic child	−0.4057***	−0.3332***	Ref.	−0.4049***	−0.3321***	Ref.
	(0.0924)	(0.0900)		(0.0929)	(0.0900)	
Pseudo-R^2	0.376			0.375		
AIC/N	1.372			1.374		
Number of observations (*N*)	4 764			4 764		

Notes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Standard errors in parentheses.
Source: Authors' own elaboration.

Table 26. *Recommended mean WTP values for a one-step reduction in asthma severity by surveyed country*

USD PPP per year	Adult asthma	Adult mild asthma	Adult mild plus or moderate asthma	Adult moderate plus or severe asthma	Childhood asthma	Childhood mild asthma	Childhood mild plus or moderate asthma	Childhood moderate plus or severe asthma
Canada	430	320	500	760	840	640	970	1 200
Czech Republic	690	500	760	1 130	1 080	820	1 200	1 520
France	440	310	490	760	780	560	850	1 080
Poland	630	450	700	1 040	1 130	870	1 300	1 610
Sweden	770	340	540	820	760	560	850	1 080
United Kingdom	450	320	510	780	740	560	860	1 090
United States	590	410	640	960	1 300	940	1 380	1 720

Local currency per year	Adult asthma	Adult mild asthma	Adult moderate asthma	Adult severe asthma	Childhood asthma	Childhood mild asthma	Childhood mild plus or moderate asthma	Childhood moderate plus or severe asthma
Canada (CAD)	550	410	640	970	1 080	820	1 240	1 540
Czech Republic (CZK)	8 300	6 000	9 200	12 700	13 100	9 900	14 500	18 400
France (EUR)	330	230	370	570	580	420	630	800
Poland (PLN)	1 000	700	1 200	1 700	1 900	1 400	2 200	2 700
Sweden (SEK)	7 300	3 200	5 100	7 700	7 200	5 300	8 000	10 200
United Kingdom (GBP)	340	240	380	580	550	420	640	810
United States (USD)	590	410	640	960	1 300	940	1 380	1 720

Note: Values are rounded for clarity. The conversions are done using Purchasing Power Parities for actual individual consumption of 2019 since it was used to convert bid levels across countries. Data comes from the OECD Dataset: PPPs and exchange rates as of January 2022.
Source: Authors' own elaboration.

Table 27. *Recommended mean values of a statistical case of asthma by surveyed country*

	USD PPP		National currency	
Country	Adult asthma	Childhood asthma	Adult asthma	Childhood asthma
Canada (CAD)	270 000	350 000	350 000	450 000
France (EUR)	260 000	360 000	190 000	270 000
Poland (PLN)	370 000	470 000	620 000	780 000
Sweden (SEK)	270 000	420 000	2 550 000	3 960 000
United Kingdom (GBP)	200 000	370 000	150 000	280 000
United States (USD)	330 000	610 000	330 000	610 000

Note: Values are rounded at the ten thousand for clarity. The conversions are done using Purchasing Power Parities for actual individual consumption of 2019 since it was used to convert bid levels across countries. Data comes from the OECD Dataset: PPPs and exchange rates as of January 2022.
Source: Authors' own elaboration.

cure. Supplementary material D.1 shows that WTP values estimated in the present studies are in the same order of magnitude as WTP values estimated in previous studies ranging from USD 381 to USD 6 969 for adult asthma and ranging from USD 705 to USD 10 330 for childhood asthma depending on the baseline severity. However, estimates from the present study tend to be smaller probably because asthma is not completely cured. Notably, available estimates of COI that include medical costs and lost earnings are larger than the disutility of adult and childhood asthma valued in the present article.

The second way to compare estimates is to compute the WTP equivalent for a reduction of severity from severe asthma to mild asthma in USD_{2022} derived from the present studies with values derived from the estimates of Zillich *et al.* (2002) and Dickie and Messman (2004). Similarly, the estimates reported in the present study and in previous studies are of similar order of magnitude (Supplementary material D.1). Comparing the values of a statistical case of asthma reported in the present study with the previous literature is not straightforward either.

Supplementary material D.2 shows that there is a large variation across studies. Only one stated preference study, Priez and Jeanrenaud (1999), estimated the value of a statistical case of chronic bronchitis in 1999. Their value, when transferred over time using Equation (19) (see. 7.5.1 downstream) that is when the growth in GDP per capita and in prices is taken into account, is equal to USD 21 355, more than 10 times smaller than the value elicited in the present study. The other studies focus on chronic bronchitis or more generally chronic lung disease and are based on small-scale surveys implemented in the early 1990s. Transferring the value over time results in a value of a statistical case equal to USD_{2022} 1 016 000 for Viscusi *et al.* (1991) and USD_{2022} 3 099 000 for Krupnick and Cropper (1992), which are 3 to 10 times larger than the value elicited in the present study. These much larger values are likely due to the small samples and to the risk–risk trade-off method where respondents choose among different pairs of death risk and chronic bronchitis risk. Finally, the present discounted value of the lifetime COI estimates including both medical cost and lost earnings reported by Belova *et al.* (2020) are 10 times smaller than the value of a statistical case of adult and childhood asthma estimated in the present article.

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7.4. Strengths and weaknesses of results

This study provides new, useful, and internationally validated estimates of WTP for several asthma endpoints for seven OECD countries using an original, state-of-the-art stated preference survey. The study makes available for the first time in a consistent framework WTP estimates for a large panel of asthma endpoints: adult asthma risk, adult asthma severity, childhood asthma risk, and childhood asthma severity. In addition, the present study provides values of a statistical case of asthma that does not rely on a VSL estimate unlike previous studies relying on risk–risk trade-offs. The survey was implemented through an online tool to samples selected to be demographically representative of each country's population. Using various validity and robustness checks, the survey performs well and as intended. For all countries except the Czech Republic in the case of the asthma risk valuation, the coefficients for variables explaining variations in WTP have signs that are consistent with expectations. In all countries, the cost for the reduced risk or severity option has a statistically significant negative effect on the probability to choose the reduced risk or severity option. Baseline estimation results are robust to various methodological choices that are extensively tested in the article.

Despite these numerous strengths, the study has several potential weaknesses. First, some respondents did not comply with the instruction to think only about non-monetary benefits when responding to the survey. Some thought they could save on their medical bills by choosing the reduced risk or severity option. Therefore, the mean WTP values reported in Sections 7.1 and 7.2 cover not only the disutility associated with getting asthma or having a more severe asthma but also partially cover anticipated savings on medical expenditures. Mean WTP for a one-step reduction in asthma severity is twice as large (around USD 448 per year more) when respondents anticipated they could save on medical costs (Table 20). Mean WTP for a 1 in 1 000 risk reduction in developing asthma is also twice as large (around USD 20 per year more) when respondents anticipated they could save on medical costs (Table 24). If socioeconomic analysis practitioners wish to monetize only the disutility of asthma, then they should use the WTP estimates from respondents who did not think about medical cost savings.

Although the samples come close to the target quotas on gender, education, and age for each country, samples of asthmatic adults and samples of parents of an asthmatic child exhibit higher deviation from the target quotas. Given the mode of administration of the survey and the reduced size of these samples, this result is not surprising. However, using post-stratification weights as additional regressors allowed for the control of these sampling deviations.

While the study significantly expands the number of WTP estimates for asthma risk and severity available for policy analysis, many countries are, of course, excluded. Countries for which a country-specific value is not provided in the current article would need to use a benefit transfer method based on best practices.[18] In the absence of benefit transfer guidance specific to the health effects covered by the SWACHE project, it is recommended as a starting point that non-surveyed countries use the value estimated for a surveyed country from Table 26 and from Table 27 that shares similar characteristics such as income, age, and public healthcare systems.

[18] The OECD will publish benefit transfer guidance that can be applied to the SWACHE project.

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7.5. *Using these recommended values in policy analysis*

7.5.1. Using the value of a statistical case of asthma in cost–benefit analysis

The estimates of a value of statistical case should be used in cost–benefit analyses addressing proposed regulations of chemicals or other pollutants that influence asthma. Presented here is the recommended use.

Assume a policy is appraised over T years in country c. Compared to the status quo, this policy is estimated to lead to a reduction of SCA_{ct} statistical cases of adult asthma and to a reduction of SCC_{ct} statistical cases of childhood asthma in country c in year t. The discounted benefits of the policy in terms of avoided asthma should be computed as follows:

$$Discounted\ benefits_c = \sum_{t=0}^{T} \frac{VSCA_{ct} \times SCA_{ct} + VSCC_{ct} \times SCC_{ct}}{(1+k_c)^t}, \tag{18}$$

where k_c is the discount rate used in country c,[19] $VSCA_{ct}$ is the recommended value of a statistical case of adult asthma and $VSCC_{ct}$ is the recommended value of a statistical of childhood asthma in country c in year t. $VSCA_{ct}$ and $VSCC_{ct}$ are based on the recommended values $VSCA_{c,2022}$ and $VSCC_{c,2022}$ reported in USD PPP in Table 27 and should reflect increase in prices and in GDP per capita over time such that

$$VSCA_{ct} = VSCA_{c,2022} \times PPP_{c,2019} \times (1 + \%\Delta P_{c,2022-t}) \times (1 + \%\Delta Y_{c,2022-t})^{\beta}, \tag{19}$$

$$VSCC_{ct} = VSCC_{c,2022} \times PPP_{c,2019} \times (1 + \%\Delta P_{c,2022-t}) \times (1 + \%\Delta Y_{c,2022-t})^{\beta}, \tag{20}$$

where $PPP_{c,2019}$ is Purchasing Power Parities for actual individual consumption in national currency per USD for 2019 that was used to convert bid levels in the survey, $\%\Delta P_{c,2022-t}$ is the increase in consumer price index from 2022 to year t, $\%\Delta Y_{c,2022-t}$ is GDP per capita growth from 2022 to year t and β is the income elasticity.

An example for a fictional policy that reduces the number of statistical cases of adult asthma by 1 000 every year in France for 2022–2025 is provided in Table 28 for illustration purpose.[20] Based on a Value of Statistical Case of USD 260 000 in 2022, the discounted benefits of the policy over the 4 years equals EUR_{2022} 767 million.

Finally, the discounted costs of the policy should be subtracted from these discounted benefits to compute the discounted value of the policy.

7.5.2. Using the WTP value for reduced asthma severity in cost–benefit analysis

Similar to the WTP for the reduction of asthma risk, WTP for the reduction in asthma severity can be used in cost–benefit analysis. Suppose a risk management option or a policy reduction leads to a quantified number of severity steps in a given population of asthmatics. There are two potential scenarios. Either the reduction of severity is quantified for each baseline severity or more likely, only the number of severity reductions for the average baseline severity is available. In the former case, discounted benefits should be computed as follows:

[19] Note that the discount rate can also varies over time but generally it changes over long time period.
[20] For clarity, only adult asthma is considered in the illustrative example.

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Table 28. Measuring the benefits of policy intervention in France: an illustrative example using the value of a statistical case of adult asthma

	2022	2023	2024	2025
GDP per capita, volume in USD, at constant PPP (USD_{2015})	43 081	43 258	43 676	43 929[a]
GDP per capita growth since 2022 ($\%\Delta Y_{c,2022-t}$)		0.40%	1.40%	2.00%
Consumer Price Index (2015)	112	114[b]	116[b]	118[b]
Consumer Price Index growth since 2022 ($\%\Delta P_{c,2022-t}$)		1.80%	3.60%	5.40%
PPP for actual individual consumption ($PPP_{c,2019}$)	0.75			
Value of a statistical case of adult asthma (*VSCA*)				
(USD_{2022} PPP thousand)	260			
(EUR_{2022} thousand)	194			
(EUR thousand)	194	197	201	204
Annual statistical cases of adult asthma avoided (SCA_{ct})	1 000	1 000	1 000	1 000
Discounted annual benefits (EUR_{2022} thousand)	193 704	192 409	191 138	189 767
Discount rate	2.5%[c]	2.5%[c]	2.5%[c]	2.5%[c]
Discounted benefits (EUR_{2022} thousand)	767 018			

Note: This illustrative example assumes a fictional policy that would reduce the number of statistical cases of asthma by 1 000 every year in France from 2022 to 2025. GDP per capita projections for 2022–2024 are provided by the OECD Economic Outlook (2022).
[a]GDP per capita for 2025 is computed by the authors based on the linear fit of 2022–2024 values over time.
[b]Consumer Price Index data for 2022 comes from the OECD Dataset: Consumer price indices (CPIs) as of January 2022. A 2% increase per year is assumed for the Consumer Price Index for 2023–2025 and is not an OECD forecast. PPP for actual individual consumption data is for year 2019 as used to convert bid levels across countries and comes from the OECD Dataset: PPPs and exchange rates as of January 2022.
[c]The discount rate comes from Quinet (2013) and is what is used in France for short assessment period for which there is no systemic risk in the implementation of the policy. The income elasticity equals 0.07 as estimated for total adult asthma risk in this article.
Source: Authors' own elaboration.

$$Discounted\ benefits_c = \sum_{t=0}^{T} \frac{1}{(1+k_c)^t} \left(\begin{array}{c} \overline{WTP}_{mild,ct} \times RS_{mild,ct} \\ + \overline{WTP}_{mildplusmoderate,ct} \times RS_{mildplusmoderate,ct} \\ + \overline{WTP}_{moderateplussevere,ct} \times RS_{moderateplussevere,ct} \end{array} \right), \quad (21)$$

where $\overline{WTP}_{baselineseverity,ct}$ is the mean WTP for going from baseline asthma severity to one step lower in country c in year t, $RS_{baselineseverity,ct}$ is the number of asthmatic people whose asthma severity is reduced by one step from the baseline asthma severity for 1 year due to the policy intervention in country c in year t and k_c is the discount rate used in country c.

In most cases, data are scarcer. Then, the discounted benefits can be estimated as follows:

$$Discounted\ benefits_c = \sum_{t=0}^{T} \frac{\overline{WTP}_{ct} \times RS_{ct}}{(1+k_c)^t}, \quad (22)$$

where $\overline{WTP}_{ct}$ is the mean WTP for going from baseline asthma severity to one step lower, RS_{ct} is the number of asthmatic people whose asthma severity is reduced by one step for

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Table 29. *Measuring the benefits of policy intervention in France: an illustrative example using the mean WTP to reduce adult asthma severity by one step*

Year	2022	2023	2024	2025
GDP per capita, volume in USD, at constant PPP (USD_{2015})	43 081	43 258	43 676	43 929[a]
GDP per capita growth since 2022 ($\%\Delta Y_{c,2022-t}$)		0.40%	1.40%	2.00%
Consumer Price Index (2015)	112	114[b]	116[b]	118[b]
Consumer Price Index growth since 2022 ($\%\Delta P_{c,2022-t}$)		1.80%	3.60%	5.40%
PPP for actual individual consumption ($PPP_{c,2019}$)	0.75			
Mean WTP to reduce asthma severity by one step ($\overline{WTP}_{ct}$)				
(USD_{2022} PPP)	440			
(EUR_{2022})	328			
(EUR)	328	334	340	346
Annual number of asthmatics people whose asthma severity is reduced by one step for 1 year (RS_{ct})	1 000	1 000	1 000	1 000
Discounted annual benefits (EUR_{2022} thousand)	328	326	324	323
Discount rate	2.5%[c]	2.5%[c]	2.5%[c]	2.5%[c]
Discounted benefits (EUR_{2022} thousand)	1 300			

Note: This illustrative example assumes a fictional policy that would reduce the number of statistical cases of asthma by 1 000 every year in France from 2022 to 2025. GDP per capita projections for 2022–2024 are provided by the OECD Economic Outlook (2022).
[a]GDP per capita for 2025 is computed by the authors based on the linear fit of 2022–2024 values over time and is not an OECD forecast.
[b]Consumer Price Index data for 2022 comes from the OECD Dataset: Consumer price indices (CPIs) as of January 2022. A 2% increase per year is assumed for the Consumer Price Index for 2023–2025 and is not an OECD forecast. PPP for actual individual consumption data is for year 2019 as used to convert bid levels across countries and comes from the OECD Dataset: PPPs and exchange rates as of January 2022.
[c]The discount rate comes from Quinet (2013) and is what is used in France for short assessment periods for which there is no systemic risk in the implementation of the policy. The income elasticity equals 0.3 as estimated for total adult asthma risk in this article.
Source: Authors' own elaboration.

1 year regardless of their current asthma severity due to the policy intervention in country c in year t and k_c is the discount rate used in country c.
$\overline{WTP}_{baselineseverity,ct}$ and $\overline{WTP}_{ct}$ are based on the recommended values $\overline{WTP}_{baselineseverity,c2022}$ and $\overline{WTP}_{c2022}$ reported in USD PPP in Table 26 and should reflect increase in prices and in GDP per capita over time such that:

$$\overline{WTP}_{ct} = \overline{WTP}_{c2022} \times PPP_{c,2019} \times (1 + \%\Delta P_{c,2022-t}) \times (1 + \%\Delta Y_{c,2022-t})^{\beta}, \qquad (23)$$

where $PPP_{c,2019}$ is Purchasing Power Parities for actual individual consumption in national currency per USD for the 2019 that was used to convert bid levels in the survey, $\%\Delta P_{c,2022-t}$ is the increase in consumer price index from 2022 to year t, $\%\Delta Y_{c,2022-t}$ is GDP per capita growth from 2022 to year t and β is the income elasticity. An illustrative example for a fictional policy that increases the number of asthmatics people whose asthma severity is reduced by one step for 1 year by 1 000 every year in France for 2022–2025 is provided in

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Table 29 for illustration purposes.[21] Based on a mean WTP of USD 440 in 2022, the discounted benefits of the policy over the 4 years equals EUR_{2022} 1.3 million.

8. Conclusion

Asthma is a non-curable long-term condition affecting children and adults. Asthmatics experience symptoms such as cough, wheezing, shortness of breath, and chest tightness. Depending on its severity, asthma can prevent normal outdoor activities and require routine medication and sometimes oxygen intake. Severe asthma can require emergency room visits and hospitalization.

Previous valuation work does not provide internationally comparable WTP values for asthma risk and severity for adults and children. To fill this gap, the SWACHE asthma survey asks what asthmatics are willing to pay to reduce their asthma severity and/or the asthma severity of their youngest child e.g. from severe to moderate, moving away from previous valuation efforts estimating WTP for an unrealistic cure of asthma. Further, the survey asks people who do not have asthma what they are willing to pay to reduce their risk of getting it. Finally, the survey asks parents what they are willing to pay to reduce: (i) the severity of the asthma of their youngest asthmatic child, and (ii) the risk that their youngest non-asthmatic child gets it, without relying on the VSL.

The survey was implemented in seven countries. In each of these countries, a sample of at least 1 600 respondents (1 200 non-asthmatic adults, 300 asthmatic adults and 190 parents of asthmatic children) representative of the general population was collected and analyzed empirically.

The WTP for reducing adult asthma severity equals USD 529 per year on average and varies from USD 430 per year in Canada to USD 770 per year in Sweden. The WTP for reducing asthma severity in children is higher at USD 948 per year on average and varies from USD 740 in the United Kingdom to USD 1 300 in the United States. The Value of a Statistical Case of adult asthma varies from USD 200 000 in the United Kingdom to USD 370 000 in Poland. The value of a statistical case of childhood asthma varies from USD 350 000 in Canada to USD 610 000 in the United States.

The mean WTP for reduced asthma severity estimated in this article are of similar magnitude as the mean WTP estimated in previous work. The mean value of a statistical case of asthma estimated differs significantly from the values of a statistical case of other chronic lung diseases estimated in previous studies. The results show that, for the United States, relying exclusively on COI estimates underestimates the benefit of avoiding an adult asthma case by around USD 285 000 and a childhood asthma case by around USD 554 000.

The present article provides recommended values for asthma severity and risk and offers guidance on how to use these values in policy analysis. Further work should offer comprehensive benefit transfer guidance to estimate what values countries that were not included in the survey should use in policy analysis.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/bca.2024.4.

[21] For clarity, only asthmatic adults are considered in the illustrative example.

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