Valuing the avoidance of IQ losses in children

A large scale multi-country stated preference approach

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Abstract

Exposure to chemicals has been shown to reduce IQ in children. In turn, a person's IQ is likely to affect their educational achievements, which may then affect lifetime earnings, more generally, a person's quality of life. At the same time, authorities face challenges in regulating chemical 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 IQ loss 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 avoid IQ loss, filling an important gap in the valuation literature and addressing a need for applied benefits analysis for chemicals regulation. The SWACHE IQ loss survey was fielded in eleven countries: Australia, Canada, Denmark, Korea, Netherlands, Poland, Portugal, South Africa, Sweden, the United Kingdom and the United States. In each country, a sample of 1 200 respondents, representative of the general population, was collected and empirically analysed.

The estimated mean WTP to avoid the loss of 1 IQ point equals USD_{2022} Purchasing Power Parity (PPP) 609 per year (USD_{2022} PPP 3 046 per IQ point in total over the 5 years considered in the survey without discounting) and the median WTP to avoid the loss of 1 IQ point equals USD_{2022} PPP 150 per year (USD_{2022} PPP 748 per IQ point in total over 5 years without discounting).

Keywords: IQ, education outcome, health risk, economic valuation, health valuation, morbidity valuation, monetised benefits, chemicals regulation, non-market valuation, stated preferences, surveys, willingness-to-pay.

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

Résumé

Il a été démontré que l'exposition aux composés chimiques peut réduire le QI des enfants. À son tour, le QI d'une personne est susceptible d'affecter ses résultats scolaires, ce qui peut ensuite affecter ses revenus durant toute la vie et, plus généralement, sa qualité de vie. Dans le même temps, les autorités sont confrontées à des défis lorsqu'elles souhaitent réglementer des substances chimiques par des mesures telles que des interdictions, car il est difficile de prendre en compte de manière explicite les bénéfices et les coûts économiques de telles mesures réglementaires. En outre, il n'existe pas encore d'études économiques montrant la valeur de la réduction des pertes de QI causées par l'exposition aux produits et composés chimiques.

Ce document fait partie d'une série d'études portant sur le consentement à payer (CAP) 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 CAP pour éviter la perte de QI chez l'enfant, 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 la perte de QI a été menée dans onze pays : Australie, Canada, Danemark, Corée, Pays-Bas, Pologne, Portugal, Afrique du Sud, Suède, Royaume-Uni et États-Unis. Dans chaque pays, un échantillon de 1 200 répondants, représentatif de la population générale, a été recueilli et analysé empiriquement.

Le CAP moyen estimé pour éviter la perte d'un point de QI est de USD_{2022} 609 en parité de pouvoir d'achat (PPA) par an (soit USD_{2022} PPA 3 046 par point de QI au total sur les 5 ans prises en compte dans l'étude sans actualisation) et le CAP médian pour éviter la perte d'un point de QI est de USD_{2022} PPA 150 par an (soit USD_{2022} PPA 748 par point de QI au total sur 5 ans sans actualisation).

Mots-clés : QI, résultat scolaire, 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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Executive summary

Exposure to chemicals has been shown to reduce IQ in children. In turn, a person's IQ is likely to affect their educational achievements, which may then affect lifetime earnings and, more generally, a person's quality of life. Regulatory risk management programmes for chemicals are often required to monetise the expected health benefits of curbing emissions of hazardous substances. Among the impacts of being exposed to chemicals are reductions in a person's IQ.

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 revealed preference methods to evaluate the benefits of improved IQ. If revealed preference approaches have the advantage of looking at real choices, it is usually at the expense of generality to the wider population whose preferences are also relevant in estimating policy benefit. In the context of measuring the effects of chemicals on ecological systems and human health, the only way to capture the full WTP to avoid illness, that includes the disutility, is to conduct a stated-preference (SP) study. Only one previous SP study for IQ loss was identified but it focused on a single country, the United States, and on a specific group of chemicals, PCBs.

This paper reports on a new stated preference study which estimates a policy relevant WTP value to avoid IQ loss 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 13 200 respondents from eleven OECD countries: Australia, Canada, Denmark, Korea, Netherlands, Poland, Portugal, South Africa, Sweden, the United Kingdom and the United States, asking respondents whether they would be willing to pay a monthly fee over a period of 5 years to avoid with certainty the loss of 1 or 5 IQ points in a hypothetical child due to exposure to chemicals. Respondents are representative of the respective general populations.

This study fills gaps in previous research in a number of important ways. First, the contingent scenario focused specifically on the links between IQ and educational outcomes, as the most direct effect of IQ changes in children. Second, respondents were asked to imagine the impacts of IQ losses in their own hypothetical child, so the survey is applicable to those with and without children. Third, the survey accounted for the impact of losing IQ points from different baseline IQ (below average, average, and above average). Fourth, scope sensitivity was tested for by valuing 5 and 1-point IQ losses. Finally, the paper adopted a scenario whereby IQ losses from chemical exposure were avoided with certainty but the impacts on educational outcomes were probabilistic, making it simpler for respondents to consider the changes being valued. The survey design underwent extensive testing and piloting.

Whereas a significant degree of heterogeneity was found across countries, the estimated average WTP to avoid a 1 point IQ loss stands at USD_{2022} PPP 3 046 in total over 5 years without discounting or USD_{2022} PPP 609 per year. The study also derives country-specific WTP values, which mean values vary between USD_{2022} PPP 327 per year for the United Kingdom and USD_{2022} PPP 935 per year for Poland.

Various checks indicate that both the mean and the country-specific WTP estimates are fairly robust towards different modelling, data cleaning and screening choices. A comparison to previous studies that have estimated the value of IQ loss or gain shows that the estimates of the present studies are of similar magnitudes than the estimates based on lost earnings from revealed preferences studies but three times larger than the existing SP study.

1 The valuation of IQ losses

1.1. Motivation

Increasing concern surrounds the impact, in terms of neurotoxicity, of a range of environmental chemicals and related substances (Bellinger, 2018[1]). For example, previous studies on lead indicate that even very low-level lead exposure might cause significantly negative health and behavioural effects (Koller et al., 2004[2]; Bellinger, 2018[1]). Moreover, this evidence also points to the burden of these risks for children (Ziegler et al., 1978[3]; Lidsky and Schneider, 2003[4]; Chandramouli et al., 2009[5]). For example, exposure to chemicals, together with environmental and genetic factors, has been shown to affect IQ (Bellinger, 2012[6]; Grandjean and Landrigan, 2014[7]). IQ possibly affects several life outcomes, especially via its influence on – or association with – educational attainment with the impact on lifetime earnings being the most well-studied of such outcomes (Schwartz, 1994b[8]; Salkever, 1995[9]; Gould, 2009[10]). Others suggest a broader set of outcomes might result given the impact of educational attainment on life prospects (Miranda et al., 2007[11]; Nevin, 2007[12]; Reyes, 2007[13]).

This leads naturally to questions about the appropriate regulatory response by policy-makers, and the empirical evidence that is needed for any policy appraisal that might help guide this response. Moreover, if this is to involve economic appraisal, notably cost-benefit analysis (CBA), then this further requires regulatory impacts, e.g. the benefits on IQ from reducing low-level chemical exposure, are relatable in monetary terms. In this way, the monetary value of policy benefits can be compared with monetary cost. However, research on the valuation of IQ losses is scant, overly focused on estimating lifetime earnings as well as restricted in terms of its geographic focus. As a result, the existing empirical record lacks scope for meaningful comparisons and generalisability. 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 IQ loss and other chemically induced health risks, which are applicable in and transferable across different countries and policy contexts (see Box 1.1).

[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[14]).

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[15]). 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

A number of studies estimate the monetary value of IQ loss in terms of changes in lifetime earnings. For example, the US EPA (2020[16])in an assessment of revisions to US lead and copper regulations, estimates that a change in one IQ point ranges between USD_{2016} 5 708 and USD_{2016} 22 503 depending on the base value and the rate used to discount lifetime earnings.[2] As noted by Freeman et al. (2014[17]) the rationale for this approach is that it equates 'value' with an individual's productive contribution to the market economy and further assumes this productivity can be measured with reference to the earnings of that individual. This approach has its place, notably in valuing human capital in studies of wealth in the economy, such as in UNEP (2018[18]) and World Bank (2021[19]). In this respect, knowing how wealth (human capital) changes because of regulatory actions that influence education attainment is arguably a relevant metric of policy outcomes.

Nonetheless, in settings which involve economic appraisal, 'value' is more explicitly equated to an individual's evaluation of their own utility or wellbeing. As noted again by Freeman et al. (2014[17]), while this should bear some relation to earnings given that individual income permits consumption that, in turn, yields utility and wellbeing; this human capital approach does not capture the way in which attitudes and preferences for factors such as risk differ across individuals. Another way of thinking about this is that approaches that equate value with lifetime earnings might be a lower bound on policy benefits that will not fully capture the way in which an individual assesses how their quality of life changes as a result of a policy intervention.

Various means exist for estimating this full picture of the value of policy benefits (Champ, Boyle and Brown, 2017[20]; OECD, 2018[21]). These methods typically examine the WTP of a household (or individual) for some policy-related change in a good or service (e.g. a decrease in exposure to a neurotoxic chemical). Agee and Crocker (1996[22]), for example, estimate parents' WTP for reduced lead exposure in their children by looking at demand in the United States for chelation therapy, a medical treatment that removes heavy metals (such as lead) from the body. Their study of 256 households found an overall mean parental WTP for a 1% reduction in child lead burden of USD_{1980} 16. Lutter (2000[23]) translates these findings into a parental WTP per IQ point gained of USD_{2000} 1 100 - 1 900. However, it is important to note that it was found later that there is no IQ benefit to chelation therapy in lead-poisoned children making the results from Lutter (2000[23]) difficult to use in practice (Rogan et al., 2001[24]; Dietrich et al., 2004[25]). Finally, Lin, Lutter and Ruhm (2018[26]) estimated the effects of cognitive performance near the end of secondary schooling on labour market outcomes through age fifty and found a lifetime income gains of USD_{2014} 14 764 per IQ point.

Such revealed preference approaches have the advantage of looking at real choices, although perhaps at the expense of generality to the wider population whose preferences are also relevant in estimating policy benefits (Prosser, Grosse and Wittenberg, 2012[27]). Asking people more directly for these values in hypothetical or contingent markets using survey instruments – i.e. stated preference (SP) approaches – is one way of addressing this, although is itself subject to a critical debate (Hausman, 2012[28]; Haab et al., 2013[29]; Desvousges, Mathews and Train, 2016[30]). However, in the context of measuring the effects of chemicals on ecological systems and human health, the only way to capture the full WTP to avoid illness, that includes the disutility, is to conduct a stated-preference study (Alberini, 2017[15]).

Von Stackelberg and Hammitt (2009[31]) is the only SP study identified to derive a monetary value for increased IQ points, which can be applied to reductions in low-level chemical exposure. The study adopted a parental method of valuation (Dockins et al., 2002[32]) in finding a WTP per IQ point of USD 466. Another

[2] These monetary values for lifetime earnings are discounted back, in both cases, to age 7. The basis for these calculations is also built on a re-evaluation of Salkever (1995[9]) , which finds that a one-point change in IQ results in a mean 1.9 percent change in lifetime earnings for males and a mean 3.4 percent change in lifetime earnings for females.

study of this type is Atherton et al. (2016[33]) who estimated the UK public's preferences for reducing neurobehavioral damage in young children, if it were caused by exposure to lead from a range of largely unregulated consumer products. Using data from over 3 000 people in the United Kingdom, this study estimated the annual mean value of reducing the amount of lead in a child's bloodstream at GBP 434 per microgram of lead removed, per decilitre of blood.

1.3. Current effort: SWACHE project and selection of IQ loss

Given the absence of internationally comparable WTP estimates for IQ loss and its association with many chemicals, it was identified as one of the initial five priority health endpoints for valuation through SWACHE, along with chronic kidney disease, asthma, very low birth weight, and infertility. The OECD recruited a panel of prominent experts 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.

The core contribution of this study is to elicit the WTP of adults for avoiding reductions in IQ in young children, arising from childrens' exposure to chemicals, specifically focusing on the impact of IQ losses on educational attainment. Two metrics of educational achievement were used, a high educational achievement indicator (i.e. performance in exams at age 15/16) and a low educational achievement metric (high school drop-out rates).

The reason for focusing on educational outcomes is two-fold. On the one hand the IQ score of a person becomes stable in the early years, and has a direct impact on the person's educational achievement. In turn, educational outcomes are arguably the most valuable consequence of losing IQ points given how focal these outcomes are for life prospects. On the other hand, while computing the value of IQ losses solely through their impact on education may not capture all the consequences of losing IQ points, it avoids double-counting, e.g. children with better IQ score better at school and tend to earn more, but part of the reason for the higher earnings is the higher education received. Moreover, IQ changes are a convenient, and generalisable, conduit for connecting (changes in) educational attainment to (changes in) exposure to chemicals.[3]

The focus in this paper is on avoiding losses in IQ of respondents' own hypothetical child (a private good setting). This allowed respondents to be drawn across the general population of adults across study countries, rather than restricted to respondents with children only. Indeed, this is the largest study of its kind: using online contingent valuation surveys, over 13 000 responses were collected from nationwide broadly representative samples from 11 countries. This large sample size also permits analysis of how WTP varies across adults with and without children. By including respondents with no children, this study does not filter out a significant part of the population who would be affected by the policy change. Of course,

[3] It is worth noting that framing the valuation end-point as IQ changes ignores important health issues such as hyperactivity, which may have an influence on education attainment. The survey described in this paper explicitly relates education attainment to IQ. In terms of use in economic appraisal, as a practical matter, the results are most appropriately applied to IQ-endpoint. If hyperactivity, for example, is thought to be a significant impact of exposure to chemicals then a separate valuation study is likely to be warranted.

it is a matter for practical appraisal to determine subsequently how to circumscribe the population whose values are to be considered.

Another contribution of the paper is to value IQ loss using a scenario involving chemicals exposure in general. In contrast to existing studies focusing on a single chemicals, the WTP estimated in the present study can be used in a wide range of policy scenarios.

This is also the first study in which respondents were asked to value a loss in IQ from different IQ baselines (which, broadly speaking, correspond to ‘below average’, ‘average’ and ‘above average’ IQ).[4] In addition, scope sensitivity was tested for by valuing both 5 and 1 IQ point losses. This permits an assessment of whether and how WTP increases when the consequences of the loss are potentially more severe. In the CV scenario, IQ losses from chemical exposure were avoided with certainty, while the IQ impacts on educational outcomes were probabilistic making it less cognitively demanding for respondents to consider the changes being valued.

The remainder of the paper is structured as follows: Section 2 details the survey design. Section 3 discusses the survey data and presents descriptive statistics. Section 4 summarises the empirical strategy followed. Section 5 presents the WTP estimates. Section 6 specifies the recommended values for policy. Finally, Section 7 presents conclusions.

[4] IQ scores are standardised at the country level to have an average of 100 and a standard deviation of 15 points. Three baseline IQ were considered. A baseline of IQ = 110 (“above average”), a baseline of IQ = 100 (average) and a baseline of IQ = 90 (“below average”). The scenario presented 5-point losses from these baselines, so that a child starting at IQ = 110 drops to IQ = 105 (remaining above average), a child starting at IQ = 90 drops to IQ = 85 (remaining below average), and a child starting at IQ = 100 drops to an IQ score below average (IQ=95).

2 Survey design

2.1. Scope and description of IQ losses

The study was designed to assess WTP to avoid the reduction in the IQ of a hypothetical child, drawing on Von Stackelberg and Hammitt (2009[31]), from exposure to chemicals. A distinguishing feature of the study is the exclusive focus on educational outcomes, arguably the most direct effect of changes in IQ in children. A great deal of care was placed on associating the risk of IQ reduction with educational outcomes in each of the countries considered in the study. Two metrics were chosen for educational attainment, a (positive) high achievement metric (performance in exams at age 15/16) and a (negative) low achievement metric (high school drop-out rate). These achievements were chosen because of data availability (studies estimate these likelihoods on large samples) and because they ease participants' understanding of the consequences of losing IQ points. Studies used in the present study for the impact of IQ on educational outcomes have not been replicated, but the WTP value estimated by the present analysis are easily adjustable should the impact of IQ losses on education be revised. The school exams chosen and grades achieved were specific to each country and familiar to respondents from those countries. Annex A provides detailed information on the calculations used to approximate the effects at different baselines and the exams used in each country.

In the final version of the study, each respondent was randomly attributed a 5 IQ points change or a 1 IQ point change to test for sensitivity to scope. This choice was made to balance the necessity of a realistic policy change (1 IQ point) with individually meaningful changes (5 IQ points or higher). At the same time, this approach also reflects an expectation that respondents likely find it more difficult to conceptualise and value small changes. A test of the impact of baseline IQ was also performed with respondents being asked to imagine that their hypothetical child had one of three IQ levels (randomly assigned): 90 (below average), 100 (average), or 110 (above average) IQ points. It is important to note that IQ are standardised scores, with an average of 100 and a standard deviation of 15 points. Hence, even if the population was not exposed to chemicals that could affect the IQ of children, an IQ of 100 would still be an "average" IQ, and IQ scores of 110 and 90 would correspond to higher-than-average and lower-than-average IQ scores.

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.[5] 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.

The survey started with questions on socio-demographic information, including gender, age, marital status, region, education achievement, whether the respondents have children and, if so, their age. Responses to some of these key demographic characteristics (gender, age group, level of education and geographic region) were used during fieldwork to select respondents and ensure that samples were representative of the different populations based on quota matching. Respondents were then presented with information on IQ, stating that

> *"**IQ, or Intelligence Quotient,** is a **measure of a person's intelligence relative to their age group**. IQ scores measure people's abilities, including reasoning, vocabulary and comprehension. People with higher IQ scores are better at these skills".*

Next, respondents were shown information relative to the average IQ, stating that an average IQ is equal to 100, and that 25% of the population is expected to have an IQ level below 90, and that 25% will have an IQ level above 110. This was in preparation for the contingent valuation exercise whereby respondents

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

were randomly allocated to one of the treatments with different IQ baselines for their hypothetical child (90, 100 or 110 IQ points).

Prior to the CV questions, respondents were informed of the risks posed by chemicals, with the following information:

> *"A **child's IQ can be affected by many factors**. Some factors are genetic while others come from environmental factors. Environmental factors include things such as what the child eats, the education they receive, and parents' behaviours (e.g. alcohol, smoking, and drugs consumption). Environmental factors also include children's **exposure to pollutants and toxins in the air they breathe, the food and water they consume, and the chemicals present in the everyday products that we use in our households** (e.g., kitchenware, toiletries, toys, furniture, stationery, and clothing). **Long-term exposure to some chemicals present in everyday products has been shown to cause reductions in children's IQ.** Young children are at the highest risk of exposure to these chemicals because they often suck on everyday products, are more likely than older people to inhale or ingest household dust and old paint-flakes, and their bodies are more susceptible to the harmful effects of chemicals.".*

Next, respondents were presented with screens delivering two key pieces of information. First, the link between IQ and educational outcomes (Figure 2.1); second, two figures visualising the probability of achieving a positive educational outcome, i.e. the high level educational metric of exam attainment (Figure 2.2) and the probability of achieving a non-positive educational outcome, i.e. the low-level educational metric of school drop-out rate (Figure 2.3).

These screens differ depending on the treatment and country considered. The text and figures presented were tested in the UK and amendments to them were made following comments from the pilot respondents. The text was then translated into the respondents' mother tongue by professional translators, in order to make the survey more accessible. The list of countries included in the study is discussed in section 3. The visualisation of probabilities in Figures 2 and 3 were chosen following a review of the literature and extensive pre-testing. For more information on how the specific changes were calculated please see Annex B.

Figure 2.1. Language for the link between IQ and educational outcomes, example of 5 IQ points treatment with baseline IQ = 110 in the United Kingdom

Children with higher IQ scores are more likely to get better grades at school and have higher educational achievement than those with lower scores. IQ also affects their ability to study.

Specifically:

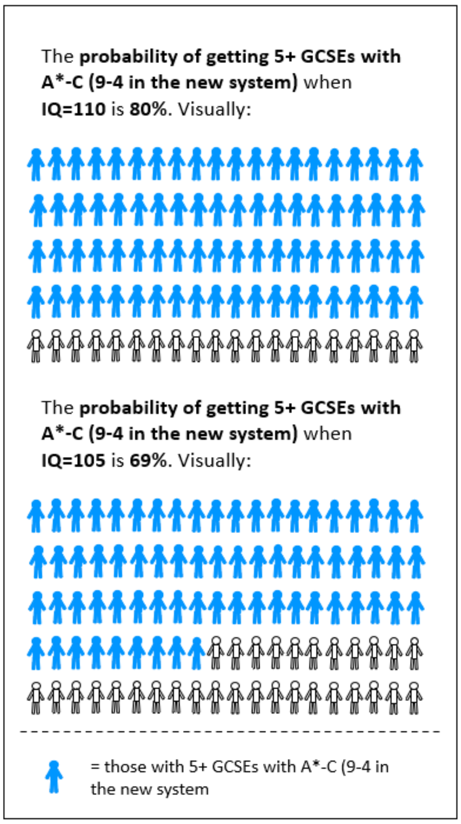
- **children with an IQ of 110 have a very high chance (about 80%) of getting five or more GCSEs with a grade of A*-C (9-4 in the new system), and a very low chance (about 2%) of not completing high school;**
- while **children with an IQ of 105 have a relatively lower chance (about 69%) of achieving five or more GCSEs with a grade of A*-C (9-4 in the new system)**, and a relatively **higher chance (about 4%) of not completing high school.**

The graphs in the following screens illustrate these differences.

The educational achievement of a person is also associated with better socio-economic prospects later in life.

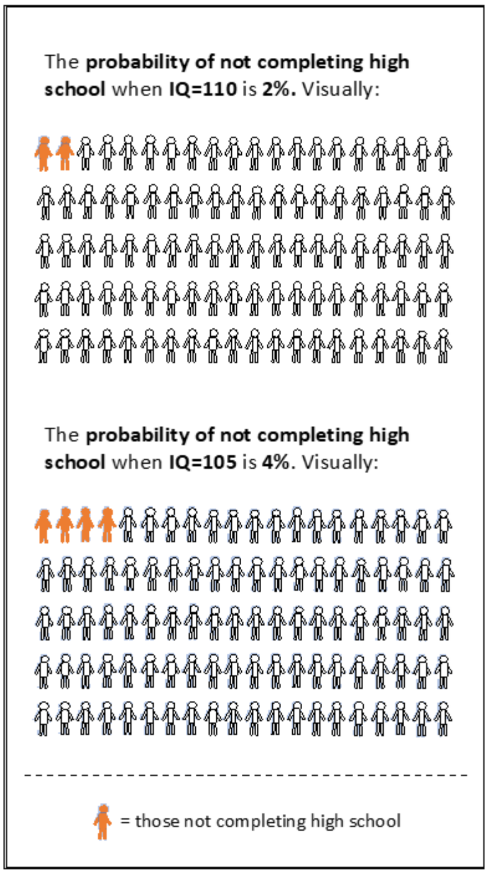
Note: Authors' own elaboration.

Figure 2.2. Visuals for the link between IQ and exam attainment, example of 5 IQ points treatment with baseline IQ = 110 in the United Kingdom



Note: Authors' own elaboration.

Figure 2.3. Visuals for the link between IQ and school drop-out rate, example of 5 IQ points treatment with baseline IQ = 110 in the United Kingdom



Note: Authors' own elaboration.

Respondents were then presented with the policy scenario and asked to consider a ban from the government on harmful chemicals, leading to a price increase on affected everyday products. A price increase in everyday products was the payment vehicle chosen to value IQ. The price increase was said to last for five years. The following information was presented:

> *"As mentioned, **long-term exposure to some chemicals present in everyday products has been shown to cause reductions in children's IQ**. **The government could place a ban on harmful chemicals that affect children's IQ**. If the ban goes ahead, **the price of everyday products would increase**. This is because many products would be more costly to produce due to the need to use better quality materials and the cost of product compliance checks. Suppose the price increase would last five years, after which research and development would bring down the costs of production. Please assume that **these chemicals do not have any other effects on children's health**, apart from IQ."*

After this section, the valuation questions were presented to respondents, in the form of double bounded dichotomous choice payment questions followed by an open-ended maximum WTP question. Below is an example of the payment question for the treatment with 5 IQ points change and 110 IQ points baseline:

> *"Would you be willing to pay an extra [bid] per month in higher prices (which amounts to [bids times 12] per year), over and above your normal household monthly shopping bill, to avoid a reduction in your child's IQ by 5 points (from 110 to 105)?"*

The first bid depended on the size of the IQ loss and was randomly attributed to each respondents. For instance, for the United Kingdom the bid vector for the first contingent valuation question, for the 5 points change scenario, was: GBP 5, 15, 30, 75 and 150 with each value being equally likely to be drawn. When considering instead the 1 IQ point change, again considering the example of the United Kingdom, the bid vector for the first contingent valuation question was: GBP 1, 3, 6, 15 and 40.

These final bid vectors are different from the initial bid vectors assessed and were chosen as a result of the pilots in the United Kingdom, so that the valuations were meaningful from a policy perspective and credible for participants. Specifically, the top bid was raised, as the initial pre-pilot one had an overwhelming percentage of participants willing to pay the top amount (GBP 100) and stating a very high WTP in the open-ended question. The bid vector for the 1-point change was adjusted accordingly.

Depending on the answer to this initial question, respondents were presented with a higher bid, if the answer was yes to the initial bid, or with a lower bid, if the answer was no to the initial bid (Table 2.1). In addition, respondents were also asked an open-ended question to gauge their maximum willingness to pay, if any. All bids were presented in local currencies and converted from the United Kingdom values using OECD data on Purchasing Power Parities for actual individual consumption.

Table 2.1. Monthly bid levels used in the double bounded dichotomous choice for the United Kingdom

	5 points loss			1 point loss		
	First bid	Second if "yes" to first question	Second if "no" to first question	First bid	Second if "yes" to first question	Second if "no" to first question
I	5	15	1	1	3	0.5
II	15	30	5	3	6	1
III	30	75	15	6	15	3
IV	75	150	30	15	40	6
V	150	200	75	40	75	15

Note: Bid levels in expressed in GBP. Respondents living in other countries saw these bid levels expressed in the currency of the country they live in. The conversions in the different local currencies were done using Purchasing Power Parities for actual individual consumption of 2019 since it was used to convert bid levels across countries. Data are provided by the OECD. https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm.

The survey concluded with a series of debriefing questions to assess reasons of positive or zero WTP, as well as familiarity with the information on chemicals and impacts on health. Finally, a few more socio-demographic questions were asked, for instance to determine household income and also COVID effects following Mourato and Shreedhar (2021[34]).

2.2. Impacts on educational outcomes and uncertainty

Respondents were informed of a given probability of achieving a given positive educational outcome (achievement in exams), and a given probability of achieving a non-positive outcome (school drop-out rate). They were not given a range, or a distribution of such probabilities, so as to balance the realism of the information provided with the extent to which it would be understandable by the respondents. As noted before, there were no probabilities attached to the impact of exposure to harmful chemicals on IQ, which was presented as not being uncertain, in order to avoid an excessive use of probabilities and the associated cognitive burden in the scenarios.

The educational outcomes were made relevant for each country considered. For instance, whilst the questionnaire referred to GCSE exams for the UK, it referred to Folkeskolens 10 Klasseprove for Denmark, Australian Tertiary Admission Rank for Australia, Hoger Algemeen Voortgezet Onderwijs (HAVO) diploma for the Netherlands, Matura Exam for Poland, Provas Finais do 9º ano for Portugal, Senior Certificate for South Africa, High School Exams for South Korea, and Slutbetyg fran Grundskolan exams for Sweden. For Canada and the United States there was no direct comparison in terms of exams, so the impact of IQ losses on the GPA in year 12 (Canada) and high school (United States) were considered. More details of how the educational outcomes were chosen can be found in Annex A. Education experts, as well as people living in the different countries surveyed, were interviewed to ensure that the educational outcomes were relevant and comparable.

2.3. Split sample strategy

A total of four treatments, by country, were administered. Three treatments contained a 5 IQ points change, whereas one treatment contained a 1 IQ point change. Respondents were allocated to one of the treatments randomly. Additionally, the three treatments with a 5 IQ point change had IQ baselines respectively of 90 (below average), 100 (average), or 110 (above average) IQ points, hence a decrease of 5 IQ points would imply falling to 85, 95, or 105 IQ points respectively. The 1 IQ change treatment had a baseline of 100 (average) IQ points. Table 2.2 summarises the four different treatment that were randomly and equally distributed among respondents within the various surveyed countries.

Table 2.2. Baseline IQ and change in IQ points randomly allocated to respondents

Treatment	Baseline IQ	Baseline IQ relative to the population	Change in IQ points
1	110	above average	5
2	100	average	5
3	90	below average	5
4	100	average	1

Note: The four treatments were randomly and equally attributed to respondents within each surveyed country.

2.4. Approach to minimising bias

Respondents were all presented with a script designed to minimize their potential bias caused by the hypothetical nature of the situation:

> "In surveys such as this one **people sometimes indicate that they are willing to pay for a policy even if they would not actually pay for it in the marketplace**, as they underestimate the sacrifices they would need to make to afford these changes in reality. Some people may think the proposed policy is worth spending money on, while others may think it is not worth it. We want to get the opinions of both kinds of people. Please **treat the following questions as if they were a real-life situation**, so that your answers are as accurate as possible. **Please don't agree to pay an amount if you cannot afford to pay it, if you think the proposed change is not worth it, or if you feel that there are more important things to spend your money on**. Try to think about where any additional money might come from and if your budget allows the expense. **Also remember that there are a number of different ways in which your child's intellectual abilities could be improved (e.g. through extra tutoring).**"

In addition, the scenario focused exclusively on, firstly, the impacts of chemicals on IQ and, secondly, on the impacts of IQ on educational outcomes of respondents' own hypothetical children, excluding other types of impacts and impacts on other people. Debriefing questions were asked to assess drivers of WTP and whether respondents valued the intended changes in IQ.

The final questionnaire and bid levels used were completed after several rounds of revisions and testing. This included over twenty one-to-one interviews, a pre-pilot conducted by the researchers with 400 respondents in the United Kingdom (who completed an online survey consisting of a preliminary version of the questionnaire, with several open-ended debriefing questions), and Ipsos pilots with 50 respondents each, first in Portugal and Sweden using a near-final version of the survey instrument, and then in the other target countries. As is standard in survey methods, low quality responses were removed from the final sample. This included incomplete responses, respondents answering the survey too quickly (“speeders”) and those answering attitudinal questions in unlikely patterns (“straight liners”) or providing too many “don’t know” answers.

3 Survey data

Survey implementation and screening strategy

The IQ Loss Valuation Survey was carried out by Ipsos European Public Affairs in the following eleven countries: Australia, Canada, Denmark, South Africa, Korea, Netherlands, Poland, Portugal, Sweden, United Kingdom, and the United States of America. The Ipsos fieldwork took place between 05 February 2022 and 11 April 2022 (pilot and main stage fieldwork). The internet panels used for all SWACHE surveys including the IQ loss survey are described in detail in Box 3.1.

The survey was open to adults (respondents aged 18 or older). A total of 13 200 high quality interviews were completed, 1 200 in each of countries surveyed. The selection of respondents was based on quotas matching key demographic characteristics (gender, age group, level of education and geographic region) to ensure representativeness.

The fieldwork was first conducted for Sweden and Portugal in two phases: (1) pilot phase, and (2) main stage. The pilot (50 completed interviews) was completed for both countries during 5-8 February 2022. Main stage fieldwork occurred from 1-17 March 2022. The pilot for the remaining countries was completed from 7-11 April, 2022, with mainstage fieldwork occurring from 27 April to 27 May 2022 (see Table C.1 in Annex C).

Table 3.1 provides information on the break-off rate (respondents who started the survey beginning with the first question of the questionnaire, but did not complete all questions, i.e. partially completed questionnaires). In total 20 846 people started the survey (i.e. passed all screener questions and quota checks) and 13 744 finished it (break-off rate of 34.1%). While the attributes of people who broke off are not known, 26.5% of them broke off after the first 5 screens and 32.4% of them broke off during the valuation questions.

Box 3.1. Quality of the internet panels used in SWACHE

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.

Table 3.1 also shows the number of interviews removed by Ipsos due to low quality. The online survey data were evaluated by several quality markers that fed into an overall quality score for each respondent (survey completion time and speeding, straight lining and proportion of “don’t know” answers). In total 544 interviews did not pass a lower threshold for this quality score and were removed from the final data.

Table 3.1. Details on low-quality interviews and the number of interviews removed by country

	Number of surveys completed in full	Number of surveys removed due to low quality	Low quality rate (out of surveys completed in full)	Number of surveys completed in part	Break-off rate (out of total surveys)
Australia	1 260	60	4.76%	613	32.73%
Canada	1 255	55	4.38%	878	41.16%
Denmark	1 240	40	3.23%	380	23.46%
Korea	1 225	25	2.04%	291	19.20%
Netherlands	1 234	34	2.76%	1204	49.38%
Poland	1 235	35	2.83%	614	33.21%
Portugal	1 224	24	1.96%	293	19.31%
South Africa	1 250	50	4.00%	1242	49.84%
Sweden	1 223	23	1.88%	272	18.19%
United Kingdom	1 260	60	4.76%	898	41.61%
United States	1 338	138	10.31%	417	23.76%

The mean, median, minimum and maximum survey times (in minutes) of the mainstage fieldwork are shown in Table C.2. The median survey duration varies between approximately 15 minutes in the United Kingdom to nearly 26 minutes in South Africa.

As noted above, a number of interviews were removed due to low quality by Ipsos, with one quality marker being survey completion time. A valid complete is one where the time spent by a respondent on the questionnaire is not lower than one third of the median survey duration.

The survey respondents were screened based on core principles for empirical analysis agreed upon by the SWACHE researchers (see Box 3.2). Accordingly, respondents who took less than 48% of the country's median time to complete the survey were classified as speeders and excluded from the analysis following the recommendations of Survey Sampling International (2013[35]) and Mitchell (2014[36]). This excluded 234 responses overall, evenly distributed across the eleven countries.

Box 3.2. Consistent analysis of survey responses across SWACHE health effects

Each focused on a single 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 practical use by practitioners including guidance on benefit transfer that is the transfer of value over time and toward non-surveyed countries. Consequently, the different teams involved in the SWACHE project adopted a similar core strategy on how datasets 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 set up core principles that are consistent with the economic valuation literature and are widely recognised in the field. 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 0.

3.1. Demographics and representativeness of the achieved samples

Table C.5 and Table C.6 report the sample demographics before the sample weights were applied and show that in each country has great variation across gender, age, education, marital status and area where the respondent lived. Samples are balanced over the number of children the respondents had in different countries, the respondents' employment status, household size and income levels. High-income respondents tend to be overrepresented in all countries as shown in Figure C.2. This is especially true for South Africa, Korea and Poland.

Table 3.2 shows the target and achieved quotas for key demographics by country after excluding all speeders from the sample. The samples come close to the target quotas on age for each country, except for respondents aged 18-29 who are slightly underrepresented in the samples for Sweden and the United States. For most countries, male respondents are slightly underrepresented by 3 percentage points on average. In all countries, respondents with low education are underrepresented by 11 percentage points on average. This underrepresentation is more important for the samples for Portugal, South Africa and the United Kingdom. In contrast, respondents with medium education are overrepresented by 9 percentage points on average. This overrepresentation is high for the samples for Portugal, South Africa and the United Kingdom. Finally, the samples come close to the target quotas on highly educated respondents for each country.

To account for differences between achieved and target quotas, a post-stratification weighting procedure is carried out to adjust the samples to selected population totals. The post-stratification weights are then used in the empirical analysis described in 4.1 so that the estimated mean and median WTPs are representative of the population in sampled countries. The principle behind this type of weighting is that by aligning the sample and population on key variables for which population statistics are known, the accuracy of the other variables in the survey (which may have been affected by non-response or coverage bias) is expected to be improved. The following socio-demographic variables were used in all national raking procedures (with categories levels used):

- **Gender :**(1) Male (2) Female
- **Age:** (1) 18-29 year-olds (2) 30-44 year-olds; (3) 45-60 year-olds; (4) 60+ year olds

- **Educational level:** (1) low or medium level and (2) high level

Specifically, a raking procedure was performed to compute the weight by iterative proportional fitting using contingency table analysis. Any weights larger than 3.0 are automatically set to equal to 3.0 at the end of each iteration of the algorithm. This prevents giving a too large or too small weight to any observation.

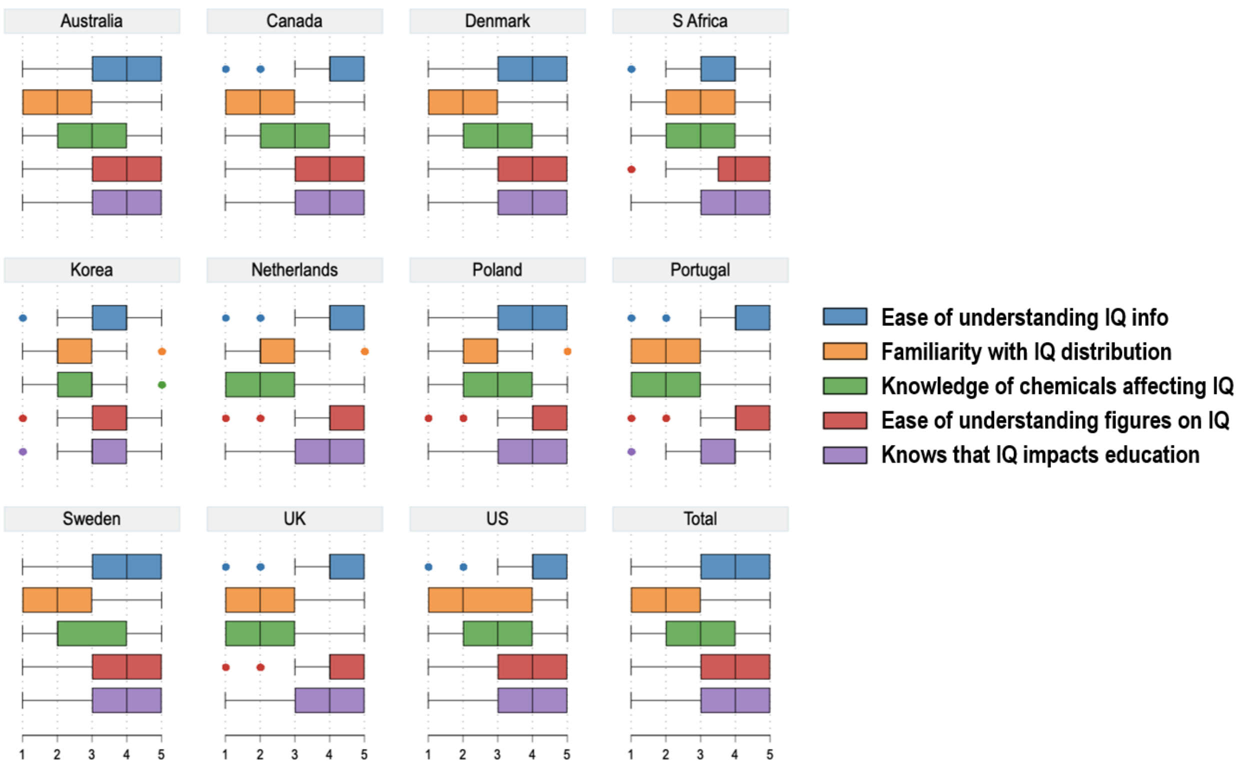
3.2. Summary statistics

3.2.1. IQ and hypothetical child

The valuation scenario was found credible for most participants, and on average respondents found it easy to imagine having a child with the assigned level of IQ. Table C.3 and Figure 3.1 show these results by country.

Most participants were aware of IQ as a general measure of intelligence, with an average of 3.4 out of 5 in the sample and with no country having an average below 3.1. In contrast, there was less awareness of the IQ distribution in a population. Most participants believed that a higher IQ was important to them (with an average of 3 out of 5 overall) and beneficial for society (average of 3.4 out of 5 overall). Many participants were aware of the link between IQ and educational attainment, but less so of the fact that exposure to chemicals was likely to lower a person's IQ. Reassuringly, respondents found the information provided easy to understand (with an average of 4 out of 5 overall for the information and visuals shown).

Figure 3.1. Average understanding of IQ information and prior knowledge of IQ

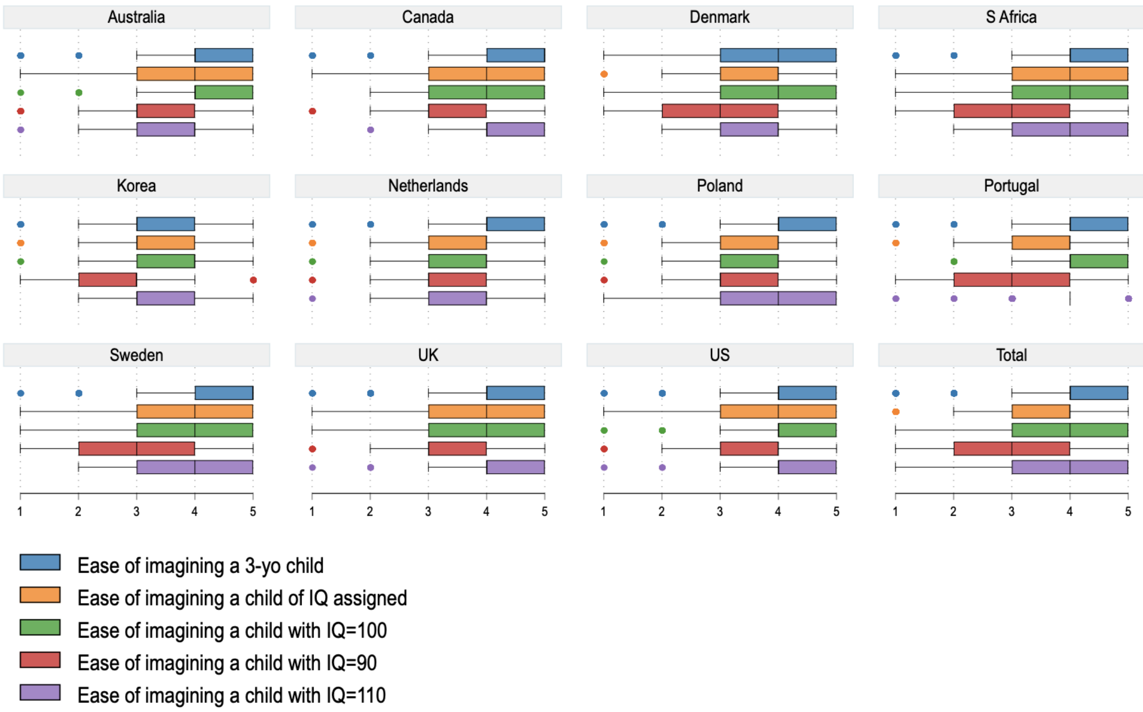


Note: The figure shows boxplots summarising participants' answers by country. The box shows the interquartile range, the vertical bars show the minimum (1 in all questions), maximum (5 in all questions), and the dots show outliers.

Overall, participants found it easy to imagine having a 3-year old child (average of 4 out of 5 overall) and perceived their understanding of IQ to improve after the survey (from an average understanding of 3.5 out of 5 to an average of 3.9 out of 5 (see Table C.4 and Figure 3.2). However, the ease of imagining a child with below-average IQ was slightly lower than the ease of imagining a child of average of above-average intelligence, with an average of 3 out of 5 overall.

Unsurprisingly, respondents who already had children found it easier to imagine having a child of any IQ level than respondents with no children (see Figure C.1).

Figure 3.2. Ease of imagining a child for respondents who already have children



Note: The figure shows boxplots summarising participants' answers by country. The box shows the interquartile range, the vertical bars show the minimum (1 in all questions), maximum (5 in all questions), and the dots show outliers.

3.2.2. Imputed income

Respondents were asked to indicate their household's monthly income after income taxes have been paid and were presented with 10 income ranges corresponding to income deciles in their respective countries. Income deciles correspond to unequivalised income that is the total (net) household income. Unequivalised income deciles are derived by multiplying equivalised income deciles in 2019 from OECD Income (IDD) database by the number of 'equivalent adults' using data on family composition from OECD Family database.[6]

Respondents who did not indicated their range for the income deciles were presented bigger ranges corresponding to income quintiles in their respective countries. The vast majority of respondents (90%)

[6] See https://www.oecd.org/els/soc/OECD-Note-EquivalenceScales.pdf and https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Equivalised_income for more information on equivalized income. 2019 was chosen because it was the last year of available data before the covid-19 crisis.

provided information about the total income of their household. Income ranges were then converted into a single amount to facilitate the use of income data in the empirical analysis. For the smallest income range between 0 and first decile, the income equals 0.5 times the first decile. For the largest income range above the last deciles, the income is computed as equal to 1.5 times the top decile. For all the other incomes ranges, the computed income is the simple average between the two deciles. All income values were then converted in USD PPP using PPP for actual individual consumption data for 2019 from the PPPs and exchange rates OECD database.[7]

To derive missing income values from respondents who chose to not state it, country-level Ordinary Least Square (OLS) regression analyses of logged income as a function of age dummies, couple dummy, female dummy, high education dummies, number of people in the household, employment dummy, part time work dummy, and retired dummy were performed. The models were used to predict income for respondents who did not provide it.

3.2.3. Debriefing questions

The survey data indicates that the survey scenario was well-understood and that participants believed the survey to be consequential and the payment mechanism to be credible. Figure C.3 shows the different motivations of respondents for paying or not paying by country. For instance, the majority of participants who did not agree to pay the proposed bid agreed that the change in IQ proposed was too small to warrant payment, or implementing the ban was too expensive. Participants who agreed to pay the proposed bid agreed that it was worth paying to avoid even a small change in IQ. Overall, participants stated that in making their decision they valued the educational benefits that would accrue to their (hypothetical) child and only those benefits, as intended by the survey design.

Moreover, survey data shows that participants did not protest. Figure 3.3 shows that participants believed they answered the survey as they would in real life, focused on their children, stated that the information provided was enough for them to make a decision and believed the scenario presented to be credible and the survey to be consequential.

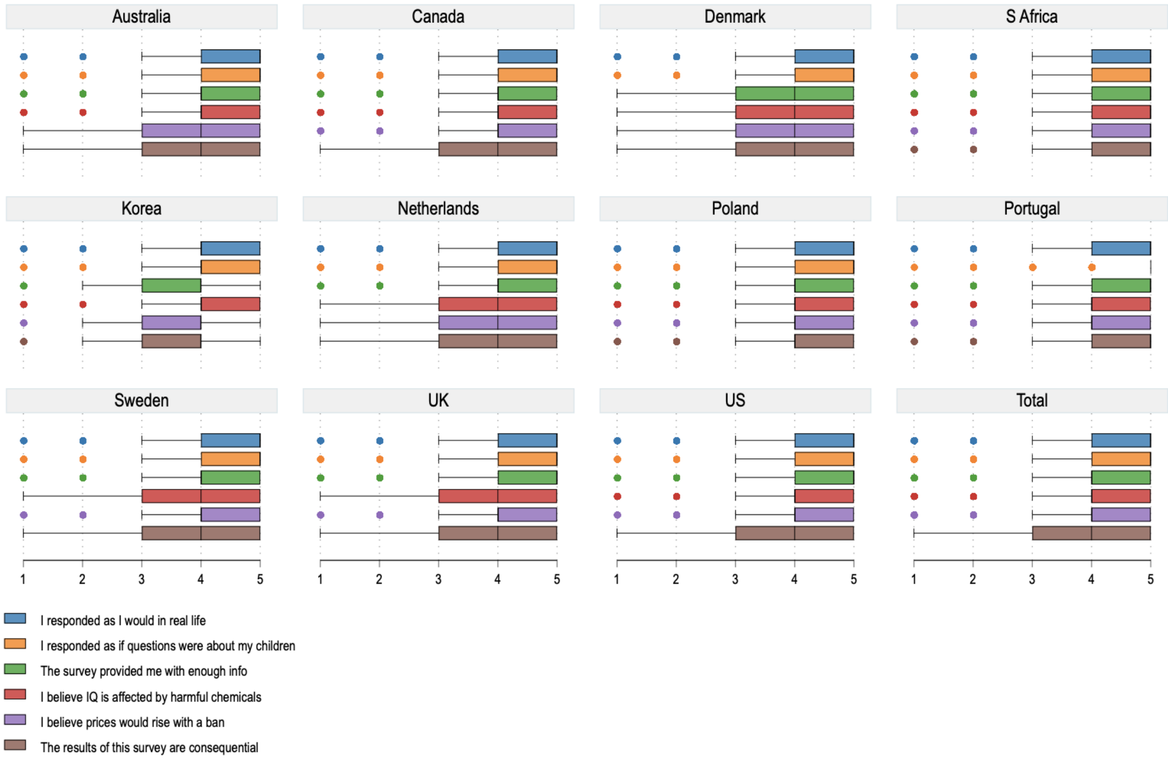
[7] The PPP data was extracted on 22 Feb 2021 08:44 UTC (GMT) from OECD.Stat, but has subsequently been revised. The exact series can be provided upon request.

Table 3.2. Target and achieved quotas for key demographics by country

	Australia	Canada	Denmark	Korea	Netherlands	Poland	Portugal	South Africa	Sweden	United Kingdom	United States
Male											
Target quota	50%	50%	50%	50%	50%	48%	47%	49%	50%	49%	49%
Achieved quota	43%	44%	53%	52%	48%	44%	49%	45%	43%	46%	45%
Female											
Target quota	50%	50%	50%	50%	50%	52%	53%	51%	50%	51%	51%
Achieved quota	57%	56%	47%	48%	52%	56%	51%	55%	57%	54%	55%
18-29											
Target quota	24%	22%	22%	20%	21%	19%	18%	33%	22%	22%	23%
Achieved quota	14%	15%	22%	20%	18%	19%	19%	34%	12%	22%	18%
30-44											
Target quota	29%	28%	25%	28%	25%	32%	28%	36%	27%	27%	27%
Achieved quota	32%	28%	25%	29%	26%	34%	33%	38%	29%	28%	29%
45-60											
Target quota	27%	28%	29%	32%	30%	25%	30%	20%	27%	29%	27%
Achieved quota	30%	30%	26%	35%	31%	27%	35%	21%	32%	30%	29%
60+											
Target quota	20%	23%	24%	19%	24%	24%	24%	11%	23%	22%	22%
Achieved quota	23%	28%	27%	16%	25%	20%	13%	7%	27%	20%	24%
Low											
Target quota	17%	8%	18%	11%	20%	7%	48%	26%	16%	20%	9%
Achieved quota	14%	4%	15%	3%	16%	3%	13%	0.3%	8%	5%	0.2%
Medium											
Target quota	36%	32%	41%	39%	39%	61%	26%	67%	40%	33%	42%
Achieved quota	29%	43%	43%	42%	42%	62%	54%	89%	54%	46%	55%
High											
Target quota	47%	59%	40%	50%	40%	32%	26%	7%	44%	47%	48%
Achieved quota	56%	54%	42%	54%	42%	35%	33%	10%	39%	49%	45%

Note: Achieved quota are computed based on the final sample excluding all speeders.
Source: Data for target quota comes from Ipsos based on official statistics.

Figure 3.3. Debriefing questions by country on credibility of the scenario proposed



Note: The figure shows boxplots summarising participants' answers by country. The box shows the interquartile range, the vertical bars show the minimum (1 in all questions), maximum (5 in all questions), and the dots show outliers.

4 Empirical strategy

4.1. Estimation strategy

A Random Utility Model (McFadden, 1974) is used in this paper to characterise individuals' preference where the indirect utility of individual i can be defined as follows:

$$v(IQ_{Bi}, y_i) + \epsilon_i$$

where IQ_{Bi} denotes the baseline level of IQ of the child or hypothetical child of individual i, y the income and $v(IQ_B, y_i)$ the indirect utility function; finally, ϵ_i denotes the random component. The WTP is modelled as the maximum monetary amount an individual is willing to spend to maintain the same utility level, considering a given reduction of income to preserve of the baseline level of IQ:

$$v(IQ_{Bi} - \Delta IQ_{Bi}, y_i - WTP_i) = v(IQ_{Bi}, y_i)$$

where ΔIQ_{Bi} indicates the change in baseline IQ for an individual i.

To estimate the WTP, a sample of the population were asked if they would pay a certain amount of money to avoid the reduction in IQ, employing a double-bounded dichotomous choice (DBDC). Respondents were presented with two questions, with levels of bids dependent on their first answer: if their first answer to the initial bid, denoted as bid_{i1}, was "no", the second bid was then decreased (bid_{i2}^L); if instead their first answer was "yes", the second bid was then increased (bid_{i2}^H). Hence, the possible answers that can be obtained from the respondents are as follow: CV_i^{YY}, CV_i^{YN}, CV_i^{NY} and CV_i^{NN} (namely yes-yes, yes-no, no-yes, and no-no, respectively). These are coded as dummy variables with 0-1 values depending on the pair of answers given by the respondent.

The probability of each of these outcomes, conditional on the bids presented, can be defined in the following way:

$$Pr\{CV_i^{YY}|bid_{i2}^H\} = Pr\{bid_{i2}^H \leq WTP_i\} = 1 - F(bid_{i2}^H, \theta)$$

$$Pr\{CV_i^{YN}|bid_{i1}, bid_{i2}^H\} = Pr\{bid_{i1} \leq WTP_i < bid_{i2}^H\} = F(bid_{i2}^H, \theta) - F(bid_{i1}, \theta)$$

$$Pr\{CV_i^{NY}|bid_{i2}^L, bid_{i1}\} = Pr\{bid_{i2}^L \leq WTP_i < bid_{i1}\} = F(bid_{i1}, \theta) - F(bid_{i2}^L, \theta)$$

$$Pr\{CV_i^{NN}|bid_{i2}^L\} = Pr\{WTP_i < bid_{i2}^L\} = F(bid_{i2}^L, \theta).$$

Where F represents the cumulative distribution of the random component, and θ the parameter of the distribution. Given the above, the log-likelihood function for a sample of n respondents can be written as:

$$\ln L(bids, \theta) = \sum_{i=1}^{n} [CV^{YY} Pr\{YesYes|bid_{i2}^H\} + CV^{YN} Pr\{YesNo|bid_{i1}, bid_{i2}^H\} + CV^{NY} Pr\{NoYes|bid_{i2}^L, bid_{i1}\} + CV^{NN} Pr\{NoNo|bid_{i2}^L\}]$$

Where $bids$ represents the vector of bids presented to the respondents. Maximizing $\ln L(b, \theta)$ permits us to estimate θ and produces the mean WTP and median WTP more efficiently than with a single bounded dichotomous choice.

4.2. Model specifications

To compute $\ln L(b,\theta)$, it is necessary to assume a distribution F for the utility error. In this report, the paper assumes a Weibull distribution as the baseline because it generally has a shorter right tail than the log-normal (Carson and Hanneman, 2005[37]). A Weibull distribution $\theta = \{k, \lambda\}$ is characterised by a shape parameter k and a scale parameter λ. All estimations assume a shape parameter equal to 1. The baseline specification of the scale parameter when $bid > 0$ is :

$$\lambda_{ic} = \alpha_0 + \beta_1 IQ110_i + \beta_2 IQ90_i + \beta_3 \Delta IQ1_i + \beta_4 \ln Cost_i + \sum_c \delta_c (d_{ic} \times \omega_i)$$

Where β and δ are the parameters of the model. The baseline group are respondent that were asked their WTP to avoid a 5 IQ points loss for their child starting with 100 IQ points. $IQ110_i$ is a dummy variable equal to 1 when respondent i was asked to imagine having a child with IQ equal to 110 (above the average), $IQ90_i$ is a dummy variable equal to 1 when respondent i was asked to imagine having a child with IQ equal to 90 (below the average), $\Delta IQ1$ is a dummy variable equal to one if respondents were asked their WTP to avoid a 1 IQ point loss for their imaginary child, $\ln Cost_i$ is the logged cost or bid proposed to respondent i, d_{ic} is a country dummy equal to 1 when respondent i lives in country c, and ω_i is the post-stratification weight of respondent i, which computation is described in Section 3.1. The inclusion of post-stratification weights, ω_i, as a control allows to take into account of potentially over or under-represented categories of respondents vis-à-vis the population targets.

In order to further assess the determinants of WTP, the model is also estimated when the scale parameter includes additional explanatory variables as follows:

$$\lambda_{ic} = \alpha_0 + \beta_1 IQ110_i + \beta_2 IQ90_i + \beta_3 \Delta IQ1_i + \beta_4 \ln Cost_i + \sum_c \delta_c (d_{ic} \times \omega_i) + \beta_5 Female_i + \beta_6 \ln y_i$$
$$+ \beta_7 Missing\ y_i + \beta_8 HighEduc_i + \beta_9 Age_i + \beta_{10} Children_i$$

$Female_i$ is a dummy variable equal to 1 when respondent i identifies as a female, $\ln y_i$ is the logged monthly income for the household of respondent i, $Missing\ y_i$ is a dummy variable that identifies whether a given respondent did not provide an answer for his/her income, $HighEduc_i$ is a dummy variable equal to 1 when respondent i achieved high education outcome, Age_i represents the age of the respondent (continuous variable), and $Children_i$ indicates the number of children under the age of 18.

The pooled model was also estimated including factors to account for health characteristics. These factors include whether respondents perceive their health as below or above the average of people of their gender and age; whether they perceive their youngest child's health as below or above the average of people of their gender and age; whether they are aware of individuals with health problems in their household; and whether they or a relative was ever diagnosed with COVID-19.

4.3. Deriving mean and median WTP based on individual WTP

The mean WTP for avoiding a 1 IQ reduction for a month is computed as a simple average of the individual mean WTP as follows:

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

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

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

f is the density function of the Weibull distribution and k denotes the shape parameter. Truncation at maximum bid level b_{max} is necessary since the right tail is not null when the cost goes to infinity. The median WTP is computed as a simple average of individual median WTP. Individual mean and median WTP are computed conducting model estimation for each country separately. Mean and median WTP are also presented considering a time frame of 5 years, since the contingent valuation scenario framed a 5-year period.

4.4. Robustness checks

Robustness checks were conducted by re-estimating the baseline model excluding potentially problematic answers, besides testing different specifications of the errors' distributions. A crucial robustness check is conducted with the removal of respondents who stated to have found difficult or very difficult to imagine having a child, as this was an essential part of the contingent valuation scenario. Furthermore, the estimates obtained from the sample of respondents who received the 1 IQ point treatment were compared to the estimates obtained for respondents who were assigned to the 5 IQ points treatment.

Additional determinants of WTP are also assessed including health-related variables, as follows: whether the respondent perceives their own health to be above average, whether the respondent perceives the health of their own youngest child to be above average, whether there were individuals with health problems in the household, whether the respondent was diagnosed with COVID-19, and whether a family or friend was diagnosed with COVID-19.

5 Results

5.1. Main results

The presentation of the results starts by showing the share of answers to the sequence of dichotomous choices, "Yes" indicating that the respondent chose the reduced risk option (Table 5.1). As expected, the share of "Yes" responses to the first bid decreases monotonically as the value of the bid increases.[8] At the same time the share of "No-No" responses increases monotonically as the value of the bid increases. This result holds for respondents facing a 5 IQ points loss and for respondents facing a 1 IQ point loss.

On average, the share of "Yes-Yes" responses (40%) and the share of "No-No" responses (31%) are large in comparison with the share of "Yes-No" responses (15%) and the share of "No-Yes" responses (14%). This indicates that the gap between the first and second bid could have been larger in order to obtain a larger amount of responses with intervals. Overall, the results indicate that the survey was successful in avoiding "yea-saying" that is that too many survey takers responded yes even if they could or did not want to spend the given amount of money to avoid the loss in IQ.

Table 5.1. Share of answers to the dichotomous choices by treatment, all countries pooled

	BID	% of Yes to first bid	% of first Yes and then No	% of first No and then Yes	% of first Yes and then Yes	% of first No and then No
Loss of 5 IQ Points	I (e.g. GBP 5)	70%	14%	10%	55%	20%
	II	63%	19%	13%	44%	24%
	III	52%	22%	15%	30%	33%
	IV	41%	17%	24%	24%	35%
	V (e.g. GBP 150)	32%	10%	16%	24%	52%
Loss of 1 IQ Point	I (e.g. 1 GBP)	74%	11%	5%	63%	21%
	II	63%	11%	11%	52%	25%
	III	56%	13%	13%	43%	31%
	IV	53%	18%	13%	35%	34%
	V (e.g. 40 GBP)	41%	15%	21%	26%	38%
	Average	54%	15%	14%	40%	31%

Note: All countries, excluding speeders. The values of the bids are described in Table 2.1.

[8] A monotonic decreases means that the share of yes at any given bid level is always lower than the share of yes at bid levels that are higher.

The share of “Yes-Yes” and “No-No” responses varies across countries (Table 5.2). The largest share of “Yes-Yes” responses is found in Korea (45.1%) and Poland (48.2%) while the lowest share is found in the UK (27.1%). The largest share of “No-No” responses is found in Australia, the United Kingdom (both 37.2%) and Canada (37%) while it is the lowest in Poland (22.1%). These differences can be attributed to differences in preferences in terms of avoiding IQ losses since respondents from all countries faced the same questionnaires with the same vector of bids in USP PPP values converted in local currencies.

Table 5.2. Share of answers to the dichotomous choices by country

Country	% of first Yes and then Yes	% of first Yes and then No	% of first No and then Yes	% of first No and then No
Australia	30.4%	14.8%	17.5%	37.2%
Canada	37.6%	12.3%	13.2%	37.0%
Denmark	39.2%	16.6%	14.1%	30.1%
Korea	45.1%	14.5%	10.0%	30.4%
Netherlands	41.9%	13.5%	13.6%	31.1%
Poland	48.2%	16.2%	13.4%	22.1%
Portugal	36.6%	18.0%	15.7%	29.7%
Sweden	35.4%	17.9%	22.4%	24.3%
South Africa	29.3%	17.7%	20.1%	32.9%
United Kingdom	27.1%	17.6%	18.1%	37.2%
United States	40.3%	12.0%	13.7%	33.9%

Results from the estimation of the model where samples from all countries are pooled together are presented in Table 5.3. Column (1) present the baseline estimation, column (2) is similar to the baseline but does not use the post-stratification weight. Column (3)-(5) assumes statistical distributions of the error term that are different from the Weibull estimation used in the baseline. Column (6) is similar to the baseline but excludes people having difficulties to imagine having a child. Column (7) is similar to the baseline but excludes people who actually have children in real life. Finally column (8) assumes a spike at zero that is the model capture the possibility that some people are indifferent to the valued good.

In all estimations, the bid level has a statistically significant negative impact of the probability to choose to pay to avoid IQ losses as expected. In all columns, people who were asked their WTP to avoid 1 IQ point loss were willing to pay more per IQ point than people who were asked their WTP to avoid a 5 IQ point loss. The split sample strategy randomly and equally attributed the treatment groups to respondents. Consequently, respondents share very similar characteristics across treatment groups as shown by Table C.7. Thus, the difference of WTP per IQ point found between a 5 IQ points loss and a 1 IQ point loss is likely due to respondents taking into account their budget constraint or having a decreasing marginal WTP per IQ point loss avoided. Logically, paying to avoid a loss of 5 IQ points is putting more pressure on budget than paying to avoid a loss of 1 IQ point.

In all estimated models, people who were asked to imagine having a child with baseline IQ above average at 110 are willing to pay less on average to avoid IQ losses than people asked to imagine having a child with an average IQ equal to 100. Conversely, people who were asked to imagine having a child with baseline IQ below average at 90 are willing to pay more on average. This latter effect is larger in magnitude than the effect found for parents asked to imagine a child with a 110 IQ except in column 6 where respondents having difficulties to imagine having a child are excluded from the sample. The fact that people value a loss in % of total IQ more is not surprising given the larger negative impacts on education achievement of an IQ loss from lower baseline IQ as described in the survey questionnaire and in Annex B.

The baseline estimation provides a mean WTP to avoid 1 IQ loss equal to USD PPP 50.76 per month or USD PPP 609 per year, and a median equal to USD PPP 12.47 per month or USD PPP 150 per year (Table 5.3). When post stratification weights to correct the difference between target and achieved quotas are not used, the mean and median WTP values obtained are highly similar to the baseline estimation (see column 2). The statistical distribution assumed for the error term has significant impact on mean and median WTP (see column 3-5). Assuming a logistic distribution yields a mean WTP equal to USD PPP 26.77 per month while assuming a log-logistic and log-normal provides a mean WTP around USD PPP 76 per month. Nevertheless, the baseline estimation assuming a Weibull distribution is performing better according to the Akaike information criterion (AIC) that measures the amount of information lost by a given model. When respondents having difficulties to imagine having a child are excluded from the sample the mean and median WTP value obtained are still greatly similar to the baseline values (see column 6). Excluding people who actually have children in real life from the sample (36% of the respondents) yields highly similar coefficients but a mean WTP that is 11% smaller than the baseline (see column 7). Finally, allowing for a spike of zero has very little impact on the estimated mean and median WTP (see column 3 and 8).

Table 5.4 shows the main determinants of WTP to avoid IQ loss in children that are presented here by decreasing order of magnitude. Respondents who were asked their WTP to avoid 1 IQ point loss are willing to pay USD[9] 35.5 per month more per IQ point than people who were asked their WTP to avoid a 5 IQ point loss. Respondents who achieved high education outcome are willing to pay USD 31.1 per month more than others, which is not surprising given that high IQ contributes to higher education outcomes. Respondents who stated that their health was above average are willing to pay USD 21 per month more on average. This likely signals that health is important for these persons. In contrast, people who indicated the existence of health problems among household members are willing to pay only USD 5.7 per month more.

People self-identifying as female are willing to pay USD 20.8 per month less per IQ point on average, conditional on income and other determinants. This statistically significant result is also found for WTP to reduce adult asthma severity, WTP to reduce the risk of infertility and WTP to reduce the risk of very low birth weight as reported in the other SWACHE working papers.[10] One potential explanation, that is not empirically tested here, is that women pay more attention to the language used in the survey to prevent yea-saying.

[9] In Purchasing Power Parities.

[10] The only exception is the WTP to reduce the risk of chronic kidney disease where female are willing to pay less on average but the effect is not statistically different from zero.

Table 5.3. Main parametric estimations of WTP to avoid IQ loss

	Baseline	Without weights	Logistic	Log-logistic	Log-normal	Excluding those who found difficult to imagine having a child	Excluding respondents who have a child in real life	Spike[a]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Preventing IQ loss from IQ = 110	-0.092**	-0.093**	-0.085+	-0.151**	-0.097***	-0.113***	-0.103**	-0.114**
	(0.031)	(0.031)	(0.045)	(0.047)	(0.028)	(0.034)	(0.038)	(0.044)
Preventing IQ loss from IQ = 90	0.117***	0.118***	0.150***	0.166***	0.103***	0.104**	0.141***	0.150***
	(0.031)	(0.031)	(0.045)	(0.046)	(0.028)	(0.034)	(0.039)	(0.044)
1 IQ point loss	0.327***	0.326***	0.467***	0.379***	0.230***	0.322***	0.326***	0.420***
	(0.032)	(0.032)	(0.047)	(0.047)	(0.029)	(0.035)	(0.040)	(0.047)
Bid (cost)	-0.482***b	-0.006*** b	-0.043***	-0.667*** b	-0.396*** b	-0.496*** b	-0.480*** b	-0.057***
	(0.006)	(0.006)	(0.001)	(0.009)	(0.005)	(0.007)	(0.008)	(0.001)
Observations	12 966	12 966	12 966	12 966	12 966	11 133	8 335	12 966
Spike	No	No	No	No	No	No	No	Yes
Weight x country dummies	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Log-likelihood	-16 589	-16 595	-18 935	-16 701	-16 754	-14 273	-10 572	-23 579
LR statistics	458	445	334	342	341	417	348	330
AIC	33 210	33 220	37 902	33 434	33 540	28 578	21 177	47 190
Mean WTP (USD PPP per month) to avoid a 1 IQ point loss	50.76	50.78	26.77	77.6	74.30	51.47	45.33	24.20
Median WTP (USD PPP per month) to avoid a 1 IQ point loss	12.47	12.4	17.56	11.262	10.82	13.475	10.87	18.79
Mean WTP (USD PPP for 5 years) to avoid a 1 IQ point loss	3 046	3 047	1 606	4 656	4 458	3 088	2 720	1 452
Median WTP (USD PPP for 5 years) to avoid a 1 IQ point loss	748	744	1 054	676	649	809	652	1 127

Note: The baseline estimation corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution without a spike configuration. All columns exclude survey and valuation speeders. Coefficients for country x weights are not reported for clarity. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '+' 0.1. ° integral truncated at maximum bid level with adjustments. WTP is expressed in USD PPP per IQ point. [a]Assuming a logistic distribution since the algorithm does not converge when assuming a Weibull distribution. The spike coefficient is equal to 0.257***. [b]Logarithm of the bid variable considered in this model.

Consistent with the baseline model, people asked to imagine having a child with baseline IQ below average at 90 are willing to pay USD 11.5 per month more than people asked to imagine having a child with average IQ (100) and USD 18.4 per month more than people asked to imagine having a child with average IQ (110).

Like in all SWACHE surveys, income has a statistically significant but small effect on WTP. A USD 500 increase in monthly income leads a modest USD 3.3 per month in the WTP to avoid the loss of 1 IQ point. People who did not want to disclose their income tend to state a WTP that is USD 24.6 per month lower than people who disclosed their income.

Table 5.4. The determinants of WTP to avoid IQ loss due to exposure to chemicals

	Baseline	With controls	With health controls	
	Odd ratios	Odd ratios	Odd ratios	Marginal effects (USD PPP per month)
Preventing IQ loss from IQ = 110	-0.092**	-0.092***	-0.094***	-6.9
	(0.031)	(0.031)	(0.031)	
Preventing IQ loss from IQ = 90	0.117***	0.130***	0.133***	+11.5
	(0.031)	(0.031)	(0.032)	
1 IQ point loss	0.327***	0.345***	0.350***	+35.5
	(0.032)	(0.032)	(0.032)	
Female (0/1)		-0.237***	-0.226***	-20.8
		(0.024)	(0.024)	
Log(Income)		0.254***	0.233***	+3.3[a]
		(0.016)	(0.016)	
Non disclosed income (0/1)		-0.329***	-0.323***	-24.6
		(0.036)	(0.036)	
High education (0/1)		0.343***	0.332***	+31.1
		(0.025)	(0.025)	
Age		-0.004***	-0.003***	-2.9[b]
		(0.001)	(0.001)	
Number of children under 18		0.048***	0.042***	+4.0[c]
		(0.013)	(0.013)	
Health perceived above average (0/1) (self)			0.224***	+21.0
			(0.024)	
Health problems among household members (0/1)			0.060*	+5.7
			(0.028)	
Was diagnosed with COVID-19 (0/1)			0.041	+3.8
			(0.026)	
Relative was diagnosed with COVID-19 (0/1)			0.076**	+7.0
			(0.023)	
Log(Cost)	-0.482***	-0.498***	-0.500***	
	(0.006)	(0.006)	(0.006)	
Observations	12 966	12 966	12 966	
Spike	No	No	No	
Weight x country dummies	Yes	Yes	Yes	
Log-likelihood	-16 589	-16 166	-16 115	
LR statistics	458	1 303	1 405	
AIC	33 210	32 376	32 282	
Mean WTP (USD PPP per month) to avoid a 1 IQ point loss	50.76	55.31	55.93	
Median WTP (USD PPP per month) to avoid a 1 IQ point loss	12.47	15.63	16.09	
Mean WTP (USD PPP for 5 years) to avoid a 1 IQ point loss	3 046	3 319	3 356	
Median WTP (USD PPP for 5 years) to avoid a 1 IQ point loss	748	938	965	

Note: The baseline estimation corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution without a spike configuration. All columns exclude survey speeders. Coefficients for country x weights are not reported for clarity. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '+' 0.1. ° integral truncated at maximum bid level with adjustments. WTP is expressed in USD PPP per IQ point. [a]This marginal effect corresponds to an increase in income by USD PPP 500 per month. The elasticity that is the % of increase in WTP when income increases by 1% is equal to 0.4%. [b]This marginal effect corresponds to a ten years increase in age. [c]This marginal effect corresponds to an increase of one child.

While being ever diagnosed with COVID-19 does not have a statistically significant effect on WTP to avoid IQ loss, having a diagnosed relative is positively associated with WTP (+ USD 7 per month). Other things equal, the older respondents are willing to pay less to avoid IQ losses in children. WTP decreases by USD 2.9 per month for an increase of 10 years of age. While the effect is economically small, it is not astonishing as the willingness and capacity to imagine or have children tend to diminish over time. Consistently, the income elasticity is also small and equals 0.4%.[11]

5.2. Country-level estimates

Mean and median WTP to avoid a 1 IQ point loss are provided for each country in Table 5.5. There is substantial variation in WTP values across surveyed countries. Mean WTP ranges from USD PPP 327 per year in the United Kingdom to USD PPP 935 per year in Poland. Median WTP values ranges from USD PPP 74 per year in in the United Kingdom to USD PPP 246 per year in Poland. Figure C.4 shows that mean and median are highly correlated.

Table 5.5. Country-level WTP to avoid IQ loss derived from pooled baseline model

	Mean WTP per IQ point		Median WTP per IQ point	
	USD PPP per month	USD PPP per year	USD PPP per month	USD PPP per year
Australia	31.47	378	7.16	86
Canada	76.51	918	20.20	242
Denmark	45.43	545	10.75	129
Korea	64.29	771	16.15	194
Netherlands	55.20	662	13.47	162
Poland	77.91	935	20.50	246
Portugal	42.79	513	10.05	121
South Africa	34.38	413	7.88	95
Sweden	47.39	569	11.31	136
United Kingdom	27.25	327	6.13	74
United States	54.93	659	13.40	161

Note: The baseline estimation reported in detail in column 1 of Table 5.3 corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution without a spike configuration chosen based on goodness of fit. All columns exclude survey speeders. ° integral truncated at maximum bid level with adjustments.

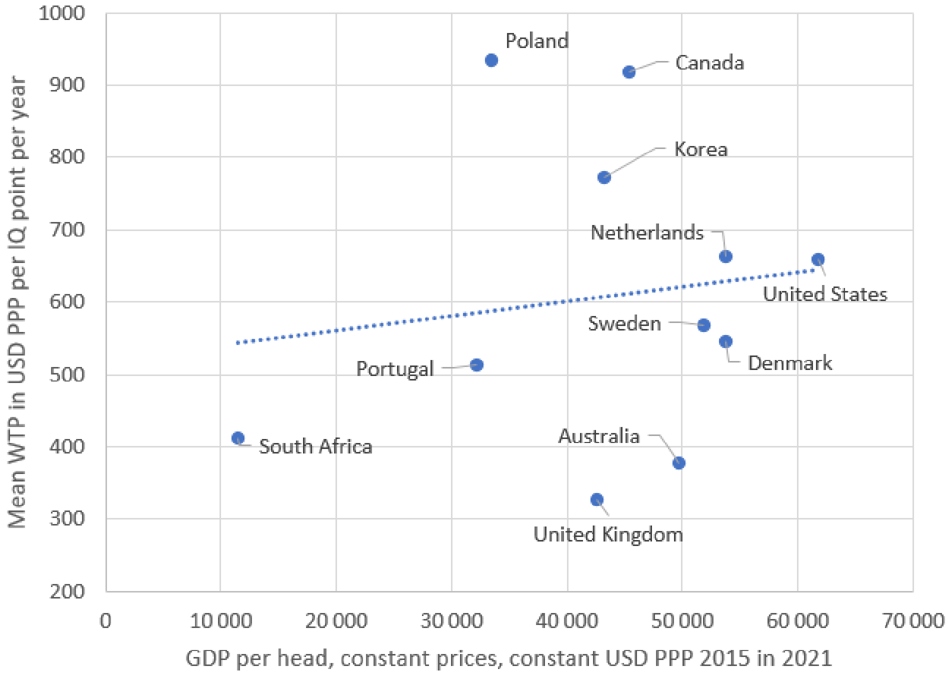
Figure 5.1 shows that real GDP per capita is correlated positively to WTP to avoid IQ loss. Nevertheless, difference in real GDP per capita is explaining very little of the cross-country difference in WTP to avoid IQ loss. This finding, similar in the SWACHE surveys eliciting WTP for asthma severity and chronic kidney disease, suggests that GDP per capita alone should not be the only determinant to consider when performing benefit transfer between countries. However, GDP per capita growth remains relevant for benefit transfer over time between countries thou its effect will not be large as the income elasticity estimated equals 0.4.

Other country-level characteristics might play a more important role in explaining cross-country differences in WTP. For example, Figure 5.2 shows that WTP to avoid IQ loss is negatively correlated with the share of government expenditure dedicated to education. One interpretation could be that in countries where

[11] When income increases by 1%, WTP to avoid the loss of 1 IQ point increases by 0.4%.

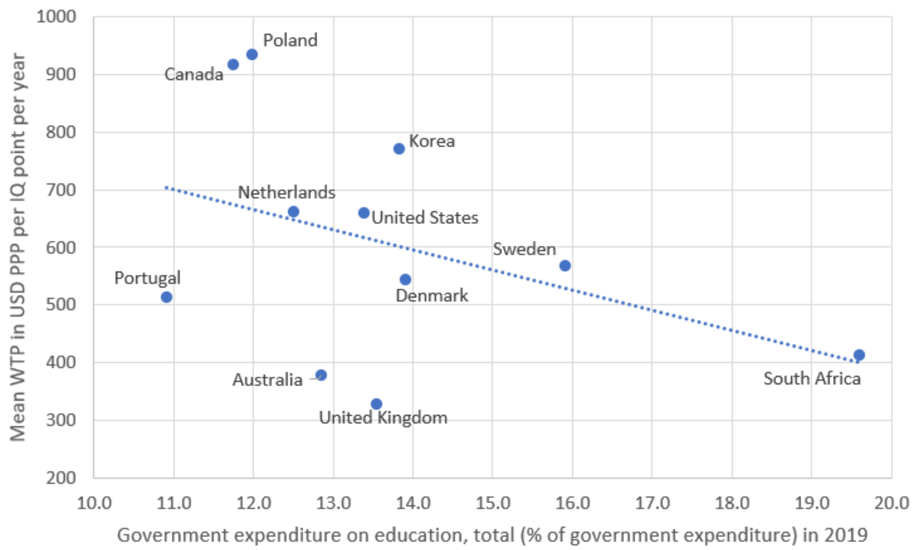
there is a large amount of public resources allocated to education, the IQ loss might be perceived as less problematic in terms of education outcomes.

Figure 5.1. Mean WTP and real GDP per capita



Note: Mean WTP values come from Table 5.5.
Source: Data on GDP per capita comes from OECD.Stat Annual national accounts based on the expenditure approach.

Figure 5.2. Mean WTP and government expenditure on education



Note: Mean WTP values come from Table 5.5.
Source: Data on government expenditure on education as share of total government expenditure comes from UNESCO Institute for Statistics (UIS). UIS. Stat Bulk Data Download Service. Accessed 24 October 2022. https://apiportal.uis.unesco.org/bdds.

5.3. Additional robustness checks

The baseline model is estimated iteratively removing potentially problematic respondents based on debriefing questions included in the survey questionnaire that help detecting potential protest responses and consequentiality issues. These results are presented in Table 5.6. Column 1 excludes respondents who disagree that they responded as in real life (4.6% of the sample). Column 2 excludes respondents who disagree that they responded as if the questions had been about their actual children (4.5% of the sample). Column 3 excludes respondents who disagree that the survey provided them with enough information to make informed choices (5.8% of the sample). Column 4 excludes respondents who disagree that children's IQ can be affected by harmful chemicals (5.7% of the sample). Column 5 excludes respondents who disagree that consumer prices would rise if a ban on harmful chemicals that reduce IQ is implemented (6.2% of the sample). Column 6 excludes respondents who disagree that results of this survey may inform the decision on the ban of harmful chemicals that cause IQ reductions in children (5.6% of the sample). Finally, column 7 excludes people who disagree with all of these aspects (18.4% of the sample).

In all columns, the estimated coefficients are highly similar to the baseline estimates reported in column 1 of Table 5.3. Likewise, mean WTP values range from USD PPP 49.6 per month per IQ point to USD PPP 51 per month per IQ point, very close to the baseline value of USD PPP 50.76 per month per IQ point. Similarly, median WTP values range from USD PPP 12.44 per month per IQ point to USD PPP 14.32 per month per IQ point, very close to the baseline value of USD PPP 12.47 per month per IQ point.

Table 5.6. Estimations of WTP to avoid IQ loss removing potentially problematic responses

	Responded to the survey as I would have done in real life	I responded as if the questions had been about my actual children	The survey provided me with enough information	Children's IQ can be affected by harmful chemicals	Consumer prices would rise if a ban is implemented	The results of this survey may inform the decision on the ban	Combined exclusions (1) to (6)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Preventing IQ loss from IQ = 110	-0.104**	-0.100**	-0.085**	-0.090**	-0.072*	-0.085**	-0.078***
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.035)
Preventing IQ loss from IQ = 90	0.108***	0.116***	0.120***	0.120***	0.128***	0.131***	0.122***
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.035)
1 IQ point loss	0.323***	0.332***	0.338***	0.342***	0.349***	0.353***	0.368***
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.036)
Log(Bid)	-0.488***	-0.488***	-0.486***	-0.496***	-0.494***	-0.493***	-0.514***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
Observations	12 376	12 384	12 216	12 228	12 166	12 240	10 579
% of observations dropped	4.6%	4.5%	5.8%	5.7%	6.2%	5.6%	18.4%
Spike	No	No	No	No	No	No	No
Weight x country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log-likelihood	-15 829	-15 806	-15 624	-15 665	-15 557	-15 682	-13 522
LR statistics	451	453	446	455	453	478	438
AIC	31 690	31 644	31 279	31 361	31 147	31 396	27 077
WTP to avoid 1 IQ point loss							
Mean (USD PPP per month)	49.60	50.34	51	50.83	50.05	50.93	50.74
Median (USD PPP per month)	12.44	12.70	12.92	13.28	12.95	13.16	14.32
Mean (USD PPP for 5 years)	2 976	3 020	3 060	3 050	3 003	3 056	3 044
Median (USD PPP for 5 years)	746	762	775	797	777	790	859

Note: In each column, respondents who disagree and strongly disagree to the statement were removed from the estimation sample. The baseline estimation corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution without a spike configuration. All columns exclude survey and valuation speeders. Coefficients for country x weights are not reported for clarity. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '+' 0.1. ° integral truncated at maximum bid level with adjustments. WTP is expressed in USD PPP per IQ point.

6 Recommended values policy analysis

6.1. Baseline estimate of the WTP value to avoid IQ loss

After some consideration, the baseline model reported in Table 5.3 was identified as the preferred model. This baseline specification corresponds to a maximum likelihood estimation of the joint probabilities assuming a Weibull distribution without a spike configuration. The estimated mean WTP to avoid the loss of 1 IQ point in a hypothetic child using the pooled data equals USD_{2022} PPP 609 per year.

Table 6.1. Recommended mean WTP values to avoid a loss of 1 IQ point in children by country

	Mean WTP per IQ point per year		Mean WTP per IQ point (total over 5 years)	
	USD_{2022} PPP	Local currency	USD_{2022} PPP	Local currency
Australia	378	AUD 566	1 900	AUD 2 800
Canada	918	CAD 1 140	4 600	CAD 5 700
Denmark	545	DKK 3 980	2 700	DKK 19 900
Korea	771	KRW 686 000	3 900	KRW 3 431 000
Netherlands	662	EUR 548	3 300	EUR 2 700
Poland	935	PLN 1 590	4 700	PLN 8 000
Portugal	513	EUR 304	2 600	EUR 1 500
South Africa	413	ZAR 2 640	2 100	ZAR 13 200
Sweden	569	SEK 5 470	2 800	SEK 27 300
United Kingdom	327	GBP 245	1 600	GBP 1 200
United States	659	USD 659	3 300	USD 3 300

Note: WTP values come from the estimation reported in Table 5.5. The conversions are done using Purchasing Power Parities for actual individual consumption of 2019 since it was used to convert bid levels across countries. Data are provided by the OECD. https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm.

While the pooled values from the baseline model are interesting, the country-specific estimates reported in Table 5.5 and summarised in Table 6.1 are more useful for policy analysis.[12] Preferences for health risk reductions can be expected to vary by country in ways that cannot fully be controlled for in the pooled values. The country-specific values reflect the preferences of fairly representative sets of respondents in those countries. Consistency with the principles of cost-benefit analysis requires that benefits be valued

[12] Recommended median WTP values by country in USD_{2022} PPP and in local currencies are provided in Table C.8.

as those who are affected would value them, and the country-specific estimates are the best reflection of preferences in each country.

6.2. Comparison with previous revealed and stated preference studies

It is worth comparing the results of the present analysis with previous revealed preferences studies and previous stated preferences studies adjusting for GDP per capita growth and inflation. The comparison is done for the United States, for which previous studies are available. Table C.9 shows that the US WTP value estimated in the present study equal to 3 296 per IQ point is lower than values estimated by the US EPA (2020[16]) USD2022 PPP 7 233 – 28 515 per IQ point and lower than the values estimated by Lin, Lutter and Ruhm (2018[26]) that are both based on lost earnings. The US WTP value estimated in the present study is of the same order of magnitude as the values reported by Lutter (2000[23]).[13] However, the US WTP value reported in this study is 3 times larger than the value reported in Von Stackelberg and Hammitt (2009[31]), the only SP study that could be identified. This difference could be due to several factors including differences in survey design, the focus on a specific chemicals in Von Stackelberg and Hammitt (2009[31]), the three times larger number of respondents in the present study and the structural shift in preferences that might have occurred between 2009 and 2022.[14]

6.3. Strengths and weaknesses of results

This study provides useful and internationally validated estimates of the WTP to avoid IQ loss for several 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. In all models, 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. Unsurprisingly, baseline IQ has an effect on WTP. People who imagine having a child with lower IQ as a starting point are willing to pay more to avoid IQ loss because the impacts in terms of educational outcome is larger. Respondents who were asked about avoiding a 5 IQ points loss are willing to pay less per IQ point avoided than respondents asked to value a 1 IQ point loss, providing some evidence that respondents took into account their budget constraint when taking the survey. Other statistically and economically significant determinants of WTP include gender, education achievement, income and perceived health.

Although the samples come close to the target quotas on gender and age for each country, low-education and low-income respondents tend to be underrepresented in all countries. This is especially true for South Africa, Korea and Poland regarding income and for Portugal, South Africa and the United Kingdom regarding low education. Additionally, most countries have a slight underrepresentation of male individuals. However, using post-stratification weights as additional regressors allow to control for these deviations from the population.

Adopting a certainty approach in relation to the effects of chemicals on young children's IQ can be considered a limitation of this study that is not considering different risks associated with the effect of chemicals on IQ. Furthermore, the study focuses on the impacts of IQ losses on educational outcomes of a respondent's own hypothetical child, that is a private good setting. As such it might understate the true

[13] It is important to note that Lutter (2000[23]) is not a peer-reviewed paper and relies on WTP for chelation therapy which has been later found to have no effect on IQ in lead-poisoned children (Rogan et al., 2001[25]; Dietrich et al., 2004[26]).

[14] People are likely more aware of the effect of chemicals exposure in 2022 than they were in 2009.

WTP to avoid IQ losses in society. By focusing on private benefits, the study avoids having to scale the participants' WTP and possible double-counting when considering the benefits created by banning chemicals for society at large; but conversely, the study cannot account for all the plausible benefits of avoiding IQ losses in society such as avoiding increases in crime which might also be linked to lower IQ levels. As such, the estimates presented in this paper should be considered as lower-bound estimates of the WTP to avoid IQ losses in society. Further research could explore potential differences in valuations within a public good setting.

While the study significantly expands the number of WTP estimates for IQ loss available for policy analysis, many countries are, of course, excluded. Countries without their own country-specific values will need to conduct benefit transfer using best practices.[15] 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 education systems.

6.4. Using the WTP value to avoid IQ loss in cost benefit analysis

WTP values to avoid IQ loss can be used in cost benefit analysis. Suppose a risk management option or a policy reduce leads to a quantified number of IQ points lost in a given population. The discounted benefits should be computed as follows:

$$Discounted\ benefits_c = \sum_{t=0}^{T} \frac{1}{(1+k_c)^t} (\overline{WTP}_{ct} \times RIQ_{ct}) \qquad (1)$$

Where $\overline{WTP}_{ct}$ is the mean 5-year WTP for avoiding the loss of one IQ point provided by Table 6.1, for example USD PPP 3 300 for the United States in 2022. RIQ_{ct} is the avoided loss of IQ points due to the policy intervention in country c in year t , k_c is the discount rate used in country c and T is the length of the policy intervention under appraisal.

$\overline{WTP}_{ct}$ is based on the recommended values $\overline{WTP}_{c2022}$ reported in USD PPP in Table 6.1 and should reflect increase in prices and in GDP per capita over time such that:

$$\overline{WTP}_{ct} = \overline{WTP}_{c2022} \times PPP_{c,2019} \times \left(1 + \%\Delta P_{c,2022-t}\right) \times \left(1 + \%\Delta Y_{c,2022-t}\right)^{\beta} \qquad (2)$$

Where $PPP_{c,2019}$ is Purchasing Power Parities for actual individual consumption in national currency per USD for the 2019 that was used to convert bid levels in the survey, $\%\Delta P_{c,2022-t}$ is the increase in consumer price index from 2022 to year t, $\%\Delta Y_{c,2022-t}$ is GDP per capita growth from 2022 to year t and β is the income elasticity. An illustrative example is provided in Table 6.2 for a fictional policy that decreases the number of IQ points lost by 80 to 12 600 between 2022 and 2027 in the United States and in Denmark. For simplicity, it is assumed in Table 6.2 that all of the IQ benefits are delivered in 2027 so that discounted benefits are computed as follows when WTP is adjusted for GDP per capita growth and inflation:

$$Discounted\ benefits_c = \frac{\overline{WTP}_{c2027} \times RIQ_{c2027}}{(1+k_c)^5} \qquad (3)$$

For example, if this fictional policy avoids the loss of 6 000 IQ points between 2022 and 2027, this represents a discounted benefit of nearly USD2022 PPP 21 million in the United States assuming a 3%

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

discount rate[16] and a discounted benefit of about DKK$_{2022}$ PPP 147 million assuming a 4% discount rate.[17] Discounted costs of the policy must be subtracted from these discounted benefits in order to obtain the net present value of the policy.

Table 6.2. Measuring the benefits of policy intervention in the United States and in Denmark: an illustrative example using the mean WTP to avoid a loss of 1 IQ point

	United States		Denmark	
Currency	Thousand USD PPP	Thousand USD PPP	Thousand USD PPP	Thousand DKK PPP[a]
Discount rate	7%	3%	4%	4%
Estimated avoided IQ point loss from 2022 to 2027	Discounted benefits non adjusted for GDP per capita growth and inflation			
80	188	227	217	1 582
1 600	3 760	4 549	4 335	31 638
6 000	14 100	17 059	16 254	118 643
12 600	29 610	35 824	34 134	249 151
	Discounted benefits adjusted for GDP per capita growth and inflation[b]			
80	229	277	269	1 961
1 600	4 586	5 548	5 373	39 217
6 000	17 197	20 805	20 148	147 062
12 600	36 113	43 691	42 311	308 831

Note: Discounted benefits are computed following equation (3) and WTP values for the total over 5 years reported in Table 6.1. [a] The conversions are done using Purchasing Power Parities for actual individual consumption of 2019 since it was used to convert bid levels across countries. Data are provided by the OECD. https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm. [b] WTP values are adjusted using equation (2). GDP per capita projections for 2022-2024 are provided by the OECD Economic Outlook (2022[38]). Between 2024 and 2027, it is assumed that GDP per capita grows by 1% every year, which is not an OECD forecast. Consumer price index are assumed to increase by 5% every year between 2022 and 2027, which is not an OECD forecast. [c]The discount rate for Denmark comes from the guidelines of the Danish Energy Agency and is based on a net present value analysis of the economic costs and benefits over a period of 20 years. The discount rates for the United States are the one that are usually used in guidelines. The income elasticity equals 0.4 as estimated in this paper.

[16] Alternatively, if the 6 000 IQ points are avoided evenly across the 5 years, the discounted benefit of this fictional policy in the United States would be equal to USD$_{2022}$ PPP 20 million as illustrated in Table C.10.

[17] These values assumes that GDP per capita and inflation will grow over time as described in details in Table 6.2.

7 Conclusion

A large body of literature links exposure to chemicals to IQ loss in children affecting their lifetime outcome. To inform decision-making regarding options that seek either to limit, or permit, certain chemicals and manage their exposures requires a range of policy evidence including estimates of the monetary value of benefits such as avoidance of IQ losses associated with changes in such chemicals exposure. In turn, for the purposes of consistency with (standard) cost-benefit analysis, it is important that these monetary values have correspondence to the willingness to pay of people for these changes, specifically reflecting the value of reducing IQ losses from exposure to chemicals in young children that incorporates a range of benefits associated with wellbeing. The impact on educational attainment is a critical element of these benefits and, as such, it has been the focus of this study.

The current study is a cross-country assessment of WTP, using the contingent valuation method, for reducing IQ losses in children from exposure to chemicals based on its likely impacts on educational attainment. The survey was implemented in eleven countries. In each of these countries, a sample of at least 1 200 respondents who are representative of the general population was collected and analysed empirically.

Results indicate that presence of a significant WTP to avoid IQ loss in all countries considered, averaging a total of USD_{2022} PPP 609 per IQ point per year (USD_{2022} PPP 3 046 in total over 5 years without including discount factor), with some heterogeneity across countries. Mean WTP to avoid the loss of 1 IQ point ranges from USD_{2022} PPP 327 per year (USD_{2022} PPP 1 230 in total over 5 years) in the United Kingdom to USD_{2022} PPP 935 per year (USD_{2022} PPP 8 000 in total over 5 years) in Poland.

These relatively high values stand in favour of the setting of measures to account for the negative externalities posed by certain chemicals on children's IQ. The present paper provides recommended values for IQ loss and offers guidance on how to use these values in policy analysis. Further work should offer comprehensive benefit transfer guidance to estimate what values countries that were not included in the survey should use in policy analysis.

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Annex

Annex A. GCSE equivalents

To value educational achievement the drop-out rates and results in the UK General Certificate of Secondary Education (GCSE) are used because previous literature estimates the impact of having different levels of IQ on these outcomes. Specifically Deary et al (2007) study the likelihood of obtaining 5 or more GCSEs at A*-C at different levels of IQ and Gottfredson (2004) does the same for drop out rates. They offer the probability of obtaining a given score or dropping out at an IQ level that is a standard deviation above average, average and a standard deviation below average. This section explains how the GCSE equivalents were chosen in each of the countries considered.

United Kingdom

The impact of IQ losses on the probability of receiving A*-C in 5+ GCSEs is considered. Students in the UK take their GCSEs (General Certificate of Secondary Education) at the end of their secondary school. Students must sit exams in three core subjects, English, Maths and Science. The other subjects taken at GCSE level are optional. Schools are responsible for determining the number of GCSEs their students can take, with students taking between 7 and 12 exams. Historical data (available here) shows that on average 57-60% of students achieve 5 or more GCSEs with A*-C, but there is some variation over the years and region of the UK. It is noted that the grading scale for GCSEs has recently changed. In 2017, students started sitting reformed GCSEs in English language, English Literature and Maths, graded on a 9 to 1 scale. New GCSEs in other subjects were phased in for first teaching from September 2016 to 2018 (see the government guidelines). In the past GCSE students were given marks between A* (the highest) and G (the lowest). Scores below a G were marked as U for 'ungraded'. Under the new scale grades now range from 9 (highest) to 1 (lowest). The conversion is given below:

- Grade 9 – The top mark is even higher than the old A*
- Grade 8 – Below an A* but above an A
- Grade 7 – Slightly below an A but only just
- Grade 6 – Slightly better than a B
- Grade 5 – Below a B but above a C. Also called a 'strong pass'
- Grade 4 – Equivalent of a C. Also called a 'standard pass'
- Grade 3 – Below a D but above an E

- Grade 2 – Between an E and an F
- Grade 1 – Between an F and a G
- Ungraded - The lowest mark possible. As in the old system, a U denotes a fail

To avoid confusing participants in the study after extensive piloting it was decided to include grades in the previous and better known scale. To find GCSE equivalents around the world there was a focus on results students obtain towards the end of secondary (and mandatory) education that are consequential both to students who choose to proceed with vocational training and those applying for tertiary education.

Australia

Australia's educational system is highly intricate, as the federalism of the state gives rise to multiple education paths for students. The study opted for a measure that would be considered standard by respondents from different regions, the ATAR score, a score students between the age of 16 and 20 can request to obtain and is used to assess how fit a student is for tertiary education. The ATAR score is easy to interpret as it ranges between 0 and 100 and represents the percentile for the student's achievements, e.g. ATAR=80 means being in the top 20% of the population. The main advantage in using this criterion is that it gives a percentile regardless of the subjects chosen by the student (so it's easy to compare students who took different modules) and is given at national level so local differences in the systems do not affect the score students receive. The ATAR score is used by universities to assess candidates and is a well-known measure so the study uses an ATAR score of 50% or above as equivalent to obtaining 5 GCSEs with grades A*-C.

Canada

At both the elementary level and the secondary level, the structure of the education systems in Canada varies by province or territory. For instance, in Quebec it takes eleven years to complete mandatory education, while it takes twelve years in almost all other jurisdictions. Nova Scotia is sometimes described as having a thirteen-year cycle, starting with an additional grade called "Primary." Curricula for elementary and secondary schools are also determined by the provincial or territorial education authorities. All typically include Mathematics, Arts and Languages, Science and Technology, and PE. In some provinces elementary school is followed by middle and then senior high school, whereas in others students directly progress to high school, e.g. in Quebec, six years of elementary school are followed by five years of secondary school, called Secondary I through Secondary III (Cycle I) and Secondary IV through Secondary V (Cycle II). Other provinces divide secondary education into junior and senior high school (also known as junior and senior secondary) or, in the case of Ontario, simply refer to the first eight years of education as elementary and years 9 through 12 as secondary school. In all provinces, promotion from one grade to the next and from elementary to secondary school is based on passing subjects rather than standardised exams. Instead, progression and placement are at the discretion of the individual schools. For Canada the High School Graduation Certificate/Diploma with a percentage of 60% or above (equivalent to a GPA of 2.3 or higher) is used.

Denmark

The Denmark education system starts with pre-school (one year) and nine or ten years in a basic comprehensive school (Folkeskole). This may be followed by three years at a gymnasium culminating in the Studentereksamen STX (Upper Secondary School Leaving Examination) and then tertiary education. The Folkeskole, including public special needs schools, covers the vast majority of the teaching of the students at primary and lower secondary level. Municipalities are responsible for providing public education, so the 98 Danish municipal councils themselves determine the contents of their respective school policies within the scope of the Folkeskole Act. Students take some tests in years 6-8 and "leaving exams” at the end of year 9. The following subjects are compulsory in the Folkeskole: Danish, English, Christian studies, social studies, history, physical education and sport, music, art, textile design, wood/metalwork, home economics, mathematics, science, geography, biology, and physics/chemistry. In addition, all schools must offer German and may offer French. For this reason, the study uses the Folkeskolens 10 Klasseprøve (formerly Folkeskolens Afgangsprøve) as the GCSE equivalent in Denmark. These exams are now marked on a 7-point scale (-3, 00, 02, 4, 7, 10, 12) , partially developed to simplify the compatibility between Danish and foreign grading scales. The study considers a grade of 7 or higher to be equivalent to obtaining 5 or more GCSE with A*-C.

Netherlands

After completing primary school, students move on to one of three types of secondary education: pre-vocational secondary education (VMBO), senior general secondary education (HAVO) or pre university education (VWO). Secondary education prepares students for secondary vocational education (MBO), higher professional education (HBO) or university education. In the lower years of secondary school, pupils follow a broad curriculum. Students in the upper years of HAVO and VWO choose one of four subject combinations. Pupils in the upper years of VMBO-T choose one of four sectors, while those in other VMBO programmes choose one profile from a total of 10. The school-leaving examination for secondary education consists of a school examination and a national written examination at the end of the final school year. Schools set their own exams. The Ministry of Education, Culture and Science prescribes which subjects must be taught during the exam year. The school examination dates are not established at the national level: schools are free to test students in particular subjects whenever they wish. The school exam usually comprises two or more tests per subject, which may be oral, practical or written. Subjects outside the national exam framework may be completed before the final year of school. There is one national written exam per subject for all pupils receiving the same type of education. Whether a subject is compulsory or optional, the exam questions are the same across the whole country. Marks are awarded on a scale ranging from 1 (very poor) to 10 (excellent). To avoid overwhelming participants the study considers as equivalent to GCSEs achieving a grade of 6 or higher in the Hoger Algemeen Voortgezet Onderwijs (HAVO) diploma.

Poland

Poland currently follows a 12-year system of education, consisting of 6 years of primary school, 3 years of lower secondary school and 3 years of secondary school (general or specialised). Students have 9 years in compulsory education, which comprises the last year of pre-school education and 8 years of education in primary school. The current structure will end in 2022, and move from having 3 years of secondary school (equivalent to middle school) to including these 3 years in primary school. The first cohort experiencing the new system was the 2017 one, so presenting the new version is likely to create issues in people’s understanding. The current system includes several subjects to be taught in secondary schools: Polish language, two modern foreign languages, Latin and Ancient Culture, Mathematics, History, Knowledge about Society, Geography, Biology, Physics, Chemistry, Technology, Information Technology, Safety Education, PE, Education for Family Life, Cultural Studies, Introduction to Entrepreneurship, and, only at the extended level, History of Music, History of Art, Latin and Ancient Culture, and Philosophy. Four additional subjects are also offered: History and Society, Natural Science, Arts and Economics. Students are regularly assessed by teachers throughout the school year. The school defines its own internal assessment system but the marking scale to assess students’ learning achievements is common and ranges from 6 – excellent, to 1 – unsatisfactory (fail).

As evidence suggests that the results at the end of 9 years in school (Świadectwo ukończenia) are equivalent to the HAVO in the Netherlands, and the old system is likely to be easier to understand for most adults, this was chosen to be the outcome. Specifically, the study considers achieving a grade of 3 or higher in the Świadectwo ukończenia liceum ogólnokształcącego exams as equivalent to achieving 5 or more GCSE with a score of A*-C.[18]

Portugal

The school system in Portugal is organised in three sequential levels: pre-primary education (ages 3 to 5), basic education (typical ages 6 to 14) and secondary education (typical ages 15 to 17). Basic education is organised according to three cycles (Grades 1-4; Grades 5-6 and Grades 7-9). Students are assessed based on summative and formative assessments during the school cycle, at the end of cycles and students also sit national examinations. Schools organise internal student assessments for all subjects and the Educational Evaluation Institute (Instituto de Avaliação Educativa, IAVE) carries out external student assessments for Mathematics and Portuguese. In the second and third cycles (Grades 5-6 and Grades 7-9), the emphasis on formative and internal assessment continues but summative results in Portuguese and Mathematics are reported on a scale from 1 to 5 and there are external examinations at the end of each of the cycles. Students in other courses who wish to progress to higher education have to take the national examinations required as entrance tests for the courses they want to take, the Provas Finais do 9o ano. The OECD provides statistics for students' results (OECD, 2015[39]). For this reason, and basing the grade on the OECD statistics, it is considered that the final results in those exams as equivalent to GCSEs. Specifically, the study considers an average of 12 or higher in the Provas Finais do 9o ano to be equivalent to 5 or more GCSE with scores of A*-C.

South Africa

South Africa's education system is split into three levels: elementary, secondary and tertiary. Secondary education in South Africa lasts six years (grades 7 to 12), and is divided into two phases, lower and upper secondary school. Lower secondary (also known as the "senior phase") lasts through grade 9, and is mandatory. Students typically begin lower secondary at age 12 or 13. The curriculum for lower secondary school includes the "home language" (the family's main language), an additional language, Mathematics, Natural Science, Social Science, Technology, Economic and Management Sciences, Life Orientation, and Arts and Culture. Exams are held at the end of lower secondary school. The study uses these exams, leading students to obtain the Senior Certificate as equivalent to GCSEs. Specifically, the study considers achieving A-D in the Senior Certificate exams to be equivalent to 5 or more GCSE with scores of A*-C.

Korea

Korea has a 6+3+3+4 years of education system of primary, lower secondary, upper secondary and Higher Education, with the first nine years being compulsory. A National Curriculum covers the 10 years from primary to the first year of upper secondary education. Lower secondary education (중학교, Junghakgyo) can be taken at a middle school (junior high school), and constitutes the initial years of secondary education. In lower secondary school, subjects include: Korean language, Social Studies/Moral Education, Mathematics, Science/Information Technology, PE, English, Music and the Arts, in addition to elective courses. Students also have an "Exam-Free Semester." Introduced in 2013, the semester gives students time each day to study either a non-traditional course or to design their own independent study course.

South Korea has a system of assessments known as the National Assessment of Educational Achievement (NAEA). Each year, tests in Korean, mathematics, and English are administered to all students in grades nine and 11, and tests in science and social studies are administered to a sample of students in grade nine. The test scores are not reported for each individual student. Results are instead used to provide additional support for schools as needed and to inform policy at the Ministry level. For this

[18] See Overview of diploma evaluations | Nuffic.

country the study considers the High School Diploma as the right comparison to GCSEs, with every exam passed with a rank of 5 or higher considered as equivalent to a GCSE with a grade of A*- C.

Sweden

Swedish compulsory schooling consists of four stages: förskoleklass (‘preschool year’), lågstadiet (years 1–3), mellanstadiet (years 4–6) and högstadiet (years 7–9). A new consolidated curricula for compulsory schools for all students, Sami schools, special schools and upper secondary schools came into force in 2011. The curricula contain new general goals, guide-lines and syllabuses. The pre-school curriculum includes clearer goals for children’s linguistic and communicative develop-ment and for science and technology. Mandatory national subject tests are held in years 3, 6 and 9 of compulsory school to assess student prog-ress.

Subjects studied include Arts, English, Home and Consumer Studies, Maths, Physical Education and Health, Modern Languages, Mother Tongue (not necessarily Swedish) and Sciences. The study uses Slutbetyg från Grundskola (School Leaving Certificate from compulsory education) as GCSE equivalents in this country. Specifically, achieving A-D in the Slutbetyg fran Grundskolan exams is considered to be equivalent to obtaining 5 or more GCSE with grades of A*-C.

United States

Elementary and secondary education in the United States are often collectively referred to as K-12 education, a shorthand that refers to the grades through which students progress. The “K” refers to kindergarten, typically housed in the elementary school system. Thus, K-12 education is 12 years long for most students, plus kindergarten. As part of K-12 education, an elementary school typically enrols students from kindergarten or sometimes first grade through the fifth or sixth grade. Students then move on to a lower secondary school (middle school or a junior high school). The last three to four years of school are known as high school or senior high school.

Education in the United States is highly decentralised, and various models of K-12 education exist. The typical curriculum at both the middle school and high school levels comprises English, Mathematics, Science, Social Studies, Fine Arts, and PE. Students can often select one or several electives per year in addition to the core curriculum. The of electives offered vary widely across states and schools. Some electives may be specialised offerings related to core subjects, particularly at the high school level, while others cover subjects that are not mandatory. Unfortunately, the U.S. do not mandate exams in high school, so instead of focusing on the outcome at the end of the ninth year of education the study uses as a GCSE equivalent the GPA in the High School Diploma. Specifically, achieving a GPA of 2.33 or higher/C+ is considered to be equivalent to achieving 5 or more GCSE with A*-C.

Annex B. IQ losses and educational achievements

This study bases estimates for educational achievements on Deary et al.'s (2007[40]) study. The paper estimates the probability of obtaining 5 or more GCSEs with grades A*-C in the United Kingdom at 3 different IQ levels, at the average of IQ = 100, a standard deviation below the average (IQ = 85) and a standard deviation above the average (IQ = 115).

To account for the non-linear impact of losing IQ points from different baselines the change in probability from IQ = 115 to IQ = 100 and from IQ = 100 to IQ = 85 is first computed. Then those two estimates are divided by the amount of IQ points lost (15) to obtain an estimate of the probability loss per IQ point at different points in the distribution. A 2.2% loss per IQ point from IQ = 110 to IQ = 100 and a 2.8% loss per IQ point from IQ = 100 to IQ = 85 are obtained. These are the estimates the present study uses to compute the probabilities at the initial levels of IQ considered (IQ = 110, 100, 90) and after the 5-point and 1-point losses (IQ = 105, 99, 95, 85). For instance, for IQ = 110, the present study estimates the probability of obtaining 5 or more GCSEs with grades A*-C as the difference between the probability of obtaining 5 or more GCSEs with grades A*-C at IQ = 105 (91%, given in the study) and the estimates loss in probability due to a 5-point loss at that IQ level (2.2%×5) to obtain a probability of obtaining 5 or more GCSEs with A*-C of 80%.

The present study similarly computes the estimated loss in moving from IQ = 110 to IQ = 105 by considering the initial probability minus the loss (2.2%×5), bringing the probability of obtaining 5 or more GCSEs with grades A*-C from 80% to 69%. The same strategy for IQ levels below the average IQ of 100 is adopted. For instance, to consider the estimated probability loss between IQ = 100 and IQ = 95 the difference between the initial probability of obtaining 5 or more GCSEs at A*-C (58%) and the estimated loss (2.8%×5) are considered, leading to the probability of obtaining 5 or more GCSEs at A*-C with IQ = 95 of 44%. Table B.1 summarises all the calculations used to obtain the levels that are used in the survey.

Table B.1. Probability of obtaining 5+ GCSEs with grades A*-C by IQ level and by IQ baseline

Child IQ	Probability of obtaining 5+ GCSEs with A*-C from Deary et al. (2007[40])
85	16%
100	58%
115	91%
Change in child IQ	Change in probability of obtaining 5+ GCSEs with A*-C estimated by Deary et al. (2007[40])
From IQ = 115 to IQ = 100	33%
From IQ = 100 to IQ = 85	42%
Change in child IQ	Change per IQ point
From IQ = 115 to IQ = 100	2.2%
From IQ = 100 to IQ = 85	2.8%
Child IQ	Probability of obtaining 5+ GCSEs with A*-C used in the SWACHE IQ loss survey
110	80%
105	69%
100	58%
95	44%
90	30%
85	16%
109	77.8%

For the drop-out rates the same strategy is used. The estimates provided in Gottfredson (2004[41]) are used, studying the probability of dropping out at the average IQ level (IQ = 100), a standard deviation below the average level (IQ = 85) and a standard deviation above the average (IQ = 115). The present study obtains the loss in probability per IQ point from IQ = 115 to IQ = 100 by dividing by 15 the difference in probability between the probability of dropping out at IQ = 115 (0.4%) and the probability of dropping out at IQ = 100 (6%), obtaining a value of 0.37% for a 1-point loss starting at an IQ level above average.

The present study similarly computes the increased probability of dropping out per IQ point lost starting below the average dividing by 15 the difference in probability of dropping out at IQ = 100 (6%) and IQ = 85 (35%), obtaining a value of 1.93%. These two values are used to compute the increased probability in dropping out for the 5-point losses at the baselines considered and the 1-point loss. Table B.2 summarises all the calculations used to obtain the levels used in the survey.

Table B.2. School drop-out rate by IQ level and by IQ baseline

Child IQ	Drop-out rate from Gottfredson (2004[41])
85	35%
100	6%
115	0.4%
Change in child IQ	Change in drop-out rate from Gottfredson (2004[41])
From IQ = 115 to IQ = 100	5.6%
From IQ = 100 to IQ = 85	29%
Change in child IQ	Change per IQ point
From IQ = 115 to IQ = 100	0.37%
From IQ = 100 to IQ = 85	1.93%
Child IQ	Drop-out rate used in the SWACHE IQ loss survey
110	2.27%
105	4.13%
100	6%
95	15.67%
90	25.3%
85	35%
109	2.64%

Annex C. Additional tables and figures

Table C.1. Dates of survey data collection

	Pilot		Main stage	
	Start date	End date	Start date	End date
Australia	07/04/2022	11/04/2022	27/04/2022	27/05/2022
Canada	07/04/2022	09/04/2022	27/04/2022	20/05/2022
Denmark	07/04/2022	08/04/2022	27/04/2022	22/05/2022
South Africa	07/04/2022	11/04/2022	27/04/2022	19/05/2022
Korea	07/04/2022	11/04/2022	27/04/2022	13/05/2022
Netherlands	07/04/2022	07/04/2022	27/04/2022	11/05/2022
Poland	07/04/2022	08/04/2022	05/02/2022	16/05/2022
Portugal	07/02/2022	08/02/2022	02/03/2022	17/03/2022
Sweden	05/02/2022	05/02/2022	01/03/2022	13/03/2022
United Kingdom	07/04/2022	11/04/2022	27/04/2022	16/05/2022
United States	07/04/2022	11/04/2022	27/04/2022	16/05/2022

Table C.2. Average completion time in minutes by country (before any other exclusion criteria)

	Mean	Median	Min	Max	33% of the median time
Australia	20.2	15.2	6.08	208	5.01
Canada	19.5	14.5	6.27	298	4.8
Denmark	16.2	12.4	4.65	197	4.1
Korea	17.6	12.6	4.53	214	4.14
Netherlands	16.8	13.6	6.1	192	4.48
Poland	20.1	15.3	6.75	287	5.04
Portugal	19.6	15.4	6.22	283	5.07
South Africa	25.7	20.7	7.6	288	6.83
Sweden	18.4	14.2	6.83	185	4.7
United Kingdom	15.4	11.8	5.32	237	3.9
United States	19.9	14	5.82	228	4.61

Table C.3. Summary statistics of debriefing questions

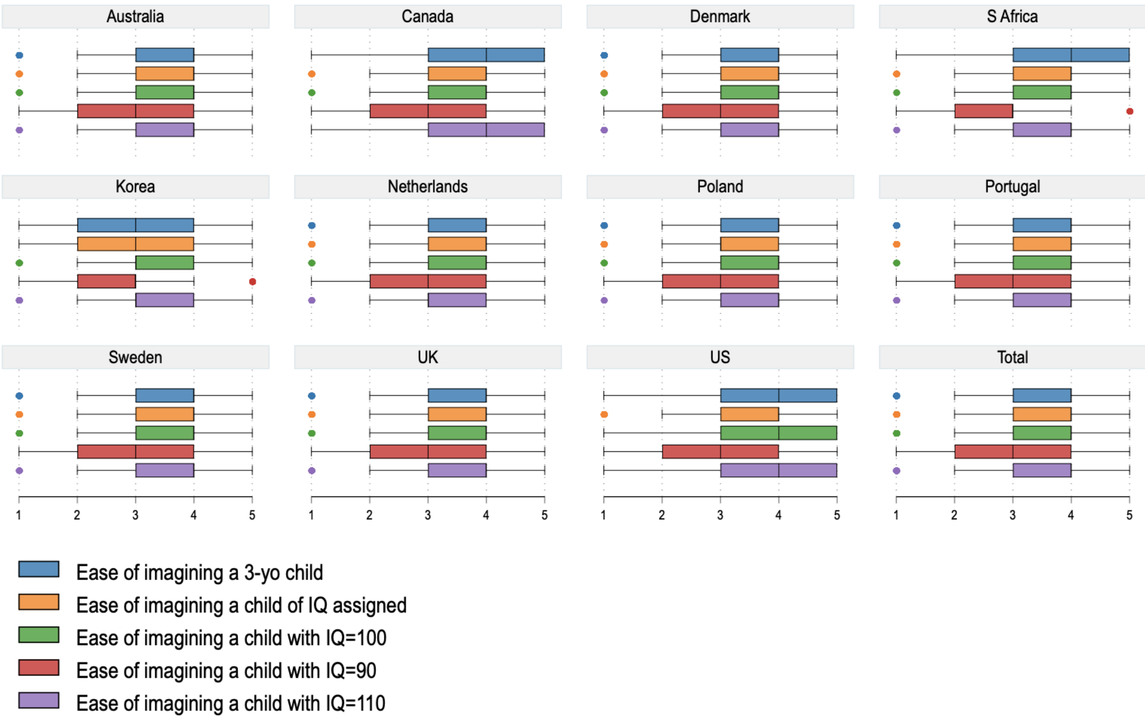
	All	Australia	Canada	Denmark	South Africa	Korea	Netherlands	Poland	Portugal	Sweden	UK	US
Initial Familiarity with IQ	3.413	3.138	3.269	3.326	3.561	3.238	3.623	3.589	3.361	3.716	3.333	3.379
	(1.173)	(1.222)	(1.22)	(1.201)	(1.158)	(0.991)	(1.183)	(1.077)	(1.076)	(1.19)	(1.202)	(1.219)
Benefits of a society with higher IQ	3.35	3.239	3.27	3	4.031	3.212	2.916	3.694	3.465	3.139	3.376	3.514
	(1.1)	(1.142)	(1.149)	(1.081)	(1.026)	(0.865)	(1.079)	(0.922)	(0.996)	(1.079)	(1.115)	(1.144)
Importance of IQ	2.961	2.756	2.923	2.577	3.783	3.139	2.543	3.258	3.028	2.515	2.87	3.202
	(1.197)	(1.239)	(1.219)	(1.185)	(1.114)	(0.918)	(1.114)	(0.996)	(1.164)	(1.118)	(1.219)	(1.237)
Own IQ estimate	2.324	2.281	2.409	2.298	2.306	2.203	2.443	2.403	2.139	2.352	2.381	2.358
	(0.536)	(0.546)	(0.531)	(0.53)	(0.522)	(0.541)	(0.533)	(0.527)	(0.431)	(0.538)	(0.56)	(0.553)
Ease of understanding IQ info	4.035	4.004	4.186	3.869	3.827	3.837	4.248	4.073	4.055	4.025	4.117	4.129
	(0.892)	(0.933)	(0.873)	(0.944)	(0.895)	(0.851)	(0.77)	(0.847)	(0.862)	(0.907)	(0.902)	(0.91)
Familiarity with IQ distribution	2.439	2.262	2.352	2.394	2.573	2.529	2.557	2.598	2.239	2.331	2.432	2.564
	(1.204)	(1.224)	(1.273)	(1.21)	(1.209)	(0.946)	(1.214)	(1.089)	(1.106)	(1.222)	(1.28)	(1.352)
Ease of imagining a 3-yo child	3.715	3.842	3.83	3.611	4.05	3.081	3.584	3.768	3.892	3.727	3.677	3.807
	(1.104)	(1.063)	(1.119)	(1.087)	(0.95)	(1.111)	(1.043)	(1.05)	(1.012)	(1.133)	(1.159)	(1.122)
Knowledge of chemicals affecting IQ	2.688	2.629	2.74	2.719	3.188	2.678	2.438	2.78	2.397	2.578	2.348	3.087
	(1.28)	(1.273)	(1.326)	(1.252)	(1.365)	(1.078)	(1.209)	(1.191)	(1.213)	(1.282)	(1.269)	(1.331)
Ease of understanding figure on IQ	3.983	3.932	4.01	3.889	4.025	3.628	4.207	4.016	4.051	3.986	4.107	3.961
	(0.945)	(0.982)	(0.979)	(0.931)	(0.93)	(1.036)	(0.819)	(0.896)	(0.827)	(0.965)	(0.931)	(0.97)
Knows that IQ impact on education	3.702	3.613	3.885	3.591	3.958	3.44	3.964	3.848	3.382	3.636	3.612	3.797
	(1.132)	(1.205)	(1.114)	(1.139)	(1.14)	(1.001)	(1.058)	(0.985)	(1.055)	(1.21)	(1.213)	(1.129)
Understanding of IQ before survey	3.515	3.506	3.531	3.557	3.49	3.083	3.769	3.66	3.209	3.583	3.578	3.703
	(0.862)	(0.923)	(0.915)	(0.819)	(0.915)	(0.746)	(0.827)	(0.768)	(0.733)	(0.887)	(0.827)	(0.851)
Understanding of IQ after survey	3.869	3.881	3.9	3.748	4.182	3.4	3.939	3.997	3.69	3.843	3.931	4.059
	(0.79)	(0.782)	(0.794)	(0.838)	(0.727)	(0.744)	(0.749)	(0.719)	(0.729)	(0.819)	(0.735)	(0.772)
Observations	12 966	1 166	1 185	1 157	1 152	1 183	1 187	1 184	1 190	1 199	1 183	1 180

Table C.4. Ease of imagining a child by baseline and country

	All	Australia	Canada	Denmark	South Africa	Korea	Netherlands	Poland	Portugal	Sweden	UK	US
Ease of imagining a child of IQ assigned	3.576	3.678	3.708	3.464	3.681	3.171	3.537	3.573	3.645	3.578	3.583	3.714
	(1.007)	(0.995)	(1.002)	(1.014)	(1.034)	(1.001)	(0.911)	(0.916)	(0.919)	(1.006)	(1.076)	(1.075)
Ease of imagining a child with IQ=100	3.762	3.894	3.919	3.619	3.897	3.413	3.753	3.65	3.874	3.756	3.752	3.863
	(0.916)	(0.867)	(0.871)	(0.936)	(0.919)	(0.95)	(0.811)	(0.863)	(0.804)	(0.951)	(0.972)	(0.989)
Ease of imagining a child with IQ=90	3.044	3.177	3.094	2.993	3.034	2.68	3.057	3.214	3.034	3.07	3.003	3.13
	(1.056)	(1.097)	(1.045)	(1.067)	(1.107)	(1.021)	(0.955)	(0.961)	(0.94)	(1.034)	(1.113)	(1.175)
Ease of imagining a child with IQ=110	3.734	3.749	3.901	3.625	3.913	3.177	3.583	3.776	3.797	3.731	3.822	3.997
	(0.942)	(0.95)	(0.955)	(0.965)	(0.888)	(0.897)	(0.88)	(0.875)	(0.839)	(0.911)	(1.029)	(0.913)
Observations	12 966	1 166	1 185	1 157	1 152	1 183	1 187	1 184	1 190	1 199	1 183	1 180

Note: Respondents are first asked about their ease of imagining a 3-year old child and then asked again how easy it would be for them to imagine having a child of the given IQ level on a scale from 1 to 5.

Figure C.1. Ease of imagining a child for respondents who do not have children



Note: The figure shows boxplots summarising participants' answers by country. The box shows the interquartile range, the vertical bars show the minimum (1 in all questions), maximum (5 in all questions), and the dots show outliers.

Table C.5. Summary statistics for key demographics by country, part 1

	Australia		Canada		Denmark		South Africa		Korea	
	No.	%	No.	%	No.	%	No.	%	No.	%
Gender										
Male	521	43.4	531	44.2	637	53.1	552	46	623	51.9
Female	673	56.1	659	54.9	561	46.8	646	53.8	570	47.5
Other	6	0.5	6	0.5	2	0.2	1	0.1	2	0.2
Prefer not to say	0	0	4	0.3	0	0	1	0.1	5	0.4
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Age Bracket										
18-26 years old	129	10.8	112	9.3	225	18.8	300	25	152	12.7
27-34 years old	151	12.6	170	14.2	148	12.3	276	23	194	16.2
35-39 years old	131	10.9	110	9.2	108	9	154	12.8	115	9.6
40-44 years old	158	13.2	127	10.6	100	8.3	132	11	134	11.2
45-59 years old	358	29.8	352	29.3	301	25.1	254	21.2	410	34.2
60-65 years old	94	7.8	159	13.2	109	9.1	48	4	123	10.2
65+ years old	179	14.9	170	14.2	209	17.4	36	3	72	6
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Education (comparable)										
Low	176	14.7	43	3.6	183	15.2	3	0.2	45	3.8
Medium	350	29.2	508	42.3	516	43	1 071	89.2	505	42.1
High	674	56.2	649	54.1	501	41.8	126	10.5	650	54.2
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Marital Status										
Married	546	45.5	573	47.8	475	39.6	409	34.1	668	55.7
Partner but not married	236	19.7	238	19.8	298	24.8	430	35.8	79	6.6
Not in a relationship	389	32.4	357	29.8	396	33	316	26.3	404	33.7
Other	29	2.4	32	2.7	31	2.6	45	3.8	49	4.1
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Has children										
No	780	65	885	73.8	851	70.9	433	36.1	834	69.5
Yes	420	35	315	26.2	349	29.1	767	63.9	366	30.5
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Area you live in										
Urban	259	21.6	562	46.8	652	54.3	457	38.1	1 004	83.7
Suburban	725	60.4	391	32.6	276	23	571	47.6	135	11.2
Rural	216	18	247	20.6	272	22.7	172	14.3	61	5.1
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Child: 3 yo or less										
No	281	66.9	193	61.3	182	52.1	421	54.9	290	79.2
Yes	139	33.1	122	38.7	167	47.9	346	45.1	76	20.8

Total	420	100	315	100	349	100	767	100	366	100
Child between 4-14 years old										
No	109	26	82	26	95	27.2	204	26.6	124	33.9
Yes	311	74	233	74	254	72.8	563	73.4	242	66.1
Total	420	100	315	100	349	100	767	100	366	100
Child between 5-18 years old										
No	262	62.4	204	64.8	200	57.3	506	66	190	51.9
Yes	158	37.6	111	35.2	149	42.7	261	34	176	48.1
Total	420	100	315	100	349	100	767	100	366	100
Child over 18 yo										
No	309	73.6	231	73.3	238	68.2	588	76.7	298	81.4
Yes	111	26.4	84	26.7	111	31.8	179	23.3	68	18.6
Total	420	100	315	100	349	100	767	100	366	100
Current employment status										
Employed full-time	435	36.2	554	46.2	487	40.6	472	39.3	602	50.2
Employed part-time	245	20.4	100	8.3	104	8.7	123	10.2	89	7.4
Self employed	65	5.4	81	6.8	50	4.2	167	13.9	136	11.3
Unemployed but looking for a job	88	7.3	53	4.4	65	5.4	202	16.8	77	6.4
Unemployed not looking/sick or disabled	66	5.5	61	5.1	67	5.6	16	1.3	36	3
Full-time parent, homemaker	94	7.8	47	3.9	20	1.7	46	3.8	121	10.1
Retired	186	15.5	259	21.6	319	26.6	55	4.6	64	5.3
Student/Pupil	21	1.8	30	2.5	86	7.2	119	9.9	75	6.2
Military	0	0	0	0	2	0.2	0	0	0	0
Prefer not to answer	0	0	15	1.2	0	0	0	0	0	0
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Household size (including you)										
1	228	19	262	21.8	324	27	65	5.4	151	12.6
2	396	33	475	39.6	439	36.6	172	14.3	246	20.5
3	239	19.9	198	16.5	217	18.1	260	21.7	344	28.7
4	218	18.2	158	13.2	158	13.2	297	24.8	358	29.8
5	78	6.5	72	6	38	3.2	198	16.5	80	6.7
6	27	2.2	21	1.8	13	1.1	99	8.2	14	1.2
7	14	1.2	14	1.2	11	0.9	109	9.1	7	0.6
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Income band in USD										
low income (1-3)	397	37	347	32.7	348	32	104	9	205	17.9
middle income (4-6)	290	27	248	23.4	247	22.7	136	11.8	250	21.8
high income (7-end)	387	36	466	43.9	491	45.2	912	79.2	690	60.3
Total	1 074	100	1 061	100	1 086	100	1 152	100	1 145	100
Can you make ends meet?										
With great difficulty	78	6.7	72	6.2	50	4.3	182	15.6	62	5.3
With difficulty	320	27.4	310	26.7	207	17.8	515	44.1	319	27.4

Rather easily	333	28.5	348	29.9	371	32	261	22.3	433	37.1
Easily	274	23.5	257	22.1	308	26.6	138	11.8	264	22.6
Very easily	163	14	175	15.1	224	19.3	72	6.2	88	7.5
Total	1 168	100	1 162	100	1 160	100	1 168	100	1 166	100
Who covers healthcare costs?										
A public health insurance scheme	406	33.8	506	42.2	584	48.7	189	15.8	497	41.4
A private health insurance scheme	155	12.9	225	18.8	152	12.7	314	26.2	106	8.8
A combination of schemes	400	33.3	377	31.4	241	20.1	161	13.4	483	40.2
I would have to cover most	239	19.9	92	7.7	223	18.6	536	44.7	114	9.5
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Free Healthcare										
No	794	66.2	694	57.8	616	51.3	1 011	84.2	703	58.6
Yes	406	33.8	506	42.2	584	48.7	189	15.8	497	41.4
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100

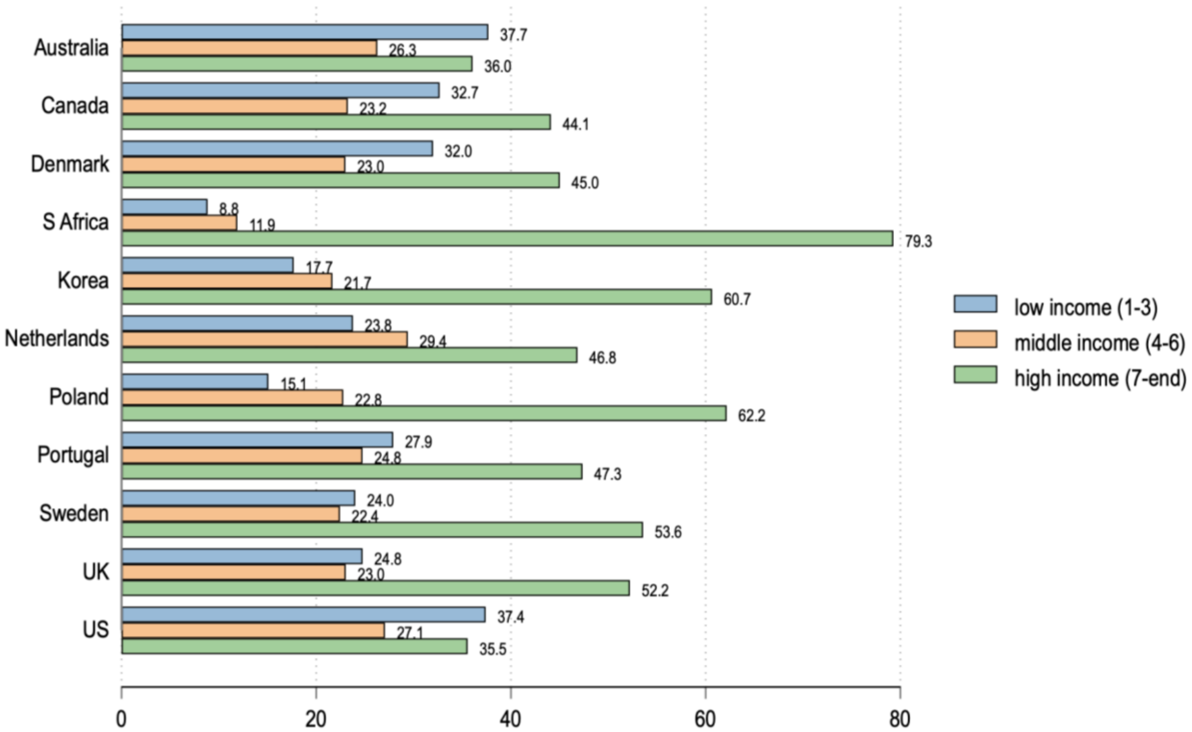
Table C.6. Summary statistics for key demographics by country, part 2

	Netherlands		Poland		Portugal		Sweden		UK		US	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Gender												
Male	574	47.8	537	44.8	587	48.9	518	43.2	554	46.2	540	45
Female	622	51.8	657	54.8	611	50.9	680	56.7	635	52.9	652	54.3
Other	2	0.2	4	0.3	2	0.2	2	0.2	9	0.8	7	0.6
Prefer not to say	2	0.2	2	0.2	0	0	0	0	2	0.2	1	0.1
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Age Bracket												
18-26 years old	153	12.8	199	16.6	169	14.1	99	8.2	195	16.2	132	11
27-34 years old	161	13.4	201	16.8	204	17	140	11.7	170	14.2	201	16.8
35-39 years old	100	8.3	136	11.3	119	9.9	117	9.8	106	8.8	124	10.3
40-44 years old	113	9.4	103	8.6	137	11.4	138	11.5	130	10.8	110	9.2
45-59 years old	375	31.2	325	27.1	418	34.8	378	31.5	358	29.8	349	29.1
60-65 years old	125	10.4	146	12.2	110	9.2	122	10.2	230	19.2	271	22.6
65+ years old	173	14.4	90	7.5	43	3.6	206	17.2	11	0.9	13	1.1
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Education (comparable)												
Low	194	16.3	36	3	153	12.8	90	7.5	58	4.8	2	0.2
Medium	499	42	744	62	648	54	643	53.6	553	46.1	662	55.2
High	496	41.7	420	35	399	33.2	467	38.9	589	49.1	536	44.7
Total	1 189	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Marital Status												
Married	547	45.6	627	52.2	459	38.2	419	34.9	550	45.8	631	52.6
Partner but not married	293	24.4	261	21.8	401	33.4	338	28.2	276	23	144	12
Not in a relationship	330	27.5	295	24.6	295	24.6	416	34.7	352	29.3	400	33.3
Other	30	2.5	17	1.4	45	3.8	27	2.2	22	1.8	25	2.1
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Has children												
No	870	72.5	697	58.1	701	58.4	859	71.6	797	66.4	779	64.9
Yes	330	27.5	503	41.9	499	41.6	341	28.4	403	33.6	421	35.1
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Area you live in												
Urban	537	44.8	844	70.3	719	59.9	655	54.6	388	32.3	393	32.8
Suburban	248	20.7	128	10.7	299	24.9	251	20.9	569	47.4	536	44.7
Rural	415	34.6	228	19	182	15.2	294	24.5	243	20.2	271	22.6
Total	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
Child: 3 yo or less												
No	226	68.5	272	54.1	299	59.9	209	61.3	251	62.3	255	60.6
Yes	104	31.5	231	45.9	200	40.1	132	38.7	152	37.7	166	39.4

Total	330	100	503	100	499	100	341	100	403	100	421	100
Child between 4-14 years old												
No	113	34.2	139	27.6	141	28.3	90	26.4	121	30	112	26.6
Yes	217	65.8	364	72.4	358	71.7	251	73.6	282	70	309	73.4
Total	330	100	503	100	499	100	341	100	403	100	421	100
Child between 5-18 years old												
No	222	67.3	321	63.8	291	58.3	206	60.4	255	63.3	243	57.7
Yes	108	32.7	182	36.2	208	41.7	135	39.6	148	36.7	178	42.3
Total	330	100	503	100	499	100	341	100	403	100	421	100
Child over 18 yo												
No	276	83.6	373	74.2	358	71.7	237	69.5	308	76.4	303	72
Yes	54	16.4	130	25.8	141	28.3	104	30.5	95	23.6	118	28
Total	330	100	503	100	499	100	341	100	403	100	421	100
Current employment status												
Employed full-time	453	37.8	677	56.4	740	61.7	547	45.6	498	41.5	544	45.3
Employed part-time	233	19.4	65	5.4	75	6.2	128	10.7	172	14.3	133	11.1
Self employed	73	6.1	59	4.9	106	8.8	53	4.4	91	7.6	90	7.5
Unemployed but looking for a job	23	1.9	60	5	46	3.8	57	4.8	58	4.8	79	6.6
Unemployed not looking/sick or disabled	114	9.5	13	1.1	44	3.7	73	6.1	93	7.8	78	6.5
Full-time parent, homemaker	63	5.2	77	6.4	38	3.2	14	1.2	108	9	86	7.2
Retired	173	14.4	181	15.1	94	7.8	256	21.3	118	9.8	145	12.1
Student/Pupil	68	5.7	51	4.2	57	4.8	71	5.9	62	5.2	26	2.2
Military	0	0	0	0	0	0	1	0.1	0	0	2	0.2
Prefer not to answer	0	0	0	0	0	0	0	0	0	0	17	1.4
Total	0	0	17	1.4	0	0	0	0	0	0	0	0
Household size (including you)	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
1												
2	270	22.5	146	12.2	130	10.8	373	31.1	234	19.5	239	19.9
3	460	38.3	347	28.9	320	26.7	451	37.6	389	32.4	385	32.1
4	210	17.5	311	25.9	388	32.3	166	13.8	254	21.2	258	21.5
5	198	16.5	257	21.4	277	23.1	147	12.2	222	18.5	188	15.7
6	45	3.8	99	8.2	63	5.2	38	3.2	74	6.2	88	7.3
7	10	0.8	31	2.6	16	1.3	16	1.3	13	1.1	27	2.2
Total	7	0.6	9	0.8	6	0.5	9	0.8	14	1.2	15	1.2
Income band in USD	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
low income (1-3)												
middle income (4-6)	240	23.9	159	15.1	311	27.8	259	24	261	24.8	414	37.5
high income (7-end)	297	29.6	243	23	280	25	242	22.4	244	23.2	300	27.2
Total	467	46.5	653	61.9	528	47.2	578	53.6	548	52	389	35.3
Can you make ends meet?	1 004	100	1 055	100	1 119	100	1 079	100	1 053	100	1 103	100
With great difficulty												
With difficulty	31	2.6	40	3.5	97	8.2	58	5	66	5.7	74	6.3

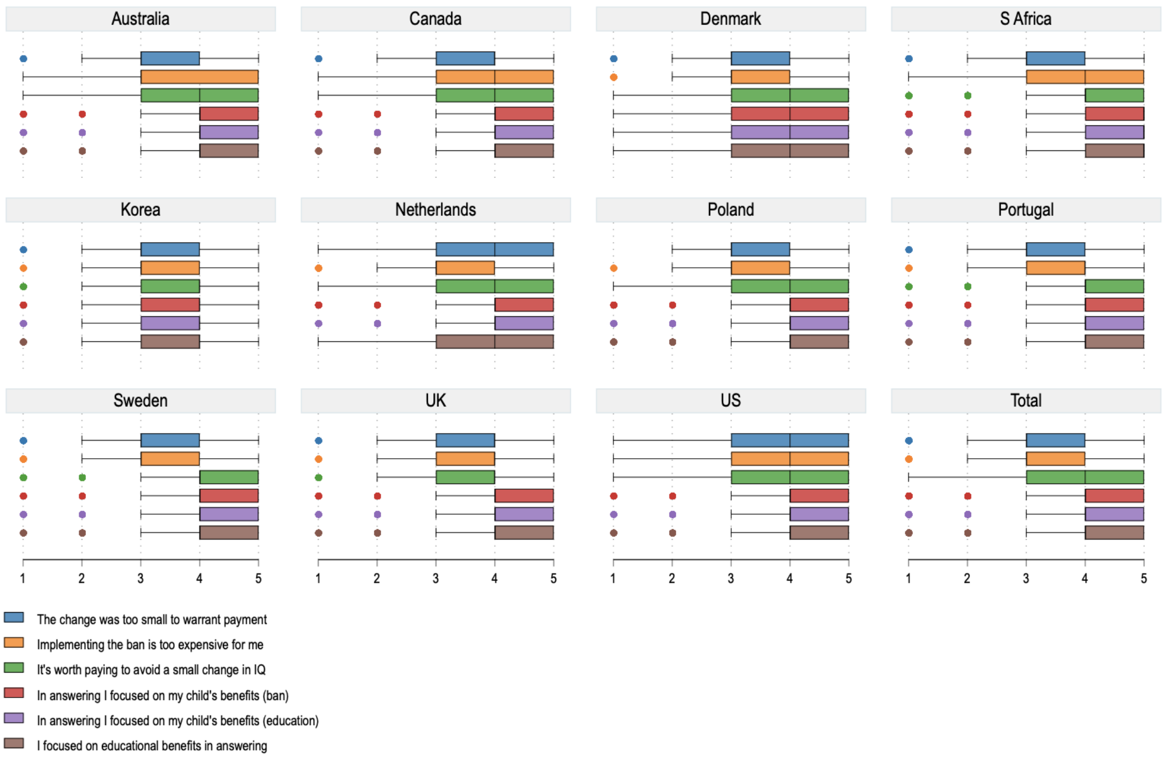
Rather easily	189	16	277	23.9	323	27.4	219	18.7	306	26.2	265	22.6
Easily	376	31.8	519	44.9	494	41.9	388	33.1	384	32.9	307	26.2
Very easily	379	32.1	235	20.3	195	16.6	261	22.3	268	22.9	294	25.1
Total	207	17.5	86	7.4	69	5.9	245	20.9	144	12.3	230	19.7
Who covers healthcare costs?	1 182	100	1 157	100	1 178	100	1 171	100	1 168	100	1 170	100
A public health insurance scheme												
A private health insurance scheme	621	51.7	690	57.5	509	42.4	908	75.7	919	76.6	262	21.8
A combination of schemes	315	26.2	117	9.8	267	22.2	70	5.8	91	7.6	560	46.7
I would have to cover most	198	16.5	188	15.7	173	14.4	149	12.4	87	7.2	197	16.4
Total	66	5.5	205	17.1	251	20.9	73	6.1	103	8.6	181	15.1
Free Healthcare	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100
No												
Yes	579	48.2	510	42.5	691	57.6	292	24.3	281	23.4	938	78.2
Total	621	51.7	690	57.5	509	42.4	908	75.7	919	76.6	262	21.8
	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100	1 200	100

Figure C.2. Share of respondent by income groups and by country



Note: The bars show the percentage of people in a given income band in each country. To ease the presentation income levels were converted using PPP for actual individual consumption for 2019 and group participants separated in low, medium and high levels of income based on the bracket selected by the respondents (with low representing respondents selecting brackets 1-3, medium selecting brackets 4-6 and high selecting a bracket higher than 6 in each country).

Figure C.3. Debriefing questions on motivation for paying or not paying, by country

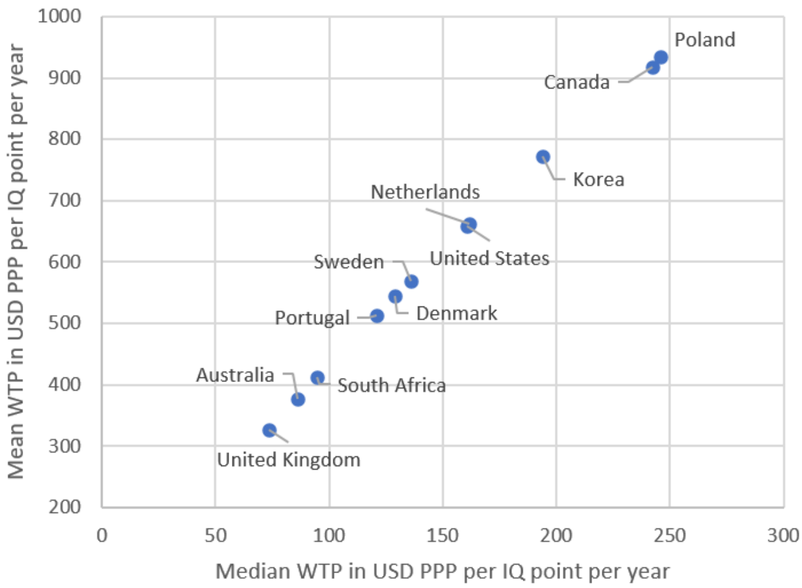


Note: The figure shows boxplots summarising participants' answers by country. The box shows the interquartile range, the vertical bars show the minimum (1 in all questions), maximum (5 in all questions), and the dots show outliers.

Table C.7. Evenly distributed demographics across treatment groups

Attribute	Treatment 1 Base IQ = 110 Loss = 5	Treatment 2 Base IQ = 100 Loss = 5	Treatment 3 Base IQ = 90 Loss = 5	Treatment 4 Base IQ = 100 Loss = 1
Female	47.5%	45.9%	46.2%	46.8%
Male	52.5%	54.1%	53.8%	53.2%
Low education	7.6%	7.4%	7.3%	7.2%
Medium education	51.1%	50.5%	51.1%	50.3%
High education	41.3%	42.2%	41.6%	42.5%
18-29	18.6%	18.4%	19.3%	20.8%
30-44	29.7%	31.2%	30.0%	29.1%
45-59	30.2%	29.1%	30.2%	29.4%
60+	21.4%	21.3%	20.5%	20.8%
Australia	8.9%	9.0%	9.1%	9.0%
Canada	9.1%	9.1%	9.1%	9.2%
Denmark	8.9%	8.9%	8.9%	8.9%
Korea	9.1%	9.1%	9.1%	9.1%
Netherlands	9.1%	9.1%	9.1%	9.2%
Poland	9.1%	9.2%	9.1%	9.1%
Portugal	9.2%	9.2%	9.1%	9.2%
Sweden	9.3%	9.2%	9.2%	9.2%
South Africa	8.9%	8.8%	9.0%	8.8%
United Kingdom	9.2%	9.2%	9.1%	9.0%
United States	9.2%	9.1%	9.0%	9.1%

Figure C.4. Mean and median WTP by country



Note: Based on estimates reported in Table 5.5.

Table C.8. Recommended median WTP values to avoid a loss of 1 IQ point in children by country

	Median WTP per IQ point per year	
	USD_{2022} PPP per year	Local currency
Australia	86	AUD 129
Canada	242	CAD 301
Denmark	129	DKK 940
Korea	194	KRW 172 000
Netherlands	162	EUR 548
Poland	246	PLN 1 590
Portugal	121	EUR 304
South Africa	95	ZAR 610
Sweden	136	SEK 1 310
United Kingdom	74	GBP 245
United States	161	USD 659

Note: WTP values come from the estimation reported in Table 5.5. The conversions are done using Purchasing Power Parities for actual individual consumption of 2019 since it was used to convert bid levels across countries. Data are provided by the OECD. https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm.

Table C.9. Comparison of WTP estimates with previous studies

Study	Type	Country or group of countries	WTP per IQ point derived from the study	WTP in USD_{2022} per IQ point adjusted for GDP per capita growth and inflation
Lutter (2000[23]) [a]	RP	United States	USD_{2000} 1 100 – 1 900	2 073 – 3 580
US EPA (2020[16])drawing from Salkever (1995[9])	RP	United States	USD_{2016} 5 708– 22 503 depending on discount rate and base value	7 233 – 28 515 depending on discount rate and base value
Lin, Lutter and Ruhm (2018[26])	RP	United States	USD_{2014} 14 764 assuming a 3% discount rate	19 189 assuming a 3% discount rate
Von Stackelberg and Hammitt (2009[31])	SP	United States	USD_{2009} 466	687
The present study	SP	United States	USD_{2022} 3 296	3 296
The present study	SP	11 OECD countries	USD_{2022} 3 046	3 046

Note: RP means revealed preferences and SP means stated preferences. Estimates from previous studies are transferred over time using equation (2), an income elasticity of 0.4 as reported in the present paper. Price indices data come from the OECD Consumer price indices (CPIs) dataset and GDP per capita data come from the OECD Economic outlook (2022[42]). [a] Lutter (2000[23]) is not a peer-reviewed paper and relies on WTP for chelation therapy which has been later found to have no effect on IQ in lead-poisoned children (Rogan et al., 2001[24]; Dietrich et al., 2004[25]).

Table C.10. Measuring the benefits of policy intervention in the United States: an illustrative example assuming an even distribution of avoided IQ point each year

Year	Estimated avoided IQ point loss per year	Adjusted mean WTP [a]	Discounted benefits (thousand USD PPP)
2023	1 200	3 430	3 997
2024	1 200	3 571	4 039
2025	1 200	3 719	4 084
2026	1 200	3 869	4 125
2027	1 200	4 020	4 161
Total	6 000		20 406

Note: Discounted benefits are computed following equation (1) and WTP values for the total over 5 years reported in Table 6.1. [a] WTP values are adjusted using equation (2). GDP per capita projections for 2022-2024 are provided by the OECD Economic Outlook (2022[38]). Between 2024 and 2027, it is assumed that GDP per capita grows by 1% every year, which is not an OECD forecast. Consumer price index are assumed to increase by 5% every year between 2022 and 2027, which is not an OECD forecast. The discount rate is equal to 3% and is one of the discount rates that are usually used in guidelines. The income elasticity equals 0.4 as estimated in this paper.

Annex D. 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 annex
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
    - Optional. 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. Optional. 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[19] 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

[19] 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[43]). 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 Hanneman, 2005[37]).
- 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[44]; Carson and Hanneman, 2005[37]) 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 annex
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 the avoidance of IQ losses in children

Exposure to chemicals has been shown to reduce IQ in children. In turn, a person's IQ is likely to affect their educational achievements, which may then affect lifetime earnings, more generally, a person's quality of life. At the same time, authorities face challenges in regulating chemical 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 IQ loss 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 avoid IQ loss, filling an important gap in the valuation literature and addressing a need for applied benefits analysis for chemicals regulation. The SWACHE IQ loss survey was fielded in eleven countries: Australia, Canada, Denmark, Korea, Netherlands, Poland, Portugal, South Africa, Sweden, the United Kingdom and the United States. In each country, a sample of 1 200 respondents, representative of the general population, was collected and empirically analysed.

The estimated mean WTP to avoid the loss of 1 IQ point equals USD Purchasing Power Parity (PPP) 609 per year (USD PPP 3 046 per IQ point in total over 5 years without discounting) and the median WTP to avoid the loss of 1 IQ point equals USD PPP 150 per year (USD PPP 748 per IQ point in total over 5 years without discounting).

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