Valuing a reduction in the risk of infertility

A large scale multi-country stated preference approach

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Abstract

While fertility decline is a global phenomenon that has many causes, part of it can be explained by exposure to substances linked to reproductive toxicity that are produced and lead to human exposure through the environment and products. Authorities face challenges in regulating reprotoxic substances through actions such as bans and prohibitions, because of the difficulty in explicitly considering the economic benefits and costs of such regulations. Moreover, economic studies that show the value of reducing the risk of infertility caused by chemical exposure are not yet available.

This paper is part of the series of large scale willingness-to-pay (WTP) studies resulting from the Surveys to elicit Willingness to pay to Avoid Chemicals related negative Health Effects (SWACHE) project that intends to improve the basis for doing cost benefit analyses of chemicals management options and environmental policies in general. The present paper details a stated preference survey estimating WTP to reduce the risk of infertility, filling an important gap in the valuation literature and addressing a need for applied benefits analysis for chemicals regulation. The SWACHE infertility survey was fielded in 10 countries: Australia, Canada, Chile, Germany, Japan, Poland, Portugal, Sweden, the United Kingdom and the United States. In each country, a sample of 1 200 adults, representative of the general population and of childbearing age who are in a relationship and plan for a(nother) child within the next five years, was collected and empirically analysed.

The estimated mean Value of a Statistical Case (VSC) of infertility equals USD_{2022} Purchasing Power Parity (PPP) 91 000 and the median VSC equals USD_{2022} PPP 50 000. Country-specific mean VSC of infertility vary between USD_{2022} PPP 65 800 for Japan and USD_{2022} PPP 108 900 for Portugal.

Keywords: infertility, health risk, economic valuation, health valuation, morbidity valuation, monetised benefits, chemicals regulation, non-market valuation, stated preferences, surveys, willingness-to-pay, value of a statistical case.

JEL Codes: D61, I18, J17, K32, Q51, Q53, Q58

Résumé

Si le déclin de la fertilité est un phénomène mondial aux causes multiples, il peut en partie s'expliquer par l'exposition des humains à des substances liées à la toxicité pour la reproduction. Les autorités sont confrontées à des défis pour réglementer les substances reprotoxiques à travers des mesures telles que des interdictions, car il est difficile de prendre en compte de manière explicite les bénéfices et les coûts économiques de ces réglementations. En outre, il n'existe pas encore d'études économiques montrant la valeur de la réduction du risque d'infertilité causée par l'exposition aux produits et composés chimiques.

Ce document fait partie d'une série d'études portant sur le consentement à payer et réalisées à grande échelle dans le cadre du projet SWACHE (Surveys to elicit Willingness to pay to Avoid Chemicals related negative Health Effects). Ce projet vise à améliorer la réalisation des analyses coûts-bénéfices des options de gestion des produits et composés chimiques et des politiques environnementales en général. Le présent document détaille une enquête sur les préférences déclarées estimant le consentement à payer pour réduire le risque d'infertilité, comblant ainsi une lacune importante dans la littérature portant sur la valorisation et répondant à un besoin dans la quantification des bénéfices lors de l'évaluation des options de gestions des produits et composés chimiques. L'enquête SWACHE sur l'infertilité a été menée dans 10 pays : Australie, Canada, Chili, Allemagne, Japon, Pologne, Portugal, Suède, Royaume-Uni et États-Unis. Dans chaque pays, un échantillon de 1 200 adultes, représentatifs de la population générale et en âge de procréer, qui vivent en couple et envisagent d'avoir un (autre) enfant au cours des cinq prochaines années, a été recueilli et analysé empiriquement.

La valeur d'un cas statistique (VCS) d'infertilité moyenne estimée est de USD2022 en parité de pouvoir d'achat (PPA) 91 000 et la VCS médiane est de USD2022 PPA 50 000. Les VCS de l'infertilité moyennes spécifiques à chaque pays varient entre USD2022 PPA 65 800 pour le Japon et USD2022 PPA 108 900 pour le Portugal.

Mots-clés : infertilité, risque pour la santé humaine, valorisation économique, valorisation de la santé, valorisation de la morbidité, bénéfices monétisés, réglementation des composés chimiques, valorisation non marchande, préférences déclarées, enquêtes, consentement à payer, valeur d'un cas statistique.

Classification JEL : D61, I18, J17, K32, Q51, Q53, Q58

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The SWACHE project is organised in co-operation between the OECD Working Party on Integrating Environmental and Economic Policies (WPIEEP) and the Working Party on Risk Management (WPRM) and with the support or the SWACHE advisory group including experts in chemicals regulation, toxicology and economic valuation that was set up for this project.

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Table of contents

Tables

Figures

Boxes

Executive summary

Fertility rates have been declining globally since the 1950s. While this decline is mostly driven by socio-economic and cultural factors, environmental pollution plays an important role as people are increasingly exposed to manufactured chemicals such as phthalates or per- and polyfluoroalkyl substances (PFASs) that can act as hormone disruptors that affect male and female fertility which can ultimately result in involuntary childlessness.

One key challenge for chemicals risk management relates to the monetisation of health benefits expected from actions to curb emissions of and exposure to such substances. Balancing the expected benefits against the costs of regulation is typically done using willingness-to-pay (WTP) values as inputs to cost-benefit analysis. Several studies have used stated preference methods to evaluate the benefits of improved fertility, but most of them have estimated WTP values for assisted reproduction technologies rather than reduced risk of infertility. Since increasing the chance of having a baby is not the same as reducing the risk of not being able to naturally conceive that is affected by chemicals exposure, it is important to estimate WTP for a reduced risk of infertility on its own that can be directly applicable in cost-benefit analyses.

This paper reports on a new stated preference study which estimates a policy relevant value per statistical case (VSC) of infertility that is part of the series of large scale WTP studies resulting from the Surveys to elicit Willingness to pay to Avoid Chemicals related Health Effects (SWACHE) project. To that end, an online valuation survey was administered to 12 000 respondents from ten OECD countries, asking respondents whether they would be willing to pay a monthly fee over a period of 20 months to ensure a reduction in infertility risk from substances in food packaging. Out of the 12 000 respondents, 9 659 passed a later quality screening based on time needed to complete the survey and whether respondents adequately understood the concept of risk. Respondents are representative of the respective general populations with the additional constraints that they and their spouses are of childbearing age, in a stable relationship and wished for a(nother) child within the next five years. In other words, they would be direct beneficiaries of the risk reductions offered in the survey.

The WTP values provided in this study are uniquely valuable for socio-economic analysis practitioners and policy makers since they are derived for different countries using the same methodology and are therefore internationally comparable. Furthermore, because the present study is part of the SWACHE project that provides an economic valuation of 10 health effects using the same general approach, the values provided by the present report are also comparable across health effects. This large scale and comprehensive valuation effort, that to our knowledge has not been attempted previously, will facilitate quantitative analyses of chemicals management options and be helpful in formulating national and regional policy affecting health outcomes.

Across the countries surveyed, the results indicate a mean WTP of USD 64 per month for an average risk reduction of 1.5 percentage points, corresponding to a VSC of USD 90 700 (all bids converted to USD and adjusted for purchasing power). The study also derives country-specific VSC of infertility, which mean values vary between USD 65 800 for Japan and USD 108 900 for Portugal.

Various checks indicate that both the mean and the country-specific VSC estimates are fairly robust towards different modelling, data cleaning and screening choices. A comparison to previous studies that have estimated the value of improved fertility rather than the value of reduced infertility suggests that the latter is about three times higher. This divergence is unsurprising in as much as it reflects the typical pattern of loss aversion found over and again in behavioural economics.

1 The valuation of infertility

1.1. Motivation

Fertility decline is a global phenomenon that has many causes. While socioeconomic, cultural and lifestyle factors are crucial in understanding the steady decline of fertility rates in OECD countries, exposure to substances that may alter the hormone system and induce reproductive and developmental toxicity has become a concern (Colborn, Vom Saal and Soto, 1993[1]; Kavlock et al., 1996[2]; Diamanti-Kandarakis et al., 2009[3]; Casals-Casas and Desvergne, 2011[4]; Kabir, Rahman and Rahman, 2015[5]).

Some researchers have even warned that, if current trends in male and female fertility continue to fall, this could threaten human survival in the long term (Swan and Colino, 2021[6]). At the same time, an ever-increasing amount of substances are produced and released to the environment (Persson et al., 2022[7]), and some substances are linked to reproductive toxicity both as individual compounds and in mixtures (Caporale et al., 2022[8]).

Against this background, authorities face challenges in regulating exposures to reprotoxic substances related to the monetisation of health benefits expected from bans and other measures to curb emissions of and exposure to these substances. As with other threats to human health, infertility is a condition that is difficult to value.

Some parallels can be drawn to the valuation of mortality risks. Similar to the value of statistical life (VSL) concept (Hammitt, 2000[9]), the objective is not to find a couple's value of conceiving a child, if they wish to have one but fail to conceive. Instead, the study seeks to obtain a value for a small reduction in the risk of not being able to naturally conceive, and the disutility related to that risk.

Whilst previous studies have attempted to value reductions in infertility risk, the valuation scenarios used in these studies were not aligned with the objective of regulators to have a VSC of infertility. Given these factors, a novel stated preference study was conducted under the umbrella of the OECD-led SWACHE project[1] that facilitates the estimation of policy-relevant valuation metrics for infertility and other chemically induced health risks, which are applicable in and transferable across different countries and policy contexts (see Box 1.1).

As there are large differences in prevailing fertility rates, a double-bound discrete choice contingent valuation survey (Carson and Hanemann, 2005[10]) was administered to 12 000 respondents from ten OECD countries (Australia, Canada, Chile, Japan, Germany, Poland, Portugal, Sweden, the United Kingdom and the United States), asking whether they would be willing to pay an extra fee over a period of 20 months to ensure a reduction in infertility risk from substances frequently found in food packaging material (Muncke et al., 2020[11]).

Respondents were sampled to be representative of their country's general population with the additional constraint that they and their spouses were of childbearing age, in a stable relationship and wished for a(nother) child within the next five years. This sampling strategy is thought to provide most reliable estimates of the VSC of infertility, whilst controlling for country-specific differences in preferences.

[1] A description of the Surveys on Willingness-to-pay to Avoid Negative Chemicals-related Health impact project can be found here: https://www.oecd.org/chemicalsafety/costs-benefits-chemicals-regulation.htm.

Box 1.1. The OECD SWACHE Project

Chemicals are part of our daily life and must be soundly managed to limit risks to human health and the environment. While countries around the world are setting up legal frameworks to address these risks, the cost of policy inaction is still poorly understood. Assessment of chemicals management options and environmental policies can be considerably improved by better estimating their costs and benefits. The resourcing of national chemicals management programmes also often requires economic justification of the benefits of such investment. However, current socio-economic analyses of chemical regulations use values for morbidity impacts that are often incomplete. In most cases, these values cover only lost productivity, lost earning or cost-of-illness and disregard the disutility costs of pain and suffering from the illnesses (Navrud, 2018[12]).

The OECD project Surveys on Willingness to Pay to Avoid Negative Chemicals-Related Health Impacts (SWACHE) brings together expertise on chemical safety and economic analysis to fill this gap. The project aims to establish internationally comparable values for the willingness-to-pay (WTP) to avoid negative health effects due to exposure to chemicals. Such values can be used to demonstrate and measure the economic benefits of minimising the impacts of chemicals on human health.

The only way to capture the full WTP to avoid illness is to conduct a stated-preference study, i.e., surveys where individuals are asked to report their WTP to reduce their risk of negative health impacts due to chemicals exposure. Contingent valuation methods and discrete choice experiments do just that, and WTP figures based on these methods have been used in assessment efforts (Alberini, 2017[13]). To derive WTP values, surveys of a large number of citizens of countries have therefore been conducted under the SWACHE project. Particularly, these stated preference surveys provide data that can shed light on the disutility in terms of symptoms and lower quality of life of a given disease or health effect, which is not captured by existing metrics such as those based on the cost of illness.

The SWACHE project is organised in two rounds focusing on 5 health effects each. The first round of health effects includes asthma, infertility, IQ loss, chronic kidney disease and very low birth weight. The first round of surveys was implemented in 2022 in at least five countries each where representative samples of at least 1 200 respondents each were collected. Overall, one to five of the surveys were implemented in 22 countries, totalling 46 surveys conducted. Survey responses are empirically analysed to estimate mean WTP for a given reduction in health risk for each country surveyed.

The results of this first round are presented in five working papers, one for each health effect. The research described in individual working papers makes a variety of empirical contributions to health valuation in the context of chemicals exposure, although, by design, the approach was not to break new conceptual, theoretical, or econometric ground. Moreover, the comparison of the estimated WTP across health effects and across countries will be carried out in a separate summary paper, which will also provide guidance for the transfer of WTP value over time and to non-surveyed countries.

1.2. Previous work

Several previous studies have used stated preference methods to value the benefits of either improving fertility or reducing infertility, see Dubourg (2016[14]) for a review. Most studies have focused on estimating the willingness-to-pay (WTP) for assisted reproduction technologies, and utility values assigned to different attributes of those technologies.

Notably, studies commissioned by the European Chemicals Agency (Ščasný and Zvěřinová, 2014[15]) and Health Canada (Ščasný and Zvěřinová, 2016[16]) have estimated the value per statistical baby by asking general population samples in Canada, the Czech Republic, Italy, the Netherlands and the United Kingdom to value a 'public good' in form of stricter regulation of chemicals in consumer products, which would afford an improvement in fertility across the population at the cost of general increases in product prices.

A subsample of respondents who indicated that they intend to have children in the future were also offered a 'private good' in form of a hypothetical vitamin complex that would increase the conception probability over a certain period. In addition, they were asked to state their maximum WTP for increasing the probability of a successful in vitro fertilisation (IVF) treatment. For the European countries, Ščasný and Zvěřinová (2014[15]) find PPP-normalised values of EUR_{2012} 29 400 per IVF pregnancy and EUR_{2012} 12 500 – 40 700 per natural conception (in EUR 2012), respectively. Values elicited for Canada are very similar (Ščasný and Zvěřinová, 2016[16]).

While these studies are methodologically sound, increasing the chance of having a baby is not the same as reducing the risk of not being able to naturally conceive. The study by Van Houtven and Smith (1999[17]) appears to be the only previous study that examines WTP for reducing the risk of infertility through the purchase of a hypothetical medication, which could be taken at some point in the future and would delay the natural reduction in fertility that comes with ageing. Because of this delay, estimates of the WTP for reductions in infertility risk require assumptions about both the respondents' discount rate and the timing of treatment onset.

Based on a relatively small sample of respondents (n = 188), Van Houtven and Smith estimated values per statistical case between EUR_{2012} 8 700 and EUR_{2012} 66 600 depending on assumptions made about the discount rate, as well as the start and the duration of treatment.

Although studies on the VSC of infertility are scarce, the conceptual problem of valuing marginal health risk reductions is well researched (Cameron, 2014[18]), and most theoretical insights on the value per statistical life carry through to the valuation of infertility risk. Specifically, the following predictions can be drawn from a standard indifference curve analysis (Hammitt, 2000[9]):

- WTP increases with disposable income;
- WTP increases with baseline risk;
- WTP increases with the size of risk reduction;
- The increment in WTP is nearly proportionate to the size of risk reduction;
- Demand for risk reduction decreases with price.

As discussed in contemporary guidance for stated preference studies (Johnston et al., 2017[19]), such theoretical predictions form a vital test of the construct validity of non-market valuation studies.

Random and targeted allocations of treatments (different versions of an otherwise identical survey) provide an ideal means for hypothesis testing. Of particular relevance in the context of infertility are the size of risk reduction, which facilitates a scope sensitivity test (Hammitt and Graham, 1999[20]), and the age-dependent baseline risk, which is an important driver of individual risk perception.

1.3. Current effort: SWACHE project and selection of infertility

Given the absence of internationally comparable WTP estimates for the risk of infertility and its association with many chemicals, it was identified as one of five priority health endpoints for valuation through SWACHE, along with chronic kidney disease, asthma, very low birth weight, and IQ loss. The OECD recruited a panel of prominent experts and academics to develop a common general approach to valuing these endpoints through stated preference methods, while still allowing the surveys for each endpoint to be tailored to specific requirements. Draft survey instruments were formally distributed and reviewed by the expert panel as well as delegates from OECD member countries in September 2019 and April 2020 and surveys were revised each time based on comments received. As the surveys evolved through focus group and one-on-one interview testing, as well as reviews by health professionals and other experts, additional less-formal discussions among the expert panel were held to help ensure the survey instruments elicit the WTP of respondents using adequate and appropriate stated preferences methods. Box 2.1 describes the SWACHE survey development process in greater detail.

While SWACHE is a coordinated effort, specific decisions about how to structure the valuation question were greatly influenced by the particular needs of the individual health endpoints. For infertility, several alternatives were considered for the valuation scenario and payment vehicle. First, using a private product such as a tap water filter was considered, but respondents who drink bottled water would have heavily protested against this payment vehicle that was also more prone to health co-benefits. With input from the expert panel, safer food packaging as a private risk reduction mechanism with out-of-pocket payments was ultimately chosen, an approach that appeared to be well accepted in one-on-one interviews and the final survey instrument.

This study is the first to explore the VSC of infertility in a rigorous setting and bearing in mind the actual use of WTP metrics in regulatory impact analysis. Indeed, the VSC values elicited are theoretically sound and directly applicable to the monetisation of statistical cases of infertility estimated to be the consequence of exposure to certain substances with reproductive toxicity effects.

Section 6.3 and Section 6.4 briefly illustrates how the VSC can be used in applied regulatory impact analysis in a straightforward manner, rather than having to make auxiliary assumptions about the number of babies wished for by the average family and the value per statistical baby.

The remainder of the paper is structured as follows. Section 2describes the survey design. Section 3presents an overview of the data collected. Section 4explains the empirical strategy including the logic behind the robustness checks performed and how sample weights are included in the regression analysis. The results including median and mean WTP estimates are reported in Section 5In Section 6the monthly WTP estimates are converted into country-specific VSC values recommended for policy making and provide an illustrative application related to the regulation of four phthalates in the European Union. Section 7 presents conclusions.

2 Survey design

2.1. General SWACHE approach to survey design

All surveys developed in the SWACHE project share a common approach. As summarised in Box 2.1, this includes the development of a clear definition and description of the health effect (endpoint) to be valued, a credible risk reduction mechanism, a payment vehicle and an elicitation method developed in consultation with the SWACHE expert panel. Moreover, all surveys feature a harmonised approach to risk communication, identical background and debriefing questions, and a common approach to adapting the survey for use in different countries and to pretesting and fielding.

2.2. Scope and description of infertility

The focus of the present study is on the VSC of infertility, i.e. the total monetary amount a reference population would forgo to avoid one case of infertility among them. The present study follows the medical definition of infertility as the inability of naturally conceiving after 12 months (or more) of regular unprotected sex or the inability of a woman to carry a pregnancy to a live birth (Gnoth et al., 2005[21]). In this sense, (in-) fertility is treated as a binary outcome even though, in reality, there may be varying degrees of fertility loss. The definition provided to respondents reads as follows:

Doctors say a couple is infertile when they are not able to become pregnant after one year of trying to conceive. If a woman gets pregnant but keeps having miscarriages or stillbirths, that's also called infertility.

The choice of this valuation endpoint is consistent with Cameron (2014[18]) who notes that "[f]or benefit-cost analysis of proposed environmental policies, useful measures of the value of morbidity risk reductions should be derived prospectively. It is important to understand what types of costs different groups in society are willing to incur, ex ante, to reduce the risk of future illness."

When taking the survey, respondents were informed that infertility is not uncommon and that age of both partners is crucial but other factors such as genetics and lifestyle (including alcohol consumption, smoking, very high or low body mass index) also contribute to fertility loss. Then respondents were informed that chemicals also play an important role as people are increasingly exposed to substances that may disrupt the hormone system or affect sperm and egg quality.

To give respondents a clear idea about how they could be exposed, it was explained that food contact materials often contain substances that may impair fertility when leaching into foods and beverages (Muncke et al., 2020[11]); e.g., plastic wrap or containers to store fresh fruits and vegetables stored, burger wrappers or pizza boxes, or plastic cups and bottles.

Box 2.1. Development of SWACHE survey questionnaires and application of best practices

Each SWACHE survey questionnaire was drafted by a team of authors that includes recognised experts in the field of stated preference surveys related to health impacts as well as practitioners in the socio-economic analysis (SEA) of chemicals management options.

Each survey questionnaire was developed in several steps. First, a description of the health effect (endpoint) was drafted including information about the related quality-of-life health impact, a review of any prior stated preference studies on the same health effect and suggestions for how to characterise the endpoint in a new study. Second, various valuation scenarios were developed describing the target population, the risk reduction mechanism, the payment vehicle and the elicitation method. Third, a complete draft survey questionnaire was developed including the most appropriate valuation scenario.

A steering group of experts including internationally renowned academics, SEA practitioners, regulators and health professionals provided regular feedback throughout the process. The final working papers were reviewed by the expert group as well as by country delegations as per the OECD review process.

All SWACHE survey instruments featured a harmonised introduction that contains language to minimise non-response bias and comply with ethics principles:

> *Welcome!*
>
> *This survey is part of an international initiative coordinated by the Organisation for Economic Co-operation and Development (OECD) that aims to help design better policies.*
>
> *The survey asks for your views about a proposal to reduce the risk of [health effect] due to the exposure to chemicals and chemical products.*
>
> *Please read all the information and answer the questions carefully.* ***There are no right or wrong answers to the questions asked in this survey. It is your honest opinion that matters to us.*** *The survey can be completed on a mobile device, but we recommend doing it on a larger device, such as a tablet, laptop or desktop.*
>
> *We will ask some questions related to your health, habits and attitudes. Rest assured that a "Prefer not to answer" option will be available for you to select, at your discretion.*
>
> *Your answers throughout this survey will be kept* ***confidential****. Participation in the survey is* ***voluntary*** *and you may withdraw consent at any time by writing to support. Before agreeing, please also read this information sheet [hyperlink to information sheet screen].*

The informed consent of all participants to the surveys was collected by the internet panel provider. All survey response data are anonymised and participation in the survey was voluntary. In addition, best practices in terms of safe data storage are applied.

A description of the SWACHE project and the first five draft questionnaires were submitted to an institutional review board, the Inserm Ethics Evaluation Committee (CEEI), for an external, independent ethics review.[2] The submission process included a detailed description of the research project including type of data collected, measures to protect personal data, research objectives, research hypotheses and methodology. CEEI gave a favourable opinion on the project and had no significant concerns.

All survey questionnaires also include language to minimise non-response bias within the questionnaire. For example, the following language reduces the risk of "yea"-sayers:

> ***Please keep these things in mind***
>
> *In surveys such as this one, people sometimes say that they would pay for a reduction in risk even if they cannot afford it.*
>
> *Please treat the following questions as if they were a real-life situation, so that your answers are as accurate as possible.*
>
> *Don't agree to pay an amount that you cannot afford to pay or if you feel that there are more important ways to spend your money.*
>
> *When answering the next questions, please consider:*
>
> *your personal income and savings*
>
> *that the payment would reduce your spending on other things you may value.*

All surveys included harmonised debriefing questions to collect data on predictors of WTP such as income and age but also questions to control for non-response bias in empirical analysis. For instance, respondents were asked how much they agree with the following statements:

- I responded to the survey as I would have done in real life.
- The survey provided me with enough information to make informed choices.
- Did you agree or disagree with the description of [health effect] provided in this survey?

All survey questionnaires included a series of debriefing questions specific to the health effect valued in order to capture potential co-benefits or protests linked to the risk reduction mechanism. These survey specific questions are described in individual working papers.

Finally, all draft surveys questionnaires were tested in at least ten one-on-one interviews with people of various background and characteristics in an English-speaking country and in a non-English speaking country. The survey questionnaires were programmed and extensively tested. The translation into languages of target countries was verified by native speakers. Some surveys benefited from a pre-pilot to further revise the survey questionnaires.

Each survey questionnaire was piloted in all target countries with 50 survey responses per country. The pilots allowed for calibration of the bid levels that were presented to respondents to maximise the even distribution of responses across the four possible outcomes of the double bounded dichotomous choice.

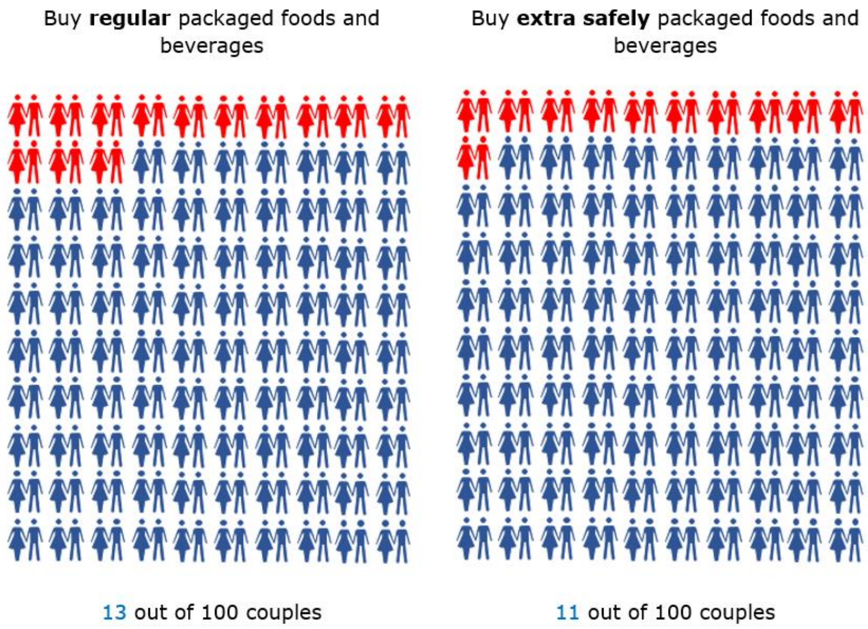
2.3. Risk reduction provision

Next, respondents were informed that they could reduce their infertility risk by buying foods and beverages that come in extra safe packaging. While extra safe packaging materials do exist (OECD, 2020), their use makes food purchases more expensive. Obviously, the extra amount one must pay for extra safely packaged food depends on the type and quantity of products consumed.

What difference would it make? Respondents were told that it was difficult to estimate but that a good guess was that their infertility risk could be reduced by one or two percentage points (depending on the treatment arm) if they bought extra safely packaged foods and beverages. They were also shown a graphical representation of the risk reduction that 100 couples like them could achieve (see Figure 2.1). This graphical representation was tailored to the situation of the respondent (see Section 2.4).

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

Figure 2.1. Graphical representation of the infertility risk reduction



Note: Authors' own elaboration.

2.4. Target population

For the survey, population samples were drawn that match the respective target population in each country in terms of gender, age group, level of education and geographic region. As additional constraints survey respondents were required to be (1) of child-bearing age (18-44 for female respondents, 18-65 for male respondents), (2) in a heterosexual relationship[3], and (3) willing to have a(nother) child within the next five years. Since the survey uses a private good scenario, these constraints were necessary as targeting the general population would have resulted in responses from people who are not directly concerned by infertility (Bergstrom, 2006[22]).

As the baseline infertility risk in current populations correlates strongly with the age of couples (ESHRE Capri Workshop Group, 2005[23]), the baseline risk communicated to respondents was varied based on their age and that of their partner. In practice four different baseline risk groups were differentiated. Table 2.1 summarises the composition of the four groups and specifies baseline risks that are broadly consistent with the study by (Dunson, Baird and Colombo, 2004[24]).

Table 2.1. Determination of baseline risk according to age of the respondent and their partner

Age of male partner	Age of female partner 18-26	27-34	35-39	40-44
18-39	8 out of 100 couples	13 out of 100 couples	18 out of 100 couples	24 out of 100 couples
40-65	13 out of 100 couples	18 out of 100 couples	24 out of 100 couples	24 out of 100 couples

[3] This constraint was imposed to elicit informed preferences from couples willing to naturally conceive. It does not imply any policy views on who should have children or whose values should count in regulatory impact analysis.

2.5. Valuation question

The actual valuation question first recalled that respondents had indicated their couple wished to have a child in the not-too-distant future. It then prompted respondents to plan for a baby in about a year from now. They should thus consider a purchase proposal which would ensure that, at an extra cost, all foods and beverages bought by their household would from then on come in extra safe packaging material.

Respondents were told that this would prevent harmful chemicals from leaching into their food, reducing their infertility risk. In all other respects, the food would be identical to regular food and the packaging had no other health benefits. Since it often takes several months of trying before a woman gets pregnant (Gnoth et al., 2005[21]), they had to start now and continue purchasing extra safely packaged foods and beverages over the next 20 months to effectively reduce their infertility risk.[4]

Next, respondents were offered a choice between two food bundles, one with regular packaging and one with extra safe packaging. As illustrated in the example choice card in Figure 2.2, each of the bundles were described in terms of four attributes: (1) the chance of naturally conceiving within the first year of trying to have a baby; (2) the chance of naturally conceiving within the second year of trying; (3) the chance of not conceiving despite trying; (4) the extra amount compared to the respondent's current expenditure on foods and beverages. The latter was expressed both as an extra cost per month and over the full 20-month period mentioned in the valuation question.

Figure 2.2. Example of dichotomous choice shown to respondents

	Buy regularly packaged foods and beverages	**Buy extra safely packaged foods and beverages**
Chance of getting pregnant in the **first** year of trying	92 in 100	**93** in 100
Chance of getting pregnant in the **second** year of trying	4 in 100	4 in 100
Chance of **not** getting pregnant despite trying	4 in 100	**3** in 100
Extra expenditure until becoming pregnant	EUR 0	EUR 10 per month (EUR 200 in total)
Which one would you choose?	☐	☐

The additional expenditure for the extra safely packaged bundle was randomly determined from a vector of four starting bids (see Table 2.2). Following the conventional double bounded dichotomous choice (DBDC) contingent valuation design (Carson and Hanemann, 2005[10]), respondents were offered the same bundle at a cost twice or half as high as the starting bid, depending on their answer to the first purchase decision.[5] As a follow-up, the survey inquired about the maximum additional expenditure per month respondents were willing to make to obtain the extra safely packaged bundle.

[4] The period of 20 months was meant to reflect the average time to pregnancy if couples tried to conceive 12 months from the date of survey completion.

[5] A slightly different bid ladder was used in Germany, where the starting bids were randomly assigned from EUR 5 | EUR 10 | EUR 25 | EUR 50 and EUR 10 | EUR 25 | EUR 50 | EUR 75 for treatment groups 1 and 2, respectively. Depending on the approval or rejection of the starting bid, follow-up bids moved up or down one step on the bid ladder,

As Table 2.2 suggests, a split sample approach inspired by previous research on the value of accident risk reduction (Leiter and Rheinberger, 2016[25]; Rheinberger, Schläpfer and Lobsiger, 2018[26]) was applied with treatment groups 1 and 2 being offered reductions in infertility risk of one and two percentage points, respectively. Treatment group 1 saw the bid ladder on the left column of Table 2.2, whereas treatment group 2 saw the staggered bid ladder in the right column.

Table 2.2. Starting bids as monthly additional expenditure for the United States

Treatment group 1 (risk reduction of 1 percentage point)			Treatment group 2 (risk reduction of 2 percentage points)		
Starting bid	Follow-up bid if starting bid rejected	Follow-up bid if starting bid approved	Starting bid	Follow-up bid if starting bid rejected	Follow-up bid if starting bid approved
7	3.5	14	14	7	28
14	7	28	35	17.5	70
35	17.5	70	70	35	140
70	35	140	105	52.5	210

Note: all values are in USD PPP.

This design offers the possibility to test for scope sensitivity (Hammitt and Graham, 1999[20]) and framing effects (Rheinberger, Schläpfer and Lobsiger, 2018[26]); e.g., being willing to pay USD 35 for a 1 percentage point risk reduction entails the same VSC as being willing to pay USD 70 for a 2 percentage points risk reduction. Hence, one ensuing test is whether a similar fraction of respondents receiving these two starting bids approved them. More generally, economic theory predicts a lower approval rate of bundles that provide a lower risk reduction. Non-parametric approval curves as in Rheinberger et al. (2018[26]) provide an overall test of construct validity.

i.e. somebody approving (rejecting) a starting bid of EUR 25, saw a follow-up bid of EUR 50 (EUR 10). Respondents approving the highest or rejecting the lowest starting bid saw follow-up bids of EUR 100 and EUR 2.5, respectively.

3 Survey data

3.1. Key information on the survey implementation

Ipsos European Public Affairs (hereafter Ipsos) conducted the “Fertility Loss Valuation Survey” on behalf of the OECD, in collaboration with the European Chemicals Agency. The Fertility Loss Valuation Survey was fielded in the following ten countries: Australia (AU), Canada (CA), Chile (CL), Japan (JP), Germany (DE), Poland (PL), Portugal (PT), Sweden (SE), the United Kingdom (UK) and the United States (US). Fieldwork took place between 11 May 2021 and 13 September 2021 (pilot and main stage fieldwork) in all countries but Canada, where the fieldwork took place between 3 May 2022 and 18 June 2022.

The survey was administered to samples drawn from large panels of individuals maintained by Ipsos (participation in the survey was voluntary). The internet panels used for all SWACHE surveys including the infertility survey are described in detail in Box 3.1. For the infertility survey, the target population included males (aged 18-65) and females (aged 18-45) who were actively planning to have a biological child within the next 5 years, including those who were currently expecting and wished to have another child within the next 5 years.

To ensure representativeness, the selection of respondents was based on quotas matching key demographic characteristics (gender, age group, level of education and geographic region). Completion statistics suggest that 13.1% of eligible respondents abandoned the survey, which is not uncommon for complex surveys like this according to Ipsos.

A total of 12 000 respondents (1 200 per country) completed the survey. The survey data was screened using several quality markers that feed into an overall quality score for each respondent (survey length and speeding, straight-lining, and proportion of “don’t know” answers). In total 213 interviews did not pass the threshold for this quality score and were removed from the final data.

In the baseline analysis, an even stricter filter was applied, (see Section 4.1 for details). This filter removed speeders and those respondents that failed the probability quiz question. The remaining sample size is 9 659 respondents.

Box 3.1. Quality of the internet panels used in the SWACHE project

The field implementation of the SWACHE surveys was carried out in all surveyed countries by Ipsos European Public Affairs (hereafter Ipsos), selected after a careful call for tender process. Ipsos has significant experience in multi-country projects and maintains panels of respondents in many countries. Fieldwork, pilot and main stage, took place between June 2021 and June 2022 for the first round of surveys. The surveys were conducted via Computer-Assisted Web Interviewing (CAWI). Random samples of at least 1 200 respondents matching the target population were drawn for each country from a high-quality network of online access (non-probability) panels. Some surveys had specific requirements regarding the target population due to the endpoint under consideration. This is elaborated in survey-specific information.

Online panels are databases of potential participants who declare that they will cooperate for future data collection if selected, generally in exchange for a reward or incentive. Loyalty card and subscription databases are included here if there is a continuous relationship with members who understand the commitment asked of them. Ipsos has its own supply of sample through its globally managed i-Say (IIS) panels and some locally owned Ipsos panels. In addition, Ipsos partners with many different types of external suppliers to source sample when needed to fulfil project requirements. This includes other traditional research panels, reward or loyalty communities, intercept or offer wall providers, and sample exchanges. Ipsos can also leverage its Direct-to-Survey channel which accesses respondents directly through social media platforms. To reach respondents, Ipsos has a proprietary project management and workflow system that controls access to their panel assets and where necessary, external respondent sources.

Importantly, Ipsos implements procedures to make sure that respondents to surveys are real, unique, engaged and fresh. To ensure that their respondents are real, i.e. they are who they claim to be, Ipsos uses country geo-IP validation and digital fingerprinting to check if the respondent used a device that is truly located or if it is evading detection and also if the respondent's device has any past history of fraud. These tools used in combination with cookies can make sure that each respondent is unique and has not already accessed the survey. To guarantee respondents are engaged, their survey taking behaviour is evaluated in real time, through standard self-adjusting algorithms involving speeding and straight-lining detection (i.e., always choosing the first (or nth) answer in multiple choice). The worst offenders are automatically removed from the data deliverables and are not counted against quotas. Finally, Ipsos invited members of their panels that were fresh, i.e., that have not taken part in any of the other SWACHE surveys and were not overburdened with surveys in general.

After the main stage was completed, the online survey data were evaluated by Ipsos using several quality markers that feed into an overall quality score for each respondent: survey length and speeding, straight lining and proportion of "don't know" answers.

For each of the quota variables, a comparison between the target population and the sample was made after the filters were applied to the sample. Females were slightly overrepresented in the final sample. However, for the age quota and the education quota, the differences between the sample quota and the achieved sample are more significant. Table 3.1 compares the age distribution of the realised samples and the respective quotas, showing that respondents aged 18-24 are overrepresented whilst respondents in the next age class (25-34) are underrepresented.

Table 3.2 compares the education distribution of the realised samples and the respective quotas, showing that low-educated and medium-educated respondents are somewhat underrepresented, whilst high-educated respondents are overrepresented. There are two explanations: (1) low-educated individuals are generally underrepresented in online panels, and (2) the break-off rate is higher among these respondents.

Table 3.1. Comparison of the sample quota and the realised samples in terms of age

	Australia	Canada	Chile	Germany	Japan	Poland	Portugal	Sweden	United Kingdom	United States
Sample quota										
18-24	10%	8%	19%	7%	7%	11%	9%	9%	13%	18%
25-34	58%	60%	57%	57%	62%	64%	51%	61%	57%	57%
35-39	23%	23%	15%	25%	21%	19%	27%	21%	21%	17%
40-44	7%	7%	6%	8%	8%	5%	10%	7%	7%	5%
45-65	2%	2%	3%	3%	2%	1%	3%	3%	3%	2%
Realised (achieved) samples										
18-24	19%	15%	26%	14%	16%	23%	20%	22%	18%	20%
25-34	46%	52%	48%	50%	51%	52%	46%	48%	49%	51%
35-39	25%	22%	17%	24%	23%	18%	21%	20%	22%	20%
40-44	7%	8%	7%	9%	8%	5%	10%	7%	8%	6%
45-65	2%	2%	3%	3%	2%	1%	3%	3%	3%	2%

Table 3.2. Comparison of the sample quota and the realised samples in terms of education

	Australia	Canada	Chile	Germany	Japan	Poland	Portugal	Sweden	United Kingdom	United States
Sample quota										
Low	17%	8%	33%	13%	48%	7%	48%	16%	20%	9%
Medium	36%	32%	42%	57%	20%	61%	26%	40%	33%	42%
High	47%	59%	25%	30%	32%	32%	26%	44%	47%	48%
Realised (achieved) samples										
Low	8%	2%	13%	13%	27%	2%	16%	3%	4%	0%
Medium	26%	44%	45%	49%	25%	58%	42%	48%	35%	42%
High	66%	55%	43%	36%	47%	39%	43%	50%	61%	58%

the empirical analysis using appropriate sample weights. For this purpose, a post-stratification weighting (PSW) procedure was applied that permits controlling for deviations from the quotas.[6]

Data are weighted to match official population statistics on gender crossed by age, educational level and geographic region. PSW was applied on a country-by-country basis to ensure that each of the samples accurately reflects the socio-demographic structure of the respective target population; the following strata were applied:

- Gender × Age: (1) males aged 18-24; (2) males aged 25-34; (3) males aged 35-39; (4) males aged 40-44; (5) males aged 45-65; (6) females aged 18-24; (7) females aged 25-34; (8) females aged 35-39; (9) females aged 40-44.
- Educational level: (1) low, (2) medium, and (3) high.
- Geographic region: country-specific NUTS 2 regions.

Based on these strata, post-stratification weights were obtained through an iterative proportional fitting procedure using contingency tables. However, it is important to consider the efficiency of the weights, such that ideally the overall weighting efficiency remains above a certain value to avoid any significant impact on the effective sample sizes obtained and, consequently, on the statistical power of the analyses conducted.[7]

[6] Weights were estimated using the R package 'anesrake' (v0.8).

[7] Weighting efficiency can be further improved by collapsing weighting cells and capping weights at each of the steps to reduce the impact on the variance of the final weights. For this survey, at the end of each iteration of the algorithm, any weights larger than 3 or lower than 1/3 were automatically set equal to this cap.

3.2. Descriptive statistics

Table 3.3 summarises the sample statistics for several of the main regressors used in the empirical analysis including country, gender, age of the respondent, education level, subjective (perceived) risk, and whether the respondent has already a child. Respondents were also asked to indicate their monthly net household income on a list of 11 different income intervals; if they refused to answer, they saw a follow-up question with six income intervals. In total, 451 (561 in the full sample) respondents refused to indicate their household income. For these non-respondents, the income was predicted using an OLS regression model that controlled for country, age and education effects (see the Appendix). Missing observations were then filled with values predicted from this model.

Table 3.3. Summary statistics on the main regressors

	Gender (Female %)	Mean age (Years)	Education level (%)			Mean household net income per month (in 2021)*	Subjective risk (5-item Likert scale)**	Couples with children (%)
			Low	Medium	High			
Australia	55%	31.2	8	26	66	5 621	2.6	57%
Canada	58%	31.5	2	44	55	5 395	2.6	57%
Chile	56%	30.1	13	45	43	2 304	2.4	59%
Germany	53%	32.1	13	49	36	4 659	2.8	50%
Japan	58%	31.4	27	25	47	3 373	3.0	50%
Poland	52%	29.9	2	58	39	3 578	2.5	64%
Portugal	51%	31.4	16	42	43	2 655	2.5	46%
Sweden	56%	30.6	3	48	50	4 408	2.6	54%
United Kingdom	58%	31.3	4	35	61	4 820	2.9	54%
United States	62%	30.7	0	42	58	6 037	2.7	66%

Note: * Calculated based on the mean of the reported interval (bounded at USD 8 800 per month); ** 1 - substantially lower than average, 2 - lower than average, 3 - about average, 4 - higher than average, 5 - substantially higher than average.

Respondents were randomly assigned a risk reduction of either one or two percentage points. 4 864 (6 010) respondents were asked to state their WTP for a risk reduction of one percent point, whilst 4 795 (5 990) respondents were asked to state their WTP for a risk reduction of two percent points.

Out of the 9 659 respondents, 4 269 did not have underaged children in their household; 3 251 had one, 1 674 had two, 352 had three, and 113 had more than three children. In the empirical analysis, the impact of having children is modelled using a dummy variable indicating whether respondents were already parents.

As for the intention to have a child in the future, 6 316 respondents intend to have a child within the next 1-2 years; and 2 710 intend to have a child within the next 3-5 years. 633 respondents were not sure of the timing but had indicated a possible intention to have a child within the next 5 years.

Before stating their WTP, respondents were informed about the nature of infertility. The concept of risk was described to them in comparison to the average risk of a couple with the same age profile. Respondents were then asked a question to check whether the description of the risk was clear to them. 9 891 (82%) respondents answered correctly, while 2 109 (18%) did not. These 2 109 respondents were screened out from the baseline sample alongside with the speeders.

After stating their WTP, respondents were asked to evaluate their couple's subjective risk of being infertile compared to that of their cohort: 1 731 (18%) respondents stated that their risk is clearly lower; 2 112

(22%) stated that their risk is somewhat lower; 4 000 (41%) stated that their risk is about average; 1 3532 (14%) stated that their risk is somewhat higher; 453 (5%) stated that their risk is clearly higher.

3.3. Willingness-to-pay answers

The opening bids ranged from USD 7 to USD 105 depending on the survey version, see Table 3.4. The second bids were either doubled or halved, contingent on the answer to the first bid. The bids were converted using purchasing power parity (PPP) for each of the countries to both express the bids in national currencies and adjust for differences in purchasing power across countries.

After the PPP-conversion, the opening bids were rounded to have easy-to-grasp and meaningful bid amounts in all countries. As the conversion rate does not match the PPP-rates exactly (due to the rounding), conversion rates that differ slightly from the official PPP-rates were used in the empirical analysis. However, the same rates were applied in Section 6 to calculate the nominal value per statistical case for each country, thus eliminating any slight difference.

Table 3.4. Repartition of responses for the DBDC

Answers to the bid questions – one percentage point reduction in risk						
First bid asked	USD 7	USD 14	USD 35	USD 70		Total
“no, no”	321	354	416	472		1 563
“no, yes”	230	244	250	272		996
“yes, no”	172	203	206	200		781
“yes, yes”	499	419	323	283		1 524
Share of “yes, yes” answers	40.8%	34.3%	27.0%	23.1%		4 864
Answers to the bid questions – two percentage point reduction in risk						
First bid asked		USD 14	USD 35	USD 70	USD 105	Total
“no, no”		264	338	398	472	1 472
“no, yes”		229	238	243	242	952
“yes, no”		217	233	222	191	863
“yes, yes”		496	384	331	296	1 507
Share of “yes, yes” answers		41.1%	32.2%	27.7%	24.6%	4 795

3.4. Quality controls

Best practices in the design of stated preference surveys were followed to ensure that respondents provide informed and deliberate answers to the survey (Johnston et al., 2017[19]).

Specifically, respondents were reminded to consider their household budget as well as the risk reduction offered before showing them the choice cards. If a respondent refused any payment, they were offered a possibility to explain why they were not willing to pay anything for foods and beverages that are extra safely packaged.

Moreover, the survey stressed that there were no positive or negative impacts from using extra safely packaged food other than those described in the choice cards. After the valuation questions the survey inquired whether respondents had nonetheless considered other advantages or disadvantages when making their choices.

Before answering the valuation questions and to guarantee that they understood the risk reduction offered and knew how high their current infertility risk was, respondents took a short probability tutorial including a simple risk quiz. After the valuation questions, the survey elicited both the perceived risk relative to the average couple and the perceived relevance of food packaging material as a cause of infertility.

The time it took respondents to answer the valuation questions was recorded separately to check for inattention, speeding and straight-lining in this core task of the survey.

4 Empirical strategy

4.1. Screening of responses

To ensure informed preference elicitation, the study applied a two-staged screening process based on a set of core principles for the empirical analysis agreed upon by the SWACHE researchers (see Box 4.1): (1) initial screening by the service provider based on several quality markers that feed into an overall quality score; and (2) additional screening based on indicators of uninformed preferences.

Box 4.1. Consistent analysis of survey responses across SWACHE health effects

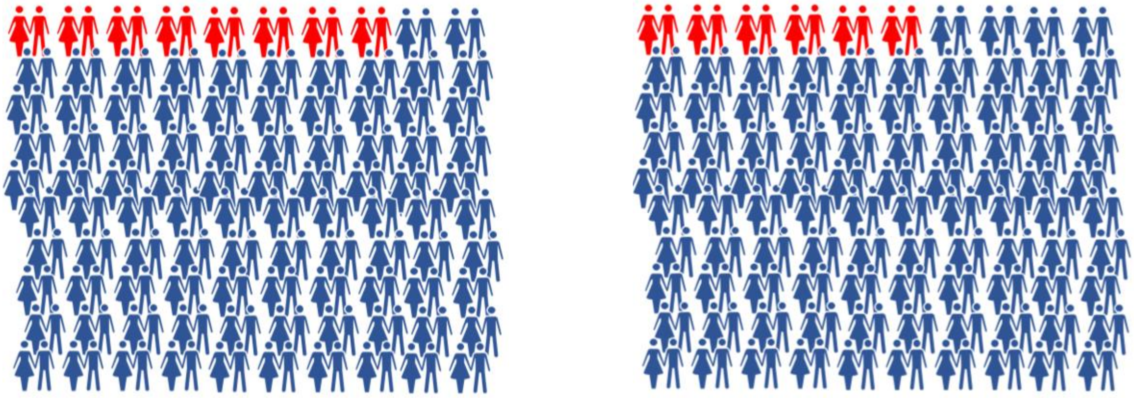
Each focused on a specific health effect, the SWACHE working papers will ultimately feed into an OECD summary paper that will gather the recommended estimates for WTP values and Value of a Statistical Case (VSC) for all endpoints, compare them across countries, and offer comprehensive guidance for benefit transfer. Consequently, the different teams involved in the SWACHE project adopted a similar core strategy on how the data would be cleaned and analysed empirically to allow the proper comparison of WTP values across countries and endpoints. A series of consensus meetings with the teams of survey authors led to the adoption of a set of Core Principles of Survey Analysis that are applied but adapted, when necessary, to survey specificities and data. As indicated in Box 1.1, the idea is not to break new conceptual, theoretical or econometric ground, but to set up core principles that are consistent with and widely recognised in the economic valuation literature. These shared principles ensure that all the working papers apply the same empirical strategy in terms of data cleaning, screening of respondents, specification, estimators, robustness checks and guidance on which central WTP or VSC value should be used in regulatory impact analysis. The final version of these Core Principles of Survey Analysis is presented in Annex B.

In the initial phase, the respondents who passed the screening questions (related to age and plants to have a child) and belonged to a sampling quota were directed to continue to the questionnaire. In total, 14 051 individuals started the survey, and 12 213 finished it, implying a break-off rate of 13.1%. A total of 213 interviews did not pass the Ipsos quality threshold (based on survey length and speeding, straight-lining, and the proportion of “don’t know” answers). Most notably, respondents were eliminated from the survey if they spent less than one third of the median survey time to fill the survey. As the median completion time was 12 minutes, the cut-off was approximately 5 min 40 sec.

In the second stage, a stricter set of screening rules was applied. A dummy variable indicating the passing/failing of each of the screening criteria was generated. The first screening question was related to how well the respondents understood a graphical representation of risk. Respondents were asked to state which of couples displayed in Figure 4.1 has a higher risk of infertility—the one that has a risk profile as the left-hand or the right-hand cohort. 9 891 of the respondents correctly stated that the couple represented by the left-hand cohort (8% chance) has a higher risk of being infertile than the couple represented by the right-hand cohort (6% chance).

In the empirical analysis of the responses, a stricter criterion was applied in relation to survey speeders based on the recommendation of Survey Sampling International (2013[27]) and Mitchell (2014[28]) to filter out speeders by discarding respondents that took 48% less time than the median respondent.

Figure 4.1. Understanding the risk using a graphical representation



The median response time for the survey was approximately 12 minutes. By this criterion, 329 respondents are classified as speeders. The intersection of those failing the probability quiz and the speeder results into 2 341 respondents that are eliminated from the baseline estimation strategy. If a threshold of more than 48% of the median time is used to identify distracted respondents, additional 2 767 responses would have to be discarded. However, it should be noted that because of the complexity of the questionnaire, some of the distracted respondents might have just needed more time to consider their answers. For this reason, respondents that took additional time to answer to the questionnaire are included in the estimation.

Other possibly incoherent answers were related to a mismatch between the information given about the household (e.g., the number of children or of people living in the household). However, only minor mismatches were detected, mostly related to typing errors related to the number of children (reporting e.g., 22 children). These were not screened out from the final sample even under the stricter screening criteria applied for the robustness checks.

After the DBDC questions, respondents were also asked to state their maximum WTP per month to obtain the risk reduction. This created another possibility for incoherent answers when the open bid was lower or higher than the amount implied by the two discrete choices. Importantly, respondents could skip the open-ended maximum bid question.

9 019 respondents provided an answer to the open-ended maximum bid question, whereas 2 981 skipped the question. In the screened baseline sample, the corresponding figures were 7 402 and 2 257. Applying a budget constraint of USD 700 per month as upper limit, 8 591 (7 097 of the filtered sample) respondents gave a plausible estimate of maximum WTP per month. Out of those bids at the filtered sample, the mean (median) WTP per month was USD 72 (USD 35).

In total in the screened sample, 911 respondents reported a lower maximum WTP than implied by the left bound of the WTP interval implied by their answers to the DBDC questions, while 621 reported a higher maximum WTP compared to the right bound of WTP interval. The open-ended maximum WTP was used in the analysis for determining the true zero respondents; this was roughly 4% of the bidders at the filtered sample.

4.2. Baseline estimation strategy

Different summary measures of WTP can be derived by analysing the survey responses. To this end, survey responses are treated as realizations of a random variable drawn from a latent population WTP distribution. Following Carson and Haneman (2005), let $G(x)$ denote the cumulative distribution function (cdf) which specifies the probability that an individual's WTP is equal to or less than x:

$$G(x) = \Pr(WTP \leq x).$$

There are parametric and non-parametric methods for estimating the distribution of the population WTP. Parametric methods specify a functional form (mostly logistic, log-normal or Weibull) with unknown parameter values, which are commonly estimated by maximum likelihood methods. Carson and Haneman (2005[10]) name the following advantages of a parametric approach: (1) one can fit a specific utility function to obtain a theoretically motivated estimate of mean WTP; (2) estimates depend less on the bid design; (3) one can test the effect of various covariates on the mean WTP; and (4) including answers to a sequence of choice questions increases the statistical efficiency.

By contrast, the non-parametric approach views response probability as an unknown function of the bid amount so that values are only observed for the bids that respondents actually encountered. The most likely response probability is then estimated only at those points, resulting in a step function. For calculating the welfare measure different assumptions can be made—the most conservative being that the response probability is constant between two adjunct bid levels so that decreasing the bid amount by one step in the bid ladder would not affect the response probability between these bids. This assumption results in the so-called Kaplan-Meier-Turnbull estimator which generates a lower bound estimate of WTP.

In the baseline strategy, both parametric and non-parametric models are estimated. The parametric model may be further refined by assuming that there is a spike at zero (Kriström, 1997[29]), meaning that a proportion of the sample is indifferent between having the good (i.e., the reduction in infertility risk) or not. As the target population of the survey is comprised of people who wish to have a(nother) child within the next 5 years, they should theoretically hold a positive value of infertility risk reduction. This is confirmed by the empirical data, which suggest that only 488 respondents indicated a zero value in their open bid, after answering "no" to both bid amounts prompted.

Since this is just about 4% of all respondents, it was concluded that there is no need to accommodate a spike in the empirical analysis. Instead, a conventional Weibull model is chosen as baseline specification for the estimation. The Weibull distribution has desirable characteristics. Specifically, this specification offers a flexible survival function which mimics other distributional forms quite well, and thanks to its shorter right tail it typically performs better than the log-normal distribution (Carson and Hanemann, 2005[10]).

4.3. Deriving mean WTP and VSC of infertility

The estimated survival function can be used to predict the mean and median WTP per month, where the former is defined as:

$$WTP_{mean} = \frac{1}{n}\sum_{i=1}^{n} WTP_{mean,i}, \text{ and}$$

$$WTP_{mean,i} = \int_0^{B_{\max}} g_i(x)\ \mathrm{d}x,$$

where $g_i(x)$ represents the estimated survival function for individual i and the upper integration limit $B_{\max}$ is the maximum (plausible) bid amount. Theoretically, this can be either the maximum bid amount that the respondent saw, or any other theoretically supported maximum value. In the analysis, the maximum follow-up bid of USD 210 per month that US respondents approving the highest starting bid saw is used as upper integration limit.

The median WTP corresponds to the bid amount approved or rejected with a probability of 0.5, i.e. half of the respondents would be willing to pay this amount, whilst the other half would not. It is computed as follows:

$$WTP_{median} = \frac{1}{n}\sum_{i=1}^{n} WTP_{median,i}, \text{ and}$$

$$0.5 = 1 - G_i(WTP_{median,i}),$$

where $G_i(WTP_{median,i})$ represents the estimated cumulative distribution function (cdf) for individual i. Finally, the mean value of a statistical case of infertility is computed as follows:

$$VSC_{mean} \frac{1}{n}\sum_{i=1}^{n}(WTP_{mean,i}/RR_i),$$

where RR_i is the risk reduction for which the $WTP_{mean,i}$ was elicited from respondent i.

4.4. Weighting

Post-stratification weights are used in the empirical analysis to correct for under- or oversampling of certain characteristics that affect the estimated sample welfare measure (i.e., the mean and median WTP) to better match the population welfare measure. As the weights are set on a country-by-country basis, they can be included in the regression analysis in interaction with the country dummies thereby rebalancing the contribution of each observation to the maximum likelihood estimator in such a way that observations of overrepresented individuals contribute less and those of underrepresented individuals contribute more. In spirit this is similar to—albeit less complex than—the correction method for choice-based samples proposed by Manski and Lerman (1977[30]).

4.5. Robustness checks

Robustness checks include the fitting of different model specifications, and/or the use of constraint datasets. The first point relates to the estimation of models assuming alternative parametrisations and/or an alternative set of predictors to test the robustness of the results obtained with the main model. Specifically, a logistic DBDC model was estimated as an alternative to the Weibull parametrisation. The second point is particularly relevant for the screening of problematic responses discussed in Section 4.1, where applying stricter filtering criteria necessarily results in smaller samples and this selection may or may not alter the regression results. In Section 5.1, the main results of the parametric analysis with the filtered sample are reported. In Section 5.3, the analysis is repeated with the full sample of 12 000 respondents so that the screening criteria are included as dummy variables to test their effect.

5 Results

5.1. Main results

Table 5.1 presents the results of the baseline Weibull DBDC model including risk reduction (percentage points), log of net income, gender, risk group (considering both age of the respondent and of the partner), country, whether the respondent has children, and the bid amounts as regressors to explain the probability of accepting a specific bid.

To facilitate the interpretation of the results, average marginal effects (AME) have been calculated for each of the regressors. The reduction of infertility risk by one additional percentage point is estimated to increase the monthly WTP by USD 27. This implies weak scope sensitivity as the estimated mean WTP per month is USD 64 for an average risk reduction of 1.5 percentage points (USD 50 for a risk reduction of one percent point vs USD 77 for two percentage points).

Other things equal, respondents identifying as women (-USD 10) and highly educated respondents (-USD 6) stated a significantly lower WTP. As expected, the net household income has a positive effect, increasing WTP by approximately USD 0.08 for every additional percentage point increase in income. This corresponds to an income elasticity of WTP of 0.12. There were also significant differences between countries with Chileans (USD 12) and Portuguese (USD 13) showing the highest WTP premium over the mean WTP, and Japanese (USD -18) and UK respondents (USD -13) showing the most significant discount to the mean WTP.

The corresponding (unweighted) welfare estimates for the full sample correspond to a median WTP of USD 34 (USD 32, USD 35) per month and a mean WTP of USD 63 (USD 62, USD 65) per month, respectively (where figures in brackets indicate 95th percentile confidence intervals as calculated by the Krinsky and Robb (1986[31]) method).

Figure 5.1 illustrates the estimated response distribution where the median WTP equals the amount that corresponds to a 50% probability of “Yes” and the mean WTP corresponds to the area under the curve. Notably, there is a share of approximately 12% of respondents that are predicted to be willing to pay more than at USD 200 per month for the risk reduction.

The Weibull DBDC model permits calculating country-specific welfare measures as reported in Table 5.2, which sums the (unweighted) sample mean and median WTP plus the country-specific AME reported in Table 5.1. The values reported reflect a tail effect with mean WTP values being between 48% and 106% higher than the corresponding median WTP values.

Table 5.1. Results of the baseline Weibull DBDC model

Coefficient	Estimate	Std. Error	Average marginal effect (USD2022 PPP[a])
Risk reduction	0.417***	0.025	27.2
Net household income (log)	0.127***	0.024	0.08 per 1% increase in net household income
Gender (female)	-0.160***	0.027	-10.3
Risk Group 2 (medium baseline risk)	-0.059*	0.033	-4.2
Risk Group 3 (high baseline risk)	-0.022	0.041	-1.9
Risk Group 4 (highest baseline risk)	0.080*	0.047	4.6
Education-high	-0.097**	0.031	-6.0
Australia	-0.001	0.050	-0.6
Germany	-0.190**	0.062	-11.7
Chile	0.191**	0.060	12.4
Japan	-0.300***	0.056	-18.0
Poland	-0.074	0.061	-4.7
Portugal	0.193***	0.060	12.6
Sweden	-0.074	0.056	-4.6
United Kingdom	-0.218***	0.052	-13.3
United States	0.053	0.060	3.4
Canada	0.044	0.057	2.8
Respondent has children	0.031	0.026	2.0
Missing income	-0.196	0.056	-11.8
Bid amount	-0.641***	0.009	

Note: Signif. Codes: '***' 0.001 '**' 0.01 '*' 0.05 '+' 0.1 ' ' 1. [a] For clarity, WTP values and VSC are expressed in USD2022 because the field implementation of the surveys was completed in 2022.

Figure 5.1. Weibull DBDC model and the graph of the estimated survival function

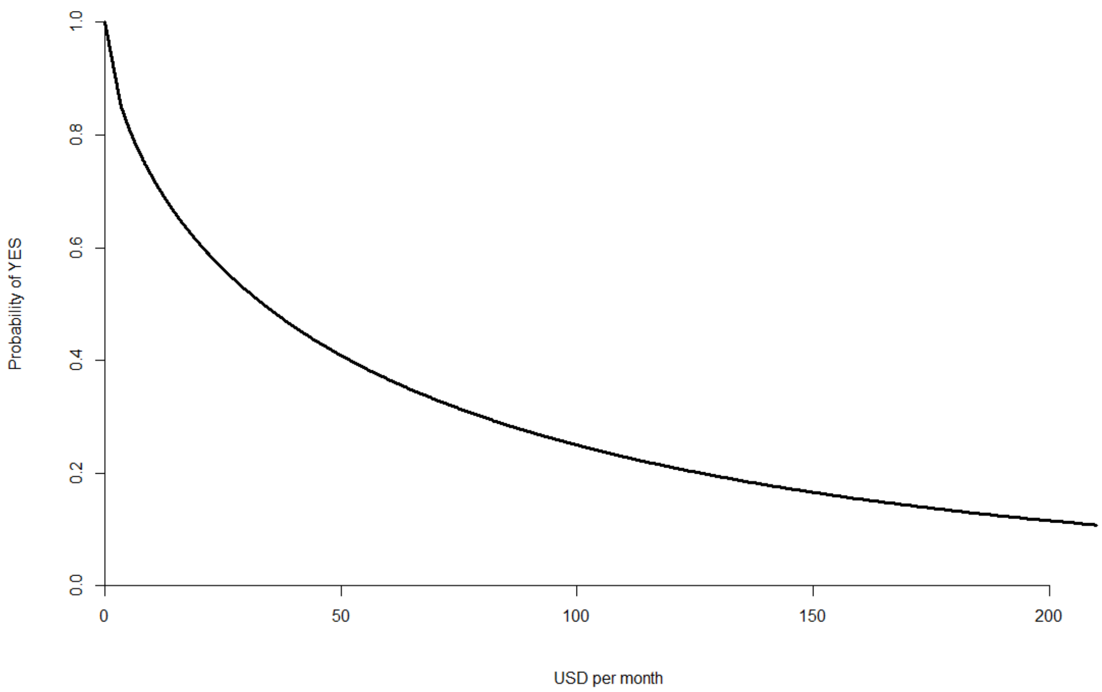


Table 5.2. Estimated (weighted) welfare measures per country

	Mean WTP per month in USD2022	Median WTP per month in USD2022
Pooled across countries	64	33
Australia	67.7	39.3
Canada	71.3	42.8
Chile	74.4	46.7
Germany	57.5	30.2
Japan	47.5	23.1
Poland	62.5	34.4
Portugal	76.6	49.2
Sweden	64.5	35.2
United Kingdom	54.1	27.7
United States	71.7	43

5.2. Robustness checks

5.2.1. Non parametric approach

To establish a conservative upper bound on mean WTP, a non-parametric Kaplan-Meier-Turnbull model was estimated. As noted by Carson and Hanemann (2005[10]), this estimator is sensitive to the particular bid design used, but as the possible support for the WTP distribution is filled in by using more design points, the Kaplan-Meier-Turnbull estimator theoretically approaches the sample WTP from below.

Figure A.1 from Annex A shows the response distribution for the Kaplan-Meier-Turnbull model. The corresponding mean WTP amounts to USD 63 per month which is very close to the parametrically estimated mean WTP. Similar to the parametric analysis, non-parametric WTP estimates can be estimated for each of the countries in the sample individually (see Table A.1 in Annex A).

5.2.2. Alternative parametric distribution

Another commonly used parametric response model is the logit. For a robustness check, the logit model is fitted with the same regressors, i.e. a logistic distribution of WTP is assumed (see Table A.2 in Annex A). A comparison with the Weibull model suggests no major differences. It can be noted that the signs of coefficient estimates are the same and their statistical significance is close to that obtained with the Weibull model.

Moreover, the mean WTP estimate from the logit model is USD 61 per month, which is close to that obtained with the Weibull model (USD 64). Due to the differently shaped survival function, there is a larger difference in median WTP with that of the logit model (USD 45) being approximately USD 12 larger than that obtained with the Weibull model (USD 33).

5.2.3. Impact of screening choices

As explained in Section 3, there are several responses that may be seen as problematic because the respondent did not pass the risk quiz, went through the survey in a very short time, or gave an answer to the open-ended bid question that was inconsistent with their previous response to the dichotomous choice questions. However, as explained in Section 3, screening based on the information gathered from the open-ended bid question was deemed problematic as it would have resulted in a large drop of otherwise robust responses. Instead, the screening was done using only the first two criteria: failing the risk quiz (2 109 respondents) and speeding (329 respondents).

As a robustness check, for both the speeders and those failing the risk quiz dummy variables were included in the model estimations using the entire unscreened sample (see Table A.3 in Annex A). However, there were no statistically significant effects on the mean or median WTP for these dummy variables, and the estimated mean WTP (USD 65) is very close to that of the screened sample (USD 64).

In both models, there was a negative effect predicted for speeders and a positive effect for those failing the risk quiz. The average marginal effect of speeding was estimated at around –USD 5 and that of failing the risk quiz at USD 4, explaining the slightly lower mean WTP value obtained for the screened sample.

The baseline results are robust to different definitions of some of the variables. In Table A.3, income is reported in thousands of USD to help showcase the effect of absolute increase of income (USD 1 000 increase is estimated to increase the WTP by USD 3), and education is divided into low, medium and high (as opposed to only low/medium and high).

6 Recommended policy values

6.1. Central value across countries and by country

The estimated VSC of infertility is calculated based on the mean and median WTP per month. Respondents were offered a risk reduction of either one or two percentage points. Thus, the respective WTP amount is multiplied by 20 to match the period indicated to respondents as the average time needed for the consumption of extra safely packaged food to result in reduced infertility risk.

Depending on the treatment received, the WTP for a 20-month period is divided by either 1% or 2% to obtain the value per statistical case avoided. An interaction between country and individual sample weights is used to account for deviations from the target quotas. The resulting VSC values per country are reported in Table 6.1. Across-country pooled results suggest median and mean VSC of USD 50 100 (USD 48 200 – USD 52 000) and USD 90 700 (USD 88 600 – USD 92 800), respectively (with figures in brackets indicating 95th percentile confidence intervals).

Table 6.1. Values per statistical case of infertility

	Median VSC (in USD_{2022})	Mean VSC (in USD_{2022})	Mean VSC (in local currency)
Pooled across countries	50 100	90 700	USD 90 700
Australia	52 800	95 000	AUD 135 700
Canada	57 800	100 600	CAD 115 100
Chile	63 000	105 300	CLP 42 104 000
Germany	40 700	79 900	EUR 57 100
Japan	31 300	65 900	JPY 6 590 600
Poland	46 200	87 300	PLN 137 200
Portugal	66 600	108 900	EUR 62 200
Sweden	47 000	88 100	SEK 817 900
United Kingdom	37 200	74 800	GBP 53 400
United States	58 400	100 800	USD 100 800

Note: The conversions are done using Purchasing Power Parities for actual individual consumption of 2019 since this figure was also used to convert bid levels across countries. Data are provided by the OECD. https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm. For clarity and simplicity, VSC are expressed in USD_{2022} because the field implementation of the surveys was completed in 2022.

6.2. Strengths and weaknesses of results

This study provides useful and internationally validated estimates of the VSC of infertility for several OECD countries using an original, state-of-the-art stated preference survey. The survey was administered electronically 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. The coefficients have signs that are consistent with expectations and scope sensitivity is statistically significant. The cost for the reduced risk option has a negative effect on the probability to choose the reduced risk option that is statistically different from 0. The statistically significant determinants of WTP include the size of the risk reduction, gender, income and education.

Although values across studies are not directly comparable, the magnitude of the simple average of mean VSC of infertility across the surveyed EU countries reported in this paper that is equal to EUR_{2022} 66 000 can be compared to the magnitude of the VSC of EUR_{2012} 29 400 per IVF pregnancy reported by Ščasný and Zvěřinová (2014[15]) and the VSC of EUR_{2012} 12 500 – 40 700 per natural conception reported by Ščasný and Zvěřinová (2016[16]). The order of magnitude is similar but the VSC for infertility is higher. This is not surprising as reducing the risk of not being able to naturally conceive is not the same as increasing the chance of having a baby naturally or via IVF.

Although the samples are close to the target quotas for gender and age for each of the countries surveyed, several samples missed the quotas for other key demographics – most notably the samples from Portugal, Chile and Japan where respondents with low education are underrepresented. However, using post-stratification weights as additional regressors allows to control for these deviations from the population structure.

While the study vastly expands the WTP estimates for infertility available for policy analysis, they were obtained in ten countries. Non-surveyed countries without country-specific values will need to conduct benefit transfer using best practices.[8] 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 6.1 that shares similar characteristics such as income, population by age, and public health care systems.

6.3. Application in regulatory impact analysis

This section shows how the new VSC of infertility estimated in the paper improves the basis for doing cost benefit analysis of chemicals management options. It starts by showing how the damage to society of male infertility associated with exposure to four phthalates was monetised in past opinion from ECHA. Then it shows how the new VSC should be used to improve this type of socioeconomic analysis.

A recent REACH Annex XV restriction report (ECHA, 2017[32]) estimated the damage to society of male infertility associated with exposure to four phthalates. The analysis concluded that approximately 0.08% of a male birth cohort could become infertile as a result of diminished androgen activity during critical foetal development. This corresponds to roughly 2 000 male children across the EU which would experience costs from infertility at their desired age of fatherhood (assumed to be at age of 30).

The REACH Annex XV restriction report estimated an annual cost of around EUR 40 million per year, starting from 2050. This cost includes (1) direct costs of infertility treatment for the individual, (2) indirect costs for the public in terms of health care costs, and (3) intangible costs presented in terms of the WTP per statistical infertility case. Broken down to the statistical case, the cost figure entails a cost per case of about EUR 19 000, out of which around EUR 5 500 are direct costs; EUR 1 900 public costs; and EUR 11 500 correspond to the WTP for avoiding one case of infertility.

The latter value is calculated from a WTP figure of EUR 29 700 estimated in a study commissioned by ECHA (Ščasný and Zvěřinová, 2014[15]), which estimated the value for a statistical baby. The regulatory impact analysis assumes that of those individuals trying to conceive but having fertility problems, 60% seek IVF treatment (42% out of the total succeed, and 18% do not), and 40% do not even seek treatment.

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

A reduced value of 50% of the estimated EUR 29 700 per statistical baby was applied to those individuals who would not seek IVF treatment, and the full value of EUR 29 700 to those who would seek treatment and would fail to conceive. The resulting value per case is close to EUR 11 500.

The WTP values from the current study are more applicable to the endpoint and straightforward to apply. They are obtained by estimating an individual's WTP for a reduction in the risk of infertility, prior to any choice of getting treatment or not. Ideally, this would mean that individuals also take accounts for the possible choice to seek or not to seek treatment following the realisation of the risk, and the possible resulting direct costs. The public costs could in theory still be added to the total.

Four EU countries (Germany, Poland, Portugal and Sweden) were included in the study. The average WTP of these four countries (in EUR 2021, PPP adjusted for Germany) is about EUR 65 000. If one assumes that these countries are reasonably representative of the different cultural areas in EU, one may directly apply this value as common EU VSC. By applying it to 2 000 individuals, a nominal welfare loss from phthalates-induced infertility of around EUR 130 million per birth cohort affected is estimated. Inclusion of public costs from the dossier (ECHA, 2017[32]) would result in a nominal welfare loss of roughly EUR 134 million per cohort.

6.4. Using these recommended values in policy analysis

The obtained VSC estimates for infertility can used in cost-benefit analyses addressing proposed regulations of chemicals or other pollutants that negatively affect fertility. 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 SC_{ct} statistical cases of infertility in country c in year t. The discounted benefits of the policy in terms of avoided infertility should thus be computed as follows:

$$Discounted\ benefits_c = \sum_{t=0}^{T} \frac{VSC_{ct} \times SC_{ct}}{(1+k_c)^t} \qquad (1)$$

where k_c is the discount rate used in country c[9], VSC_{ct} is the recommended value of a statistical case of infertility in country c in year t. VSC_{ct} is based on the recommended values $VSCI_{c,2022}$ reported in USD PPP in Table 6.1 and should reflect increase in prices and in GDP per capita over time such that:

$$VSC_{ct} = VSC_{c,2022} \times\ PPP_{c,2019} \times \left(1 + \%\Delta P_{c,2022-t}\right) \times \left(1 + \%\Delta Y_{c,2022-t}\right)^{\beta} \qquad (2)$$

where $PPP_{c,2019}$ stands Purchasing Power Parity for actual individual consumption in national currency per USD for the year 2019 that was used to convert the 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 infertility by 1 000 every year in Poland for 2022-2025 is provided in Table 6.2 for illustrative purpose. Based on a VSC of USD 87 000 in 2022, the discounted benefits of the policy over the 4 years equals PLN_{2022} 580 million.

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

[9] Note that the discount rate may vary over time, but is generally stable over shorter horizons.

Table 6.2. Measuring the benefits of policy intervention in Poland: an illustrative example using the value of a statistical case of infertility

		2022	2023	2024	2025
GDP per capita, volume in USD, at constant PPP (USD$_{2015}$)		33 889	34 472	35 487	36 243[a]
GDP per capita growth since 2022 ($\%\Delta Y_{c,2022-t}$)			1.72%	4.72%	6.95%[a]
Consumer Price Index (2015)		121	136[b]	141[b]	146[b]
Consumer Price Index growth since 2022 ($\%\Delta P_{c,2022-t}$)			5%[b]	10%[b]	15%[b]
PPP for actual individual consumption ($PPP_{c,2019}$)		1.66			
Value of a Statistical Case of Infertility ($VSCI$)	(USD$_{2022}$ PPP thousand)	87			
	(PLN$_{2022}$ thousand)	145			
	(PLN thousand)	145	152	160	168
Annual statistical cases of infertility avoided (SC_{ct})		1 000	1 000	1 000	1 000
Discounted annual benefits (PLN$_{2022}$ thousand)		144 639	144 936	145 112	144 849
Discount rate		5%[c]	5%[c]	5%[c]	5%[c]
Discounted Benefit (PLN$_{2022}$ thousand)		579 536			

Note: This illustrative example assumes a fictional policy that would reduce the number of statistical cases of infertility by 1 000 every year in Poland from 2022 to 2025. GDP per capita projections for 2022-2024 are provided by the OECD Economic Outlook (2022[33]). [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. Consumer Price Index data for 2022 comes from the OECD Dataset: Consumer price indices (CPIs) as of January 2022. [b]a 5% increase per year is assumed for 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 is based on the EU recommendation for CEE countries,. The income elasticity equals 0.12 as estimated in this paper.

7 Conclusion

Whilst previous studies have attempted to value reductions in infertility risk, the valuation scenarios used in these studies were not aligned with the objective of regulators to have a value per statistical case of infertility. Given these premises, this paper develops a novel stated preference study to estimate a policy-relevant valuation metric for infertility risk, which is applicable in and transferable across different countries and policy contexts. A double bounded discrete choice contingent valuation survey (Carson & Hanemann, 2005) was administered to 12 000 respondents from ten OECD countries (Australia, Canada, Chile, Japan, Germany, Poland, Portugal, Sweden, the United Kingdom, and the United States), asking whether they would be willing to pay an extra fee over a period of 20 months to ensure a reduction in infertility risk.

Both parametric (Weibull, logic) and non-parametric (Kaplan-Meier Turnbull) models were employed for estimating the distribution of the population WTP. A conventional Weibull model, without a spike, was chosen as baseline specification for the estimation of the WTP. The model includes a set of weights that correct a bias resulting from the fact that the sample in each country does not represent the underlying population in each country in full accuracy.

The main results of the estimation are presented in Table 5.1. The table includes the estimated coefficients for the chosen regressors, the standard errors, and the estimated average marginal effects on the monthly WTP values. As expected, (i) WTP increases with disposable income; (ii) WTP increases with baseline risk; (iii) WTP increases with the size of risk reduction; (iv) The increment in WTP is nearly proportionate to the size of risk reduction; and (v) Demand for risk reduction decreases with price. Moreover, the study shows that there are large differences in the values per country when controlling for other factors.

Based on the estimated mean and median WTP values per month, a VSC values were derived both on a pooled, cross-country-level and on the country level. The main output of this study are pooled and country-specific VSC values. The pooled results suggest a median and mean VSC of USD_{2022} 50 100 and USD_{2022} 90 700, respectively. Country-specific values are reported in Table 6.1, with the lowest estimated VSC found in Japan (USD_{2022} 65 900) and the highest in Portugal (USD_{2022} 108 900). Robustness checks in Section 5.3. show that both the cross-country and country-specific results are robust toward different modelling choices and towards stricter filtering criteria of observations.

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Annex A. Additional results

Table A.1. Kaplan-Meier-Turnbull estimates for the mean WTP per month in each country

USD2022 per month	Australia	Canada	Chile	Germany	Japan	Poland	Portugal	Sweden	United Kingdom	United States
	70.5	72.9	77.2	43*	48.6	59.5	79	62.9	50.2	73.3

Note: * Because of the different bid ladder, the German value is not directly comparable to other estimates as the Kaplan-Meier-Turnbull estimator is sensitive to the maximum bid value (the maximum bid in the German sample was USD 140, while for other countries, the maximum bid value was USD 210).

Figure A.1. Kaplan-Meier-Turnbull model and the corresponding response

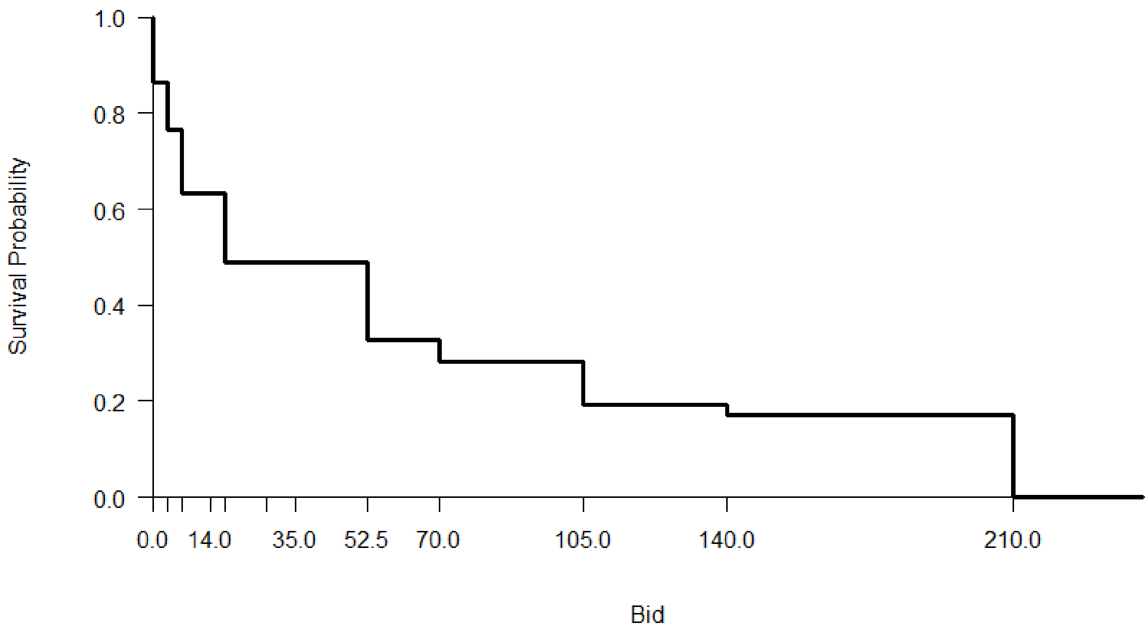

Table A.2. Results of the logistic DBDC model

Coefficient	Estimate	Std. Error
Risk reduction	0.554***	0.038
Net household income (log)	0.181***	0.036
Gender (female)	-0.173***	0.041
Risk Group 2 (medium baseline risk)	-0.108*	0.050
Risk Group 3 (high baseline risk)	-0.096	0.062
Risk Group 4 (highest baseline risk)	0.110	0.070
Education-high	-0.149**	0.047
Australia	0.007	0.073
Germany	-0.281**	0.093
Chile	0.277**	0.088
Japan	-0.508***	0.088
Poland	-0.099	0.093
Portugal	0.285**	0.089
Sweden	-0.104	0.086
United Kingdom	-0.327***	0.083
United States	0.096	0.085
Canada	0.036	0.088
Respondent has children	0.032	0.039
Missing income	-0.289***	0.088
Bid amount	-0.020***	0.000

Note: Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '+' 0.1 ' ' 1.

Table A.3. Results of the Weibull DBDC model with the full (unscreened) sample

Coefficient	Estimate	Std. Error	Average marginal effect (USD_{2021} PPP)
Risk reduction	-0.046	0.022	26.5
Net household income (in USD 1 000s)	-0.223***	0.006	2.7
Gender (female)	0.169**	0.024	-10.2
Risk Group 2 (medium baseline risk)	-0.327***	0.030	-3.6
Risk Group 3 (high baseline risk)	-0.057	0.037	-2.9
Risk Group 4 (highest baseline risk)	0.178***	0.042	3.9
Education-medium	-0.070	0.043	-3.4
Education-high	-0.248***	0.047	-7.7
Australia	-0.010	0.045	-3.0
Germany	-0.001	0.055	-13.8
Chile	0.029	0.053	11.1
Japan	-0.078	0.051	-19.8
Poland	0.060	0.055	-3.6
Portugal	-0.635***	0.053	11.7
Sweden	-0.046	0.050	-4.5
United Kingdom	-0.223***	0.047	-15.3
United States	0.169**	0.050	-0.6
Canada	-0.327***	0.050	-0.1
Respondent has kids	-0.057	0.023	1.8
Speeding	0.178***	0.066	-4.8
Risk quiz failure	-0.070	0.030	3.7
Bid amount	-0.248***	0.008	

Note: Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '+' 0.1 ' ' 1.

Annex B. Core principles of survey analysis

Detect potentially problematic responses

1. Generate a dummy variable for people failing the probability test
2. Speeder management: Generate one dummy variable for *survey* speeders and one dummy for *valuation* speeder. A respondent taking less than 48% of the median time is a speeder (ISS definition). Median values should be country specific to account for difference in languages that impact reading time.
3. Generate two dummies variable for distracted respondents: respondents who took an abnormally long time to respond:
   a. 48% longer than the median *survey* time,
   b. 48% longer than the median *valuation* time.
4. <u>Optional</u>. Generate a dummy variable for straightliners: when survey respondents give identical (or nearly identical) answers to items in a battery of questions using the same response scale. Note that there should not be any of them in the data sent by the internet panel provider.
5. <u>Optional</u>. Generate a dummy variable for respondents having incoherent answers:
   a. E.g. mismatch between the number of children, number of people in the household, or year of youngest child
6. Generate a dummy variable for unrealistic max WTP in open-ended question
7. Generate a dummy variable for probability test failers
8. Generate a dummy variable for protesters. This varies between endpoints. For example, in the asthma survey, people who disagree with the description of asthma provided in the survey or who are very doubtful that the information provided by the survey is correct or who thought they could just lower consumption of cleaning products can be considered as protesters.
9. Generate a dummy variable for respondents stating high co-benefits
10. Generate a dummy variable for consequentiality (real life debrief)
11. <u>Optional</u>. Read written responses to open ended questions to detect potentially problematic responses
12. <u>Optional</u>. Compute number of problematic responses to debriefing:
    a. that could overestimate WTP
    b. that could underestimate WTP
    c. that could go in either direction or a non-directional

Screen out problematic responses

- Baseline:
  - Exclude survey and valuation speeder (reinforced compared to Ipsos)
  - Exclude straightliners (already done by Ipsos)
  - Exclude respondents who fail the probability test (not applicable for IQ loss)
  - Keep pilot respondents if the survey design is the same even if parameters (such as bid levels) changed except if the changes are significant
  - Keep co-benefiters
  - Keep protesters to have a conservative estimate
  - Keep distracted respondents
  - Variations to perform as robustness checks:
- Optional robustness: stricter screening
  - Exclude survey and valuation speeder (same as option A)
  - Exclude straightliners (same as option A)
  - Exclude respondents who fail the probability test (same as option A)
  - Keep pilot respondents if the survey design is the same even if parameters (such as bid levels) changed (same as option A)
  - Keep co-benefiters (same as option A)
  - Exclude protesters because no does not mean true zero
  - Exclude distracted respondents
  - Exclude pilot respondents if pilot parameters differ too much (case of VLBW)
- Optional: exclude respondents that took more than 12h to complete the survey

Provide information on the sample of respondents

1. Compute summary statistics to describe the screened sample
   - Put main descriptive in body of text
   - And other e.g. country level in the appendix
2. Check that achieved quotas (age, education, location, gender) and income distribution in the screened sample are consistent with available population statistics (target quotas) at the country level (from OECD.Stat and Eurostat).
3. For each country separately, compute post-stratification weights to reweight later the observations through an iterative proportional fitting procedure (raking algorithm) using the following strata:
   - Gender × Age: (1) males aged 18-24; (2) males aged 25-34; (3) males aged 35-39; (4) males aged 40-44; (5) males aged 45-65; (6) females aged 18-24; (7) females aged 25-34; (8) females aged 35-39; (9) females aged 40-44.
   - Educational level: (1) low, (2) medium, and (3) high
   - Geographic region: country-specific NUTS 2 regions

It is important to consider the efficiency of the weights, such that ideally the overall weighting efficiency remains above a certain value to avoid any significant impact on the effective sample sizes obtained and, consequently, on the statistical power of the analyses conducted. Weighting efficiency can be further improved by collapsing weighting cells and capping weights at each of the steps to reduce the impact on the variance of the final weights. At the end of each iteration of the algorithm, any weights larger than 3.0 or lower than 1/3 should be automatically set to equal this cap.

Analyse responses to the valuation questions after baseline screening

1. Compute the DBDC response matrix for both the pooled dataset and each country of the dataset
2. Scope analysis:
    - Verify that the share of yes response decreases with the cost to be paid
    - Verify that the share of yes response increases with the risk reduction offered
3. Analyse written (open-ended) questions:
    - Use examples to illustrate the thinking of respondents if they were asked why they made their choice
    - <u>Optional</u>. Check consistency between OE and DBDC responses
4. As a preliminary step, regress SBDC (response to first dichotomous choice) on income, bid amount, baseline risk (if relevant) and risk reduction using a logit model
5. <u>Optional</u>. Try to find determinants of no-no and yes-yes responses using responses to debriefing questions

Compute harmonised variables

1. Compute continuous income level in USD PPP[10] based on unequivalised income range selected by the respondents:
    - Average of each interval
    - 0.5 lowest interval and 1.5 highest interval
2. Predict missing income using the following strategy
    - Generate the following dummies
        - Missing income dummy equal to 1 if the respondent did not provide income information
        - Couple dummy equals 1 if the respondent is married or have a partner
        - Employed dummy equals 1 if the respondent is in one of the following situations:
            - employed full-time
            - self employed
            - military
            - Own business manager
        - Part time dummy equals 1 if the respondent is employed part time

[10] This is OECD standard. PPS is the technical term used by Eurostat for the common currency in which national accounts aggregates are expressed when adjusted for price level differences using PPPs. Thus, PPPs can be interpreted as the exchange rate of the PPS against the euro.

- Retired dummy equals 1 if the respondent is retired
- Replace employed and part time dummies by 0 if they are missing
- Replace retired dummy by 1 if it is missing and the person is aged 60 or more or by 0 if it is missing and the person is younger than 60 years old.

- For each surveyed country separately, run the OLS regression of log(income) on age dummies, high education dummy, female dummy, couple dummy, number of persons in the household, employed dummy, part time dummy and retired dummy. For surveys targeting couples planning to have children, do not include couple dummy nor retired dummy that are naturally omitted since perfectly colinear.
- Predict income based on the regressions
- Replace missing income with predicted value in the main dataset

3. Compute one dummy variable for each age category
4. Compute a variable for education using Ipsos's low, medium and high category (directly available)
5. For all countries except the United States, compute bid level in USD PPP equivalent using OECD data on PPP for actual individual consumption. Because of rounding after currency conversion, respondents in non-US countries had bid levels that are slightly different than the bid levels seen by US respondents. Reconverting actual bid levels to USD PPP equivalent allows to obtain a more precise bid amount.

Apply a standard specification

1. Baseline:
   - All surveys: intercept, female, age, kids02, category dummies, log(income), missing income dummy, low, medium, high education dummies, baseline risk (if relevant), risk reduction
   - Add country dummies interacted by the post stratification weights to account for the difference between target and achieved sample quotas. This is similar to—albeit less complex than—the correction method for choice-based samples proposed by Manski and Lerman (1977[34]). Do not add country dummies to these interactions to avoid multi collinearity.
   - Add the number of children for fertility loss and VLBW
2. Robustness checks:
   - Health augmentation: own health perception, know someone having the condition, lifestyle, covid
   - Run the estimation without the missing income dummy.

Estimate average and median WTP based on DBDC

1. Estimator: DBDC or SBDC:
   - Baseline: interval-data maximum likelihood estimator using DBDC
   - Robustness check: Estimate WTP based on SB choice with logit model to compare to DB estimate
2. Distribution of the error:

- Baseline (preferred to allow comparison across endpoints): Weibull. The Weibull distribution has desirable characteristics. Specifically, this specification offers a flexible survival function which mimics other distributional forms quite well, and thanks to its shorter right tail it typically performs better than the log-normal distribution (Carson and Hanemann, 2005[10]).
- Robustness checks:
  - Non-parametric: Turnbull (e.g. Kaplan-Meier)
  - Basic parametric: normal, log normal, logistic, log logistic
  - Identify estimator with the lowest Akaike information criterion ($AIC = 2k - 2\ln\hat{L}$)

3. Spike configuration:
   - Baseline: use spike configuration (Kriström, 1997[29]; Carson and Hanemann, 2005[10]) if the spike variable is higher or equal to 5%. In other words, use spike when the average probability that people are indifferent to the valued item is higher or equal to 5%. Spike configuration can still be used if spike is lower than 5% but close to it. Spike is less likely to be relevant when people that have a priori no preference for the good are screened out by design. This is the case of the infertility and VLBW where only people planning to have a child over the next years were able to respond to the survey.
   - Robustness check: Compare estimates using spike and without using spike.
4. Compute WTP and VSC on pooled dataset based on a simple model with constant, country dummies interacted with weights and risk reduction as the only covariates using the following formulas:
   - Baseline: $\widehat{VSC} = \frac{1}{n}\sum_i \widehat{VSC}_i$ where $\widehat{VSC}_i = \widehat{WTP}_i / RR_i$ and $\widehat{WTP}_i$ is the individual mean WTP (truncated at the maximum bid with adjustment)
   - Robustness check (optional): Compute average WTP at sample mean: $\overline{WTP} = \widehat{b_0} + \widehat{b}_1\overline{RR} \rightarrow \widehat{VSC} = \overline{WTP}/\overline{RR}$
5. Compute WTP and VSC for each country based on the ***pooled*** regression estimated above. Do not use separate country-level regressions to generate country-level WTP and VSC as indicated in the previous version. Using the pooled model allows to capture the "cultural" differences between the countries (by also taking into account the fact that the sample is not perfectly representing the population in the country), by multiplying the country dummies with the weights, and using this as a coefficient to predict the values in each country. The pooled approach also increases dramatically the statistical power.
6. Perform the estimation using the standard specification defined above to test determinants of WTP:
   - Assess scope sensitivity:
     - Inference of the risk reduction coefficient
     - Optional. Estimate WTP for different risk reduction separately
   - Estimate income elasticity by simulating an increase in income by 1% for all respondents.
     - Increase income of all respondents by 1% before computing individual WTP. This relies on the same estimates derived from original data.

– Compute the new mean of the individual mean WTP (truncated at the maximum bid with adjustment)

– The elasticity is equal to this % change between this new mean and the baseline mean WTP.

- Other effects using the regressors of the specification: age, gender, etc.

Derive central value and range of VSC for pooled dataset and each country

1. Estimate central value (mean VSC) using the baseline approach. The central value should be clearly identified for regulators to choose.
2. Clearly present country-specific values as recommended values because they can be directly use in cost benefit analyses.
3. Provide pooled (all countries) mean VSC for information.
4. Provide pooled and country specific median WTP and VSC in the appendix
5. Provide an example of how the VSC can be used in CBA.
6. Compare WTP and VSC with magnitude of available WTP, QALY and Cost of Illness estimates from the literature for similar endpoints.

Prepare and share your code

1. <u>Baseline:</u> Prepare your code in R because it is free and more flexible (see dbchoice and dbspike packages). In contrast, only interval data ML estimators based on normal distribution are directly available for Stata (intreg, doubleb). In the long run, it is planned to make the code of the working paper publicly available.
2. Comment your code sufficiently so that a third person can run your code from scratch.
3. Share your code in shared folders.

Valuing a reduction in the risk of infertility

While fertility decline is a global phenomenon that has many causes, part of it can be explained by exposure to substances linked to reproductive toxicity that are produced and lead to human exposure through the environment and products. Authorities face challenges in regulating reprotoxic substances through actions such as bans and prohibitions, because of the difficulty in explicitly considering the economic benefits and costs of such regulations. Moreover, economic studies that show the value of reducing infertility caused by chemical exposure are not yet available.

This paper is part of the series of large scale WTP studies resulting from the Surveys to elicit Willingness to pay to Avoid Chemicals related negative Health Effects (SWACHE) project that intends to improve the basis for doing cost benefit analyses of chemicals management options and environmental policies in general. The present paper details a stated preference survey estimating WTP to reduce the risk of infertility, filling an important gap in the valuation literature and addressing a need for applied benefits analysis for chemicals regulation. The SWACHE infertility survey was fielded in ten countries: Australia, Canada, Chile, Germany, Japan, Poland, Portugal, Sweden, the United Kingdom and the United States. In each country, a sample of 1 200 adults, representative of the general population and of childbearing age who are in a relationship and plan for a(nother) child within the next five years, was collected and empirically analysed.

The estimated mean Value of a Statistical Case (VSC) of infertility equals USD_{2022} Purchasing Power Parity (PPP) 91 000 and the median VSC equals USD_{2022} PPP 50 000. Country-specific mean VSC of infertility vary between USD_{2022} PPP 65 800 for Japan and USD_{2022} PPP 108 900 for Portugal.

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