Valuation of Environment-Related Health Risks for Children

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Foreword

Epidemiological studies suggesting a causal relationship between exposure to specific environmental pollutants and adverse health effects in children have flourished in recent years. Concern for children's health risks from environmental pressures is reflected in the numerous examples of laws and regulations aimed at protecting children's health.

However, there are very few studies which seek to "value" the benefits of reducing environment-related health risks. As a consequence, in the past in the past, most assessments of the economic efficiency of environmental policies have relied upon values of a statistical life (VSL) estimates which are derived from adult populations (e.g. through wage-risk studies). If members of society have different preferences for risk reductions for children relative to adults, then the use of such values could result in a misallocation of resources and policy efforts, perhaps with inadequate attention paid to the specific vulnerabilities of children.

In order to fill this gap, the OECD has co-ordinated a project in which leading researchers from the Fondazione Eni Enrico Mattei (FEEM), the Charles University Environment Centre (CUEC), and the University of East Anglia (UEA) have obtained estimates of the value of environment-related risk reductions for children (and adults).

The project involved a consortium of research teams in Italy, the United Kingdom and the Czech Republic. The Italian team was led by Anna Alberini, with contributions from Aline Chiabi and Stefania Tonin. In the United Kingdom, the research team was led by Graham Loomes and Ian Bateman, with contributions from Silvia Ferrini, Katie Bolt and Brett Day. Milan Ščasný was the project leader in the Czech Republic, with contributions from Markéta Braun Kohlová, Hana Škopkova, and Jan Melichar. Further inputs were provided by Ståle Navrud. Pascale Scapecchi, Nick Johnstone and Henrik Lindhjem were responsible for the drafting of this publication, based upon the technical reports provided by the research teams. Throughout the project the research teams benefited from an Advisory Group composed of leading experts and policymakers in the field. The project has also benefited from the oversight of the OECD's Working Party on National Environmental Policies.

Analysis of the data indicates (qualified) support for evidence for a "child premium". This highlights the need to take into account differences in social risk preferences for children and adults when designing environmental policies. This is likely to be most important in cases where the policy intervention particularly affects children due to nature/scope of policy (e.g. pesticides in school grounds) or because

children are particularly vulnerable to this particular hazard (e.g. *lead in drinking water*). *In such cases, child-specific values are likely to be particularly helpful in ensuring that resources and policy efforts are allocated efficiently.*

The project has been financed by the European Commission Directorate-General for Research under the 6th Framework Programme, and the support is gratefully acknowledged.

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List of Acronyms

CAA	Clean Air Act
CAFÉ	Clean Air for Europe
CAPI	Computer assited personal interview
CBA	Cost-benefit analysis
CCE	Conjoint choice experiment
CEHAPE	Children's Environment and Health Action Plan
CO	Carbon monoxide
COI	Cost-of-illness
CUEC	Charles University Environment Center
CV	Contingent valuation
CVM	Contingent valuation method
CZK	Czech Republic Koruna
EAF	Environmentally attributable fraction
EPA	Environmental Protection Agency
ETS	Environmental tobacco smoke
FEEM	Fondazione Eni Enrico Mattei
IIASA	International Institute for Applied Systems Analysis
IVM	Instituut voor Milieuvraagstukken (Institute for Environmental Studies)
MRS	Marginal rate of substitution
MWTP	Marginal willingness to pay
NILU	Norwegian Institute for Air Reseach
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
O_3	Ozone
OECD	Organisation for Economic Co-operation and Development
OR	Odds ratio
PM	Particulate matter
PPP	Purchasing power parity
PTO	Person trade-off
RP	Revealed preference
RR	Relative risk
SAR	Seasonal allergic rhinitis
SG	Stardard Gamble

SP	Stated preference
UEA	University of East Anglia
USD	United States Dollar
VERHI	Valuation of environment-related health impacts
VOC	Volatile organic compounds
VSC	Value of a statistical case
VSL	Value of a statistical life
WTA	Willingness-to-accept
WTP	Willingness-to-pay

Executive Summary

Epidemiological studies suggesting a causal relationship between exposure to specific environmental pollutants and adverse health effects in children have flourished, particularly with respect to air pollution. Concern for children's health risks from environmental pressures is reflected in the numerous examples of laws and regulations aimed at protecting children's health.

Why do policymakers care about how members of society values mortality risk reductions for children?

- Firstly, there is some evidence that children are particularly vulnerable to some environmental hazards.
- Secondly, the health of children can be seen as a public good in some sense – with the good health of children having positive spillovers both for their parents and for society-at-large.
- And finally, while the interests of children are often defended by parents (and other caregivers) policymakers in OECD governments have always had a special role in protecting the interests of children.

However, in the past, most assessments of the economic efficiency of environmental policies have relied upon values of a statistical life (VSL) estimates which are derived from adult populations (*e.g.* through wage-risk studies). If members of society have different preferences for risk reductions for children relative to adults, then the use of such values could result in a misallocation of resources and policy efforts, perhaps with inadequate attention paid to the specific vulnerabilities of children.

Given the importance of the issues, the OECD held a workshop in September 2003 at which leading researchers in the field presented their work (OECD 2006). However, it was widely recognised by participants at the workshop that new research was desperately needed. In order to fill this gap the OECD co-ordinated a research project financed by the European Commission's 6th Framework Programme, involving research teams in Italy, the United Kingdom, and the Czech Republic.

The objective of the project was to obtain estimates of the value of risk reductions that have the following three general characteristics:

- the risk is *environmental* in nature;
- it affects *children*; and
- it has a non-negligible probability of resulting in *death*.

Each of these characteristics poses specific challenges to the researcher. However, taken together, the challenge is that much greater. As such, over two years of survey development work was undertaken by the research teams, with a large number of focus group discussions, one-on-one interviews and pilot studies.

Based upon insights gained from this work, two innovative survey instruments were developed, with a total sample of almost 6 000 respondents in the three countries. The objective was to obtain VSL estimates both for children and (for purposes of comparison) adults. Moreover, the effects on the estimated VSL of a large number of risk characteristics (*e.g.* context, latency), demographic and economic factors (*e.g.* income, gender), and programme attributes (*e.g.* private measures vs. public programmes)

Analysis of the data indicates (qualified) support for evidence for a "child premium", which is consistent with previous literature. In the case of a conjoint choice experiment, "child premium" is, however, modest at best, *i.e.* in Italy the VSL for an adult (EUR 4.0 million) is not statistically different from a child (EUR 4.6 million), whereas in the Czech Republic there is a 30% difference in VSL values (CZK 19.2 million and CZK 24.5 million). However, we come to a different conclusion if child and adult VSL are compared for different causes of death: while VSLs for cancers are not statistically different, the child VSL figures for the other causes of death are about 40% larger in Italy and almost 60% larger in the Czech Republic than the adult VSL figures.

In addition the implementation of a different survey instrument using the so-called "chaining approach" – found robust evidence of a "child premium" in VSL in the United Kingdom and the Czech Republic (122% and 64% respectively). Looking at direct trade-offs in risk reductions for children and adults also found strong evidence of a premium on the value attached to risk reductions for children, with values in the range of 50% to 100% greater.

These findings highlight the need to take into account differences in social risk preferences for children and adults when designing environmental policies. This is likely to be most important in cases where the policy intervention particularly affects children due to nature or scope of the policy (*e.g.* pesticides in school grounds) or because children are particularly vulnerable to this particular hazard (*e.g.* lead in drinking water). In such cases,

child-specific values are likely to be particularly helpful in ensuring that resources and policy efforts are allocated efficiently.

However, it must be borne in mind that the estimated "adult" VSL obtained in the VERHI study is derived from a sample of parents only. As a consequence, the VSL for all adults (those above 18 years of age) could be different than that obtained in the study, resulting in a different estimated "premium" for child VSL.

In conclusion, the VERHI project has provided a large body of evidence on the conditions under which the VSL for children is likely to be most different from that for adults. For instance, it is clear that context matters, but it plays a different role in the case of children and adults. There is less variation across context for children than for adults. Conversely, private interventions and public programmes are valued differently, with some qualified evidence that there is a premium placed on the latter for children relative to adults. Exploring such issues in further work is important for efficient policymaking.

Introduction: The VERHI Project and its Goals

Epidemiological studies suggesting a causal relationship between exposure to specific environmental pollutants and adverse health effects in children have flourished, particularly with respect to air pollution.[1] While the evidence is far from definitive, it is becoming increasingly clear that children are particularly vulnerable to certain kinds of environmental health risks. Concern for children's health risks from environmental pressures is reflected in the numerous examples of laws and regulations aimed at protecting children's health [see Scapecchi (2007) for an overview].[2]

The relationship between environment and children's health has been the subject of increasing interest in recent years. From their daily behavioural patterns, adults and children are exposed neither to the same environmental risks, nor to the same level of risk. In addition, from a metabolic point of view, children are more receptive and more sensitive to pollution than adults, as their bodies are still developing. Thus, even though they are exposed to the same environmental risk and to a level *a priori* identical to that of adults, the body of a child can be more affected than that of an adult by this form of pollution. Recent epidemiological studies highlight the particular susceptibility of children to environmental pollution (Tamburlini, 2006).

Moreover, there is no reason to believe that the economic value of an equivalent health risk reduction for children and adults is necessarily the same. There is evidence that willingness to pay (WTP) for risk reductions within adult populations differ, and thus it is likely that there would also be differences between adults (in general) and children (in general), as well as within children as a group. While there are some studies that have valued risk reductions for children, few of these relate to the "environmental" context. In the absence of specific estimates for children, cost-benefit analysis (CBA) studies of environmental policies with implications for health have used a single estimate of the value of such health risk reductions for the entire population.

In the event that the value of risk reductions differs (and a single value is applied in the absence of evidence to the contrary), there could be a misallocation of resources and policy efforts in the economy. On the one hand, this may be

reflected in terms of environmental priorities. For instance, if the value of a risk reduction for a child is greater than for an adult and a single value is applied, those environmental risks to which children are particularly vulnerable will be "under-regulated" relative to those risks to which adult populations are more vulnerable.

On the other hand, it may also be reflected in terms of the priority given to environmental concerns in general relative to other public policy objectives. Assuming once again that the value of a risk reduction for a child is greater than that for an adult, but a single value is applied and which is based upon an adult sample, the social benefits of environmental policies will be under-estimated and insufficient resources and policy efforts will be devoted toward reducing environmental health risks in general.

These considerations suggest that more empirical work is needed on the valuation of health benefits for children. To help fill this gap, a project on the valuation of environmental health risks to children was undertaken: the VERHI project (Valuation of Environment-related Health Impacts, with a particular focus on children). This involves leading researchers in the field of environmental and health valuation, who implemented innovative surveys in three OECD countries (Table 0.1).

Table 0.1. **The VERHI Research Teams**

Organisation	Acronym	Country	Participants	Tasks/Expertise
Sustainability Indicators and Economic Valuation Program, Fondazione Eni Enrico Mattei *www.feem.it/Feem/default.htm*	FEEM	Italy	Anna Alberini, Aline Chiabi, Stefania Tonin, Marcella Veronesi	Survey development (CCE), survey implementation, data analysis
Centre for Social and Economic Research on the Global Environment, University of East Anglia *www.uea.ac.uk/env/cserge/*	UEA	United Kingdom	Ian Bateman, Silvia Ferrini, Katie Bolt, Graham Loomes, Brett Day	Survey development (Chaining), survey implementation, data analysis
Environmental Economics Unit, Charles University Environment Center *http://cozp.cuni.cz/COZPENG-5.html*	CUEC	Czech Republic	Milan Ščasný, Markéta Braun Kohlová, Hana Škopková, Jan Melichar	Survey development, survey implementation, data analysis, benefits transfer

The VERHI project seeks to obtain estimates of the value of environment-related mortality risk reductions for children. To do so, the project was composed of two phases. The first phase consisted of taking stock of available epidemiological and economic research on children's health and the environment. A workshop was organised to present recent work from leading experts in this area. Findings and discussions raised during that meeting are summarised in OECD (2006).

The main lessons learned from the workshop were that the valuation of children's health differs in many important respects from the valuation of adults' health, and this constitutes a real challenge for analysts, as well as for decision-makers. Methodological issues, such as the elicitation of children's preferences, the choice of the valuation methodology and benefit measure, the discounting of benefits for children's health, and the influence of parental altruism on estimates obtained are of primary importance when estimating the health benefits of environmental policies for children.

This initial publication served as a basis for the second phase of the project, which was more empirically-oriented. The objective of this second phase was to estimate the benefits of reducing environment-related mortality risks for both adults and children. A number of methodologies can be applied for the estimation of such values, including both revealed preference studies which examine behaviour in markets related in some way to the risk in question (*e.g.* wage-risk studies, hedonic property value studies, averting behaviour) and stated preference studies which seek to elicit values directly by positing hypothetical markets for the risk itself (*e.g.* contingent valuation, conjoint choice analysis methods).

Based upon an initial review undertaken as part of the project, it was decided that the flexibility associated with stated preference methods were more appropriate for this study. To this end, stated preference surveys have been implemented in three OECD countries (the Czech Republic, Italy and the UK). These surveys have been developed so as to obtain methodologically comparable values for adults and children for reductions in similar risks which can be used in CBA.

In the theoretical foundations of CBA, the benefits associated with a given policy intervention are defined as increases in human well-being (utility). From an economic perspective, the value of health impacts are ideally estimated as willingness to pay (WTP) for a given reduction in risk, or willingness to accept (WTA) a given increase in risk. Whether measured in terms of WTP or WTA, this should ideally include direct and indirect costs of illness such as medical costs and lost productivity, as well as intangible aspects, such as pain and suffering. Given the interest of the study in valuing policy interventions in the remainder of this chapter reference is made to WTP rather than WTA.[3]

However, it should be noted that some CBA use "cost of illness", which is an "ex post" measure of health benefits from policy interventions, reflecting costs once an event (accident, sickness, etc.) has occurred. Since cost of illness studies do not include the value of "intangible" impacts such as pain and suffering, they will often under-estimate the benefits of policy interventions.

As such, although both measures can be used in policy-making, the use of WTP values is recommended in part because of their broader coverage. If WTP figures for specific health endpoints are not available, cost of illness values should be used instead, because they generally provide a lower bound estimate of the true costs of a disease since they don't include defensive expenditures, lost leisure time and pain and suffering, as well as any potential altruism benefits.

The overall objective of the VERHI project is to improve the evaluation of environmental policies – in particular, of policies which directly affect the health of *children*. To this end, the results of the VERHI project include estimates of the WTP for risk reductions which are specific to children. The focus of the project has been on the value of reductions in the *risk of mortality*, and thus the value of a statistical life (VSL).[4] However, at least some of the methods applied have allowed for the estimation of WTP for risk reductions in morbidity, which could be thought to be "environmental".

In addition, values have been obtained from adults, as well as children. Past research has shown that study design and implementation can have an effect on the values obtained, and as such in order to ensure a degree of comparability between the values obtained for children and adults directly within the study, similar surveys were implemented in the two cases. This will allow for the generation of estimates of the "marginal rate of substitution" between equivalent risk reductions for children and adults. This has policy relevance above and beyond the absolute level of the values estimated.

It is reasonable to assume that differences in the WTP for risk reductions for *adult and child* populations can be attributed in part to differences in age. However, age differences do not capture all the potential sources for differences in WTP between these populations. The distinctive role of children within the household, the relative importance of paternal altruism, and other factors (*i.e.* risk perceptions, degree of voluntariness of exposure and perceptions of dread) may well affect WTP for children, relative to adults in a manner which is distinct from simple differences in age.

The project has also used a variety of study designs in order to assess the relative importance of other factors which can have significant impacts on estimated WTP for both children and adults. For instance, it has been possible to examine the effects of context on estimated VSL, with values for respiratory diseases, cancer and accidents. This gives an indication of the value of risk reductions related to "environmental" exposures relative to other risks. Context may, of course, be more or less important for children than adults.

Thus, in addition to the focus on children, another key objective of the VERHI project is to derive values for *environment-related* health impacts. This is significant since the majority of studies undertaken relate to other contexts. For instance, of the 26 studies reviewed as part of the EPA's *Guidelines for Preparing Economic Analyses* (2000), 21 were wage-risk studies. DG Environment at the European Commission uses an "anchor VSL" which has been derived from the transport context.

Since risk characteristics may be very different in the environmental context than in the transport context or the occupational health and safety context, transferring values without appropriate adjustment may be inappropriate. Mortality risks associated with environmental pressures are generally low, often latent, and frequently perceived as involuntary – and all of these factors can influence estimated values. Indeed a recent meta-analysis of stated preference studies finds that context has a significant impact on estimated VSL (Navrud and Lindhjem, 2010).

In summary, a significant challenge for the project has been the need to obtain estimates for risk reductions which have the following three general characteristics:

- they are *environmental* in nature;
- they affect *children*; and
- they have a non-negligible probability of resulting in *death*.

Each of these characteristics poses specific challenges to the researcher. However, taken together, the challenge is that much greater. Risks which have these three attributes may be relatively unfamiliar to respondents. Moreover, the baseline risks (and thus proposed risk reductions) for environmental mortality risks for children are exceedingly low. As is well-documented in the literature, such probabilities can be difficult to communicate to respondents, and the values obtained may be relatively insensitive to changes in risk reductions.

Efforts have been made in study design to address these challenges through extensive survey development work. Four different valuation methods were applied in different combinations in two distinct survey instruments. (See Box 0.1)

Given the discussion above, in addition to the project's contribution to policy development and risk assessment, the VERHI project makes a significant contribution to improving methodological approaches for valuing children's health. Since so few studies have been undertaken in this area, this is perhaps the most important contribution of the project. To this end, particularly extensive survey development work was undertaken. Insights from this work should be of value to the wider research community.[5]

Box 0.1. **Characteristics of the Surveys Implemented**

In each of the three countries involved in the project responses from a sample of parents was obtained. Data was obtained on risk preferences, with the objective of obtaining estimates of the value of a statistical life (VSL) for themselves and their children. In all cases approximately 1 000 parents were sampled.

In Italy and the Czech Republic a conjoint choice experiment (CCE) was implemented, in which there was variation across five different attributes: cause of death, whether the risk reduction is achieved through a public policy intervention or by private means; the extent (if any) of latency; the size of the risk reduction; and the cost of the public or private measure. This gives rich variation in the factors which may affect WTP for risk reductions. In the Czech Republic some additional questions were posed in which respondents were requested to "trade off" risk reductions for themselves and their children.

In the United Kingdom and the Czech Republic (a different sample from the CCE exercise) a questionnaire involving the "chaining" method was implemented. In this case, a contingent valuation exercise is applied in order to determine willingness-to-pay to avoid a non-fatal health condition. This is followed by a "standard gamble" question is applied in which two alternative treatments are proposed, one of which carries a risk of death. Combining the two responses, the VSL is obtained.

The report is structured as follows. Chapter 1 provides an introduction to the valuation of environmental health risks, along with an annex which reviews the economic and epidemiological evidence. Chapter 2 summarises the key methodological issues associated with the valuation of health risks for children. Chapter 3 gives an overview of the extensive survey development work undertaken. Chapter 4 presents the summary results and Chapter 5 concludes with a discussion of the policy implications of the project. AEA Technology Environment. (2005), *CAFE CBA: Baseline Analysis 2000 to 2020*. Brussels: Final Report to the European Commission DG Environment.

Notes

1. The results of a number of these studies are reviewed below.
2. See EPA (2008) for a review of recent measures in the US. In Europe, the Children's Environment and Health Action Plan (CEHAPE) reports on measures undertaken with respect to ambient and indoor air quality, water and sanitation, physical and chemical risks, and accidents and injuries. *http://ec.europa.eu/health/ph_determinants/environment/Pollution/CEHAPE_en.htm* .

3. In theory WTP and WTA should be approximately equal. However, if the change in risk is important then there may be large differences due to the income effect. In addition, if the good in question cannot be substituted there may be differences between the two measures.
4. The "value of a statistical life" (VSL) is the aggregate value of reducing (usually small) mortality risks across a large number of people. The specific lives saved are not identifiable. It is also sometimes referred to as the "value of a prevented fatality" (VPF).
5. Reports arising out of the project are available at *www.oecd.org/social/envhealth/verhi*.

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Chapter 1

The Valuation of Environmental Health Risks

Environmental policy affects human health by reducing environmental risks that result in either premature mortality or non-fatal ill-health. People attach value to the reductions in health risk associated with environmental policies, and valuing such benefits can be undertaken using either revealed preference or stated preference methods. Depending on the nature of the environmental pressure and health impact, it has been found that health benefits can represent a majority of benefits of policy interventions. However, most such studies have been done using adult samples, and there is a need for similar estimates for children.

Introduction

Environmental policy affects human health by reducing environmental risks that result in premature mortality. Second, it may reduce the risk of acute non-fatal health impacts which are temporary in nature, or improve the health conditions of those living permanently with a disease or other health condition. These are known as morbidity benefits. Indeed, health-related benefits often dominate the benefits associated with the introduction of environmental policies.

A review (Pearce, Atkinson and Mourato 2006) of valuation studies undertaken in the European Union reveals that health benefits account for a minimum of one-third and a maximum of nearly 100% of overall benefits from pollution control.[1] The US EPA's (1997) assessment of the Clean Air Act (CAA found that the benefits of the Act (1970) and its amendments (1977) are dominated by health impacts. These can be as great as 99%, if effects on children's IQ are included. A prospective analysis (EPA 1999) of the CAA Amendments of 1990 found that health benefits represented over 96% of total estimated benefits.[2]

An analysis (Holland *et al*. 2005) of the benefits associated with the Clean Air for Europe (CAFÉ) programme reached comparable conclusions. Positing a set of scenarios based upon potential policy developments, it was found that health benefits relative to the baseline (current legislation) were between EUR 37 and EUR 160 billion per year in 2020, while non-health impacts were estimated to be less than EUR 1.0 billion. However, it is important to emphasise that the latter only includes damage to crops from ozone exposure and material damages from acid deposition.

Given their relative importance in total benefits, it is important to determine how best to ensure that values for health risks are estimated correctly if cost-benefit studies are to be a reliable input into policy-making processes.

Valuing health risks in general

As noted in the Introduction, there are two main approaches to estimating the WTP for a mortality risk reduction. The first approach, revealed preference studies, uses actual behaviors to infer the rate at which individuals trade off income for safety, and includes compensating wage

studies, consumer behavior studies, and hedonic pricing approaches. For example, labor market studies (see Viscusi and Aldy, 2003) relate wage rates to the risk of fatal and non-fatal accidents on the job, reasoning that workers would be prepared to accept a riskier job only for higher pay.[3] Other studies have related the price of automobiles to the risk of dying in an accident associated with an automobile's safety features (Atkinson and Halvorsen, 1990; Andersson, 2005), or the value of a home to the risk of dying for environmental exposures in the neighborhood (Gayer *et al.*, 2000). In the case of child mortality, Jenkins *et al.* (2001) have used expenditures on bicycle helmets to infer the VSL for children of various ages and adults, and Blomquist *et al.* (1996) have relied on the time spent fastening car seatbelts. Davis (2004) uses a cluster of children's leukemia cases in a Nevada community and housing prices to infer the value of a statistical case of child leukemia.

The second approach to estimating the VSL – stated preference studies – queries individuals about what they would do under specified hypothetical circumstances. Stated preference methods include contingent valuation (CV) and conjoint choice experiment surveys. Unlike revealed preference studies, stated-preference studies can be designed to cater to any population and any risk of interest (see Bateman *et al.*, 2002 for a review). In addition, since they rely on hypothetical scenarios created by the researchers, stated preference studies can be designed to deal squarely with the issue of latent risks, in which there is a lag between exposure and the health impact. For these reasons it was decided to implement stated preference surveys in this study.

Once the value associated with a change in mortality risk is estimated, the risk change in question is divided by this value, which then gives the VSL. The social impacts of the policy can then be derived upon the basis of an assessment of the change in risk arising from some change in an environmental variable, say pollution concentrations (*e.g.* a dose-response function). This function can be used to estimate numbers of premature mortalities, and it is these mortalities that are multiplied by the VSL to give an aggregate measure of the social benefits associated with the introduction of the policy. The final equation is:

$$VSL = \frac{dw}{dp} = \frac{u_a(w) - u_d(w)}{(1-p)u'_a(w) + pu'_d(w)}$$

where w is wealth (which is often proxied by income), p is the probability of dying in the current period, (1 – p) is the probability of surviving the current period, u is utility. The subscripts "a" and "d" refer to survival and death respectively. The numerator thus shows the difference in utility between

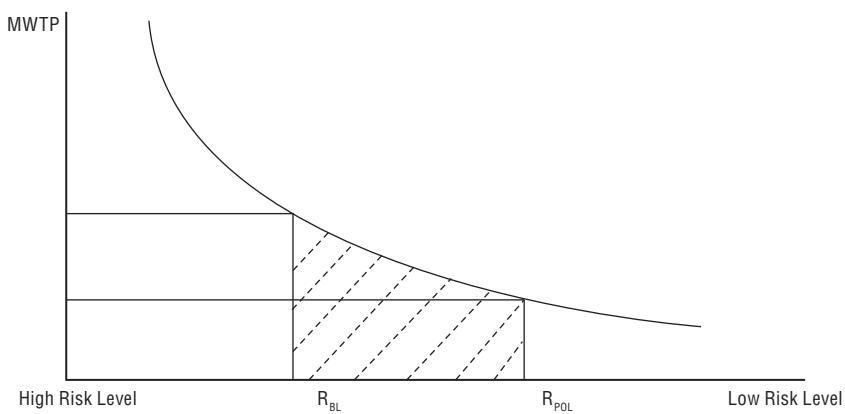
surviving and dying in the current period, while the denominator is the marginal utility of wealth conditional on survival or death (see Pearce *et al.* 2006 for a discussion).

As such, the equation gives the marginal rate of substitution between a risk of dying and wealth. VSL is necessarily positive since people attach a positive value to both survival and wealth. As such, both the numerator and the denominator are positive. Respondents are presented with changes in the risk of dying (*e.g.* through a public policy or a private purchase), and are requested to "trade off" this change in risk by their WTP for a public policy (*i.e.* tighter standards) or a private purchase which reduces the risk.

Figure 1.1 illustrates this relationship between marginal WTP (on the y-axis) and risk levels (on the x-axis). Risk levels are decreasing from left to right. WTP is expressed in marginal terms (MWTP) because this is what is elicited in valuation studies – *i.e.* what the respondent is WTP for a change in risk. The MWTP is assumed to be decreasing with risk levels, which implies that at very low levels of risk people are WTP relatively less for still further reductions in risk.[4]

In Figure 1.1 the baseline risk level is at point R_{BL} (*e.g.* 10 in 10 000). Suppose the policy measure in question reduces risk levels from the baseline level of risk to point R_{POL} to the right on the x-axis (*e.g.* 5 in 10 000), then the WTP for that risk reduction is equal to the shaded area under the marginal WTP curve between these two points. If the results of a valuation study indicate that the mean WTP to secure this risk reduction is USD 100. Then the VSL would be USD 200 000 [*i.e.* (USD 100 × 10 000) / (10 – 5)].

Figure 1.1. **Marginal WTP for a Risk Reduction**



On the basis of available empirical evidence WTP is affected by a number of factors, including quality of life of the period survived as a consequence of the risk reduction, *i.e.* WTP to reduce risks should be higher if the individual anticipates being in good health (apart from the risks in question), and lower if the individual expects to be in poor health. Some of the other factors which affect WTP for reductions in mortality risks are discussed below.

Latency and Discounting

WTP is likely to be affected by the point in time at which the risk reduction is incurred. In the environmental health context, this would arise when the risk is latent, *i.e.* situations in which exposure now does not cause death (or ill-health) until some point in the future. The immediate risk would be relevant to, say, road or occupational accidents. What is sought in this context is the WTP to avoid that risk which could occur tomorrow or in the very near future, *i.e.* acute risks. However, in the case of air pollution, there may be a lag between the "dose" (air pollution concentrations) and the "response" (*e.g.* respiratory problems), *i.e.* there is a degree of latency. Depending upon the environmental pressure under consideration this lag can be very long.

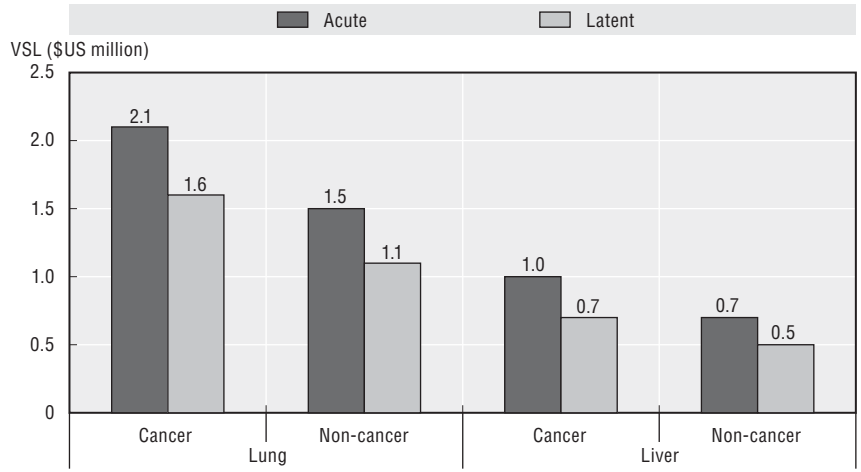
According to standard economic theory, a good received today is valued more than a good received tomorrow. The discount rate is a measure of the extent to which delayed satisfaction differs from immediate satisfaction. While "private" discounting reflects the such inter-temporal trade-offs from the narrow perspective of the individual (or firm), the "social discount rate" should reflect such trade-offs at the level of society as a whole, and is thus more appropriate for cost-benefit analyses. However, the social discount rate applied in a given CBA should reflect the private discounting practices of those affected by the policy. Whether the rates differ in practice will depend upon factors such as the efficiency and taxation of capital markets. Policies with intergenerational impacts raise particular complications.[5]

Since reductions in risk are valued by individuals in a manner analogous to other goods and services, the point in time at which the benefits of such risk reductions are accrued should also be discounted. As such, it might be imagined that latent impacts would be valued less than immediate impacts. However, this may not be the case since latency implies: A) the date will be later; B) the person exposed will be older. The effect of A is reflected in the discount rate. However, since preferences for reducing risks depend on the perceived utility associated with different periods of life, the effect of B may result in latent impacts actually being valued more than immediate impacts.

For this reason empirical evidence is much-needed. A study by Hammitt and Liu (2004) for Taiwan finds that, irrespective of the organ affected, or whether the risk relates to cancer or not, with a proposed latency of 20 years the estimated VSL is at least 30% less than for equivalent acute risks

(see Figure 1.2). They estimate a discount rate of approximately 1.5% per year. However, this is less than what was estimated in a number of other studies [*i.e.* 8% per year in Krupnick *et al.* (2002), and 4.5% per year in Alberini *et al.* (2006a), and as much as 17% in Itaoka *et al.* (2007)].

Figure 1.2. **Estimated Value per Statistical Life**



Source: Hammitt and Liu (2004).

Age and Life Expectancy

Early studies of the VSL made little or no reference to the age of the individuals at risk, perhaps because of the focus on road accident or occupational risks where the mean age of the person at risk is fairly constant. However, in the context of environmental policy the issue of age becomes more important for VSL since it is the very old and (perhaps) the very young which are most vulnerable. The implications of the very old have been examined, since it is well-known that pollution control policy reduces mortality amongst the elderly (Pope *et al.*, 1995; Krupnick *et al.*, 1999).

While there may be differences in risk for different age groups, whether or not WTP for the same risk reduction varies with age is less clear (Krupnick, 2007). The most evident impact of age on WTP for a risk reduction is that since older people have lower life expectancy, the benefit of any current reduction in risk declines. As such, one would expect VSL to decline. However, assuming that there are fewer alternative uses, the opportunity cost of spending money on a risk reduction declines as time goes by, and as a consequence, WTP for risk reduction may actually rise with age.

Which of these two effects dominates will depend upon many factors, and it is commonly asserted that it may follow an inverted-U, first increasing

with age and then falling. One of the first studies to look at this issue (Jones-Lee *et al.* 1985) found VSL to be fairly flat, but increasing to mean age (about 40) and decreasing thereafter. Krupnick *et al.* (2002) found WTP flat from age 40 to 69 and decreasing from age 70 to 74. Based upon revealed preference evidence, Viscusi and Aldy (2007) find an inverted-U relationship, reaching a maximum in the mid-40s and then falling relatively sharply thereafter.

Risk characteristics and context

The precise nature of the risk may also have an influence on the WTP for risk reductions.[6] For instance, some risks may be particularly "dreaded", and thus for which risk reductions would be particularly highly valued. The "dread" aspect of a given risk can indeed have a significant impact on WTP, because it is generally associated with greater fear. Cancer risk is a notable example frequently discussed in the literature, and some studies which have sought to estimate the "cancer premium" (see van Houtven *et al.* 2008 for a recent example). Other types of risk which are thought to inspire "dread" include particular types of fatal accident.

Another important risk characteristic which appears to have an influence on WTP is "voluntariness", which can be understood as the choice people have of voluntarily exposing themselves to the risk in question. Research in both psychology and economics has shown that people are more concerned about risks that they perceive to be involuntary (*e.g.* exposure to air pollution) than about risks perceived to be voluntary (*e.g.* smoking) (Fischoff *et al.* 1978 and Slovic 1987). As such, they generally prefer voluntary risks to involuntary ones, suggesting that the degree of "risk voluntariness" could have an impact on the WTP. Closely related is the issue of "controllability", which reflects the extent to which people believe they are able to undertake preventive actions which reduce their exposure to risk.

In a study of Tokyo Metropolitan residents which examined risk characteristics in a systematic manner, Tsuge *et al.* (2005) examined four types of risks: accidents, cancer, heart disease, and general risks. The study showed that voluntariness, controllability, severity, public knowledge and exposure each had a significant and positive impact on the WTP to reduce a given risk. They found a small preference for avoiding cancer risks. Overall, respondents displayed the highest preference for the measures against cancer, and the lowest preference for measures against accidents.

Size of baseline risk and risk reductions

The VSL is usually derived by considering only the WTP for a risk change and the size of the risk change itself. However, WTP may also be influenced by other risks. That is, competing risk reduces the chance that the individual will

benefit from the policy-related risk. This effect is likely to be most important for those most at risk of mortality in general. Given the generally low baseline risks in our study (mortality risks for children associated with environmental pressures), this is unlikely to be important. However, in other cases it may be important, *e.g.* for the elderly and/or those in poor health.

In addition, the size of the proposed risk reduction may affect WTP in a manner which is not strictly proportional, as predicted by theory. Hammitt and Graham (1999) test for two predicted relationships: a) that WTP increases with the size of the risk reduction, and b) for low risks WTP should be virtually proportional to the change in risk. For the 10 studies which contain sufficient information to test scope sensitivity, the studies confirm the first hypothesis that WTP varies with risk reduction, but proportionality is not observed. Overall, a significant minority of respondents report the same WTP regardless of the size of risk change.

While a number of arguments have been put forward to try and explain scope insensitivity, in the context of this study, one possible explanation relates to the problems of communicating low risk levels to respondents. In effect scope insensitivity may not reflect underlying preferences, but rather failings in study design. However, it is also clear from the literature that small risks are difficult for people to understand and judge.

Morbidity

As noted above, some of the most important health benefits associated with the introduction of environmental policies relate to improved health, and not reduced mortality risks *per se*. Clearly many of the issues raised above (*e.g.* context, baseline risks) are relevant to the valuation of morbidity risks. However, it is perhaps the nature of the risk characteristics which pose the most significant complications for the valuation of morbidity, and in particular issues related to dread concerning pain and suffering.

Table 1.1. **Marginal WTP for a Risk Reduction**

Health Endpoint	% attributable to pain and suffering
Respiratory hospital admission	25.87%
Cardiac hospital admission	21.33%
Respiratory emergency department visit	46.73%
Cardiac emergency department visit	23.15%
Reduced activity day	47.92%
Asthma symptom day	57.14%
Acute respiratory symptom day	7.69%

Source: Stieb *et al.* (2002).

The relative importance of these costs for different environment-related health end points can be assessed based on two studies. In one case, Stieb *et al.* (2002) estimate the economic benefits of reducing acute cardio-respiratory morbidity associated with air pollution in Canada (see Table 1.1)[7] In a contingent valuation study undertaken in Strasbourg, France, Rozan (2005) found that pain and suffering represented between 15%-100% of the total value of health impacts related to air pollution. Interestingly, the proportion is highest for children (and the elderly).

Conclusions

All of the issues raised above highlight the complexity of obtaining reliable estimates of WTP for health risk reductions for children. This is exacerbated by the fact than many of these factors are related in complicated ways. For instance, there is, a link between context and age. Indeed, much debate in the VSL literature has focussed on how the age of an individual matters in relation to different risk contexts. By and large this has involved assessing whether VSLs derived in accident contexts (especially road accidents and workplace accidents) are equally applicable to pollution contexts. Accidents tend to affect people of much lower average age than pollution.

In addition, there may well be a link between the degree of latency and age. For instance, the risk associated with air pollution may well be immediate for older people since we know that it is older people who tend to be most affected by air pollution, *i.e.* the risks they face are still acute. But for younger people the risk of immediate premature mortality will be considerably less. The benefit of reducing pollution will accrue to this younger group when they are much older. Distinguishing between age and latency is crucial to understanding the determinants of VSL.

And finally, latency and risk characteristics may also interact. If the latent risk is accompanied by a period of suffering which is "dreaded" then the respondent may well prefer to die immediately than pay for an intervention which increases his chances of surviving for a specific period. Preferences for reducing current and latent mortality risks cannot be divorced from the quality of life associated with the period "survived", and the results cited above concerning "pain and suffering" underscore this point.

Valuing health risks for children

Perhaps, the most important challenge in children's health valuation relates to the impossibility of directly eliciting preferences from children since they do not have command over resources to make trade-offs in actual markets, and may not have the maturity to make such trade-offs in a hypothetical market. Since it is not possible to directly elicit preferences from

children, three alternative perspectives have been proposed to elicit children's preferences indirectly. The first approach is referred to as the "societal perspective", and consists in eliciting preferences from a representative sample of the population, including all adults. The "adult-as-child" perspective, in which the adult respondents are requested to place themselves in the "place" of children is another possibility. Finally, the "parental perspective" can be used, in which parents are asked about the value they place on their children's health.

None of the perspectives is ideal. The societal perspective may be affected by the capacity of the researcher to distinguish between different types of altruism, only some of which should be included in a measure of social WTP to avoid double counting.[8] The "adult-as-child" perspective is very demanding on the respondent, requiring them to think back to their own childhood and assess the risks they faced (and preferences they held) at that time. There is a general consensus in the literature that the parental perspective would appear to be the most promising approach (Viscusi *et al.*, 1987). Although the difficulties associated with properly accounting for people's altruism are also likely to be a major concern with this perspective, it has the advantage of asking the persons who have the interests of the child at heart, and who are used to making decisions on their behalf (see Dockins *et al.* 2002).

The valuation of children's health brings to the fore the problem that the valuation exercise does not take place in the traditional individual context where someone is asked to state a WTP for his/her own risk reduction, but rather in a household context where someone is asked to evaluate a risk reduction for another member of his/her household. As a consequence, the choice of the intra-household allocation model and household-related factors may affect the WTP estimates.

Two types of household allocation model can be used: a unitary model in which the household is treated as a unit and financial resources are pooled, or a collective model in which the individual utility functions of each household member (at least the adults) are pooled to obtain a collective decision, taking account of the differences in household members' preferences. Generally, children are considered as passive participants in family decision-making. But what happens when the child becomes adolescent and is in a better position to express his/her preferences? What about two parents having different preferences concerning their own children? Alternative approaches that could fit better to these particular contexts should also be considered and examined. For further details on the various household allocation models, see Dickie and Gerking (2006).

Irrespective of the model assumed, household-related factors may affect estimates of the value of risk reductions for children. As an example,

the family structure and composition affect resource allocation and health outcomes experienced (Dickie and Ulery, 2002). Some studies have highlighted differences between children according to their health status, gender or age (Pitt and Rosenzweig, 1990; Hanushek, 1992; Liu *et al.*, 2000). Finally, altruism from parents toward their children may significantly affect the estimates and be a source of disparity between adults' values and children's values (Dickie and Ulery, 2001). These results suggest that applying a unique value for all children would lead to unreliable estimates of children's health.

Moreover, a number of the risk factors which are important for valuation in general (*i.e.* context and risk characteristics, age, latency, size of baseline risk and risk reduction, etc.) have particular resonance for the valuation of children's environmental health risks in particular. For instance, the non-linear relationship between age and WTP for risk reductions clearly has important implications for children. However, extrapolating this relationship to childhood would clearly be inappropriate, given that the studies were based only on adult samples. What determines the age-WTP relationship within childhood may be very different from the relationship within the adult population.

In addition, latency can have different implications for risks for children and for adults. On the one hand, there is evidence that parents discount latent impacts differently for themselves than for their children. On the other hand, the issue of latency has particular implications when exposure is incurred in childhood but the health impacts are realised much later as an adult. In the event that risk preferences differ between children and adults, do these differences relate primarily to differences associated with exposure or with response? As such, latent impacts which can manifest themselves ten or more years after the point of exposure raises particular complications for the researcher (and policymaker).

The degree of "voluntarism" of a given risk may also mean something very different for a 6-year old than for an adult. While respondents to a survey may perceive the risks associated with traffic to be voluntary for adults, the very same risks may be perceived as involuntary for children due to the more restricted options, *e.g.* in order to get to school.

Similarly, a risk which is perceived as "controllable" for an adult may be seen as uncontrollable for children. Even if a defensive expenditure is undertaken as a means to reduce risk, the parent may feel that they have "imperfect control" over its ability to protect their child from a given risk. Mitigation of the risk of skin cancer from UV rays through the application of suntan lotion may represent such a case. Another case might be the purchase of bicycle or motorcycle helmets.

And finally, the issue of dread may be understood very differently for children than for adults. It is quite possible that dread may be very different for a similar risk (in terms of context) which affects children than adults. For instance, the perception of welfare losses attributable to the pain and suffering associated with some types of risks may be different for children and adults.

Review of previous epidemiological and economic studies

Given these difficulties, it is hardly surprising that epidemiological and economic evidence on children's environmental health is limited. The lack of available data specific to children precludes an evaluation of the health impacts of existing environment-related health policies. More studies are necessary, particularly on specific health endpoints comparable to those for adults, such as chronic asthma morbidity. Therefore, priority should be given to the collection and assessment of epidemiological data to implement valuation studies to provide meaningful policy advice. However, improved epidemiological data of this sort is not sufficient. Ignoring valuation differences between adults and children could lead to biased estimates of health benefits associated with a reduction of environmental risk and therefore to inefficient and wasteful policies.

Some of the most important health impacts associated with air and water pollution are listed in Tables 1.2 and 1.3. However, these are based upon general epidemiological studies on adult populations. A paper prepared by Hunt and Arigoni Ortiz (2006a) for this project reviews the epidemiological evidence on the relationship between environmental exposures and adverse health impacts for children.[9] The review highlights the emphasis on air pollution (PM, NO_2, CO) in epidemiological research. However, there are some studies that relate to other environmental pressures (*e.g.* pesticides) and that find some evidence of adverse health impacts. The impacts of exposure to lead and other heavy metals on cognitive capacity have been the subject of numerous studies.

In general, the evidence from mortality studies is limited compared to that from morbidity studies. For instance, almost all of those studies that have been conducted in European countries have focused on morbidity, not mortality. Nonetheless, the evidence suggests that children are susceptible to exposure to environmental pollution, with the health endpoints of most importance being air pollution-induced mortality and respiratory symptoms, and perhaps cancers associated with pesticide use. (See Annex for a summary of some of the most important studies.)

Differences in the estimation of the benefits associated with the introduction of environmental policies arise not only from differences in the

Table 1.2. **Health Effects Associated With Selected Water Pollutants**

	Disease/Pollutant	Health impacts
Bacterial	Amoebic dysentery	Abdominal pain, diarrhoea, dysentery
	Capbylobacteriosis	Acute diarrhoea
	Cholera	Sudden diarrhoea, vomiting. Can be fatal if untreated
	Cryptosporidiosis	Stomach cramps, nausea, dehydration, headaches. Can be fatal for vulnerable populations.
Chemical	Lead	Impairs development of nervous system in children; adverse effects on gestational age and fetal weight; blood pressure
	Arsenic	Carcinogenic (skin and internal cancers)
	Nitrates and nitrites	Methaemoglobinaemia (blue baby syndrome)
	Mercury	For fetuses, infants, and children, the primary health effect of mercury (in the form of methylmercury) is impaired neurological development. At high doses, mercury is also known to induce higher incidences of kidney damage, some irreversible.
	Persistent organic pollutants	These chemicals can accumulate in fish and cause serious damage to human health. Where pesticides are used on a large-scale, groundwater gets contaminated and this leads to the chemical contamination of drinking water.

Source: EEA/WHO-Europe (2002).

Table 1.3. **Health Effects Associated With Selected Air Pollutants**

Pollutant	Short-term effects	Long-term effects
PM	– Increase in mortality – Increase in hospital admissions – Exacerbation of symptoms and increased use of therapy in asthma – Cardiovascular effects – Lung inflammatory reactions	– Increase in lower respiratory symptoms – Reduction in lung function in children and adults – Increase in chronic obstructive pulmonary disease – Increase in cardiopulmonary mortality and lung cancer – Diabetes effects – Increased risk for myocardial infarction – Endothelial and vascular dysfunction – Development of atherosclerosis
O_3	– Increase in mortality – Increase in hospital admissions – Effects on pulmonary function – Lung inflammatory reactions – Respiratory symptoms – Cardiovascular system effects	– Reduced lung function – Development of atherosclerosis – Development of asthma – Reduction in life expectancy
NO_2	– Effects on pulmonary structure and function (asthmatics) – Increase in allergic inflammatory reactions – Increase in hospital admissions – Increase in mortality	– Reduction in lung function – Increased probability of respiratory symptoms – Reproductive effects

Source: Adapted from WHO (2004b; 2006).

risks faced by different populations (*e.g.* adults and children), but also differences in the values which society attributes to risk reductions for different populations. While there are relatively few studies that have sought to value the benefits of health risk reductions for children which are explicitly related to environmental exposures, there are a number of studies which have estimated the WTP to reduce health risks associated with other causes for children and adults.

Although the evidence is mixed, most of the studies concluded that the WTP to reduce mortality risks to children was greater than the WTP to reduce similar risks to adults. Table 1.4 provides a summary of some recent studies in which values (mortality and morbidity) have been estimated for both adults and children, while the Annex discusses these and other relevant studies in more detail.

The objectives of the VERHI project

In the area of children's environmental health risks, policymakers have been forced to make decisions and set priorities on the basis of very limited evidence and limited information. This raises a question on the appropriateness of policies currently in place that have significant implications for children's health.

Environmental standards are generally based on evidence related to their impacts on adult populations, which may be quite different from those for children. Proper valuation of impacts on children may well result in standards which are different from those currently in place. Analogously, policy priorities across different environmental health impact areas are based on values obtained for adult populations which may be inappropriate for children. In such cases, governments are not allocating investments cost-effectively so as to avoid loss of lives or reduce ill-health. It is, therefore, important to obtain values for environmental health risk reductions specifically for children. Moreover, it is important that these values be comparable to those obtained for adult populations in order to set policy priorities in an optimal manner.

The rest of this document discusses how this was done in the context of the VERHI project. The next chapter reviews some of the main methodological concerns associated with addressing environmental health impacts for children. Chapter 3 summarises the survey development work which was undertaken in order to ensure that the surveys implemented generated credible estimates. Chapter 4 provides a summary of the main results of the project. The document concludes with a discussion of policy implications.

Table 1.4. **Estimates of VSL and WTP for Children and Adults**

Study	Country	Valuation Method	Benefits Measure	Value
Mortality				
Takeuchi *et al.* (2008)	Japan	Contingent valuation	Societal WTP to reduce fatality risks	VSL (in Yen billion)
				1.17 to 7.74 (child)
Mount *et al.* (2000)	United States	Averting behaviour – automobile safety purchases	Parental WTP to reduce fatality risks	VSL (in USD million)
				7.3 (child)
				7.2 (adult)
				5.2 (elderly)
Jenkins *et al.* (2001)	United States	Averting behaviour – child bicycle helmets	Parental WTP to reduce fatality risks to children	VSL (in USD million)
				2.9 (child of 5-9)
				2.8 (child of 10-14)
				4.3 (adult)
Hammitt and Haninger (2010)	United States	Contingent valuation	Parental WTP to reduce fatal-disease risks by consuming pesticide residues on food	VSL (in USD million)
				12.4 (child)
				7.5 (adult)
Morbidity				
Liu *et al.* (2000)	Taiwan	Contingent valuation	Mother's WTP for preventing a cold to her and her child	USD 57 (child)
				USD 37 (mother)
Agee and Crocker (2001)	United States	Contingent valuation	WTP for a 10% increase of the health status of the child and the respondent	USD 452 (child)
				USD 249 (adult)
Dickie and Ulery (2001)	United States	Contingent valuation	WTP to avoid seven days of one symptom	USD 150 to USD 350 (child)
				USD 100 to USD 165 (adult)
			WTP to avoid one-week incident of acute bronchitis	USD 400 (child)
				USD 200 (adult)
Dickie and Brent (2002)	United States	Contingent valuation	WTP to avoid one day of first symptom	USD 92 (child)
				USD 35 (adult)
Braun Kohlová and Scasny (2006)	Czech Republic	Contingent valuation	WTP to reduce mild bronchitis	EUR 38 (child)
				EUR 21 (adult)
Dickie and Gerking (2001)	United States	Contingent valuation	WTP for a 1% reduction in non-melanoma exposure to skin cancer risk	USD 3.18 (child)
				USD 1.29 (adult)

Notes

1. Studies included in the review include: Holland and Krewitt, 1997; Holland *et al.* 1999; Krewitt *et al.*, 1999; IVM, NILU and IIASA, 1998; Olsthoorn *et al.*, 1999.
2. It is important to note that both studies did not include monetised estimates of the benefits of certain health (*e.g.* from toxic pollutants) and non-health (ecosystem damage) impacts.
3. See Schnier *et al.* (2009) for a somewhat different approach, based on a commercial fishing vessel captain's decision to go fishing in the Alaskan red crab fisheries as a function of weather and policy variables intended to improve safety. Schnier *et al.* (2009) obtain VSL values of USD 4.6-4.9 million, and attempt to disentangle the value of crew members from that of the vessel's captain.
4. This is discussed below.
5. An example is climate policy, see Arrow *et al.* (1996) for a discussion.
6. US EPA (2000) lists the following pairs of risk characteristics: voluntary/involuntary; controllable/uncontrollable; ordinary/catastrophic; delayed/immediate; natural/man-made; old/new; necessary/unnecessary; and occasional/continuous. There can be a high correlation between some of the pairs listed. In this sub-section we focus on the first three. The fourth pair has been discussed above in the context of latency. Aspects related to the last pair are discussed below.
7. In estimating the value of pain and suffering, the researchers mapped symptoms and activity restrictions to the various health outcomes identified in epidemiological and clinical studies.
8. See Takeuchi *et al.* (2008) for a recent example in which an effort is made to disentangle the two types of altruism in the context of child mortality using a societal perspective.
9. *www.oecd.org/dataoecd/16/21/39338429.pdf*

ANNEX 1.A1

Review of the Epidemiological and Economic Evidence

As noted above, part of the motivation for this study was the perception that environmental health risks for children are significant and distinct from that for adults. It is important, therefore, to review the epidemiological evidence on the relative importance of such risks. Moreover, robust measures of the value of health concerns for children based upon stated preference methods require the use of scenarios which reflect risks which are meaningful to respondents. Since the valuation of health end-points depends on quantification of the risk, it is necessary to know for which end-points there was solid epidemiological evidence.[1]

This Annex, which draws extensively, upon reports by Hunt and Arigoni Ortiz (2006a and 2006b), reviews the relationship between children's health and the environment, summarising the characteristics of the main health outcomes associated with children's environmental exposures. It also provides a review of the economic studies which have been undertaken which relate (sometimes indirectly) to the valuation of environmental health risks for children. Studies which relate to both morbidity and mortality are included in the review.

Review of the Epidemiological Studies

Mortality studies

Only a few epidemiological studies have focused on the association between child-mortality and environmental hazards, and a causal relationship has been found for at least some studies in the case of air pollution. Some studies have established a relationship between different environmental risk factors and potential chronic diseases such as cancer, but these studies are presented in the next section, which addresses morbidity.

Several epidemiological studies based on time-series data analysis have identified causality between exposure to specific air pollutants and mortality in children. For instance, Currie and Neidell (2005) found that carbon monoxide

(CO) had a significant effect on infant mortality in California (US). In Sao Paulo (Brazil), Conceicao *et al.* (2001) observed a significant association between respiratory mortality in children and daily levels of CO, sulphur dioxide (SO_2), and particulate matter (PM_{10}). Similarly, Lin *et al.* (2004) also showed a consistent relationship between exposure to PM_{10} and SO_2 and daily neonatal mortality with a short time lag in Sao Paulo (Brazil). These results confirmed those of previous studies on similar issues led in the US (Chay and Greenstone, 1999) and Brazil (Saldiva *et al.*, 1994).

Woodruff *et al.* (1997) evaluated the relationship between infant mortality and PM_{10} in the US, through analysis of a cohort of approximately four million infants between 1989 and 1991. The study focused on four infant death causes: sudden infant death syndrome with normal birth weight; and, respiratory deaths for normal birth weight and low birth weight infants; and all-cause mortality. The odds-ratio[2] for all-cause mortality for the high exposure group *versus* the low exposure group was 1.10; for sudden infant death syndrome, the odds-ratio was 1.26; for respiratory deaths in normal birth weight infants, the odds-ratio was 1.40, while for low birth weight infants, high exposure was not significantly associated with mortality from respiratory diseases. Woodruff *et al.* (1997) concluded that exposure to PM_{10} was associated with increased risk of post-neonatal mortality.

Morbidity studies

Many epidemiological studies have focused on the impact of air pollution on children's health. For instance, Gauderman *et al.* (2005; 2007) and McConnell *et al.* (2006) found that the proximity to major roads and freeways increased the prevalence of asthma and wheezing for children living in Southern California (US). Gauderman *et al.* (2007) found that local air pollution had detrimental and independent effects on lung functions, resulting in pronounced lung function deficit at the age of 18. Chauhan *et al.* (2003) found a positive association between high exposures to NO_2 and the severity of resulting asthma exacerbation in 8-11 year old children in the UK.

However, Penard-Morand *et al.* (2005) did not find any consistent positive relationship between NO_2 and asthma. The same study found that an increase in the exposure to PM_{10}, SO_2 and ozone was positively related to increased prevalence of asthma and allergic rhinitis. More recently, Brauer *et al.* (2007) used data from a Dutch birth cohort of children between 0 to 4 years of age, and they found a significant and positive association between traffic-related air pollution and asthma and wheezing, as well as with several types of respiratory infections (*e.g.* ear, nose, and throat infections; flu and serious colds). Other studies which find some evidence of a link between respiratory diseases and air pollution in include Segala *et al.* (2008), Hertz-Picciotto *et al.* (2007), Dales *et al.* (2006) Triche *et al.* (2006), Pierse *et al.* (2006) and Zhang *et al.* (2002). Exposure to air pollution was

also found to be associated with low birth weight in several case studies (see for example Bobak and Leon, 1999; Dugandzic *et al.*, 2006; Bell *et al.*, 2007), and with developmental delays at age 3 (Perera *et al.*, 2006).

Although outdoor air pollution is still the focus of the largest number of studies (in particular, traffic-related air pollution), other environmental hazards have been considered in the literature, both in OECD and non-OECD countries. For instance, there is an increasing interest in the linkages between indoor air pollution (mainly as environmental tobacco smoke – ETS) and child-morbidity. Tanaka *et al.* (2007) studied the relationship between passive smoking at home and the prevalence of allergic disorders in Japanese schoolchildren; they estimated a relative risk[3] of 1.33 of incident asthma among 6-18 year old children. Lewis *et al.* (2005) and Crain *et al.* (2002) also found a significant association between ETS and childhood asthma in the UK and the US, respectively. Rauh *et al.* (2004) observed negative impacts of early exposure to ETS on mental development at 2 years of age in New York City (US), using data from a birth cohort. Similar results were obtained by Yolton *et al.* (2005), who determined an inverse relationship between exposure to ETS and cognitive and academic abilities among 6-16 year old US schoolchildren, even at low exposure levels.

Lead and other heavy metals have also received attention from researchers. Lead exposure was found to be associated with decreased cognitive performance in children by Lanphear *et al.* (2005), who used data from birth cohorts in the US, Mexico, Australia and the former Yugoslavia. As another example, mercury, especially methylmercury, has been consistently linked to impaired cognitive performance (Axelrad *et al.*, 2007) and damaged brain functions (Grandjean *et al.*, 1997). Arsenic exposure may have similar effects on children, as suggested in Rosado *et al.* (2007), Wang *et al.* (2007) and Wasserman *et al.* (2007).

Many recent studies have focused on chemicals and pesticides. For example, Gouviea-Vigeant *et al.* (2003) investigated the link between exposure to some chemicals (solvents, pesticides and petrochemicals) and childhood cancers in the US. They found that exposure to such chemicals may increase the likelihood of childhood leukaemia and other cancers (in particular brain and central nervous system cancers); however, it was not possible to find evidence of cancer from exposure to specific chemicals. Indeed, mixtures or groups of chemicals (*e.g.* pesticides, hydrocarbons and solvents) were more likely to affect children's health. Their analysis also showed that early-life exposure significantly increased the likelihood of cancer.

Zahm and Ward (1998) reviewed the epidemiological studies analysing the linkages between exposure to pesticides (for both adults and children) and several types of cancers (*e.g.* leukaemia, lymphoma and sarcoma). They found that exposure of children to pesticides resulted in greater risks of cancers, suggesting that children may be particularly sensitive to the carcinogenic effects

of pesticides. Rudant *et al.* (2007) also found a significantly positive association between use of domestic pesticide (at the household level) and childhood blood diseases in France. Similar results were obtained by Menegaux *et al.* (2006) who investigated the impact of pesticide exposure on childhood leukaemia in France.

Only a few studies have analysed the effects of water pollution on children's health. Schwartz *et al.* (1997) investigated the linkages between drinking water turbidity and gastrointestinal illnesses in the US. They found that an increase in water turbidity consistently resulted in increased emergency visits and hospital admissions for gastrointestinal diseases. As another example, Xiong *et al.* (2007) examined the impact of fluoride in drinking water on liver and kidney functions in Chinese children. They found that drinking water fluoride levels above 2 mg/l can seriously damage liver and kidney functions in children. Finally, as mentioned above, elevated arsenic levels in drinking water were associated with impaired cognitive performance in China (Wang *et al.*, 2007) and in Bangladesh (Wasserman *et al.*, 2007).

Discussion

The review of the epidemiological literature highlights the emphasis on air pollution in epidemiological research, either because it is a high-priority issue in political agendas or because of data availability. Evidence from mortality studies is limited, compared to that from morbidity studies. Those studies which have been conducted in European countries have focused on morbidity, not mortality. Nonetheless, the evidence suggests that children are susceptible to exposure to environmental pollution, the health endpoints of most importance being air pollution-induced mortality and respiratory symptoms, and perhaps cancers associated with pesticide use.

Although the literature suggests a causal relationship between exposure to air pollution and mortality or morbidity in children, the complex interdependencies among variables should be borne in mind when interpreting the findings of at least some mortality studies. In addition, new "confounding" factors are still being identified. For example, Braga *et al.* (2000) investigated the potential confounding effect of respiratory epidemics on deaths associated with air pollution. They argued that controlling for influenza epidemics could result in an under-estimation of all respiratory epidemics. However they also concluded that the association between air pollution and respiratory-related deaths was still robust, even after having controlled for all types of respiratory epidemics.

Another type of confounding effect is the potential synergy of environmental pollution, either with other pollutants or with individual behaviour (*e.g.* smoking). Synergistic effects occur when the damage caused by two or more pollutants is greater than the effect caused by each individual pollutant acting alone. For instance, Lin *et al.* (2004) showed that the combined effects of PM_{10} and SO_2 on daily neonate mortality was stronger than the combined effects of the two

pollutants on their own, suggesting a potential synergy between PM_{10} and SO_2. They also concluded that primary pollutants correlated strongly with each other, and that PM_{10} presented the highest correlations with other pollutants. Unfortunately there is no evidence which relates specifically to children.

Finally, it should be noted that only studies providing empirical support for the existence of a relationship between exposure to environmental pollution and adverse health effects on children have been presented here. It must be emphasised that other studies carried out on similar issues did not find any significant relationship. For example, Lewis *et al.* (2005) found no evidence of association between living near a main road and wheezing or asthma. Similarly, Gouveia and Fletcher (2000) did not establish causality between exposure to air pollutants and mortality in children under 5 years old (RR = 0.921 for NO_2 and respiratory mortality, and RR = 1.141 for CO and pneumonia).

Review of Valuation Studies

Given the relative paucity of economic studies provide estimates of WTP for risk reductions for children related to environmental exposures this review includes a discussion of both COI and WTP studies in two sub-sections. As with the review of the epidemiological literature the studies reviewed include both those which relate to morbidity and those which relate to mortality. And finally, those studies which estimate WTP for both children and adults are discussed in a final sub-section.

Cost of illness studies

The measurement of COI for children is particularly problematic. In particular, the value of the "lost productivity" component of COI for a child is particularly uncertain. Depending upon the nature of the health impact, it may refer to future earning losses (when the child is an adult) or to parental productivity losses (when parents stay at home to care for their sick children, *i.e.* when the parents act as caregivers). In principle, it could therefore result in COI for children that is lower than (or equal to) equivalent COI for adults.

Aggregation of COI to derive an estimate of the social benefits of a risk reduction is usually done on the basis of an environmentally attributable fraction (EAF) model, in which EAF is defined as "the percentage of a particular disease category that would be eliminated if environmental risk factors were reduced to their lowest feasible levels" (Smith *et al.*, 1999). The EAF is therefore a composite value that is computed as the product of the incidence of a risk factor, multiplied by the relative risk associated with that risk factor (Landrigan *et al.*, 2002). Using that approach, social costs are computed as follows:

$$\textit{Costs} = \textit{disease rate} \times \textit{EAF} \times \textit{population size} \times \textit{cost per case}.$$

"Disease rates" are estimated by incidence or prevalence rates (depending upon information availability); and "cost per case" represents discounted lifetime expenditures ("cost of illness"). Although the determination of disease rates and EAF may be subject to uncertainty, the estimation of "cost per case" is even more controversial. A selection of recent studies estimating COI values for specific health outcomes or aggregated COI is presented here.[4]

Respiratory diseases

Weiss *et al.* (2000) assessed the costs of childhood asthma in the US in 1994. The total estimated costs of childhood asthma in 1994 were EUR 2.86 billion. Direct medical expenses were estimated to be EUR 1.75 billion and accounted for 62% of total costs. 80% of indirect costs (EUR 0.85 billion) were attributable to lost work productivity through disability.

Schramm *et al.* (2003) calculated the cost of illness of atopic asthma and seasonal allergic rhinitis (SAR) in Germany. They estimated the average annual cost of SAR to be EUR 1080 per child and EUR 1530 per adult. When adding the costs of severe asthma, total annual costs for the two health outcomes were estimated at EUR 7860 for a child and EUR 9207 for an adult. For children, 60 to 78% of the expenditures were direct costs, while 58% of adults' expenditures were indirect costs. The authors also concluded that these costs were increasing with the severity of atopic asthma and/or SAR.

Waterborne diseases

Lorgelly *et al.* (2008) assessed the cost of illness of gastroenteritis in children in the UK. The average cost for a child was estimated to be between EUR 85 and EUR 202 per episode. Based on the prevalence of this disease in the UK, the study concluded that gastroenteritis annually costs EUR 13 million to society as a whole.

Dasgupta (2004) assessed the value of damages from contaminated water supplies in India, to derive total costs of illness. The average cost of treatment of waterborne diseases was estimated at EUR 8 for a child, EUR 5 for an adult and EUR 7 for an elderly person. Wage loss due to illness was estimated to be EUR 3.5 per household. This led to an annual cost of illness of EUR 108 per household. Given that there were 150 748 households in urban Delhi, this led to an annual total cost of EUR 16.28 million for the whole population of Delhi.

Cognitive and developmental delays

Grosse *et al.* (2002) evaluated the economic benefits of reducing children's exposure to lead in the US. Discounted lifetime earnings were estimated at EUR 646 000 for each 2 year-old (using a 3% discount rate). Given that there were approximately 3.8 million 2 year-old children in the US in 2002, the total

benefits of reducing childhood lead exposure ranged between EUR 98 billion and EUR 285 billion.

Korfmacher (2003) assessed the benefits of eliminating lead poisoning in children in New York State (US). Healthcare benefits (*i.e.* direct treatment) were estimated to be EUR 2.7 million and increased potential earnings EUR 693 million (applying a 3% discount rate). Although the healthcare costs of lead poisoning in New York State were quite significant, these values probably under-estimated the true costs because some of the most costly impacts of lead (*e.g.* osteoporosis, hypertension, stroke and neonatal mortality) could not be quantified when the study was undertaken.

Similarly, Stefanak *et al.* (2005) evaluated the costs of childhood lead poisoning in Mahoning County, Ohio (US). Screening and treatment costs were estimated to be almost EUR 112 000 per child. They also assessed the future costs for the cohort of lead-poisoned children (with blood level greater than 10 mg/dl) age 12-71 months in 2002 to be EUR 1.4 million, using a 3% discount rate.

Trasande *et al.* (2005) calculated the cost of illness of exposure to methylmercury in the US, with a particular focus on the impacts on the developing brain. They estimated that lost productivity associated with methylmercury toxicity cost EUR 7.8 billion per year, applying a 3% discount rate. Of this total, the study concluded that EUR 1.2 billion was attributable to mercury emissions from US power plants.

Miller *et al.* (2006) estimated the costs of early-life exposure to ETS and developmental delays, in New York City (US). They estimated the costs of early intervention services per year due to ETS to be EUR 88 million per year for all New York City births, based on a 3% annual discount rate.

Nevin *et al.* (2008) estimated the monetary benefits of preventing childhood lead poisoning in the US by replacing old windows with lead-safe windows. The benefits per child from improved lifetime earnings were estimated to be EUR 18 934 for pre-1940 housing and EUR 7 758 for 1940-59 housing. This analysis did not take into account potential ancillary health benefits associated with the reduction of lead exposure in children (*e.g.* avoided medical costs of treatment and avoided special education in later life associated with attention deficit hyperactivity disorders).

Multiple health endpoints

Carabin *et al.* (1999) described the costs of illness of three common infections in toddlers: colds, diarrhoea and vomiting. They followed a cohort of 273 toddlers attending day care centres in Quebec, Canada. Total direct costs were estimated to be almost EUR 73 per child, while indirect costs were estimated to be EUR 129.

Landrigan *et al.* (2002) estimated the costs of paediatric environment-related diseases in the US. They focused on four major childhood diseases: lead poisoning (EAF = 100%), asthma (EAF = 30% – range: 10-35%), childhood cancers (EAF = 2, 5 and 10%) and neurobehavioral disorders (EAF = 10% – range: 5-20%). The present value was calculated using average annual earnings for full-time and part-time employees, labour force participation rates, estimates of annual home production loss, and a real discount rate of 3%. They estimated that:

- lead poisoning costs were EUR 43.3 billion;
- asthma costs were EUR 1.8 billion;
- cancer costs were EUR 0.27 billion; and
- neurobehavioural disorders costs were EUR 8.2 billion.

Total annual costs were estimated to be EUR 49 billion, which represented 2.8% of total US health care costs at that time.

Massey and Ackerman (2003) estimated the costs associated with five major environment-related health problems that significantly affect children: cancer, asthma, lead poisoning, neurobehavioral disorders and birth defects. Total costs for one year were estimated to be EUR 3 billion. When applying an EAF, their estimates ranged from EUR 0.5 billion to EUR 1.4 billion per year for Massachusetts alone. Discounting of nonmonetary future events was not included in the calculations.

Davies (2005) assessed the cost of environmental diseases that affect children in Washington State (US), also based on the EAF approach. Again, the discount rate used in the calculations was not specified. Cost estimates are presented in Table 1.A1.1. The total costs of these childhood diseases were estimated at EUR 1 675 million, of which EUR 1 429 million were indirect costs.

Table 1.A1.1. **Costs of Selected Childhood Diseases in Washington State**
(2006 EUR million)

Disease	Cost estimate
Child asthma	EUR 44
Childhood cancer	EUR 10-14*
Lead exposure	EUR 1340
Birth defects	EUR 3.8-5
Neurobehavioral disorders	EUR 64.7-273*

* Different methods were used to estimate these costs, hence a range of values is provided.

Source: Davies (2005).

Hutchings and Rushton (2007) evaluated the economic burden of childhood diseases in Europe. Based upon the EAF approach, they estimated the costs of illness associated with cancer, asthma, neurodevelopmental disorders and lead poisoning. Total costs were estimated to be above EUR 16 billion with EUR 174 million for cancer, EUR 3 billion for asthma, EUR 3 billion for neurodevelopmental disorders, and EUR 9.9 billion for lead poisoning. The authors highlighted that direct costs represented the major share of the total costs associated with childhood cancer and asthma. All costs except for lead poisoning were discounted at an annual rate of 3%.

The main findings from this review of COI studies are:

- Estimated productivity losses associated with childhood illnesses are generally greater than direct medical costs.
- Diseases presenting cognitive/developmental delays and/or neurobehavioural disorders generate extremely high costs, in particular with respect to other childhood diseases, such as cancers and asthma.
- The financial costs (direct and indirect costs) of childhood illnesses are very large, although even these do not account for intangible aspects, suggesting a potential under-estimation of the true costs.

Willingness to pay studies

As mentioned above, cost of illness values represent only the financial costs of a disease, and do not include intangible costs, such as pain and suffering, or the inability to enjoy leisure activities. Willingness to pay (WTP) studies provide values that account for intangible aspects of disease, because they measure individual preferences, which include all sources of utility and causes of disutility to the individual.

WTP values to avoid a given risk can be obtained either from revealed preference studies (based on observed purchasing behaviour) or from stated preference studies (based on hypothetical behaviour). Revealed preference studies use indirect methods to value the monetary amount required to accept a variation in the risk level. They assume that individuals reveal their preferences through consumption and expenditures which are related to health impacts. This is done by using information available on different markets, such as the labour market, the housing market, and the safety products market. The “hedonic” method and the “averting behaviour” method are revealed preference techniques.

Stated preference approaches estimate the *ex ante* valuation of a variation in individual welfare related to the variation of the status of individuals exposed to a particular health risk. These studies present people with a hypothetical scenario (via telephone, postal or individual survey), and ask them about their maximum WTP to compensate for a variation in their well-being. These studies

ultimately provide estimates of WTP values for a reduction in health risk, or analogously, willingness-to-accept (WTA) values for an increase of health risk.[5]

Stated-preferences techniques (the contingent valuation method, the conjoint analysis methods[6]) can be applied to value a reduction in mortality risk. The WTP value obtained (*i.e.* the WTP to reduce mortality probability) is then used to derive the value of a statistical life (VSL).[7] However, stated-preferences techniques are not specific to mortality risk valuation, and can be also used to value morbidity endpoints.

Only a few studies have so far dealt with the valuation of reducing health risks for children, and most of these were not specific to the environmental context. However, since most of the studies are valuing personal safety questions, they still contribute to a better understanding of the value parents place on children's health. In addition, some of the health outcomes valued could also be associated with environmental degradation (even though they were not stated as such in the associated surveys), and corresponding WTP could therefore be used in environmental policy-making. A review of the limited evidence available is proposed below.[8]

Mortality studies

Joyce *et al.* (1989) measured the impact of air pollution on neonatal mortality rates, using a health production function, and focussing on the WTP of mothers to reduce air pollution levels. The marginal WTP for prenatal care ranged between EUR 2 and EUR 7, depending on individual characteristics. The marginal WTP for neonatal care was higher, between EUR 29 and EUR 198, suggesting a higher WTP for younger infants. From these WTP values, Dickie and Nestor (1998) derived estimates of infants VSL, ranging between EUR 77 000 and EUR 2.6 million.

Carlin and Sandy (1991) calculated the implicit value of a young child's life as revealed by the decisions of the mother about using a child car safety seat. The data came from a survey implemented in 1985 and were used in a utility maximisation approach. The value of a child's life was derived from the mother's probability of purchasing and properly using a car seat. Fatality risk reductions were considered, along with the time and money costs of raising a child to the age of 18. The VSL of a child under the age of five was estimated to be EUR 942 000.

Blomquist, Miller and Levy (1996) estimated the implied values of reducing fatal and non-fatal injuries risks for different road user populations: adults, children and motorcyclists. They incorporated time and disutility costs associated with car seat belt and motorcycle helmet use. The data were obtained from a 1983 survey, which has included parents with children under the age of five. The VSL for a child ranged between EUR 5.16 million and EUR 9.22 million, while the value to reduce child non-fatal injury was EUR 218 000. These values

compared with equivalent values for adults (VSL of EUR 3.47 million and EUR 99 000 for a non-fatal injury) and for motorcyclists (VSL of EUR 2.38 million and EUR 75 000 for a non-fatal injury).

Mount, Weng, Schulze and Chestnut (2001) examined family automobile purchases, to estimate the amount of money spent on safety, and then to derive the VSL of different age groups (children, adults and the retired). They applied a hedonic price function on data from a 1995 survey (aggregated data). Central estimates derived suggested that children had a VSL of EUR 11.6 million, while adults had a VSL of EUR 11.3 million and the retired persons had a VSL of EUR 8.2 million.

Jenkins, Owens and Wiggins (2001) estimated the parental values of reduced fatality risk to children, by examining the market for child bicycle helmets. The value of reducing mortality risk was computed for 5-9 and 10-14 year-old children. Data from a survey were used in a utility maximisation model. The estimated VSL for helmet users varied between EUR 1.6 million and EUR 3.4 million (5 to 9 years); and EUR 1.4 million and EUR 3.3 million (10 to 14 years), according to different assumptions.

Takeuchi *et al.* (2006) conducted a contingent valuation survey in Japan, to estimate the parental WTP to reduce child mortality. The median WTP to reduce annual child mortality by 1% was 7 500 yen, while the median WTP to reduce annual child mortality by 5% was 11 000 yen. Based on the first value, they derived the VSL for a child of 980 million yen.

Morbidity studies

Viscusi, Magat and Huber (1987) implemented a contingent valuation survey in the US to estimate the individual WTP to prevent the risk of injury associated with two injuries: poisoning from insecticide and poisoning from toilet bowl cleaner. Injuries were proposed, depending upon whether the respondent had young children or not. WTP estimates are presented in Table 1.A1.2.

Table 1.A1.2. **WTP to Prevent Injuries Associated with Pesticides**
(2006 EUR)

Reduction of risks from insecticide: ● Skin poisoning: EUR 1 101 (individuals without young children) ● Inhalation: EUR 1 276 (both subsamples) ● Child poisoning: EUR 2 555 (individuals with young children)
Reduction of risks from the toilet bowl cleaner: ● Eye burns: EUR 545 (individuals without young children) ● Chloramine gassings: EUR 815 (both subsamples) ● Child poisoning: EUR 902 (individuals with young children)

Source: Viscusi *et al.* (1987).

Reductions of risks from insecticides were therefore valued more than injuries from toilet bowl cleaners. In particular, reducing child poisoning risk from insecticide products was valued almost three times more than reducing child poisoning from toilet bowl cleaner, which was presented in the survey as less risky than the former. Moreover, the WTPs to reduce risks to children were greater than the WTPs to reduce similar risks to adults.

Agee and Crocker (1996) estimated the benefits associated with children morbidity risks related to a low-level lead exposure. The study inferred the parents' WTP to reduce the risk of neurological impairments for children due to exposure to lead, both from parents who chose chelation as treatment for their child and from parents who did not choose chelation as treatment. The WTP of parents who chose chelation was EUR 138 per child, while the WTP of parents who did not choose chelation was EUR 14 per child. The overall mean WTP was estimated to be EUR 21 per child. Aggregated benefits for a 1% reduction in child body lead burden (over the number of US metropolitan households in 1984) ranged from EUR 216 million to EUR 2 billion. The study also noted that the parental *ex ante* WTP for a 1% reduction in child body lead burden exceeded the estimated cost-of-illness associated with the same reduction.

Liu *et al.* (2000) carried out a contingent valuation study in Taiwan to estimate a mother's WTP for preventing herself and her child from getting a cold. The mean WTP to prevent the child from getting a cold was EUR 51, while the mean WTP to prevent the mother from getting a cold was EUR 33. The mother's WTP to prevent her child from suffering a cold was approximately twice as large as her WTP to prevent herself from getting a cold of comparable duration and severity.

Dickie and Gerking (2001) implemented a contingent valuation survey to estimate the parental WTP to reduce skin cancer from solar radiation exposure, for their children and for themselves. Both melanoma and non-melanoma skin cancer risks were considered. WTP for a 1% point reduction in non-melanoma skin cancer risk was estimated at EUR 2.84 for the child and EUR 1.15 for the parent, again showing that parents were willing to pay more to reduce non-melanoma skin cancer risks to their children than to themselves.

Agee and Crocker (2001) estimated the annual WTP to increase their own and children's health, as well as the parental WTP to reduce their child's daily exposure to environmental tobacco smoke. The study focused on smoking parents and analysed parents' consumption of tobacco products and their assessment of their children's exposure to environmental tobacco smoke. The WTP for a 1% reduction in child exposure to tobacco smoke was EUR 9. The WTP for a 10% improvement in child health status was EUR 404, while the same WTP for the parent was EUR 222. These results suggested that parents valued their children's health twice as much as their own health.

Dickie and Messman (2004) implemented a stated-preference study to evaluate the parents' WTP to avoid acute illnesses. They found that WTP for avoiding episodes was less for parents than for children (Table 1.A1.3).

Table 1.A1.3. **WTP to Avoid Acute Illnesses**
(2006 EUR)

Mean WTP to avoid one symptom for one day: EUR 45
Mean WTP to avoid seven days of one symptom: ● For the child: EUR 134-313 ● For the parent: EUR 89-147
Mean WTP to avoid one-week incident of acute bronchitis: ● For the child: EUR 357 ● For the parent: EUR 179

Source: Dickie and Messman (2004).

Accounting for the endogeneity of behavioural responses to illness (*e.g.* use of medical care and absence from work or school), Dickie and Brent (2002) estimated that the mean WTP to avoid one day of symptom was EUR 84 for children and EUR 31 for adults.

Maguire, Owens and Simon (2004) measured the value of reducing babies' exposures to pesticide residues. They used hedonic methods and analysed data from observed consumption behaviour in the baby food market. They inferred the consumers' premium for organic baby food, and found that parents were willing to pay EUR 0.09-013 per jar more for organic food than for conventional varieties, *i.e.* an annual price premium of EUR 66 (600 jars × 0.11). This is approximately 16-27% more than traditional baby food. This premium could be interpreted (at least in part) as a desire to avoid pesticide residues in baby food.

Amin and Khondoker (2004) assessed the parental WTP to avoid an episode of diarrhoea in a contingent valuation survey in India, focusing on children between 5 and 7 years. The median WTP for male children was EUR 0.64, whereas the median WTP for female children was EUR 0.48, *i.e.* 34% lower than the WTP for male children.

Braun Kohlová and Scasny (2006) implemented a contingent valuation survey in the Czech Republic to estimate the WTP to reduce selected respiratory diseases: severe and mild acute bronchitis, acute laryngitis and acute asthma. They focused on children living in Teplice and Prachatice (Czech Republic). The results suggested that WTP varies according to severity, not according to duration. The WTP for an asthma attack lasting for one day (EUR 43) is significantly higher than the WTP for a mild bronchitis lasting for five days (EUR 38), and the WTP for a laryngitis requiring three days of hospitalisation plus five days at home (EUR 64) is higher than for a severe bronchitis lasting for ten days (EUR 39); the pair-wise differences except for severe bronchitis

and asthma attack were significant at the 0.05 level. For comparison, the mean WTP for reducing mild bronchitis in adult was EUR 21, that implies a marginal rate of substitution between child and adult adverse health outcome of 1.85.

Mansfield *et al.* (2006) observed the averting behaviour of parents to protect their children from exposure to ozone. They based their analysis on a sample of 231 children, between 2 and 12 years old, living in the US. The mean parental WTP for a one-day reduction in restricted time outdoors was EUR 31.

Mead and Brajer (2005) which evaluated the aggregated health benefits to children of reducing air pollution in China. They used both COI and WTP values. In addition, when no child-specific value was available, they used adult values instead (Table 1.A1.4).

Table 1.A1.4. **Health Costs of Air Pollution in China**
(2006 EUR)

Health outcomes	Average total costs
Cold	EUR 24 million
Acute bronchitis	EUR 210 million
Chronic bronchitis	EUR 446 million
Asthma	EUR 87.5 million
Asthma-related hospital admission	EUR 471 million
Paediatric outpatient visit	EUR 55 million
Emergency room visit	EUR 8 million
Total	**EUR 1.3 billion**

Source: Mead and Brajer (2005).

Valuation Studies for both Children and Adults

Some empirical studies have shown that people believe that, *ceteris paribus*, a programme that protects young people is better than one which protects old people. Examples include Lewis and Charny (1989), where people stated they preferred saving the life of a 35-year-old rather than the life of a 60-year-old.[9] Tsuchiya *et al.* (2003) offer three reasons for favouring the young over the old: i) the young have longer life expectancies; ii) the young are more productive; and iii) the old have had a greater share of expected life years. That is, other things being equal, a given health programme should favour the young, either because it delivers greater benefits due to the difference in time/age existing between young and old populations (larger benefits for young adults given their larger expected remaining lifespan), or because young people have lived less life and therefore "deserve" the health improvement more than older people.

All of these arguments are, of course, equally valid when comparing adult and child values. However, in this case there are likely to be other factors (*e.g.* parental altruism, risk perceptions), which play a role in explaining any

apparent differences in preferences. For instance, in the aforementioned person trade-off study by Lewis and Charny (1989), in addition to the differences between age groups amongst adults, they found even stronger preference for risk reductions for 5 year-olds, relative to 70 year-olds. They also found a slight preference for risk reductions for 8 year-olds over 2 year-olds.

Other economic studies have estimated the WTP to reduce health risks associated with different causes for children and adults. Although the evidence is mixed, most of the studies concluded that the WTP to reduce mortality risks to children was greater than the WTP to reduce similar risks to adults. For instance, Liu *et al.* (2000) estimated the WTP to avoid an episode of "cold". The mothers' WTP to prevent their child from having a cold was almost twice the WTP for themselves. Based on a study of automobile safety, Mount *et al.* (2001) estimated the VSL of different age groups (children, adults and the retired). They found that the VSL of a child was quite similar or slightly larger than that of adults but greater than that of an elderly person. Jenkins *et al.* (2001) estimated the VSL for a child according to different age categories: ages 5 to 9 and ages 10 to 14. The results showed that the VSL for a 5- to 9 years-old is higher than the VSL for a 10- to 14 years-old, suggesting a greater risk aversion towards the youngest.

Blomquist *et al.* (1996) have estimated the implied values of reducing fatal and non-fatal injuries risks for different road user populations: adults, children and motorcyclists. They found that the VSL for a child is greater than the VSL for an adult, reflecting the idea that parents value the life of their children more than their own. Liu *et al.* (2000) evaluated a mother's WTP for preventing herself and her child from a minor disease (a cold). They found that the mother's WTP for her child is approximately twice as large as her WTP to prevent herself from getting a cold of comparable duration and severity.

Similarly, Dickie and Ulery (2002) calculated parental WTP to avoid acute illnesses and found that WTP for avoiding episodes was less for parents than for children. The value parents were willing to pay to avoid acute illnesses in their children was about twice the value for themselves. Dickie and Gerking (2001) estimate the parental WTP to reduce skin cancer from solar radiation exposure, both for their children and for themselves. The results showed that parents are willing to pay twice as much to reduce non-melanoma skin cancer risks to their children than to themselves.

Agee and Crocker (2001) estimated the annual WTP to increase "own" and "children" health services, as well as the parental WTP to reduce their child's daily exposure to environmental tobacco smoke. They found that parents valued their children's health twice as much as their own health. More recently, Agee and Crocker (2007) found that smoking mothers were willing to pay USD 144 to improve their own health by 25%, while they were willing to pay USD 262 for a comparable improvement in their child's health.

Viscusi *et al.* (1987) estimated the WTP to prevent the risk of injury associated with household pesticides. The results showed that respondents were willing to pay almost three times as much (on average) to avoid child poisonings from insecticides than to avoid poisoning from toilet bowl cleaner. They also found that the WTP to reduce risks to children was greater than the WTP to reduce any other risks considered in the survey. Similar results were found in a study on hazardous household cleaning products carried out by Evans and Viscusi (1991). Higher WTP values were found for the reduction of child poisoning risks, as respondents with children were willing to pay on average USD 1.31 more per bottle for the reduction of child poisonings, in comparison to the reduction of pesticide inhalations.

Hammitt and Haninger (2010) estimated the VSL for children and adults in the United States based on WTP to reduce fatal-disease risks associated with exposure to pesticides through food consumption. The results indicated that WTP to reduce risk to one's child is systematically greater (USD 12-USD 15 million) than the WTP (USD 6-USD 10 million) to reduce one's own risk. The study also provides a rich body of evidence on issues such as latency, context, and the effect of the assumed household allocation.

Discussion

Overall, this literature reviewed for the VERHI project suggests that:

- WTP values in general exceed corresponding cost of illness values, suggesting the importance of intangible aspects of illness over direct and indirect costs of illness;[10]
- values for reducing child *mortality* are in general greater than values for *morbidity* outcomes; and
- parents are in general willing to pay more to reduce health risks to their children than to themselves.

Notes

1. Because it is difficult to value child health endpoints associated with parental exposure to environmental hazards (since it can be considered as ancillary effect of parent's own health effects associated with that environmental exposure), studies that refer to children's health outcomes associated with parental exposure during gestation (*i.e.* prenatal exposure) were not included in the review, and the focus was placed on direct post-natal exposures to environmental hazards.
2. The "odds ratio" (OR) represents the risk of occurrence of a health endpoint in one group, divided by the risk of it occurring in another group.
3. The "relative risk" (RR) is the risk of an event occurring (or of developing a disease), relative to exposure. Relative risk is a *ratio* of the *probability* of the event occurring in the exposed (PE) group *versus* the non-exposed group (PNE): RR = PE/PNE.

4. For comparison purposes, all reported cost figures have been converted into 2006 EUR, using PPP exchange rates, unless specified otherwise.
5. The notions of WTP and WTA are firmly grounded in the theory of welfare economics and correspond to notions of "compensating" and "equivalent" variations. WTP and WTA should not, according to theory, diverge very much. In practice, they do appear to diverge, often substantially – with WTA being greater than WTP. Hence the choice of WTP or WTA may be of importance when conducting CBA. For more details see OECD (2006b).
6. Conjoint analysis, also known as choice modelling, gathers a number of different techniques: conjoint choice experiment, contingent rating, contingent ranking, and paired comparisons.
7. VSL is also known as the "value of a prevented fatality".
8. For comparison purposes, all cost figures from studies presented in this report have been converted into 2006 EUR, using PPP exchange rates, unless specified otherwise.
9. In addition, Cropper *et al.* (1994) applied a "person trade-off approach" to compare saving lives at different ages. They found that saving one 30-year-old is perceived to be equivalent to saving eleven 60-year-olds. Johannesson and Johansson (1997) asked a sample of individuals about their choice between saving lives now and in the future. They found that saving five 50-year-olds or thirty-four 70-year-olds is judged equivalent to saving one 30-year-old. In addition, this study revealed that the age of the respondent has no effect on his/her choice, which means that both young and old adults give priority to saving the life of the youngest. Some studies provide evidence on a "senior death discount" (*i.e.* the VSL for the elderly should be lower than that of adults below 70, because older people appear to attach a lower WTP to reduce mortality risk). For instance, Tsuge *et al.* (2005) implemented a survey in Japan and found that the persons aged above 70 tend to have a lower WTP for the same risk reduction. This would imply a lower VSL for seniors. Krupnick (2007) undertook a review of 26 "stated preference" surveys, to assess the "senior death discount". His qualitative meta-analysis provided mixed results, because only half the studies supported the existence of a "senior discount" effect.
10. Stieb *et al.* (2002) and Rabl (2004) showed that intangible aspects represent a significant percentage of total health costs up to 90% for non-fatal cancers.

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Chapter 2

Valuing Health Risks for Children – The Research Challenges

There are a number of methodological complications which arise when valuing health risk reductions. These include issues associated with: the elicitation of preferences from third parties; household decision-making and composition; the low probability and unfamiliar or uncertain nature of the risks faced; the effects of different characteristics or types of risk; and, the discounting of future benefits for latent health impacts. In some cases these complications are likely to be most acute for the valuation of risk reductions for children.

Introduction

As briefly highlighted in the introduction, a range of methodological issues arise when attempting to value risk changes in economic terms. Many of these issues are particularly important when the valuation exercise concerns children. For instance, for the same context and risk reduction, respondents may have very different perceptions of the degree of controllability for adults than for children.

In addition, there are issues associated with the valuation of environment-related risk reductions which are fundamentally different for children. On the one hand, it is not possible to elicit risk preferences from children directly. On the other hand, when valuing health risk reductions for children, it is also important to adopt assumptions concerning how the household makes decisions and allocates resources towards risk reductions and other goods the household members care about.

In this chapter, the theory and evidence concerning such issues are briefly reviewed. Some of these issues have been explored more in detail in OECD (2006). The next chapter discusses how some of the most important issues were addressed in developing, testing and implementing the surveys carried out under the VERHI project.

The chapter proceeds with describing some of the main methodological challenges under five broad headings:

- third-party preference elicitation of children's risk and altruism;
- household resource allocation and household characteristics;
- low probability and unfamiliar or uncertain risks;
- characteristics of risk; and
- risk latency and discounting of future health benefits.

Who is able to "speak" for children?

A first important challenge is related to the *elicitation of children's preferences*. In the literature, different perspectives[1] to obtain the measure of social welfare associated with a given risk reduction can be considered:

- children's perspective;
- societal perspective; and
- parental perspective.

According to welfare economics, the best way to estimate the value individuals place on reducing risks is by using the value that affected people themselves place on these risk reductions. This arises directly out of the principle of consumer sovereignty: because individuals are best placed to know how they wish to allocate their own resources, the most reliable way to obtain estimates of values they place on risk reduction is to ask them directly for those values. In the specific context of valuing children's health benefits, applying this principle would imply that children be asked about the maximum monetary amount they would be willing to pay to avoid or reduce the environmental health risks they themselves experience daily (children's perspective).

However, this is neither appropriate nor applicable, for a number of reasons. Children can not usually be considered as mature decision-makers for decisions relating to health in the same sense as adults. Moreover, they are not fully aware of the budget constraint to which they are subject, and they do not have control over financial resources. Further, if understanding risks is difficult for adults, it is of course even more so for children. This does not allow them to make trade-offs between health and money as they would be required to do in order to reveal their preferences. As a result, children rely on their parents (or their caregivers) to make all important decisions that affect them, such as those related to health and safety.

From a public policy point of view, the most desirable measure of welfare is social welfare (*i.e.* a measure that represents the value individuals place on their own health and safety, as well as the value they place on reducing health and safety risks to others). The measure of social welfare to reduce environmental health risks to children can be obtained from a representative sample of the population, including parents and non-parents (societal perspective). Empirical studies have shown that people typically value the life of a child more than they do the life of an adult, for the same apparent level of risk change (see for example, Moore and Viscusi, 1988). This could be explained by the altruism both parents express towards their own and other children, but also by the altruism of non-parents towards children in general. Because external benefits accruing from investing in children (*e.g.* children's health, safety and education) are shared by society as a whole, there is a risk of over-estimating the policy benefits when altruism is a significant factor. Models taking account of altruism exist, but it is important to distinguish between the types of altruism considered.

A "paternalistic" altruist cares about some particular aspects of a person's well-being (*e.g.* the level of consumption of safety), but he/she does not take into account this person's utility in general. This is often referred to as *safety-focused altruism*. In contrast, a "non-paternalistic" altruist only cares about the general utility level of others (determined both by the level of health and safety they enjoy and consumption of other goods and services). The

paternalistic altruist has positive WTP for risk reductions to others even if their utility levels remain unchanged. If everybody pays the maximum of what they are willing to pay for a risk reduction accruing to themselves, their utility levels would remain unchanged as would the levels of non-paternalistic altruists. Failing to realise this and adding the WTP of non-paternalistic altruists for the increased utility levels of others from risk reduction would lead to "double counting". Hence, adding the WTP of the non-paternalistic altruist to that of the individuals themselves (or their parents as a proxy) would be inappropriate. As such, it is preferable, and generally agreed, to only account for the WTP of the "paternalistic" altruist (Takeuchi *et al.* 2008; Harbaugh, 1999; Jones-Lee, 1991 and 1992).

In the case of children the situation is even more complicated, because it is difficult to distinguish between paternalistic and non-paternalistic altruism (from both parents and non-parents). Given this difficulty, the valuation of safety and health benefits for children may be particularly prone to the problem of double-counting, which results in the provision of more safety and less of other goods for children than is optimal (Jones-Lee, 1991, 1992; Harbaugh, 1999).[2] Since it is not feasible to draw this distinction in practice, the conclusion is that the societal perspective may not be the best approach to elicit children's preferences, and that another is needed.

An alternative perspective has been proposed to value environmental health risks to children: the "adults-as-child" perspective (see Tolley and Fabian (1999)). This approach requires adults to place themselves in the position of children. They are asked to think back to their own childhood and the risks they faced. The advantage of this approach is that it is based on values reported by individuals considering themselves. However, this raises significant problems in terms of questionnaire design and in terms of cognitive burden for the respondent. Respondents are asked to remember their preferences and circumstances as they were as children – not as they are now as adults. In this situation, a great deal is demanded of the respondent. In addition, the issue of a relevant budget constraint remains a problem. Further research is required to determine the robustness of this approach.

A review of the literature by Scapecchi (2006) revealed that, in empirical work, the *parental perspective*, where parents are asked to make a trade-off on behalf of their children, has almost always been applied when estimating benefits of environmental risk reductions to children's health. Parents are typically seen as the most appropriate persons from whom to elicit children's preferences – partly because they are assumed to have their children's interests at heart, and partly because they supposedly know their children's preferences better than anyone else. Using the parental approach raises the question of how parents judge risks affecting themselves compared to their children and how altruism may be involved in this judgment.

Altruism from parents towards children can explain observed discrepancies between WTP to reduce a given risk to children and the same risk for adults. It can also provide evidence of a higher VSL for children than for adults. Empirical studies valuing health benefits for children are scarce, as noted earlier, but most of them find that parents generally assign a higher value to their child's health/life than to their own (see, for example, Liu *et al.*, 2000, Dickie and Messman, 2004; and Agee and Crocker 2008).[3] This can be considered as early empirical evidence that altruism from parents toward their children is indeed significant.

Dickie and Messman (2004) proposed to measure the degree of parents' altruism (or selfishness) toward their children, by directly estimating the marginal rate of substitution (MRS) between child and parent health. Parental preferences were assumed to be neutral, which corresponded to the case where the MRS equals unity. When the MRS is greater than 1, this suggests a significant degree of parental altruism toward their children. In practice, Dickie and Messman (2004) estimated the MRS between child and parent health to be almost 2, suggesting that parental preferences are not neutral, and therefore highlighting the existence of parental altruism toward children.

Agee and Crocker (2008) used data from a representative sample of US families to assess the MRS between the value of health risk reductions for parents and children. The MRS could be estimated by evaluating the marginal impact of health on parents' demand for "own" and for "child" healthcare services. The mean substitution rate between child and parent health was estimated to be 1.83. These results suggest that parents value their children's health almost twice as much as they do their own health.

From the above discussion, the parental perspective seems to be the best approach to elicit children's preferences. The "adult-as-child" perspective does not seem to be a viable alternative due to several unresolved issues.

Household composition and decision-making: How does this affect results?

Unitary and collective resource allocation models in the household

Another closely related methodological issue that can complicate the valuation of children's health risks is the consideration of how resources towards safety and other goods are allocated and prioritised within households. Type of resource allocation model assumed prevailing in a household may have important implications for the welfare measures derived from surveys asking randomly chosen respondents (parents) to represent their household.

The prevailing model used in economics to analyse resource allocation within a family is based on Becker (1991). It assumes parental consensus (*i.e.* common preferences), with active parents and passive children. This

means that parents perceive environmental health risks to their children and take decisions related to these risks on behalf of their children according to those perceptions. The household utility function is assumed to be unitary (hence the name *unitary model*), which means that the family maximises a single utility function in which financial resources are pooled. This approach has often been adopted in economic studies dealing with the valuation of children's health because of its attractive assumptions and ease of application (the single utility function implies that the household WTP is a relevant measure of "welfare").

The justification for the use of the perspective of the parent (or caregiver) is based on various theoretical economic models (Viscusi *et al.*, 1987). The most commonly considered theoretical models include utility maximisation models, household production models, and intra-household allocation models.

- In *utility maximisation models*, the parent's utility function depends on consumption, the health of the child and other goods and is subject to a budget constraint. These models allow for the estimation of individual (parental) WTP to reduce health risks to children.
- In *household production models*, the household is the relevant unit. These models allow for the estimation of the value a household places on risk reductions to their own child's health. They estimate a WTP evaluated at the level of the household, and subject to the household budget constraint. Health risks to the child are specified in those models as outputs of the household production.
- *Intra-household allocation models* examine the relationships within the household, and then seek to determine how these may affect the allocation of resources among the household members. As in the *household production* models, these models allow for the estimation of parents' WTP to reduce health risks to their own child. However, trade-offs made within the family (associated for example with an illness or an injury) are taken implicitly into account.

Empirical studies (see Viscusi *et al.*, 1987) have shown that the *household* is the most relevant decision-making unit regarding children's health. However, some issues may undermine the assumptions made by this model, such as *i)* the lack of common preferences between the parents (*i.e.* parents do not each have the same preferences for their children); and *ii)* how to deal with situations in which the child in the household is able to make decisions on his/her own that can affect the entire household. All of these concerns have therefore stimulated interest in pluralistic models of household preferences. Those models treat household decisions as individuals making collective decisions. The individual utility functions of each household member (at least the adults) are therefore "pooled", to obtain a collective decision, taking into account the

differences in household members' preferences. The household decisions can be modelled either as the outcome of a bargaining process (Manser and Brown, 1980), or as Pareto-efficient allocation of resources (Chiappori, 1988). The collective approach also includes models where each spouse is responsible for decisions and expenditures on different goods.[4]

The choice of the model is practically important for the valuation exercise, because different environmental-health impacts can have very different implications for household decision-making and will therefore necessitate the use of one particular model (for example, the unitary model) instead of another (the collective model). For instance, a recent study has looked at the valuation of the health impacts of environmental tobacco smoke for children (Agee and Crocker, 2001). This is clearly a good example of the need to introduce and understand intra-household externalities. In this case, the utility of some household members (for instance, the parents/adults) enter the health function of the other members of the household (the children).

In the specific context of valuing children's health, the unitary model has been widely applied. We can reasonably expect there to be differences between individual and household preferences, but there is no clear empirical justification for this. At best, the existing empirical evidence provides mixed results. Several studies have tried to assess the relevance of the unitary model. For example, Thomas (1997) observed that paternal and maternal incomes have significantly different effects on consumption and investment patterns – with maternal income having a significantly larger effect on children's health than paternal income, leading to the conclusion that the unitary model was not consistent with the data used in the study. Similarly, Dupont (2004) showed that mothers and fathers, and men and women more generally, have different WTP for environmental goods-related improvements, especially for time-consuming activities.

Bateman and Munro (2009) also tested whether individual and household responses matched, as hypothesised by the unitary household model. Their model rejected the hypothesis of common preferences within the household. For instance, women were more sensitive than men to price changes. The study also highlighted the clear dependence of WTP figures on the type of respondent (household or individual). However, although their findings are interesting, they interviewed both partners together, an approach which is not practically feasible in most cases due to excessive survey costs and for other reasons. In contrast, Cockerill *et al.* (2006) investigated household decision-making models in the context of children's health valuation studies. Respondents were asked to value their WTP to prevent a severe, non-fatal injury for themselves, but also for their child. The study showed no significant difference between mothers' and fathers' WTP values, thereby providing some support for the use of the unitary household model. Other recent studies

investigating household and individual models in valuation include Strand (2007) and Lindhjem and Navrud (2009).

While most of these studies do not support the unitary model, these results should not be interpreted as a complete rejection of that model. Although it relies on relatively simplistic assumptions, the unitary model was helpful in providing insights on intra-household decision-making. Some studies have therefore attempted to assess the relevance of collective models. Although most of these studies dealt with labour supply and consumption demand, most do end up supporting the collective model (see for example, Ward-Batts, 2008; Dauphin *et al.*, 2004; van Klaveren *et al.*, 2008). In many cases, relative income significantly influences the decision-making power and the relative weight of women on household decision-making increases if there are young children in the family (Dosman and Adamowicz, 2006). Smith and van Houtven (2003) extended Chiaporri's (1988) framework to consider non-market valuation of price and quality changes. They derived "compensating variation" measures that assume constant income shares within the household.

The most important conclusion from the above review is that the unitary model may not be the best conceptual framework for analysing intra-household distribution of resources. The collective approach, in which the individual's WTP depends on his share of family income, seems to be more appropriate. However, using the collective approach necessitates both distinguishing the individuals' utility functions and defining a "sharing rule", neither of which is directly observable without assuming the separability of decisions between spouses (Smith and van Houtven, 2003). Most importantly, this assumption can significantly complicate the model when issues of rivalry and intra-household externalities are present.

In view of the potential importance and complexity of household allocation models, further research work should be undertaken to better understand collective behaviour with "public goods". The validity of collective models in the context of valuation of children's health should also be specifically assessed. In the meantime, the unitary model is valid and useful simplification that has been applied in the VERHI project. However, household-related factors, such as household composition, gender preferences and age structure, can have a significant impact on WTP for reducing risks to children. Specific attention is therefore paid to controlling for the impact of some of these factors on WTP estimates. We turn to a brief review of such factors next.

Impacts of household characteristics on parental valuation

Many studies have investigated the impact of household-related factors, such as divorce, presence or absence of the father and siblings, and age structure on parental WTP for reducing environmental health risk to children.

For instance, some studies underlined the significant role and influence of the family composition and structure on parental WTP. Dickie and Messman (2004) showed the importance of family composition on the WTP: single parents were willing to pay more than married parents for a reduction in acute illnesses for a child.

Cultural differences may also play an important role in the valuation of health benefits for children. In some countries, cultural and historic customs involve gender preferences. For example, in Taiwan, mothers are apparently willing to allocate more resources to the health of their sons than to that of their daughters (Liu *et al.*, 2000). Some empirical studies have shown differences in terms of valuation between different ethnicities (Joyce *et al.*, 1989).

More recently, Chen and Escarce (2007) assessed the effects of family structure on the treatment and outcomes of children with asthma. Using data from the 1996-2006 US Medical Expenditure Panel Survey and the 2003 US National Survey of Children's Health, they found a significant effect of family structure on children's health care: asthmatic children with a single mother had fewer annual office-based visits for asthma and fewer prescriptions for medication than asthmatic children in two-parent families. Moreover, they found asthmatic children who lived with 2 or 3 other children had fewer visits for asthma and filled fewer prescription for asthma medication than asthmatic children living with no other children in the household.

Differences in parents' preferences for risk reductions for children may be associated with age, gender, or health status of the child (Pitt and Rosenzweig, 1990). For example, in Mutharayappa *et al.* (1997) male children were slightly more likely than female children to be fully vaccinated (*i.e.* they have received all of the recommended vaccinations against six childhood diseases: tuberculosis, diphtheria, whooping cough, tetanus, poliomyelitis, and measles) and breastfed for a longer time. The analysis also suggested that girls were less likely to be reported ill because less attention is given to their illnesses by their parents. Girls also tend to be taken to a health facility or health provider for treatment less often than boys; and are more likely to be severely stunted.

More empirical evidence of gender preference is provided by Whittington *et al.* (2008). They estimated the household demand for a hypothetical preventive HIV vaccine in Thailand. Looking at intra-household vaccine allocation, it appeared that spouses had the same demand function. However, at lower vaccine prices, wives were significantly more likely to allocate vaccines to their daughters than to their sons. In addition, the study showed that both husbands and wives purchased more vaccines for females whenever there are more females in the household.

Some empirical studies have shown that the premium for children declines with age of the child (Pitt and Rosenzweig, 1990), which means that parents are willing to pay more for younger children in the household than for the older ones. For example, Jenkins *et al.* (2001) found that the VSL for a 5- to 9 years-old child was higher than the VSL for a 10- to 14 years-old child. Dickie and Messman (2004) also found that WTP decreased with age of the child.

This effect is often even more pronounced when the number of children in the household is large; in this case, the youngest are more often "preferred" by the parents to the oldest, resulting in a higher WTP to protect the youngest. This issue is often referred to as a "quantity/quality" trade-off described in Hanushek (1992). Dickie and Messman (2004) provided evidence of the decreasing relationship between WTP and number of children. In their study, median parental WTP to avoid one symptom-day was USD 195 when there was only on child in the household, USD 159 when there were two children in the household, and USD 142 when there were three children in the household.

Parents are generally more risk-adverse when the child is affected. For instance, in a study of poisonings from household toxics (insecticides and toilet bowl cleaners) Viscusi, Magat and Huber (1987) found that parents of young children tend to be willing to pay considerably more for a perfectly safe product than adults without children. Evans and Viscusi (1991) found that respondents with children less than five years of age were willing to pay USD 0.50 more per bottle of toilet cleaner for the elimination of the risk of child poisonings, rather than the risk of gassings. For respondents without young children, there was no difference in the WTP for gassings and the alternative impact proposed (inhalation).

Agee and Crocker (1996) estimated the parental WTP to reduce the risk of neurological impairments due to exposure to lead on children. Their results showed differences between parents, according to the treatment they chose to assign to their child: parents who chose chelation treatment were willing to pay approximately ten times more than those who chose another type of treatment. Finally, Dickie and Messman (2004) found that the WTP to avoid acute illnesses was greater for parents whose children suffer from asthma than for parents whose children do not suffer from asthma – meaning that the health status of the child could affect the WTP stated by the parent.

Differences in terms of socio-economic status can also affect the valuation of children's health. Currie (2008) highlighted strong and significant links between parents' status and children's health. She found a significant and positive relationship between health status and income, even in early childhood: poor children suffered from more health outcomes (such as chronic illnesses and hospital admissions) than richer children. In addition, poor children were less likely to receive medical attention for their health problems, and were therefore less likely to be properly diagnosed.

Neidell (2001) found that low socio-economic status families undertook fewer actions (or revealed avoidance behaviour) aimed at reducing the effect of air pollution on childhood asthma. Curtis *et al.* (2001) also investigated the impact of income and cultural effects, and more particularly permanent income, on children's health. Consequences for children were much more strongly related to low-average income than to low-current income. Money income may therefore constitute an important influence on child's health and development.

Concluding so far, the choice of the unitary household resource allocation model is not conceptually ideal but it is a useful and practical approach to parental valuation of health risks to children. It is also clear that it is important to focus attention on how different household compositions and characteristics may impact on parental valuation of children's risks. This is the approach chosen for the VEHRI project.

How to communicate small and unfamiliar risks

From the above discussion it is clear that the choices of whose preferences to elicit and the assumptions to make about how resources are allocated within households (for risk reduction and other goods) are important for the valuation outcomes. Further, the characteristics of the people whose preferences are elicited, their children and the households they are part of also affect risk valuation in different ways. In the remaining parts of this chapter, emphasis is on the challenges related to uncovering individuals' (parents') preferences for different types and sizes of risks. This has been an important research topic in economics and psychology for decades. Below, we only provide a short discussion of some of the main issues that the VEHRI project has attempted to deal with, of specific relevance to valuation of children's risks.

An important such methodological challenge in the valuation of health risks to children is that baseline mortality risks associated with children are generally very low (*i.e.* in terms of *x* in 100 000). Individuals are generally not familiar with such low probabilities and may therefore be unable to value the risk reduction correctly. This is well-documented in the literature (see *e.g.* Kahneman and Tversky 2000; Gilovich *et al.*, 2002). Another issue is that it is difficult practically to display and communicate such small risks in the valuation survey. The VERHI project has applied several different approaches to deal with this problem, as described in the next chapter.

Uncertainty associated with the risk itself (*i.e. risk ambiguity*) may also have impacts on the estimates of WTP values. Risks for which there is scientific uncertainty (*e.g.* nuclear accidents) create more concern than risks that are relatively more certain (*e.g.* automobile accidents). Viscusi *et al.* (1991)

examined how individuals form their risk perceptions in the presence of risk ambiguity. They found that individuals preferred risks that were certain, to those that were less certain.

This finding has implications for the valuation of children's health. Epidemiological evidence on the links between environmental pollution and children's health is rather limited (see Hunt and Arigoni Ortiz, 2006 and Hunt and Ferguson 2009). Children and adults do not have similar daily exposures to environmental hazards, and most existing evidence focuses on adult populations. Given that little is known about physical responses of children to exposures to some pollutants, it is reasonable to consider children's risk assessment as being much more uncertain than that of adults. Viscusi *et al.* (1991) showed that, when parents have to make trade-offs between money and health risks, they would prefer to reduce the more uncertain risk. This lack of scientific knowledge on children's responses to environmental hazards can have an impact on parents' perceptions of the risk faced by their children – and therefore on the values they place on reducing those risks. This aversion towards risk ambiguity could result in WTP values for reducing uncertain risks being higher than those associated with less uncertain risks.

Lack of familiarity with the risk being valued (and lack of understanding) can also significantly influence the reliability and magnitude of the value people place on reducing these risks. Unfamiliar risks (*e.g.* chemical exposure) can appear as more threatening than familiar risks (*e.g.* road accidents). This can result in less reliable WTP values. For instance, Cameron and Englin (1997) showed that experience with the good being valued resulted in more precise and more credible WTP estimates.

Other studies have emphasised that unfamiliarity could lead to higher WTP values than those for familiar risks. For instance, Violette and Chestnut (1983) concluded that people placed higher values on reducing risks that were perceived as new and/or potentially catastrophic, compared with those that were familiar and voluntary. Conversely, Tsuge *et al.* (2005) found that respondents who previously experienced cancer (directly or through relatives or friends) expressed a higher WTP to reduce cancer risks (62% higher than the WTP of other respondents). Similarly, van Houtven *et al.* (2008) showed that the cancer premium was higher for cancers that are more familiar to respondents.

In previous studies, mortality risks have been communicated to respondents using pie charts, risk ladders, grids of squares, and set of dots. Corso *et al.* (2001) compared visual aids when the risks are very small. Under these circumstances, it may be useful to remind respondents of a comparable population of reference (for example, 1 in million means one person in a large city), or to aggregate small risks over a specified length of time. For example, if it is difficult to show a reduction of 1 in 10 000 a year, it might be easier to

consider 1 in 1 000 over 10 years, ending with a strictly equivalent probability reduction. This strategy was used successfully applied by Alberini *et al.* (2004) and Krupnick *et al.* (2002) in Canada and the US. These and other valuation surveys have also included simple tutorials to help respondents understand the concept of risks and probability. The VEHRI project has tested and tried different best practice approaches to risk communication, as discussed in the next chapter.

Distinguishing between different types of risk

In addition to the low and unfamiliar baseline risk associated with environmental health risks affecting children, other characteristics of such risks can influence values obtained. While these characteristics may not be specific to environmental health risks to children, their importance may be relatively greater in this context. Fishhoff *et al.* (1978) highlighted the influence of qualitative risk characteristics on risk perceptions. Risk characteristics can have a significant impact on the value people place on reducing a specific risk. This relationship could be even more complicated when children's environmental health is affected. Empirical evidence in this area suggests that "dread" effects and familiarity (as discussed above) can be of particular importance to the parental valuation of children's risks.

Some evidence suggests that the WTP to avoid a risk resulting in protracted periods of pain or suffering prior to death, loss of dignity, and/or personal control is greater than the WTP to avoid a risk of sudden death. The "dread" aspect of a given risk can indeed have a significant impact on WTP, because it is generally associated with greater fear. For example, McDaniels *et al.* (1992) found that perceived characteristics of the risk matter for risk valuation, and that dread had a positive impact on WTP. More specifically, their study showed that WTP for well-defined hazards (*e.g.* road accidents) was most influenced by perceived risk exposure, while WTP for less-defined risks (*e.g.* nuclear accidents) was most influenced by levels of dread and severity.

Cancer, which is often viewed as more threatening than other illnesses, can be used to illustrate the effect of dread on risk perceptions, and therefore on WTP. For instance, Jones-Lee *et al.* (1985) found evidence of a cancer premium, with an estimated VSL of USD 35 million for cancer, of USD 20 million for heart diseases and of USD 11 million for road accidents. Savage (1993) also found greater WTP to reduce cancer risks: stomach cancer was associated with more fear and a higher WTP than the other hazards considered in the study (household fires, commercial-airplane accidents, and automobile crashes). This illustrates that cancer premiums may come both from unfamiliarity of certain cancers (as discussed in the previous section) and the "dread" related to cancer risks.

Magat *et al.* (1996) provided evidence of the impact of dread on risk perceptions. In their survey, people preferred to lower their risk of curable lymph cancer than to lower their risk of a fatal road accident. The value attached to reducing terminal lymph cancer risk was significantly higher than the value of reducing other risks. Using a mean VSL of USD 4 million (from Viscusi, 1992), the value of avoiding a case of terminal lymph cancer was estimated to be USD 4 million, the value of preventing a case of non-fatal lymph cancer was USD 2.5 million and the VSL of avoiding a case of nerve disease was USD 1.6 million. Similarly, Hammitt and Liu (2004) found indications that people were willing to pay more to reduce an environment-related type of cancer than for a comparable reduction in the risk of another chronic disease.

Similarly, Tsuge *et al.* (2005) found a small preference for avoiding cancer risks. Their survey of Tokyo Metropolitan residents involved four types of risks: accidents, cancer, heart disease, and general risks. Respondents displayed the highest preference for the measures against cancer, and the lowest preference for measures against accidents. In addition, the study showed that voluntariness, controllability, severity, public knowledge and exposure each had a significant and positive impact on the WTP to reduce a given risk.

More recently, Chilton *et al.* (2006) investigated the effects of dread and personal baseline risk in the UK on individual WTP for mortality risk reduction. The causes of premature death considered were automobile driver/passenger deaths, pedestrian accidents, accidents in the home, fires in public places, domestic fires, drowning, rail accidents, hazardous production plant accidents and murder. The results showed that high level of dread was associated with some risks (*e.g.* rail accident, fire in public places, and drowning), resulting in a higher VSL for these risks.

Van Houtven *et al.* (2008) assessed individuals' tradeoffs between death from a car accident and death from one of the three randomly assigned types of cancer: stomach, liver, or brain cancer. The main finding was that people expressed strong preferences for avoiding cancer risks. A significant cancer premium therefore existed: on average, fatal cancers risks were valued two to three times greater than immediate, fatal, automobile risks.

"Voluntariness" (defined as the choice people have of voluntarily exposing themselves to risk) can also be a component of dread (Slovic, 1987) and therefore a potential factor influencing WTP values. It can also be understood in terms of "controllability" (*i.e.* the extent to which people exert control over the degree of risk exposure). Research in both psychology and economics has shown that people are more concerned about risks that they perceive to be involuntary (*e.g.* exposure to air pollution) than about risks perceived to be

voluntary (*e.g.* smoking, sunbathing, or mountain climbing) (Fischhoff *et al.*, 1978; Slovic, 1987). As such, they generally prefer voluntary risks to involuntary ones, suggesting that the degree of "risk voluntariness" could have some impacts on the WTP.

For instance, Fishhoff *et al.* (1978) showed that highly stigmatised risks (*e.g.* nuclear accidents), characterised by perceived involuntariness and lack of control, could be perceived as greater risks than more voluntary risks (*e.g.* alcohol or road accidents), despite the fact that nuclear accidents have a lower probability of occurrence than road accidents (and currently induce fewer annual deaths) than both alcohol and road accidents. Violette and Chestnut (1983) found that people place higher values on reducing risks that are involuntary, and/or potentially catastrophic, compared with those that are voluntary, and which may be expected to affect small numbers when an "event" does occur. Similarly, Bohnenblust and Slovic (1998) confirmed that the WTP for reducing "voluntary" risks was 20 times lower than the WTP for reducing "involuntary" risks.

Vassanadumrongdee *et al.* (2005) found opposite results when they implemented two CV surveys in Thailand to analyse the effect of perceived risk characteristics (controllability, immediacy, dread, and familiarity) on WTP for reducing lung diseases associated with air pollution and road accidents. The risks related to air pollution are less controllable, less dreadful, less immediate, less severe and less well-known than road accidents, but people are more exposed to it than to road accidents. The study found that controllability has a positive impact on WTP, but that the WTP for reducing the two risks were not statistically different. The authors concluded that risk perceptions had little impact on people's preferences and WTP estimates.

Overall, the balance of the evidence seems to indicate that degree of controllability or voluntariness of the risk, generally influence how its reduction is valued. In the context of valuation of children's risks, this context factor may have a greater influence on the estimates obtained because children may be less aware of some of the risks affecting them. Moreover, those risks which are "voluntary" for adults might be considered "involuntary" for children, since at least some risk exposure decisions are made on their behalf by their parents. Therefore, parental WTP to protect their children's health may be significantly affected by the perceived degree of voluntariness of risks faced by their children.

How people perceive different contextual factors of risk can be shaped by several factors. Different models have been proposed to better understand what lies behind people's judgements (and what can affect these judgements). The psychometric paradigm proposed by Fischhoff *et al.* (1978) defined risk

perception as a function of risk properties. Using this approach, Slovic (1987) identified three broad factors presumed to shape risk perceptions:

- *Dread factor*: includes factors such as emotional reaction inspired by the risk, perceived lack of control, threat to future generations, and the chronic or catastrophic potential of the risk (*i.e.* the potential to produce mass casualties).
- *Unknown factor*: includes dimensions of newness, lack of scientific or public knowledge and evidence, latency (*i.e.* delay in the manifestation of harm), unfamiliarity, and non-observance.
- *Exposure factor*: the number of persons exposed to the risk.

Recent studies have found that, although the Slovic (1987) paradigm was based on analysis of aggregate data, the relationship it defined between risk perceptions and risk characteristics holds true at the individual level as well (Marris *et al.*, 1997). The patterns produced by the psychometric paradigm are also very stable over time. For example, Siegrist *et al.* (2005) found similar results in implementing exactly the same survey about 20 years later than the first. The main results of recent studies in this area show that: *i*) perception of the same risk varies between individuals, as well as the rating of the risk characteristics (Marris *et al.*, 1997; Siegrist *et al.*, 2005); and *ii*) men and women differ in their risk perceptions (Flynn *et al.*, 1994; Gustafson, 1998). Hence, it is important to investigate how characteristics of parents influence their perception of risks and how these perceptions in turn affect the trade-offs they make between income and risk reductions to their children.

Taking latent risks into account

Dealing with risk reductions in the future

Latency is another major concern for the valuation of environmental health risks for children, because of their particular vulnerability to environmental pollutants and their longer lifespan. Latency, which is a characteristic of many environmental health risks, refers to the time lag between exposure and the onset of illness or death. For example, exposure to some heavy metals and chemicals (especially in childhood) has been linked with health impairments later in life. A reduction in exposure today would therefore result in risk reductions to be experienced later in life. It is necessary to know the present WTP of people for a risk reduction to be experienced in the future. In addition, trade-off decisions that involve latent health effects may be influenced by perceptions of future health states and preferences.

For environmental exposures which do not have immediate health consequences, life expectancy of the affected population is clearly an important factor in the determination of the perceived value of policy interventions. Thus,

children are more likely to have adverse health consequences arising from equivalent exposures (even if equally susceptible), and these differences increase with the length of latency – because there is a longer lifespan over which latent impacts can be realised, which increases the value of preventing exposure. As an example, there is a higher probability that the impacts of a disease with a 20-year latency period will be realised if a 10 year-old is exposed to a toxic hazard than if a 70 year-old is exposed. Therefore, latency is a major concern for the valuation of environmental health risks to children.

Trade-off decisions that involve latent health effects may be influenced by the perceptions of future health states and preferences, both of which increase the uncertainty associated with the valuation of children's health. Since health risks to children are not as well understood as those to adults, it is also likely that latency issues will be more uncertain for children than for adults. Moreover, given that children's preferences are elicited through their parents, and given that parental perceptions may be affected by a certain number of factors (*e.g.* altruism and dread) when those perceptions relate to their children, WTP for reducing latent health risks to children may be even more affected by these factors than WTP for reducing immediate risks.

Another difficulty is that latency may change parental preferences regarding the value they place on their children's health. Parents may be willing to pay a significant amount of money to protect their child from being sick (or dead) ten years after being exposed (*i.e.* when their child is still a young, say under 18 years old). However, they may be more reluctant to pay if the delay period is twenty or thirty years from now (*i.e.* when their child is now middle-aged).

The valuation of health risks may also depend on the timing of exposure and the manifestation and duration of potential effects (Hammitt, 2006a). Exposures that occur in childhood may lead to health impairments that occur only in childhood, begin in childhood but extend into adulthood, or do not begin until adulthood. An important determinant of the value of reducing future risks is that there is a chance of dying before the impact of exposure is apparent. As the decisions that influence these health effects must precede exposure, timing of exposure (and of the decisions leading to exposure) matters more than the manifestation of health effects when valuing risks to children.

Discounting future health benefits to the present

Most environmental policies and programmes, especially those related to environmental health, involve incurring costs now in return for benefits in the future. Evaluation of such policies and programmes therefore requires converting costs and benefits occurring at different points in time into a

common unit (the value today: the present value) – using a so-called discount factor. The main difficulty in discounting is determining the appropriate rate at which to discount.

When people are asked about their WTP today for risk reductions, that may start now or be latent, and last into the future, the researcher assumes that respondents apply their own implicit discount rates to future benefits. Knowing these rates, and particularly if the rates applied are different for children than adults and if risks are latent or immediate, may be relevant to determine what should be society's discount rate for environmental policies that reduce health risks to children. Despite the importance of valuing future risk reductions, very little empirical work has been conducted to date on latency and time preference related to health risks. Time preferences over future health states have been shown to be difficult to elicit from adults [*e.g.* as discussed in Cairns (2006)].

Hammitt and Liu (2004) implemented a stated preference survey in Taiwan to assess the impact of latency on the WTP to reduce environmental risks of chronic and degenerative diseases. In their survey, risks were characterised according to the latency period whether they involved cancer or non-cancer risks, and whether they affected the lungs or the liver. The latency period proposed in the scenario was 20 years. Their results showed that latency has a negative impact on WTP: the WTP to reduce latent fatal risk is about 25% smaller than WTP for reducing a similar though immediate risk. Respondents discount for latency at approximately 1.5% per year, which is less than what was estimated in other studies (*i.e.* 8% per year in Krupnick *et al.* (2002), and 4.5% per year in Alberini *et al.* (2006a)).

Itaoka *et al.* (2005) conducted a CV survey in Sizuoka, Japan, to estimate current and future WTP for reducing mortality risk by 5 in 1 000. WTP for a future risk change was found to be significantly smaller than for a current risk change. The ratio was 2.3 for median WTP and 1.4 for mean WTP. The implied discount rate was also estimated by comparing the WTP for a current risk reduction and the WTP for a future risk reduction assumed to start at age 70. The estimated rate of time preference was 7%, with an average cessation lag of 19 years.

Alberini *et al.* (2006a) assessed the effect of a latency period on the WTP for reducing mortality risk. Using data from two CV surveys implemented in Canada and the US, they estimated the WTP for a reduction in mortality risk at age 70. The sample was composed of people aged between 40 and 70 years old. The WTP for a future reduction was found to be less than half of the WTP for an immediate risk reduction. More specifically, those aged 70 and older were willing to pay around one third less than younger respondents. A latency period of 10 to 30 years reduced WTP for a reduction in mortality risk by more than 60%. Implicit discount rates were derived and estimated to range between 3% and 8.6% for the Canadian sample, and between 1.3% and 5.6% for the US sample.

More recently, Alberini *et al.* (2007) estimated the WTP for immediate and future mortality risk reduction delivered by contaminated site remediation programmes. A survey using conjoint choice experiments was implemented in four Italian cities with significant pollution problems. The VSL was EUR 5.6 million for an immediate risk reduction, while it was EUR 1.26 million for a risk reduction occurring 20 years from now. The results suggested that people discount future risk reductions at a rate of 7.4%.

Itaoka *et al.* (2007) carried out a survey to estimate the value of a statistical case (VSC) for pollen allergy, chronic bronchitis and lung cancer. Using a conjoint choice format, they proposed various latency periods (0, 2, 5 and 10 years from now). Latency was explicitly treated as an attribute of the program. VSC estimates by cessation lags are presented in Table 2.1.

Table 2.1. **Value of a statistical case, for three illnesses and different cessation lags**

	VSC (million yen) by cessation lag			
	0 year	2 years	5 years	10 years
Private goods context				
Pollen allergy	8.1	5.9	3.6	1.6
Chronic bronchitis	20.1	14.6	9	4
Lung cancer	437.7	317.7	196.4	88.1
Public goods context				
Pollen allergy	7.4	7.2	6.9	6.5
Chronic bronchitis	26.9	26.2	25.2	23.7
Lung cancer	295.9	288.6	277.9	261

Source: Itaoka *et al.* (2007).

Table 2.1 shows that WTP decreases with latency. The rate of time preference was estimated at 17% for the private goods context, and at 1.3% for the public goods context. The authors attributed the striking discrepancy between the two rates to the nature of the good. A public good would benefit the whole population (including benefits from "paternalistic" altruism), whereas benefits from the private good would only be self-concerned. In addition, risk reduction provision was specified in the public-good context (*i.e.* a programme to control air pollution), but it was abstract in the private-good scenario. These studies suggest that the WTP for a future risk reduction is less than the WTP for an immediate risk reduction, for a similar level of risk. There also appears to be some evidence that current WTP to reduce a latent mortality risk is a decreasing function of the latency period.

Although some studies report discount rates for adult's health, there is little evidence of the way parents discount their children's health. One exception is the

study done by Agee and Crocker (1996) who inferred the discount rate that parents attach to reducing lead levels in their children's blood. The mean discount rate was estimated to be 4.7%, but it varies considerably across households. Their analysis showed that income, education and household composition significantly determine intergenerational time preferences. The discount rate tended to increase with the number of children in the household, whereas it declined with high levels of income and education.

The indications from the literature that parents value their child's health differently than their own could also be related to the use of different discount rates, depending on who is affected by the risk. Some empirical studies have however found that people do not necessarily use a different discount rate for themselves than for other members of their household. Instead, they advocate similarity of time preferences for own health and others' health (Cairns and van der Pol, 1999). More research is needed to conclude on this issue.

In summary, understanding the discount rates adults use is potentially important for determining the social discount rates to be used for environmental policies that reduce health risks. The empirical evidence seems to indicate that people are WTP more for immediate risk reductions that latent ones, implying a positive discount rate. The magnitude of discount rates vary but are generally below 10%. There is little indication that people use different discount rates for other people in general or children in particular. However, there are very few studies to our knowledge that have investigated this question, so more research is required.

Summary points

This chapter has discussed five challenging issues related to valuation of children's health risk. The overview and discussion suggest the following:

- The parental perspective, where parents are asked to value risk reductions to their children, seems to be the best approach to elicit children's preferences. There are few viable alternatives.
- The unitary household resource allocation model chosen is not conceptually ideal but it is a useful and practical approach to parental valuation of health risks to children.
- Household-related factors, such as household composition, gender preferences, age structure and health status of parent and/or child, can have a significant impact on WTP for reducing risks to children. Specific attention is therefore paid to controlling for the impact of some of these factors on WTP estimates.
- Low probabilities are hard to understand and judge by survey respondents. And environmental health risks affecting children are typically very small. That many of these small risks are also uncertain and unfamiliar to

respondents, makes their assessment of such risks even harder. Good risk communication strategies in the valuation survey are essential.

- Different risk characteristics such as perceived voluntariness and controllability, dread, types of risks etc. have been found to influence individuals' valuation of health risks. The way parents potentially perceive such risk factors differently when judging risk changes affecting their children, is a largely unexplored, but important area of research.
- Many environmental health risks are latent, *i.e.* the risk reduction takes effect sometime in the future. Research shows that people generally are willing to pay more to reduce immediate risks compared to latent risks. However, parents' valuation of children's risk may depend on the time of the lag and the period of the risk reduction. WTP may be lower for health benefits that accrue to their children once they have reached adulthood.
- Higher values for immediate risk reductions imply that people discount future health benefits using a positive discount rate. Whether parents would apply a different discount rate to the future health benefits resulting from either immediate or latent risk reductions to their children is a largely unexplored issue. Understanding the discount rates people use is potentially important for determining the social discount rates to be used for environmental policies that reduce health risks.

Notes

1. In this context, the "perspective" reflects the identity of the person from whom values are elicited for reducing environmental health risks to children.
2. Empirical studies have highlighted evidence of parental altruism toward their children (see for example Dickie and Gerking, 2006; and, Liu *et al.*, 2000).
3. There are two studies we are aware of that found similar valuations for child and parent health outcomes (see Blomquist, 2002 and Mount *et al.*, 2001), and one that find the child outocme valued lower (Jenkins *et al.*, 2001).
4. For further details on unitary and collective models, see Dickie and Gerking (2006).

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Chapter 3

New Approaches to Survey Design and Implementation

Given the methodological complications associated with the valuation of health risk reductions for children, a considerable amount of survey development work was undertaken in the VERHI project. This involved innovative ways to communicate risk, present scenarios of wealth-risk trade-offs, and incorporate a rich set of alternative risk characteristics and types of risk reduction. Two different survey instruments were developed, one involving a conjoint choice experiment (Italy and Czech Republic) and the other a chaining methodology (United Kingdom and Czech Republic). In both cases contingent valuation methods were also applied, and in the Czech Republic a method involving direct "person trade-offs" was applied.

Introduction

The VERHI project focuses on the value of reducing environmental health risks to children and adult populations. The survey development work undertaken for the VERHI project was motivated by the need to assess how such issues could be addressed. This Chapter reviews the main insights obtained from the large number of laboratory experiments, large-scale pilot studies, focus group discussions, and one-on-one interview undertaken from early 2006 through to late 2008. (See Annex for a summary of the objectives and main results of the individual exercises.) The main elements of the final questionnaires are then presented.

How risk was communicated to the respondents

As the review by Hunt and Ortiz (2006a) indicated, baseline environmental mortality health risks are generally low and unfamiliar, and particularly so for children. Communicating such risks to respondents is a challenge for researchers. Moreover, low baseline risks leave little margin for risk reductions (changes in risk with the intervention). As such a considerable amount of survey development work was devoted to the identification of risks and corresponding scenarios which would be "meaningful" to respondents and to the development of good risk communication strategies.

Low and Unfamiliar Risks

As a first step in exploring such issues, a laboratory experiment using 99 students from University of East Anglia as respondents was implemented in January 2006 to investigate the separate and dual influence of both risk probability comprehension and familiarity with the good upon responses. Experimental subjects were presented with three goods of decreasing familiarity:

1. Avoiding losses of money (GBP 75).
2. Avoiding a temporary stomach complaint.
3. Avoiding a condition causing temporary blindness.

These goods were provided at a variety of probabilities and WTP sought. A first test combining both the familiarity and risk perception issue was to elicit, for each of the three goods, respondents' values for reducing risk from two different levels:

a) from 5/10 to 0/10; and

b) from 1/10 to 0/10.

A simple scope sensitivity test then compared the consistency of values obtained from these two scenarios, testing the simple hypothesis that values obtained for avoiding one risk should be different than those obtained for avoiding another risk. Note that both of these risk levels were deliberately chosen to be much more familiar probabilities than the small risks typically used in VSL studies and so any anomalous insensitivity to scope is likely to underestimate that which might occur in real VSL valuations. To go some way to address this we also elicit, for each of the three goods, respondents values for the following further risk reductions

a) from 100/1 000 to 0/1 000; and

b) from 20/1 000 to 0/1 000.

Again a scope sensitivity test examined the hypothesis that the value of avoiding one risk is higher than associated with avoiding another risk. A second analysis looked at within-good valuations of different representations of what is the same risk. For each good the value of reducing risk from 1/10 to 0/10 was compared to the value of reducing risk from 100/1000 to 0/1000. Here the null hypothesis is of course that the values should not be significantly different. Findings from the first test, the scope sensitivity tests, are presented in Table 3.1 below. The upper three rows show the values associated with risk reductions (a) and (b) and the final three rows show findings for risks (c) and (d).

Table 3.1. **Tests of scope sensitivity in split-samples**

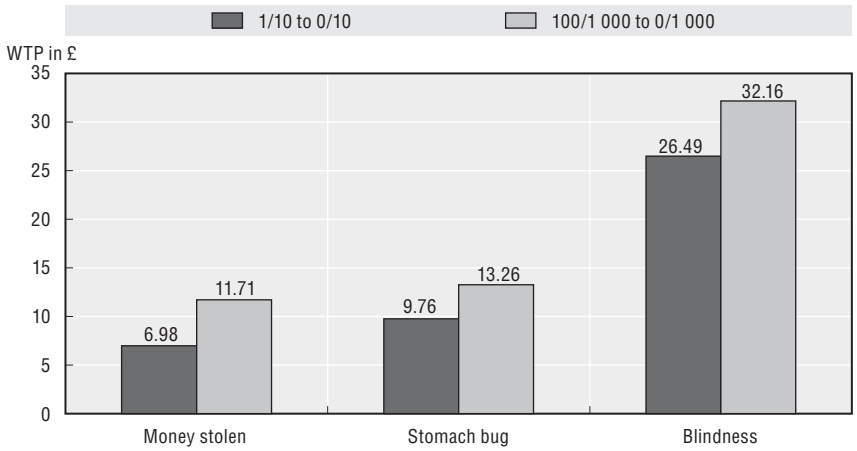
	Man WTP (GBP)		H_0^1: WTP (larger risk reduction) = WTP (smaller risk reduction)	
	Larger risk reduction	Smaller risk reduction	*t*	p-value
Risk in 10	*5/10 to 0/10*	*1/10 to 0/10*		
Money stolen	18.35	8.46	4.182	0.000
Stomach bug	22.87	13.03	2.622	0.005
Blindness	57.36	34.84	1.202	0.116
Risk in 1 000	*100/1 000 to 0/1 000*	*20/1 000 to 0/1 000*		
Money stolen	8.91	7.83	0.416	0.339
Stomach bug	10.67	8.53	0.903	0.185
Blindness	24.44	25.64	–0.132	0.448

Results from Table 3.1 show that, when risks are presented as the more readily comprehended chances out of 10 and the goods are familiar (such as avoiding money being stolen and the stomach bug) respondents present a degree of sensitivity to the scope of the risk reduction, and WTP is significantly different (as can be seen from the low p-values in the fifth column). On the other hand, when the goods are less familiar (avoiding temporary blindness) and/or risks are presented as chances out of 1000, respondents' WTP is not significantly different

for reducing risks which are in objective terms five times different from each other. These findings indicate that the theoretical consistency and hence validity of SP-based estimates of VSL declines both as the degree of familiarity falls and as the level of the risk denominator increases. This is, as mentioned, a common finding in the literature (see *e.g.* Braathen *et al.* 2009).

The results of the second test, whether WTP is the same for the same risk change displayed in two different ways for the three goods, are given in Figure 3.1 below. The figure shows that for each good respondents state a higher WTP to reduce risks from 100/1000 to 0/1000 than from 1/10 to 0/10, although these changes are the same. In absolute terms the discrepancy is roughly similar in each case. It appears that the larger numbers used as the numerator and denominator make respondents feel that risks are somehow greater, responding with higher WTP values. This is consistent with previous findings (see, for example, Beattie *et al.* 1998.)

Figure 3.1. **Mean WTP for equivalent risk reductions for different goods**



The importance of scope effect was confirmed in personal interviews with 14 respondents in the Czech Republic in May 2007. The strong framing effects identified in the lab results emphasise the importance of identifying risk which are familiar and meaningful to respondents, and communicating such risks to respondents in a manner which reduces potential framing effects.

Perceptions of Environmental Health Risks

Given the apparent importance of "familiarity", considerable efforts were made to determine which "environmental" risks were most meaningful to respondents, and how the perception of such risks differed from other types of risk more commonly assessed in the literature (*i.e.* road traffic accidents). To

this end, four focus group discussions (approx. 26 parents) were held in Milan and Mestre in September 2006, in which parents were requested to indicate their *i)* concerns about their children's health, *ii)* perceptions of environmental exposures and their effects on their children's health, and *iii)* opinions on how such exposures should be addressed (through government regulations and intervention, or individual behaviors). The different "environmental" pressures explored included: air pollution, pesticides, mercury, pathogens, drinking water, endocrine disruptors and lead, as well as other non-environmental risks (*i.e.* road-traffic accidents).

In the first instance respondents were requested to indicate whether they had heard of particular risks, and if so if they felt that their children were vulnerable to such risks. Amongst the environment-related concerns air pollution and pesticides consistently rank highest in terms of awareness and perceived risk for their children, with the majority of respondents indicating it was a concern. Respondents were also requested to prioritise different possible initiatives, taking into account that resources are limited. Not surprisingly, measures to reduce pollution are given the highest priority, by some margin (see Table 3.2).

Table 3.2. **Priority for Government Interventions Given to Different Concerns**

	Low or no priority (1)	(2)	Medium priority (3)	(4)	High priority (5)
Reduce pollution	0	0	0	2	14
Improve the school system	0	0	13	2	1
Tighten food quality regulations and inspections	0	0	1	4	11
Improve hygiene in schools	0	1	5	4	6
Create public parks and playgrounds	0	2	5	4	5
Improve road safety	0	0	1	7	8
Initiatives to improve children's hospital stays	1	1	1	5	8
Improve children's emergency rooms	0	0	4	6	6
After-school recreational and educational activities for children	0	4	6	5	0

Interestingly, the results of the focus group discussions are consistent with the epidemiological evidence, insofar as that when people think about pollution, they think first and foremost about air pollution. They seemed knowledgeable about the short-term effects of air pollution (bronchitis, allergic respiratory ailments) as well as the long-term effects (chronic respiratory illnesses, cancer). This was confirmed in personal interviews undertaken in Venice, Vittorio and elsewhere in Northern Italy in January 2007. Interestingly, cardiovascular diseases were seen as primarily a consequence of lifestyle, and not exposure to environmental risks.

A set of personal interviews and focus groups was undertaken with 15 parents in the Czech Republic in October 2006 in order to explore similar issues. In this case parents indicated that they felt their children were directly affected by air pollution (11), risk of road traffic accident (10), noise (5), mercury and heavy metals in food (4). Testing undertaken in January 2007 in the Czech Republic (18 personal interviews) confirmed the importance of air pollution, although in this case road traffic accidents were cited somewhat more frequently.

In survey development work undertaken in the United Kingdom, a scenario was presented to respondents in which respiratory problems arising out of exposure to air pollution resulted in hospitalisation. However, many people felt that could only happen to people with existing respiratory problems (such as asthmatics), and they did not believe they themselves would be affected.

In summary, the main finding from the personal interviews and focus group discussions was, therefore, that an environmental context *is* feasible and credible. The findings suggested that the risks associated with the environment and its health impacts are relevant for respondents. They were broadly familiar with most of the impacts presented, especially those related to air pollution. As such, on this basis it was decided that air pollution and associated health impacts (*e.g.* respiratory problems) are a good candidate for the valuation scenarios.

In addition, a majority of respondents in the focus group discussions undertaken in the Czech Republic were aware of concerns related to water pollution, which was also considered as the basis for an alternative scenario. The other environmental pressures considered did not seem to be as meaningful for respondents, and it was these two which were retained in the final survey instruments.

Communicating Risks

With relatively low baseline risks (and thus potential risk reductions) the means of communication of risk is central to survey design. In the survey development work undertaken it Italy and the Czech Republic, extensive testing of different visual aids was undertaken. In particular the use of grids has been used previously with success (Corso *et al*. 2001), and their use in the context of the VERHI project was examined. While grids with 100 000 squares were considered, this was not feasible, given the means of survey implementation (CAPI) in which the size of the screen poses a constraints. However, the use of grids with 10 000 squares clearly helped respondents understand the probability figures presented in the CCE scenario. Different risk reductions were proposed, generally involving small probabilities.

An example of these grids is illustrated in Figures 3.2 and 3.3. These Figures show that 10 people out of these 10 000 will die within the next 5 years, while 9 990 people will survive that period. The dark squares can be

Figure 3.2. **Risk Communication (Grid A)**

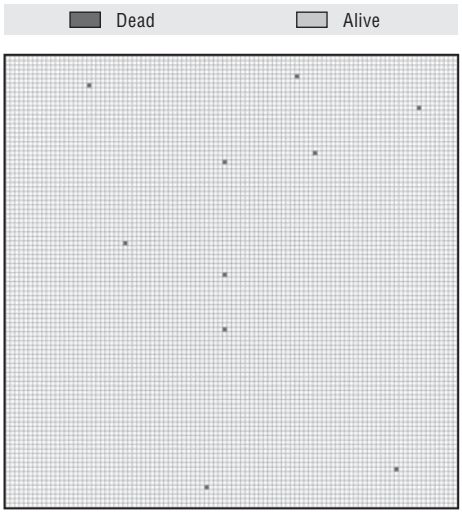
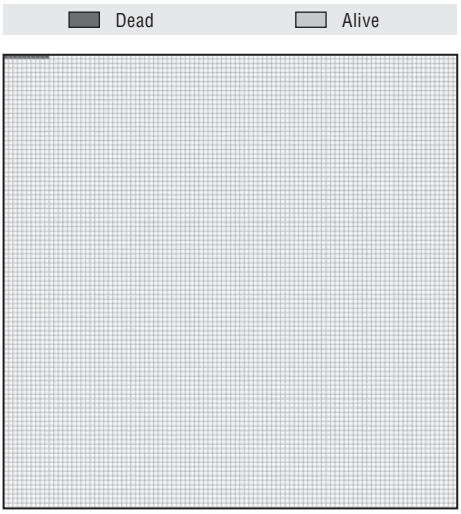


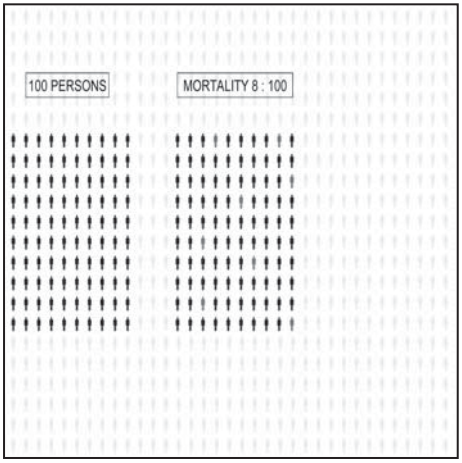
Figure 3.3. **Risk Communication (Grid B)**



scattered (Figure 3.2) to give an idea of randomness, or placed next to one another (Figure 3.3) to give a sense of the proportion.

A change in the risk reduction can then be presented with different coloured grids. This was tested extensively in all three countries, varying the scale of the grid and the visual means of presentation (*e.g.* Prague January 2007; Prague May 2007; Rome October 2006; Venice and elsewhere January 2007). For instance, in the figure below (taken from the May 2007 tests in Prague), a mortality rate of 8 in 100 is presented.

Figure 3.4. **Communicating Mortality Risks**

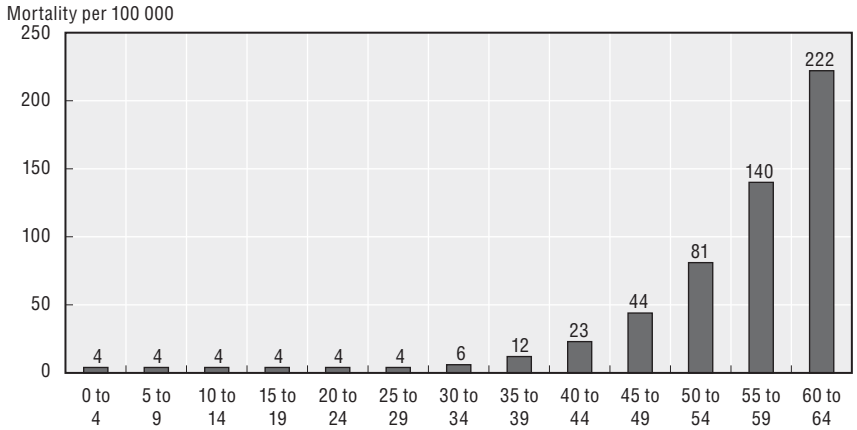


In all of the survey development work undertaken the use of grids proved to be readily understandable to respondents. However, one interesting finding was that if the numerator in the risk reduction presented is one, respondents had a tendency to identify this child as their own (Czech Republic January 2007).[1] This has important implications for values estimated, and should be avoided.

These grids were complemented through the use of histograms which give mortality rates, based on real data from national and European statistical offices (*e.g.* ISTAT and EUROSTAT), were also provided on charts – to familiarise people with such concepts and to "personalise" the risk that was being considered. This helped reduce the degree of uncertainty surrounding the perception of the risk presented in the scenario.

For instance, as displayed in Figure 3.5, respondents were presented with probabilities of dying from cancer over the next five years, differentiated by age group. Similar graphs were provided to the respondents for road accident and respiratory disease probabilities. As such, respondents could determine their baseline risk, and could more easily accept these probabilities (because they come from "official" or "reliable" sources).

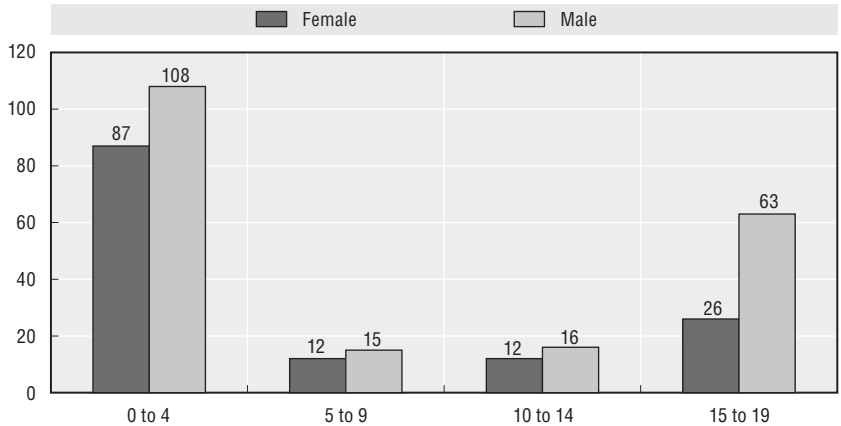
Figure 3.5. **Communication of probability and risk**
(Probability of dying from cancer over the next 5 years)



Source: ISTAT and EUROSTAT.

In this case, risk reductions can be presented as histograms, with the height of the additional bars reflecting the reduced risk following the intervention, the difference representing the associated risk reduction. This was readily understood in all of the testing work undertaken. The data can also be disaggregated (*e.g.* by gender as in Figure 3.6 below for the Czech Republic) in order to ensure that respondents understand differences in baseline risks for different groups.

Figure 3.6. **Communication of probability and risk**
(mortality per 100 000)



In some of the focus group discussions undertaken (*e.g.* in Rome in October 2006) survival curves were also presented. Changes in risk reductions could then be presented in terms of shifts outward in the survival curve. Some respondents spontaneously mentioned the "positive" spin this gave on changes in risk.

However, there was some confusion about the precise meaning of this curve (and its relationship to other means of risk communication). As a test, one interviewer provided her focus group with an explanation of the meaning of the curve, while another interviewer did not do so with another group. The degree of understanding was very different, indicating the need for considerable inputs from the interviewer. Given the likely means of survey implementation and time constraints, this approach was not further considered.

Based upon this work it was decided that the principal visual means of risk communication would be via grids. However, with the number of squares in the grid constrained to 10 000 in order to present credible baseline risks and risk reductions to respondents, it was found in the course of the survey development work that risks had to be aggregated over a number of years in order to have reasonable "numerators" for the baseline risk and risk reduction. Moreover, such an approach was consistent with the results of other work (*e.g.* Czech Republic in Oct. 2006) which indicated that respondents preferred to pay for risk reductions through annual payments equal to the period of risk reduction. On the basis of these results, it was decided that mortality risk over five years would be used, both to communicate risk and in the scenarios for the CCE.

Accounting for Risk Characteristics

As discussed in previous chapters, it is well-known that different risk characteristics can have an effect on the estimated WTP for reductions of risk of equal magnitude. As such, considerable effort was devoted toward the testing of alternative presentation of risk characteristics, and their implications for values obtained.

Dread

In focus group and personal interviews undertaken in Italy (January 2007) and the Czech Republic (October 2006 and January 2007), respondents were requested to indicate the level of "dread" they attached to different mortality risks (road traffic accidents, leukaemia, chronic respiratory illnesses, cancer, workplace accidents, etc.). In general, the results do not indicate that "dread" of cancer was not much different from other causes of death.

For instance, of 11 personal interviews conducted in the Czech Republic in October 2006, only two respondents declared that they would prefer a risk reduction of 4 in 100 000 for cancer relative to 8 in 100 000 for traffic accidents. Indeed, in the survey development work undertaken in Italy in January 2007, respondents appeared to express more "dread" with respect to violent or "drawn-out and protracted" deaths, than cancer *per se*. Other areas cited in personal interviews undertaken in Northern Italy in January 2007 included neonatal mortality.

Controllability

The degree of "involuntariness" and "controllability" of risk may also significantly affect the valuation of children's health. Research has shown that individuals generally prefer voluntary risks to involuntary ones and that the degree of "risk voluntariness" could therefore have impacts on the WTP (Fischhoff *et al.*, 1978; Slovic, 1987). In the context of valuation of children's health, this may have a greater influence on the estimates. Those risks which are "voluntary" for adults might be considered "involuntary" for children, since at least some risk exposure decisions are made on their behalf by their parents. Therefore, parental WTP to protect their children's health may be significantly affected by the perceived degree of voluntariness of risks faced by the children.

Interestingly, the focus group discussions also indicated that cancer was not only associated with "dread", but also had implications for perceived "controllability". In the survey development work undertaken in the Czech Republic in October 2006, respondents seemed to perceive cancer as "destiny", and were thus less amenable to risk reductions.

Private and Public Risk Reductions

A key determinant of the degree of "voluntarism" of a particular risk is the perceived extent to which individual preventive action will be effective in reducing the risk relative to government programmes. Results of focus group discussions in Italy show that, in general individual actions are not considered as effective as public programmes except in limited areas (*e.g.* heat waves). This finding was confirmed in interviews held in the Czech Republic, where there was a strong feeling that "the state should solve 'environmental" concerns, while for road accidents the individual is better able to solve the problem him or herself (October 2006 and January 2007).

Latency

Given the inherent nature of most environmental health risks for children, from the outset of the project it was seen as important to ensure that issues of latency were addressed in a robust manner. In the focus group discussions held in Italy in September 2006, participants were requested to indicate whether they thought the risk reduction was incurred immediately or after some time. Interestingly there was considerable congruence amongst the respondents concerning the links between air pollution and respiratory problems and cardiovascular diseases, with most respondents suggesting between seven and 15 years. However, there were some respondents who felt it might be 20 years or more.

This was confirmed in later testing undertaken in Rome in October 2006. In focus group sessions the interviewers explored people's decisions regarding the size of risk reductions and their timing. The responses indicated that people were able to make such choices – trading off smaller risk reduction incurred immediately with larger ones incurred in the future.

In the interviews and focus groups conducted in the Czech Republic in October 2006 respondents were requested to choose between risk reductions of 15 in 100 000 which occurred in 25 years, against one of 10 in 100 000 in ten years. The latter was chosen by the majority of respondents. Part of the reason cited by a number of respondents was that the child would necessarily be an adult by the time the health impact arose with the longer latency period.

The scenarios presented to the respondents

As a means to develop meaningful scenarios, considerable work was undertaken to assess the capacity of respondents to make trade-offs between affected populations, different risk attributes, etc. In this section this work is summarised, classified by the nature of the choice (*i.e.* direct contingent valuation for a programme or product, contingent valuation through location decisions, person trade-offs, risk-risk trade-offs,[2] and multi-attribute choice decisions).

Direct Contingent Valuation

While the notion of basing all the results upon the implementation of a contingent valuation scenario was quickly discarded, it was seen to be important to include such an approach as an element within the survey instruments, and testing was undertaken on alternative CV methods.

In the case of the UK a contingent valuation scenario was proposed in a pilot involving 300 respondents in the Cambridge area in August/September 2006. The questions for the contingent valuation part of the questionnaire were based on the survey in Krupnick *et al* (2002). In order to present respondents with a comparison of their overall mortality risk they were presented with risks from some of the largest single causes. The scenario presented involved a risk reduction (either 5 in 10 000 or 1 in 10 000) arising from the purchase of a product which would reduce mortality risks over the course of 10 years.

A large percentage provided a WTP of zero. More significantly, a relatively high proportion of these can be considered as "protests" (see Table 3.3). This raised concerns about the viability of using a direct CV question to elicit WTP for a mortality risk reduction.

Table 3.3. **Percent of total sample who stated a contingent valuation WTP of zero by reason**

	5/1 000		1/1 000	
	No protest	Protests	No protest	Protests
Adult	41.3	7.0	64.0	7.0
Child	20.0	4.7	45.3	5.0

In survey development work undertaken in Rome in October 2006, and in Prague in May 2007 and March 2008, a scenario was presented which proposes to the respondent the possibility to move from his/her actual city to two hypothetical cities whose attributes vary according what we want to value. The "City A v. City B" scenario was presented as follows:

"Imagine that there are two cities that are identical to each other and to the city where you actually live in all respects, except for the mortality rates and cost of living.

In city A, X in 10 000 children aged 5-9 (same age group as one of the respondent's children) die every year. The cost of living is the same as where you live now. In city B, Y (Y < X) in 10 000 children aged 5-9 die every year. In city B, the cost of living is EUR 1 000 a year higher than in city A (and than where you live now).

Where would you prefer to live, in city A or city B?"

With appropriate follow-up questions, the "City A v. City B" alternative can provide an exact indifference point between cities A and B – determining precisely the value of the risk reduction. The "City A v. city B" questions elicit information about the WTP and VSL for any desired age group. However, in general the work undertaken indicated a very high WTP for risk reductions relative to other methods, and it was decided to abandon this approach and use a direct CV question in further pilot testing.

Person Trade-Off

As a means to assess the "marginal rate of substitution" between reducing risks for adults and children, people are asked to choose between two programmes in which the programmes differ with respect to the beneficiary populations. While this can not be used to derive a VSL it can provide valuable information for policy makers (*i.e.* by adjusting the anchor VSL figure depending upon the composition of beneficiary populations).

Two alternatives were tested. In one case a policy intervention is proposed which results in different numbers of lives of adults and children being saved. Several pairs of programmes are proposed to the respondents, which then allows for the estimation of the trade-off point. This PTO approach was tested by the Italian research team and the Czech Republic, as follows:

"*Suppose now one has to choose between other public health interventions. Intervention A saves 10 lives in 10 000 children aged 0-4 this year, whereas this year intervention B saves 30 lives in 10 000 adults older than 30.*

As before, there is funding for only one of these two interventions. Which would you choose? (Please check the appropriate answer.)

- *Intervention A: saves 10 lives in 10 000 children aged 0-4.*
- *Intervention B: saves 30 lives in 10 000 adults older than 30.*
- *A and B are equally attractive.*"

However, the ratio was exceedingly high with respondents favouring relatively programmes in which a relatively small number of children are saved (relative to one in which a larger number of adults are saved). An alternative involving the provision of medical treatments tested well, providing credible ratios. It is presented in the next section below.

The Chaining Exercise/Standard Gamble

The initial survey development work undertaken in the UK in August/September 2006 indicated that the potential for zero and protest responses with a direct CV scenario for mortality risk reductions was significant. For this reason, the possibility was considered of "chaining" a WTP question for morbidity risk reductions with a second question in which morbidity and

mortality risks were traded off against each other. As noted above, this approach is known as risk-risk trade-off.

In the first instance, a so-called modified standard gamble question was tested in which respondents were told to imagine that they have been injured or have become ill and are taken to hospital where the doctors tell them that if they are not treated then they will die. However, they are told that there are two possible treatments available to them and this time both are free of charge (see example in Figure 3.7):

Treatment A: *If successful, the treatment will result in the respondent experiencing the consequences of a specified non-fatal injury or illness. However, if the treatment is unsuccessful then the patient would fall unconscious and die shortly afterwards with probability of 1/1 000 (this risk can be set at any level).*

Treatment B: *If successful, this treatment will result in a return to normal health after a couple of days but if unsuccessful there is a chance that the treatment will result in immediate unconsciousness followed shortly by death (this risk is unspecified).*

Figure 3.7. **Example of Trial Modified Gamble Question**

Treatment A	Treatment B
If successful: – Hospital for 3 weeks – Severe pain for 4 months – Permanent slight to moderate pain in your hip	If successful: – Leave hospital that day – Full health in 3-4 days – No permanent disability
If fails: – Immediate unconsciousness – Followed shortly by death	If fails: – Immediate unconsciousness – Followed shortly by death
1/1 000	?

The respondent is asked for the highest level of risk she would accept for treatment B given that treatment A has a risk of failure of 1/1 000 (or whatever level of risk is set by the researcher). As treatment B has a better successful outcome than treatment A, *i.e.* full health *versus* some level of remaining disability, it is expected that the respondent is willing to take on some additional mortality risk for the chance of this better successful outcome. While this step requires respondents to deal with small changes in risk, it does not involve a wealth-risk trade-off and is therefore thought to be easier for respondents to answer. For information, the VSL's derived from the pilot chaining exercise and the direct elicitation through CV are presented in Table 3.4.

Table 3.4. **VSL Results for the CV and Chaining Exercise Pilot Study**

	Parent (GBP)	Child (GBP)	Child/Adult Ratio
Chaining Approach: X*	471 063	2 174 422	4.6
Chaining Approach: Y*	221 710	2 611 465	11.8
Direct: 5/1 000	2 300 767	4 996 105	2.2
Direct: 1/1 000	3 015 233	14 070 910	4.7

* X refers 3 weeks hospitalisation; 4 months severe pain; permanent pain in hip and Y refers to 2 months hospitalisation; 4 months moderate pain; permanent pain in knee

Overall, the risk-risk trade-off appeared to be well-understood and respondents were engaged when providing their answers. However, many respondents reported that the trade-off in the modified standard gamble (with two treatments) was difficult, and this point was taken into consideration when designing the final survey instrument.

Conjoint Choice Experiments

The decision, to pursue the CCE methodology for at least one of the survey instruments necessitated that considerable survey development work was devoted toward more general issues of cognitive burden. For instance, in personal interviews conducted in the Czech Republic in January 2007, the difficulty of making choices was assessed with different numbers of attributes. Initially, the respondent might be asked to choose between two programmes which varied only according to the size of the risk reduction, its duration, and period of latency (as in Table 3.5)

Table 3.5. **Example of 3-attribute Conjoint Choice Question**

	A	B
Reduction of mortality risk by...	20:10 000	20:10 000
The measure will have the effect of reducing the risk of dying...	Immediately	in 5 years
The risk will be reduced for the period...	3 years	5 years

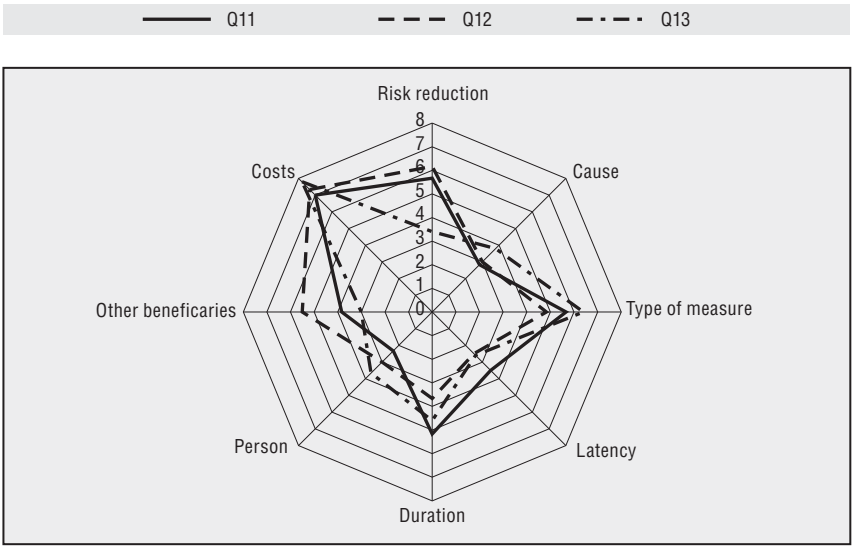
The number of attributes was incrementally increased from three to maximum of eight (risk reduction, cause, type of measure, latency period, duration of risk reduction, identity of beneficiary, whether other beneficiaries, cost). Respondents were requested to indicate how difficult they found different choices to be with different numbers and characteristics of attributes. In general, with additional attributes and the inclusion of cause of death there is a distinct increase in the perceived difficulty.

However, it is not only the number of attributes which affects the difficulty of responding. For instance, the introduction of the context (*e.g.* cancer, car accident, respiratory disease) in CE5 appeared to have a disproportionately large effect on difficulty of the choice. In addition, as noted above, addressing the question of latency appears to be particularly difficult for respondents, and considerable care was taken to address this in the survey development work.

In particular, the relationship between the length of the latency period and the identity of the respondent (self or child) was closely evaluated. Irrespective of the identity of the beneficiary, beyond a certain latency period (approximately 15-20 years), the immediate risk reduction was systematically chosen irrespective of relative size. This appeared not to be due entirely to discounting per se, but also to perceptions about possible improvements in medical care over the period.

The relative importance of different attributes in the choices was also assessed, and the results of an analysis undertaken on three different choice questions in the Czech Republic are presented in Figure 3.8 below. Latency and cause are very important. In addition, it is interesting that the relative importance of the different attributes does not vary greatly with precise choices presented. These results were used to inform the design of the final survey instruments.

Figure 3.8. **Relative Importance of Different Attributes in CC Decisions**
(Importance of the attributes, 1 = most important; 8 = least important)



Design of the final questionnaires

Given the uncertainties and difficulties associated with the valuation of children's environmental health risks it was decided to implement a combination of different methods/approaches in two distinct survey instruments. In total, four different methods were applied, all of which had been tested extensively: contingent valuation; conjoint choice experiments, standard gamble risk-risk trade-offs (chaining), and person trade-offs. However, not all methods were applied in all countries, and some of the methods are linked (See Table 3.6 below.) The two survey instruments will now be discussed.

Table 3.6. **Methods Implemented in the Three Countries**

	CR	IT	UK
Contingent Valuation	Yes (mortality and morbidity)	Yes (mortality)	Yes (morbidity)
Conjoint Choice Experiment	Yes	Yes	No
Standard-Gamble (Chaining)	Yes	No	Yes
Person Trade-Off	Yes	No	No

Chaining Exercise

In the United Kingdom and the Czech Republic a novel "chaining approach" was implemented, as well as a contingent valuation question. The questionnaire was in five parts:

1. Recruitment section.
2. Warm-up section.
3. Step 1 Chaining method: direct illness valuation.
4. Step 2 Chaining method: standard gamble.
5. Socio-economic details.

In the first step, respondents are requested to indicate how much they would be willing to pay for a treatment which would avoid all of the effects associated with one of four states of ill-health. This procedure is undertaken for all four possible health states (see below).

They are then requested to imagine that they (or their child) have one of these conditions and that if they are not treated then a worse outcome (including in some cases death) will ensue. However, they are told that there are two possible treatments available, one of which involves a measure of risk. For example, respondents may be told that they are now afflicted with the permanent health reduction Pa. One treatment results in the certain outcome Ta (stomach pains with diarrhoea and vomiting for 12 months) while the alternative treatment offers the possibility of a quick

return to full health but with a specified risk of death. The illness cards, are described as follows:

- **Temporary Adult (Ta):** Severe stomach pains affecting the respondent with diarrhoea and vomiting for 2-3 days every 2 weeks for 12 months.
- **Temporary Child (Tc):** Severe stomach pains affecting the respondents' child with diarrhoea and vomiting for 2-3 days every 2 weeks for 12 months.
- **Permanent Adult (Pa):** Severe stomach pains affecting the respondent with diarrhoea and vomiting for 2-3 days every 2 weeks for the rest of life.
- **Permanent Child (Pc):** Severe stomach pains affecting the respondents' child with diarrhoea and vomiting for 2-3 days every 2 weeks for the rest of life.

All elements of this problem (the initial health state, the various treatment outcomes and the risk of success/failure) can be varied. An example of a standard gamble is provided in Figure 3.9 below.

Figure 3.9. **Example of Standard Gamble Question in Final Survey Instrument**

Treatment A	Treatment B
For sure: Your child has severe stomach pains, diarrhoea and vomiting for 2-3 days every 2 weeks for the rest of your child's life.	50% chance Your child avoids all effects from this illness 50% chance Your child becomes unconscious and subsequently die

By "chaining" the responses to these two exercises, *i.e.* the WTP to avoid a health state and the trade off between this health state and risk of death, a VSL can be derived. The aggregated WTP stated in the first step can be equated to the average risk of dying provided in the second step so that an estimate of the VSL can be calculated as:

$$VSL = \frac{WTP}{\delta}$$

where δ indicates the average mortality risk level at which the population was indifferent between the illness and the treatment.

Other sections of the questionnaire elicited information on demographics and personal data; the health states of the respondent and child; the socio-economic characteristics of the respondent, as well as views on the questionnaire.

Conjoint Choice Experiment

A conjoint choice experiment was implemented in Italy and the Czech Republic, alongside a contingent valuation question. The revised questionnaire incorporated a probability tutorial and tested respondents for comprehension of risks in this and in other contexts (*e.g.*, lottery tickets). The following experimental design was implemented for the valuation questions in the final questionnaire:

1. Valuation questions were exclusively of the respondent or one of his or her children, selected at random from all children (but not both to avoid cueing respondents); respondents were assigned at random to the treatment where they valued own risk reductions or risk reductions for the selected child.[3]
2. There were a total of 5 pairs of risk-reducing profiles. Half of the respondents were assigned to one treatment whereby for each pair they faced a forced choice question (choose A or B?), followed by a choice question that allowed for an opt-out response (choose A, B or neither?). The other half of the respondents were given the A, B or neither question directly.
3. The context (cause of death) was held the same across alternatives in the first two pairs of risk reducing profiles in the conjoint choice questions. The latency period was always the same for both risk reduction profiles, but was varied pairs within a respondent and across respondents.
4. The conjoint choice questions used the following attributes and attribute levels:
   A) Context (cancer, road traffic accidents, respiratory illnesses).
   B) Private good or public program.
   C) Latency (0, 2, 5 and 10 years).
   D) Size of the risk reduction (2, 3, 5 and 7 in 10 000 over 5 years).
   E) (One time) cost to the respondent (EUR 200, 500, 1000, and 2 000).
5. All attributes were varied independently of one another for full identification.

Attribute and attribute levels are summarised in Table 3.7 below. To further elaborate on the reasons why the attribute levels shown were selected, it is noted that the risk reductions were similar to those assigned to the respondents in the contingent valuation exercise earlier in the questionnaire

Table 3.7. **Summary of attributes and attribute levels in the conjoint choice experiments**

Attribute	No. levels	Levels
Context (cause of death)	3	Cancer Road traffic accidents Respiratory illnesses
Private good or public program	2	Private good (no other beneficiaries); Nationwide public program (other beneficiaries)
Latency	4	0, 2, 5, 10 years
Size of the risk reduction	4	2, 3, 5, 7 in 10 000 over 5 years
(one-time) Cost to the respondent	4	EUR 200, 500, 1000, 2000 (Italy) CZK 3 200, 8 000, 16 000, 32 000 (Czech Republic)

(where the risk reductions are 2, 3, 4, 5, 6 and 7 in 10 000 over 5 years). Combined with the cost information and with plausible discount rates, they span VSL figures ranging from EUR 200 000 to EUR 25 million.

The final questionnaire is divided into 9 sections. The conjoint choice experiments were placed roughly in the middle of the questionnaire. Section 0 begins with querying the respondent about his or her age, gender, and marital status. Respondents were prompted to enter the names, ages and gender of each of their children. The computer then selected at random one child among the eligible children, *i.e.*, those aged 17 and younger. Throughout the survey, the questionnaire always refers to this selected child using his or her first name, *e.g.* "Paolo".

Section A asks several questions about the health status of the child, and section B asks questions about the health status of the parent (*i.e.*, our survey respondent). In section C, extensive information is elicited about the health, lifestyle, and perceptions of environmental exposures and exposure to road-traffic risks for both the selected child and the parent. Section D presents a simple probability tutorial and some quizzes to test the respondent's comprehension of probabilities. Probabilities naturally lead to the risk of dying, which is depicted using a grid of 10 000 squares (when the respondent was supposed to focus on the magnitude of the risks) or with bar charts (when the respondent was supposed to focus on the different mortality risks across age groups, as a child grows up, and as a person gets older). People were also requested to indicate how much they "dread" certain causes of death.

In section E, it is explained that it is possible to reduce the risk of dying both through individual actions (*e.g.*, pap smears, medical tests) as well as public programs (*e.g.*, road safety programs, air pollution control regulations). In section F, respondents are queried about purely quantitative aspects of risk, and then asked a contingent valuation question about their WTP for a

specified risk reduction (for either themselves or the selected child). Section G focuses on the three causes of death the CCE are about namely, respiratory illnesses, cancer, and road-traffic risks.

In section H, respondents were encouraged to think about the effectiveness of private vs. public risk reductions, and about the timing of the risk reductions. The conjoint choice questions were placed immediately thereafter, in section I, and were followed by extensive debriefing about reasons for wanting to pay (or not) and ways of financing the cost of the risk reduction. Section L asked various questions about risk perceptions and preferences for risk reductions now or in the future, and section M asked the usual socio-demographic questions.

Implementation of the questionnaires

Chaining Exercise

As noted above, for the chaining exercise, two surveys with the same questionnaire format have been conducted in the UK and the Czech Republic. In the Czech Republic, the survey was implemented in Prague and Brno, as well as in six provinces. In the UK, observations were obtained from a wide distribution of locations.

In the UK, in order to collect an approximately representative sample of parents, 14 UK locations have been selected. The precise geographical distribution of the respondents in the UK is listed in Table 3.8 below.

Table 3.8. **Sampling Locations in the UK**

Location	*Number of interviews*
Leeds	*59*
Hull	*85*
York	*61*
Sheffield	*104*
Glasgow	*108*
Cardiff	*70*
Romford	*84*
Southend	*24*
Holloway Road	*41*
Colchester	*64*
Bexleyheath	*167*
Lewisham	*65*
Croydon	*62*
Chiswick	*6*
Total	*1 000*

The target was parents with children aged less than 18 years of age. Respondents were recruited on the street using a recruitment questionnaire which aimed to select a representative quota sample. Subsequently, respondents were invited into a hall, adequately equipped with laptops, and they undertook the survey administered by professional interviewers. Respondents were given a GBP 5 voucher to thank them for their time in taking part. A professional survey company was responsible for data collection and data cleaning. Thirty-one days of face-to-face interviewing took place, including some weekends to ensure inclusion of working people. Interviewers were trained to deal with emotive topic such as child safety and to minimise the well-documented interviewers' bias.

A similar procedure was implemented in the Czech Republic. This involved quota sampling of parents with at least one child below 18 years of age (that doesn't necessarily have to live in respondent's household). Quotas were also used for respondent age (18-34, 35-44, 45+), gender, level of education (three levels), regions (six), and size of municipality *(cities, 50k-100k, 10k-50k, 2k-10k, 2k less)*. As in the UK, the interview mode was via computer-administered personal interviews. However, unlike the UK it took place at the respondent's home.

Overall, a good spread of respondents was obtained in terms of age, gender and socio-economic group and the main sample characteristics are reported. The mean of respondent' age is 37 in the UK and 39.5 years in the Czech Republic. The British sample consists of slightly larger families (3.66 compared with 3.46) having more children (1.75 versus 1.66). About half of selected children were boys in both countries. On average, the child selected in the Czech survey was older (9.8 years old) compared with the child selected in the UK survey (8 years).

Conjoint Choice Experiment

For the second survey instrument, the approach also involved quota sampling. However, in the case of Italy, only residents of Milan (where air pollution is a problem) were sampled. The final survey took place in two dedicated facilities in Milan, and, as in the pilots, respondents self-administered the questionnaire using the computer. Interviewers were present for the first few days of the final survey, and personally observed about 20 respondents while the latter were taking the survey. Conversations with respondents suggest that respondents traded off the attributes when they answered the conjoint choice questions. Respondents were paid EUR 10 for their participation in the survey.

Descriptive statistics of the key demographic variables from the final survey show that the sample is consistent with the sampling frame. Respondents were between the ages of 20 and 60, and only parents were included in the sample. The maximum child age was 17. The sample was evenly split between mothers and fathers, but homemakers were restricted to no more than 20% of the women in the sample. In addition equal quotas for three age categories (30-34; 35-44; and 45-49) were applied.

In terms of education, 23% of the sample has a university degree, which reflects the composition of the city's population. 51% had a high school diploma and 26% a junior high school diploma, which represents the minimum legal requirement. In addition, quotas were used for relative wealth – 50% of respondents lived in household with income less than 30 000 EUR/year, and 50% were above this threshold.

The Czech sample followed the same quotas as for the Milan sample, but was representative of the Czech population, including major cities (Prague, Ostrava and Brno), as well as smaller towns and rural areas. Interviewers were sent to people's homes, where they conducted the survey in-person using the computer in a manner similar to that used in Italy, *i.e.*, self-administered by the respondent.

As noted above, respondents were requested to indicate their health status (excellent, very good, etc.) and that of their child. The frequency of responses are presented in Figure 3.10 below, with respondents more likely to report that the health status of their child is excellent than for themselves.

Figure 3.10. **Health Status of the Respondent and Child**
(Percentage of the sample indicating each health status category)

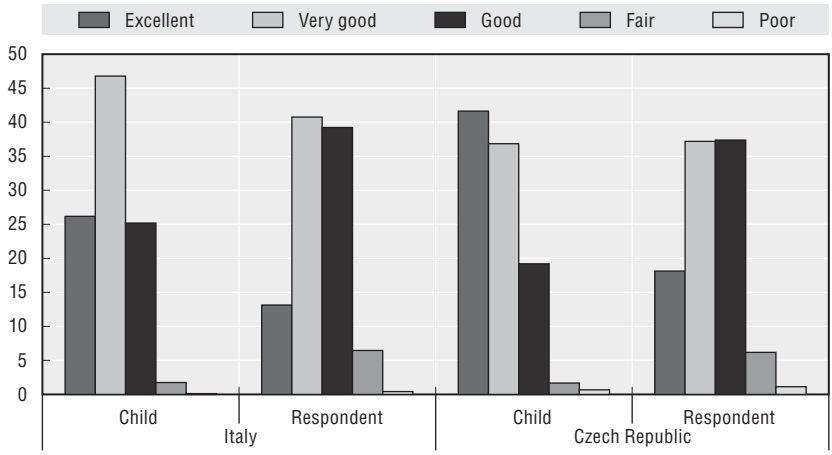


Table 3.9 shows that only minor proportions of the respondents reported chronic respiratory illnesses that require regular medication or inhalers, or cause limitations in physical activities. These proportions are slightly higher in the Czech sample, because the interviewers visited the respondents' homes. We expected persons with severe physical limitations to decline to participate in the study in Milan, since participation implies being willing to go to two centralised facilities in the winter. These expectations are borne out in the data.

Table 3.9. **Prevalence and Severity of Chronic Respiratory Illnesses in the Sample**

Has chronic respiratory illnesses that…	Italy				Czech Republic			
	Adult		Child		Adult		Child	
	N Valid	Percent	N Valid	Percent	N Valid	Percent	N Valid	Percent
Require regular medication or inhalers	1 893	5.55%	1 894	4.07%	1 506	4.45%	1 506	7.10%
Cause small limitations in physical activities	1 887	4.66%	1 885	1.91%	1 506	6.18%	1 506	7.57%
Cause serious limitations in physical activities	1 870	0.80%	1 880	0.27%	1 506	2.19%	1 506	1.66%
Force him to stay home from work or school often	1 871	1.07%	1 882	1.38%	1 506	0.80%	1 506	2.92%

Notes

1. Disconcertingly, some respondents did not protest to the presentation of risk reductions which exceeded baseline risks.
2. Risk-risk tradeoffs do not directly estimate dollar values for risk reductions, but rather, provide rankings of relative risks based on preferences. For related risks such tradeoffs may be linked to provide a value of WTP.
3. In the Czech survey, three additional choice pairs were included for the purpose of inferring the trade-offs between the parent and children risk reductions (labelled choice experiment). The data are currently being analysed.

ANNEX 3.A1

Chronology and Main outcomes of Survey Development Work

Date	Location	Sample	Type	Purpose	Main outcomes
January 2006	Norwich (UK)	99 UEA students	Experiment design	Look at the impact of risk and familiarity on scope sensitivity of WTP estimates.	Unfamiliar risks or large risk denominators impose a large cognitive burden, resulting in scope insensitivity of WTP estimates
July 2006	Cambridge (UK)	25 parents	Pilot study	Obtain WTP and VSL estimates for both adults and children using the chained method.	Premium on WTP to avoid morbidity to children; aversion to mortality risks to children; child premium for mortality risks: VSL for a child greater than VSL for an adult
August-September 2006	Cambridge (UK)	300 parents with at least a child aged 13 or under	Pilot study	Obtain WTP and VSL estimates for both adults and children using a contingent valuation survey.	Premium on reducing mortality risks to children; VSL for a child between 2 to 10 times greater than VSL for an adult
September 2006	Milan and Mestre (Italy)	16 parents in each city with at least one child aged 0-12 (8 respondents each)	Focus group discussions	Explore parents' concerns and perceptions about environmental pollution, children's health and test some methodological aspects as well.	Risks associated with the environment and its health impacts are salient to people. They focus on air pollution. People found the tools used to display risks really clear and helpful. People understood the notion of latency while extensions in life expectancy (tested in Mestre's focus groups) were difficult to convey.
October 2006	Roma (Italy)	14 parents with at least one child aged 0-12	Focus group discussions	Test the materials related to mortality rates, survival curves, life expectancy, risk reductions at different ages and conjoint choice experiment.	Mortality rates expressed as relative frequencies worked well. The bar charts and survival curves used were well understood. The grid used to display risk probabilities was found to be useful. Evidence that people trade-off the size of risk reduction with the timing of the risk reduction. People understood the concept of life expectancy and extensions in life expectancy.
October 2006	Prague (Czech Republic)	15 parents of children aged 0-14	Focus group discussions and individual interviews.	Know people perceptions about risks, environmental health risks, dread effects and test some methodological aspects as well.	People are aware of environmental health risks. No evidence of dread effect. People understood the concept of latency. Extensions in life expectancy were found to be easier to value than reductions in mortality risks.

Date	Location	Sample	Type	Purpose	Main outcomes
December 2006	Venice (Italy)	15 parents	Focus group discussions	Test for possible conjoint choice experiments. Special focus on the presentation of mortality risks, the breaking down of a risk into its possible attributes and on the conjoint choice exercises.	The approach and materials were understood by the respondents. They used all attributes to make their decisions. Person trade-off questions were well understood although people tend to always choose to save children's lives.
January 2007	Venice, Vittorio Veneto and Garda (Italy)	13 parents with children aged 0-14	One-on-one interviews	To test the concept and materials for a conjoint choice experiment (CCE) (using different ill-health causes, latency periods and modes of delivery) and person trade-offs (followed by a CV question).	Concerning the person trade-offs, respondents always chose to save children, whatever the age of the adult and the number of adult lives saved. As such, respondents are more likely to pay more to reduce risks to children than to reduce similar risks to adults. Concerning the CCE, respondents considered all the attributes when making their decisions, including context and cause of death. Dread effects seem to be associated with cancers.
January 2007	Prague (Czech Republic)	18 parents with child aged 0-14	One-on-one interviews	To test PTO questions, the workability of the conjoint choice experiment (using different ill-health causes, latency periods, as well as different modes of delivery, and changing the order of the attributes) and the feasibility of the chaining method.	Concerning the conjoint choice experiment (CCE), the order of attributes does not affect the importance of the attributes. Respondents considered all attributes when answering, including cause of death and context. The number of attributes included increased the difficulty of respondents to make a choice. In general, cause/context, beneficiary and duration of the effects were considered the most important. The chained approach was well understood and was perceived as easier (than the CCE) by the respondents. Concerning PTO the choice set which reduces risks for the respondent's own child did not dominate the choice set that reduces risks for adults.

Date	Location	Sample	Type	Purpose	Main outcomes
May 2007	Prague (Czech Republic)	14 parents with child aged 0-14	One-on-one interviews	Test the perception of the true size of annual risk of dying for children, the usability of CCE, the second PTO alternative (to derive indifference point), and the "City A v. City B" scenario.	Using three approaches creates a very long questionnaire (average time of completion 74 minutes). The most important attributes of the CCE are the cause of death and the beneficiary. The PTO question was found to be difficult to answer because people had to choose between saving children and saving adults, but in the end all respondents were able to make a choice. Trade-off point between adults and children estimated at 52 (*i.e.* people are indifferent between saving 52 children and 100 adults). The "City A v. City B" led to a mean WTP of approximately EUR 1 000 which is significantly higher than the cost figures used and accepted by individuals in the CCE.
October 2007	Norwich (UK)	10 parents	One-on-one interviews	Verify the credibility of questions, the length of the survey and the clarity of the show card information	The questionnaire was originally composed of three main sections: willingness to pay (WTP), standard gamble (SG) and personal trade-off (PTO) questions. Respondents found the survey quite credible and interesting but they suggested some fundamental changes. Respondents showed fatigue and difficulties in answering the PTO questions and some of them gave no rational answers. They asked for some rewording in this section of the questionnaire. Given the average length of the survey of more than 40 minutes, we decided to focus the survey on the first two sections (WTP and SG).

Date	Location	Sample	Type	Purpose	Main outcomes
November-December 2007	Norwich (UK)	13 parents	One-on-one interviews	Test the clarity of questions, the ability of respondents to understand risk values and the coherence of their answers throughout the questionnaire.	Significant changes were made to improve the show card information. Respondents found the survey interesting, fairly easy to understand and they gave coherent and rational answers to the WTP and SG questions. However, some of them found that the budget constraint question was too generic to be able to represent the ability to pay for health treatments. For this reason, it was decided to split the final sample in: 800 respondents with the budget constraint question and 200 respondents without. Furthermore, in the latest version of the questionnaire some questions were added to allow the respondent to reconsider their budget allocation decisions.
March 2008	Prague (Czech Republic)	9 parents with child aged 0-17	One-on-one interviews	Test the final version of the questionnaire using the conjoint choice experiment approach as well as the "City A vs. City B" questions (as applied in Italy)	The questionnaire including a conjoint choice experiment and the "City A vs. City B" questions worked very well. This suggests that using this scenario would enable to elicit respondents' WTP for reducing mortality risks to adults and children. In the conjoint choice experiment, all respondents chose the dominant variant which was purposely included.
March 2008	Prague (Czech Republic)	9 parents	One-on-one interviews	Test the applicability of the choice experiment and "city A vs. city B method" questionnaire (applied at the same time in Italy) to the Czech conditions, and the applicability of the translation. Propose alternative values of risk reduction and bids, and alternative wording of selected questions previously tested in Italy.	The choice experiment and "city A vs. city B" scenarios are feasible methods for elicitation of respondents WTP for reduction of risk of dying for both adult and their selected child. All respondents chose purposely included dominant variant. Only minor changes regarding the language or measurement of the total amount of time spent on activities which may increase respective baseline risks were proposed. Based on the positive experience with the testing in the Czech Republic the proposed questionnaire is going to be used in the final survey.

Date	Location	Sample	Type	Purpose	Main outcomes
May 2008	Colchester (UK)	30 parents	Pilot study	Test the CAPI version of the questionnaire before final survey. Verify the coherence of answers and the accessibility of the CAPI system. Test the ability of the questionnaire to elicit the value of statistical life for adult and child.	Small problems with software needed to be resolved. Some concerns about the combined use of monthly payments and one-off payments.
June 2008	Milan (Italy)	7 parents	Pilot study	Test improved visual communication of the magnitude of baseline risks and risk reductions (*i.e.* grids). Verify the new presentation of the nature of the risk and the means of risk reduction in the scenarios.	The survey is long, and there are a lot of questions which require much concentration on the part of the respondent (choices city A/B, technology A/B, conjoint, etc). There are problems with the software which need to be checked carefully.
July 2008	Prague	9 parents	One-on-one	Testing CVM	
August 2008	Prague	106 parents	Pilot	Tested CCE (56) and Ch (50)	
Sept-October 2008?	nation-wide	323 parents	Pilot	Tested CCE	

Table 3.A1.1. **Summary of Main Findings**

Issues to be addressed	Evidence	Suggestions
Third party elicitation	The parental perspective was adopted in the CCE and the chained approach as empirical evidence suggests it is the most appropriate manner to reveal children's preferences. Although it may be affected by altruism and risk perception, it worked well in both cases. Parents did state higher WTP to reduce risks to their children than to themselves.	The parental perspective was adopted in the final instrument. Although a collective approach seems preferable, it has never been used in an empirical context, probably because of modelling complexity. As such, a unitary approach was adopted.
Latency issues	People understood very well the difference between immediate and latent risks. People tend to favour reducing immediate risks when the programme deals with adults.	Latency attributes could be included in the final survey instrument.
Environmental context	Respondents declare being aware of environmental health issues and their exposure to those hazards. In the CCE, context plays an important role in decision-making. The chained method has not been tested in an environmental context, and pre-tests suggest that a context-free scenario would work better.	For policy-making purposes, the final survey instrument should use an "environmental context", as far as possible. However, for purposes of comparison, other contexts should also be included.
Health impact	Respiratory diseases worked well in the CCE but not as well in the chained method. Road accidents worked well in both approaches but they are not environment-related hazards. Cancers (tested in the CCE) worked well.	Respiratory ailments, traffic accidents and cancer adopted for the CCE. In the case of the chaining exercise, a stomach ailment was adopted, rather than an "injury", which had been used previously.
Low probabilities	Expressions such as "10 in 10 000" or "10 for every 10 000" were used in the CCE and were clearly understood by respondents. Different risk reductions were used in the chained approach, such as 20/1 000, 100/1 000 and they were well understood by respondents. Good comprehension of probabilities is associated with communication in the first part of the questionnaire on risk and probabilities using visual tools (grids). However, real probabilities of death were not presented.	The use of grids to display risk and probabilities clearly helps respondents understand the probability figures presented in the scenarios. Such tools should be used in the final instrument as well.
Comparison of values for adults and children	Distinct values could be obtained for both children and adults from both survey instruments. Depending upon the precise approach chosen for the PTO questions, people may have a tendency to choose programmes which save children, irrespective of the number of adults saved.	Split samples to ensure values obtained for both children and adults. Apply PTO questions, but not as the sole means to obtain a MRS.
Good to be valued	People are not always able to understand correctly extensions in life expectancy.	Mortality risk reductions valued in the final instrument survey.
Risk perception	The first questions of the questionnaire deal with risk comprehension and propose to train people in understanding the concept of mortality risks and of probabilities using grids. These aids were greatly appreciated by the respondents who found them very clear and easy to understand.	The use of such preliminary tools in the final survey instrument.
Valuation approach	Conjoint choice experiments were well accepted in Italy and the Czech Republic. The chaining approach was promising as respondents seem to fully engage in the exercise.	The two approaches (CCE and chaining) could be used in at least two of the three countries to be able to compare results between two countries.
Survey sampling	Only parents have been interviewed in the preparatory work.	As it would be awkward to ask a non-parent to value a risk reduction to a child, it is suggested to interview only parents.

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Chapter 4

Survey Results

Value of Statistical Life (VSL) estimates both for children and adults are presented. Analysis of the data indicates (qualified) support for evidence for a 'child premium', which is consistent with previous literature. This evidence is more robust in the case of the chaining instrument. Moreover, the effects on the estimated VSL of a large number of risk characteristics, demographic and economic factors, and programme attributes were obtained, and the main results are summarised. For instance, it is clear that context matters, but it plays a different role in the case of children and adults, with less variation across context for children than for adults.

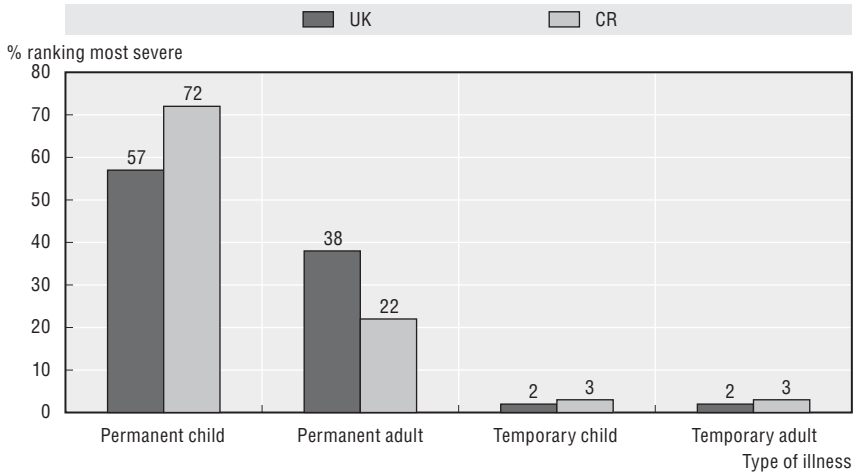
Introduction

The summary results based upon analyses of the data collected through the two survey instruments are presented below, first for the chaining method (United Kingdom and Czech Republic) and then for the conjoint choice experiment (Italy and the Czech Republic). Following this, a brief discussion of the person trade-off exercise implemented in the Czech Republic is presented. The chapter concludes with presenting some preliminary results of an analysis attempting to transfer welfare benefits between countries and contexts.

Chaining method

The objective of the first section in the chaining method was to obtain the maximum individual willingness to pay (WTP) values to avoid the effects of four different illnesses[1]: permanent child (Pc), permanent adult (Pa), temporary child (Tc) and temporary adult (Ta). However, before proceeding to the WTP questions, in the warm-up section respondents had to rank four different illnesses from the most to least adverse impact. Each illness could refer to child or adult, and have temporary or permanent effects. The percentage of respondents ranking each illness as the most severe for UK and CR are presented in Figure 4.1 below.

Figure 4.1. **The ranking exercise: Percentage of respondents ranking illness as most severe in UK and CR**



Results show that the respondents generally rank the permanent illness for their child as more severe than the permanent condition affecting themselves. This result is as expected and the same in both countries. It is a first check that people understand correctly the two dimensions of the illnesses: the severity and whether a child or an adult is affected. There is a higher proportion of British respondents ranking the permanent condition affecting the adult as the most severe compared to the Czech sample. The reason for this is not clear, but may have to do with the Brits considering it more important that they themselves are in good health to be able to care for their child. However, when adding the percentages of respondents ranking an illness as either first or second in terms of severity (rather than just first as in the figure), the shares are almost identical between UK and CR for all four conditions.

Using the total payment values, *i.e.* a lump-sum of max WTP and as equal payments over 10 years to avoid one of the four conditions, we report the main statistics of WTP measures. The results for the UK sample are presented in Table 4.1 below, followed by the Czech sample in Table 4.2.[2]

Table 4.1. **Mean and median WTP to avoid a certain illness for the British sample**
(British pounds)

	Mean (st.dev)	Median
Ta	14 387 (53 830)	3 600
Tc	25 782 (197 136)	6 000
Pa	20 640 (63 441)	6 000
Pc	44 502* (283 085)	9 000

Table 4.2. **Mean and median WTP to avoid a certain illness for the Czech sample**
(British pounds)

	Mean (st.dev)	Median
Ta	12 591 (42 261)	3 279
Tc	15 408 (44 319)	4 656
Pa	18 250 (42 424)	5 902
Pc	23 915 (57 748)	7 869

* One unlikely, extreme value was removed

Results show that respondents' initial ranking of severity of the four illnesses to some extent is reflected in the way they express their WTP. WTP is the highest to avoid the permanent condition for the child and the lowest to avoid the temporary condition affecting the adult for both countries. However, in the UK people seem to be willing-to-pay more to avoid the temporary condition affecting the child than the permanent condition for the adult, at least in terms of mean values. Statistical tests show strong evidence of a child premium in both countries. Finally, the WTP values are generally higher in the UK than in the CR, as can be expected given the income differences.

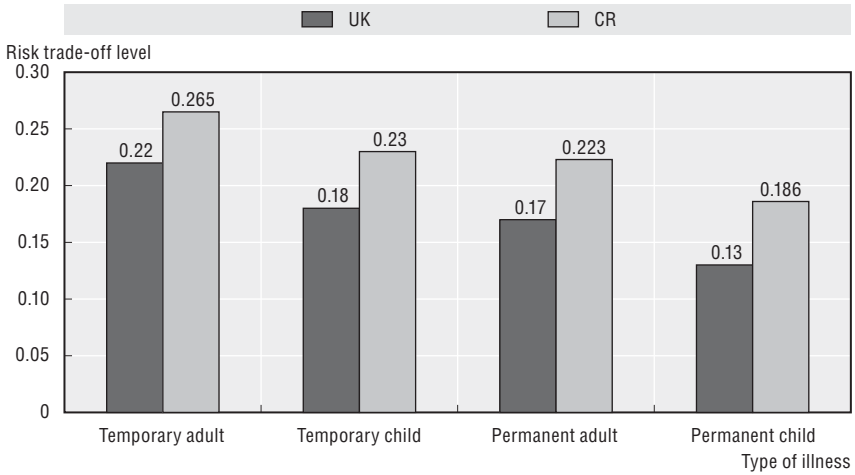
Although the WTP results between types of illnesses and affected persons generally are as expected, many respondents were also insensitive to

these two dimensions. This means that they were insensitive to the scope (quality/quantity) of the good valued and stated the same WTP for all four conditions. This problem seemed to be more severe in the UK survey than in the CR survey.

Methodological tests where subsamples of respondents were given different versions of the questionnaire were carried out. The budget constraint test, which aimed to make respondents more aware of their actual, available household budget, did not seem to affect stated WTP values in either country. This may indicate that people generally did consider their household budget carefully even if only given a simple, standard budget reminder. Second, the order of the illnesses which respondents were asked to consider did not seem to matter for their WTP, a positive result as problematic ordering effects are often found in stated preference studies.

The second part of the chaining approach first involves finding the levels of risk that make respondents indifferent between one of the temporary conditions (Ta or Tc) with certainty and an uncertain treatment that can bring them back to full health or give them or their child one of the permanent conditions (Pa or Pc). This is the standard gamble question. The second step involves trading off risk of the permanent condition (Pa or Pc) with certainty and an uncertain treatment with a risk of death. The mean risk levels elicited from respondents are given in Figure 4.2 below. Results show that respondents generally accept a lower risk of a more serious condition (permanent illness or death) for their children, and indication of their greater concern for their children. It can also be seen from the figure that British respondents are more risk averse for all types of illnesses than their adult Czech counterparts.

Figure 4.2. **Risk trade-off values in the UK and CR**



The WTP values can then be "chained" with the standard gamble question to obtain VSL.[3] On this basis the "best" estimate (*i.e.* using a single chain) for a child VSL in the United Kingdom of GBP 342 323 is significantly greater than that of an adult GBP 121 411. The difference in the Czech Republic is less pronounced (EUR 128 736 and EUR 81 892), but statistically significant at the 5% level (see Table 4.3).

Table 4.3. **The VSL using mean WTP and SG values**
(British pounds)

	UK		Czech	
	Mean VSL	Median VSL	Mean VSL	Median VSL
Single chain				
Adult	121 411	100 000	81 892	47 213
Child	342 323	1 636 364	128 736	112 412
Double chain				
Adult	374 355	523 636	212 862	131 148
Child	1 073 616	21 818 181	360 722	443 404

Elicited VSL estimates for children exceed those for the parent, indicating that parents do place a premium on reducing mortality risks to children. The ratios found for both countries using the chaining method are similar to those already reported in the literature. For example, the ratio of the parent and child VSL estimates found in the literature are between 0.6 and 2.3. However, the wider literature on child premiums for safety and health (including illness as well as mortality) range between 0.6 and 6.0 with the average being around 2.0 (Hunt and Ortiz, 2006b).

It can also be observed from the table that using a single or double chain approach to deriving the VSL has a fairly large impact on the estimated VSL. In other words there is a violation (or failure) of procedural invariance.

Assessing the determinants of VSL (for adults and children) was also one of the key objectives of the VERHI project. Several regressions were carried out using respondent and household characteristics to try to explain estimated VSL. Results of these regressions (for brevity not displayed here) show that female respondents give higher VSL. If the child is a boy, VSL also tend to be higher. On the other hand, the more members the household has, the lower is VSL. In line with economic theory and one's expectations, positive and significant effect of income on VSL was observed. Further, VSL is larger for respondents on maternity or parental leave, and smaller if the respondent was single. Being more educated increases VSL as well. These results are explorative and should be interpreted with caution as VSL is not directly

observed but a product of the stated WTP and the risk value stated in the standard gamble. More research is required to interpret these results, for example in the context of different household resource allocation models.

In conclusion, evidence from observing respondents completing the survey indicates that they seemed to engage effectively with the chaining method questions. Indeed this approach appeared quite successful in overcoming the challenges associated with asking respondents to value small changes in mortality risk. The tests suggest that no ordering bias or budget constraint effects were found in the WTP responses. However, testing of the chaining approach reveals differing sources of failure of procedural invariance, including possible double counting of a child premium which arises in both the WTP and standard gamble procedures.

As such, although the chaining method appears to be a promising procedure for valuing statistical life for children, there are grounds for some caution. Given the scarcity of previous studies, more research is needed before we can draw concrete conclusions on the ability of the chaining method to estimate a VSL for children. Finally, further research is required to investigate the effect of life expectancy and time preference factors on the child/adult VSL ratio.

Conjoint choice experiment

Conjoint choice experiments were conducted in CR and Italy. The main aim of these surveys, in addition to estimating VSL for children and adults, was particularly to investigate the effect on VSL of cause of death, the type of risk reduction program (public or private), and latency and size of risk reduction. The main results are reported in the following.

First, not distinguishing between these context factors, the survey implemented in Italy gave a VSL for an adult (EUR 4.0 million) that was not statistically different from that for a child (EUR 4.6 million). In the CR the values were statistically different at the 5% level, with values of CZK 24.5 million (EUR 1.44 million) for the child and CZK 19.2 million (EUR 1.13 million) for the adult.

However, there are differences in VSL between adults and children when differentiated by context. Table 4.4 reports the results of model runs in which the data from Italy are used and the marginal utility of a risk reduction is allowed to vary with the cause of death. Clearly, the VSL is different across causes, with the largest value being that for the cancer context. The cancer premium with respect to the VSL compared to the situation where the cause of death is a road traffic accident is 26% for a child, and 84% for adult risk reductions. The cancer "premium" would seem to be strongest among adults. This is not surprising, since cancer is extremely rare in children and the baseline risk for adults is higher, a fact that is not lost on our respondents.

Table 4.4. **Estimated mean (st.error) VSL by cause of death**

a. Italy (million EUR)

	Child	Adult
VSL for respiratory disease	4.6 (0.30)	3.3 (0.21)
VSL for cancer	4.8 (0.34)	5.3 (0.33)
VSL for automobile accident	3.8 (0.30)	2.8 (0.22)

b. Czech Republic (million CZK)

	Child	Adult
VSL for respiratory disease	23.2 (2.21)	15.0 (2.20)
VSL for cancer	31.6 (2.85)	34.3 (3.29)
VSL for automobile accident	19.3 (2.17)	12.9 (2.30)

Note: Results based on the use of a non-linear conditional logit model and using objective probabilities of survival implicit in the mortality figures showed respondents in the survey.

Differences in values between cancer and the other causes of death is even more marked in the CR, where the cancer premium is 64% for a child and 165% for adults (as compared with the risk caused by an automobile accident). Since the "composite", non-cause-specific, VSL is lower for adults than it is for children in CR, it may be due to the comparatively lower VSLs for adult respiratory and road traffic accident deaths.

In Table 4.5 the results of a model where, in addition to the key attributes of the alternatives (*i.e.* context), we enter respondent-assessed measures of: *i)* effectiveness of public programs in reducing the stated risks; *ii)* dread; *iii)* exposure to the circumstances where each cause of death would apply; *iv)* beliefs about baseline risks of dying for a specific cause of death for a person the respondent's age or a child the same age as the respondent's child; and *v)*, sensitivity (which depends on current health status). Results are divided between those respondents who valued risk reductions affecting themselves and those who valued risk reductions affecting their children, and presented for both countries in the table.

The results for Italy show clearly that the VSL increases with the dread associated with a cause of death (variable DREAD is significantly positive), with public (vs. private) programs (variable PUBLIC), with the perceived effectiveness of public programs (variable PUBEFF), and with exposure (variable HIGHEXPO). Regarding the effect of beliefs about how common a

Table 4.5. **Effects of Cause of Death and Risk Characteristics on VSL**
(Non-linear conditional logit model)

	Italy				Czech Republic			
	Adult		Child		Adult		Child	
	Coeff	t stat	Coeff	t stat	Coeff	t stat	Coeff	t stat
ALPHARESP	–0.0391	–1.372	–0.0415	–1.255	–0.1099	–4.511	–0.044	–1.917
ALPHACNCR	0.0607	4.732	0.0137	0.933	0.0836	4.86	0.0857	5.663
ALPHAAUTO	–0.0587	–4.639	–0.038	–3.189	–0.0436	–2.661	–0.0082	–0.644
PUBLIC	0.0485	7.19	0.0755	9.874	0.0271	2.921	0.073	7.963
DREAD	0.0227	5.175	0.0213	4.336	0.0035	3.911	0.0027	1.72
PUBEFF	0.0283	5.765	0.0296	5.489	0.0517	6.946	0.0271	4.132
HIGHEXPO	0.0202	2.001	0.0352	3.353	0.0464	3.593	0.0184	1.641
MORECOMM	0.0181	1.669	0.0352	3.213	0.0236	1.644	0.0185	1.420
SENSIT	–0.0055	–0.323	–0.0033	–0.128	0.028	0.942	0.1827	6.723
AGE3039	–0.0279	–1.715	–0.0139	–0.672				
AGE4049	–0.0486	–2.857	–0.0669	–3.251				
AGE5059	0.0123	0.631	–0.0513	–2.274				
MATURA	–0.0068	–0.495	0.0059	0.376				
SOMECOLL	0.0652	2.3	0.0719	2.433				
COLLEGE	0.0189	1.188	0.0397	2.266				
MOSTINC	–0.0452	–2.995	0.0161	1.032				
BETA	–0.0005	–16.702	–0.0005	–15.327	–0.005	–22.997	–0.005	–22.617
DELTA	–0.0145	–1.946	–0.0024	–0.311	0.0136	0.960	–0.0094	–0.892
N	6 999		6 059		5 450		4 998	
log L	–6 294.52		–5 416.05		–4 821.62		–4 469.82	

cause of death is for people depending upon the age of the beneficiary in the conjoint choice tasks, the estimated coefficient on this variable has the expected sign, but the significance level differs between child and adult in Italy, and is weak in the Czech Republic (see variable MORECOMM).

Even more important, the results show that controlling for the attributes of risk and risk perception has not been sufficient to explain away the differences in the VSL for each cause of death. All else the same – and so, controlling for dread, exposure, etc. – respiratory causes of death and road traffic accidents continue to be valued less, and cancer continues to be valued more, than that predicted by attributes and perceptions alone. Perhaps this is due to the fact that the constructs used do not capture all possible facets of risk perceptions, or to the fact we do not have an explicit way to control for familiarity with the type of risk being valued.

As for the chaining method, effects of respondent and household characteristics on VSL were investigated. In Table 4.6 the results of a model which focuses on demographic characteristics is presented. Results show that if the selected child is a boy, a parent would be willing to pay less than if the

Table 4.6. **Effects of Demographic and Household Characteristics on VSL in the Czech Republic**
(Non-linear conditional logit model)

	Coefficient	t stat
ALPHARESP	0.053	0.709
ALPHACNCR	0.0478	3.885
ALPHAAUTO	–0.0244	–2.188
PUBLIC	0.0732	7.978
MALECHIL (child is a boy)	–0.0557	–2.693
AGE6_10	0.0018	0.089
AGE11_15	–0.0016	–0.081
AGE16_18	–0.0078	–0.409
ONLYCHIL (child is an only child)	–0.1176	–2.671
YOUNGEST (child is the youngest child in the family)	0.0536	1.367
MOTHER (respondent is the mother)	–0.0756	–3.037
MUMBOY (respondent is the mother and the child is a boy)	0.1192	4.221
OLDEST (child is the eldest child in the family)	0.0633	1.539
CHILDREN (number of children the respondent has)	–0.0319	–1.517
MUMONLY (respondent is the mother and the child is an only child)	0.055	1.996
PRAGUE	0.0356	1.673
BRNO	0.2384	8.838
OSTRAVA	–0.0301	–0.806
SMALLTWN (resident of city with less than 20 000 people)	0.0373	2.133
MEONLY (answers to conjoint choice questions are just the respondent's opinions)	0.0321	2.077
MESPOUSE (answers to conjoint choice questions reflect the respondent and spouse's opinions)	0.0692	3.723
BETA	–0.005	–22.687
DELTA	–0.0077	–0.752
N	5 041	
log L	–4 464.26	

risk reduction was for a daughter (variable MALECHIL). The VSL for daughters is about EUR 0.4 million larger than the VSL for boys. When the selected child is a daughter, mothers would be prepared to pay less (VSL is about EUR 0.56 million smaller) than fathers (variable MOTHER). When the selected child is a boy, however, a mother would be prepared to pay more than a father for any given risk reduction (variable MUMBOY). Indeed, the highest WTP is that for reductions in the risks of boys when a mother is the respondent.

Birth order and the age of selected child do not appear to have an effect (variable OLDEST and AGE variables). However, the more the children in the family, the smaller the VSL for any selected child (variable CHILDREN). While others may interpret this as a quality v. quantity type of argument (which assumes the more children, the lower VSL is), it may be more likely that this effect is attributable to income constraints. Single mothers (MUMONLY) are

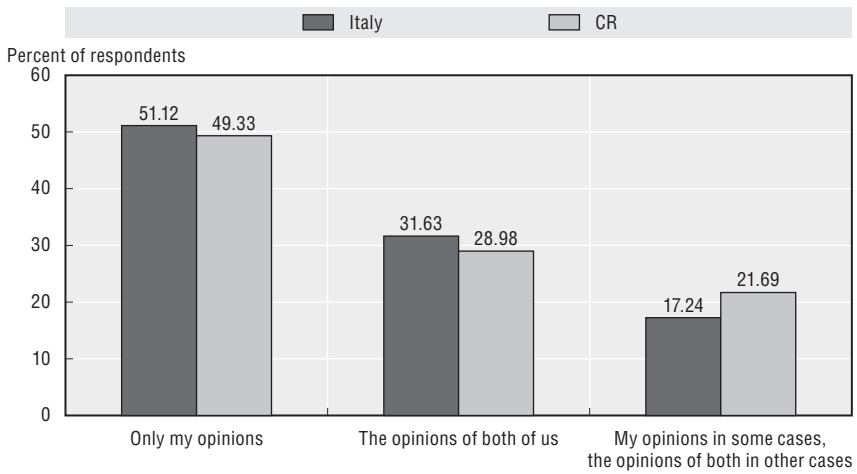
prepared to pay significantly more (the effect on the VSL being EUR 0.4 million) than mothers living with their husbands.

We find a strong effect on the VSL associated with respondents from the city of Brno and marginally, at 10% level, from Prague – *i.e.* two big cities comparable with Milano –, and a small, positive and significant effect among respondents who live in towns with fewer than 20 000 people. Finally, respondents who always report their own as well their spouse's opinions hold a larger VSL than those who always report only their own (by about EUR 0.5 million) (variables MEONLY and MESPOUSE), and the latter is in turn larger (by EUR 0.24 million) than that of people who sometimes report their own tastes and sometimes their spouses'.

Since intra-household decision-making may also be important to understanding the valuation of risk reductions for children, at the end of the conjoint choice section of the questionnaire, we asked the respondent whether in answering the choice questions he was reporting only his opinion or his spouse's opinions as well. As shown in the table below, about 50% of the respondents reported only their own opinion, and around 30% of respondents in both countries believed their answer mirrored their spouse's opinion as well. Interestingly, results are almost the same across the two countries. Further, the percentages do not vary systematically across genders. It is not easy to interpret these results in relation to questions of intra-household decision-making, and more research is clearly needed.

In summary, on the basis of different models estimated based on the data collected in Italy and the Czech Republic, the results indicate that: When we do not distinguish for the cause of death, for Italy, child VSL is about EUR 4.6 million,

Figure 4.3. **Distribution of responses to question concerning individual vs. joint responses (%)**



whereas parent VSL is about EUR 4.0 million. These figures are not statistically different from one another. For the Czech Republic, child VSL is EUR 0.91 million and parent VSL is EUR 0.71 million if we recalculate the Czech crowns by nominal exchange rate, or EUR 1.44 million and EUR 1.13 million respectively if purchasing power parity is used. VSL for child and adult are marginally statistically different at the 5% significance level.

Results show different VSL estimates depending on whether the risk is caused by respiratory illness, road traffic accident or cancer. VSL for cancer is larger than VSL for respiratory death for both countries; the VSL cancer "premium" is about 30% in Italy and 67% in the Czech Republic relative to the VSL for respiratory illness. It is interesting that the cancer premium is larger for adults than for children. The more one dreads a specified cause of death, the higher the VSL for that cause of death tends to be. This is so both in Italy and in the Czech Republic.

In both the Italy and the Czech Republic study, all else the same people are prepared to pay more if the risk reduction is delivered by a public program and the public program premium appears to be the same for all three causes of death here examined. In the Italy study, this premium is approximately EUR 1.8-2 million when the beneficiary is the child and EUR 1-1.3 million when the beneficiary is the parent; in the Czech Republic the public program premium is higher for children (CZK 10-12 million) than for the adults (about CZK 3-4 million), and is not significant among the latter. This suggests that for the average respondent altruistic considerations prevailed over potential doubts about the provision of the risk reduction itself.

The discount rate exhibited by people for future risk reductions is very low, and indeed it is not significantly different from zero in all of being estimated models. Quit small discount rates are well within the range of typical values inferred from people's choice between money now and mortality risk reductions later (*e.g.* Moore and Viscusi, 1990; Horowitz and Carson, 1990; Alberini *et al.*, 2006), but in sharp contrast with the results of an earlier stated preference survey conducted in Italy (Alberini *et al.*, 2007), where the discount rate was 7%.

The marginal utility of income declines with higher-income and this expectation is borne out in our data. The marginal utility of income is smaller by about 20% among people with income above the mean in the respective samples. In the Czech Republic, living in a relatively large city further increases the marginal utility of income. We also find that, even controlling for income, women are willing to pay less for own risk reductions. The effect of education is mixed, and that of respondent (or beneficiary) age is likewise ambiguous. Since age effects have been noted only among the eldest of the elderly (Krupnick *et al.*, 2002), our respondent may have been too young to pick any age effects.

Person trade-offs between children and adults

In addition to the conjoint choice experiment and the chaining exercise, in the CR a set of person trade-off questions was implemented. In the case of person trade-offs (PTO) the objective it to elicit preferences in public policy settings. The approach begins by asking respondents to consider different groups of people who, if left untreated, will shortly suffer a certain health state, the details of which are shown on the card. Two groups of equal size are introduced, in which one group is composed of children of about 10 years old and the other group of adults of 40 years of age. These two age groups were just the expected mean age of the children and the parents in our sample.

The respondents were asked to suppose there is a new treatment that could completely prevent a given health state and allow those affected to live a normal life. It would cost exactly the same to treat each group, but there are only enough resources to treat one of the groups, not both. What the respondent has to decide is "Which group should be treated?" In order to get the point where the respondent is indifferent between the groups, respondents are asked to decide again, successively reducing the number of members of the group that was previously preferred by the respondent.

In total, three health outcomes were considered in person-trade-offs:

- PTO1 – severe stomach pains affecting a person with diarrhoea and vomiting for 2-3 days every 2 weeks for 12 months (outcome T);
- PTO2 – severe stomach pains affecting a person with diarrhoea and vomiting for 2-3 days every 2 weeks for the rest of life (outcome P); and
- PTO3 – premature death.

Based on the responses to this exercise, the ratio of adult and child members within respective groups that makes the respondent indifferent was derived.[4] The child premium when comparing the two groups is 1.58 for the least severe illness outcome, T. The premium is around 2 both for the permanent health outcome and for the premature death outcome. Each reported statistic confirms that parents prefer to treat ill children or save children if a decision in a public context needs to be taken between children and adults.

Table 4.7. **MRS derived from person means**

	Mean	Median
PTO1(T)	1.58	1.67
PTO2(P)	2.00	2.22
PTO3(death)	1.97	2.00

Are the results transferable?

Benefit transfer (BT) is a method to apply existing welfare estimates from a study site(s) or context (where the value is transferred from) to a new policy context or site (where the value is transferred to). The most common approach of value transfer is based on transferring original study results from the literature or from a specific study in a similar context directly to a policy context, with simple price and income adjustments. The need for transferred value estimates arises if there is a proposed policy under consideration and there is no time or resources to carry out a full-blown, primary valuation study similar to those carried out under the VERHI project. In many cases, it may also not be necessary to carry out a full study if all the policy maker needs is a rough indication of the size of welfare benefits. BT of VSL estimates may be useful in such situations – both between countries and between contexts (*e.g.* if VSL is estimated for different causes of premature mortality).

Several BT techniques were tested: the naïve transfer based on adjusting benefit estimates using nominal exchange rate, a simple transfer based on using purchasing power parity (PPP) adjustments, and transfers that correct for differences in income levels (*i.e.* using assumptions about income elasticity).VSL estimates were transferred both between countries and contexts (causes of death and public vs. private risk reduction programs). BT tests were based on the chaining method and on the choice experiments.

The aim of the tests was to check how large the errors in transfer are, when using the estimated VSL values in each country and context as a "true", observed benchmark values compared to a transferred value. The transfer error is the relative difference between this benchmark value and the predicted or transferred value (see equation below). There is no generally agreed level of error that could be deemed acceptable in policy analysis, though 40-60% has been indicated as acceptable in many contexts.

$$Transfer\,Error = \frac{VSL_{transferred} - VSL_{observed}}{VSL_{observed}} \cdot 100\%$$

The first BT tests estimate transfer errors between Italy and CR for child and adult VSL based on the contingent choice data, using different types of adjustments. Transfer errors were generally found to be very high: around 400% for a naïve transfer of adult and child VSL values using nominal exchange rate adjustments. Errors were almost halved when using a PPP adjustment. The effect of the choice of income elasticity is less important for reducing transfer errors. The transfer errors continue to remain high (between 100% and 500%) when testing transfers of VSL values distinguished by the three causes of risk between Italy and CR. When distinguishing also by public

or private program (in addition to causes), the transfer errors seem to come down somewhat. One example is the transfer of an VSL value related to cancer and a public program and assuming an income elasticity of 1. Conducting this transfer results in a transfer error of 34%. However, this low level is the exception rather than the rule, unfortunately, for the tests conducted based on the contingent choice data.

When conducting BT tests based on the results from the chaining method we obtained rather more precise transfers than for the contingent choice data. We measured the transfer error rates for WTP to avoid the four investigated illnesses, mentioned above. Let us start with naïve transfer and by using both nominal values of mean WTP in British pounds (see upper part of Table 4.8 below). The error rates are the largest for transfer between the UK and the Czech Republic for the most severe illness, *i.e.* Pc. The lowest error rates were found for the transfers of WTP for parents (when WTP was stated to avoid Ta or Pa). Using nominal Euros would just slightly increase the error rates of the transfers.

Using simple BT with PPP corrections reduce the errors somewhat down to ±20%, except for the error for Pc of 34% (see Table 4.8). If the illness in parents is valued, the transferred value of WTP from the UK would be smaller than the actual WTP which is estimated from the Czech data (*i.e.* negative transfer error). Considering WTP for all valued illnesses, we conclude that PPP correction works better than the naïve transfers. PPP correction is also the recommended approach in the literature. Adjustments using two levels of income elasticity yield similar levels of transfer errors (bottom part of Table 4.8) as those for PPP adjusted simple transfers.

Table 4.8. **Transfer error rates for WTP between the UK and the CR**

	Ta	Tc	Pa	Pc
Naïve transfer				
EUR nominal	27%	86%	26%	107%
GBP nominal	16%	70%	15%	89%
Simple transfer with PPP correction				
GBP PPP	–18%	20%	–19%	34%
Adjustment by income differences				
income elasticity = 1				
GBP	39%	–5%	41%	–14%
income elasticity = 0.7				
GBP nominal	21%	–18%	22%	–26%
GBP PPP	34%	–9%	35%	–18%

Combining the WTP values to avoid the four illnesses with the risk value answers given by respondents in the standard gamble questions, we can test the errors involved in transferring VSL estimates between UK and CR. Results for transfers of adult and child VSL values derived both by the single and double chain are given in Table 4.9 below.

Naïve transfers yield quite large error rates between 50% to 240%; the error rates are larger for the double chain than for the single chain. Compared to the transfer errors only using WTP values, it is clear that errors are compounded when multiplying chains of risk and WTP. Simple transfer that adjusts by PPP reduces the error rates. In the case of the single chain, the error rate of mean VSL for parents is only 7%; for the case of children the error is still about 90%. Correcting for the income differences using income elasticity assumptions yields the lowest absolute error rates from 3% to about 50%.

Table 4.9. **Transfer error rates for VSL transfer between UK and CR**

	Single chain		Double chain	
	VSL parent	VSL child	VSL parent	VSL child
Naïve transfer				
EUR nominal	65%	196%	101%	240%
GBP nominal	51%	170%	84%	210%
Simple transfer with PPP correction				
GBP PPP	7%	91%	30%	120%
Adjustment by income differences				
income elasticity = 1				
GBP nominal/PPP	7%	–40%	–12%	–48%
income elasticity = 0.7				
GBP nominal	–7%	–48%	–24%	–55%
GBP PPP	3%	–42%	–15%	–50%

Transfers between these two national samples works the best when VSL for parents is derived. Without more detailed information about a fuller range of explanatory variables it is difficult to interpret and control for the errors involved in transfers. It is likely that other differences in socio-demographic characteristics, culture or risk aversion between different samples might drive differences in VSL. For the BT tests carried out it is clear that the transfers of VSL values based on the data from the chaining method yield the lowest errors, approaching precision levels acceptable for policy use. Different types of adjustments, especially PPP corrections and estimates of income elasticity, have been shown to reduce errors in many contexts.

Notes

1. Recall that these were diarrhoea and vomiting of various durations caused by severe stomach pains.
2. For sake of comparison amounts from the CR survey has been converted into British pounds using purchasing power adjusted exchange rate. Both sets of results are based on the full samples.
3. The mean WTP is chained with the mean risk values in the sample, rather than first chaining WTP and risk value stated by each respondent and then taking the resulting mean VSL across the sample. The latter approach is not pursued as individual responses may give extremely large values which may inflate the mean VSl to an implausible extent.
4. The experiment started with 100 persons in each group. If, for instance, a respondent chooses to treat the group A, the number of persons in the group A is reduced in next step. If then the respondent chooses to treat group B, the number of people in group A is increased but by less to have 100 in total. This procedure is repeated until reaching the point of indifference, *i.e.* where the respondent is indifferent which group with different number of persons should be treated. For example, if a respondent is indifferent between the group of 100 adults and the group of 60 children, then the ratio would be 1.66 (*i.e.* 100/60).

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Chapter 5

Conclusions and policy implications

While it is clear that there is no single ratio which can capture differences in risk preferences for children and adults, there is some evidence that the VSL for a child is greater than that of an adult. This has implications for policy evaluation and prioritisation, perhaps resulting in certain policy interventions passing benefit-cost tests when this would not have been the case with the use of an undifferentiated VSL. However, it is clear that further work is required.

Introduction

The primary objective of the VERHI project has been the estimation of a value of a statistical life for children[1] and (for reasons of comparison) adults in a context which could be said to be "environmental" in nature. The combination of these three factors (child, mortality and environment) complicates the task of the researcher significantly.

Why do policymakers care about the evaluation of mortality risk preferences for children? There are a number of related reasons:

- While the evidence is relatively limited, that which is available indicates that children are potentially particularly vulnerable to some environmental hazards – both due to relatively high levels of exposure and their greater susceptibility to health impacts for given levels of exposure.[2]
- There is a general perception that precaution should be exercised with respect to children's health, and this is reflected in policy measures in a number of areas in addition to the environmental sphere – *e.g.* product safety.
- The health of children can be seen as a public good in some sense – with the good health of children having positive spillovers both for their parents and for society-at-large.[3]
- While the interests of children themselves are defended by parents (and other caregivers), policymakers in OECD governments have always had a special role in protecting the interests of children (sometimes from their parents).[4]

Estimates of the VSL for children, however, are in short supply. Economic theory and existing empirical work do not offer unambiguous conclusions about whether they are the same as for adults. For this reason, one of the goals of this research project was to estimate the VSL for children and adults in contexts that are appropriate and relevant for environmental policy, and to assess whether the value of reducing such risks for children is greater than for adults, and if so, what does this mean for policymakers? It is the latter questions which are the focus of the concluding chapter.

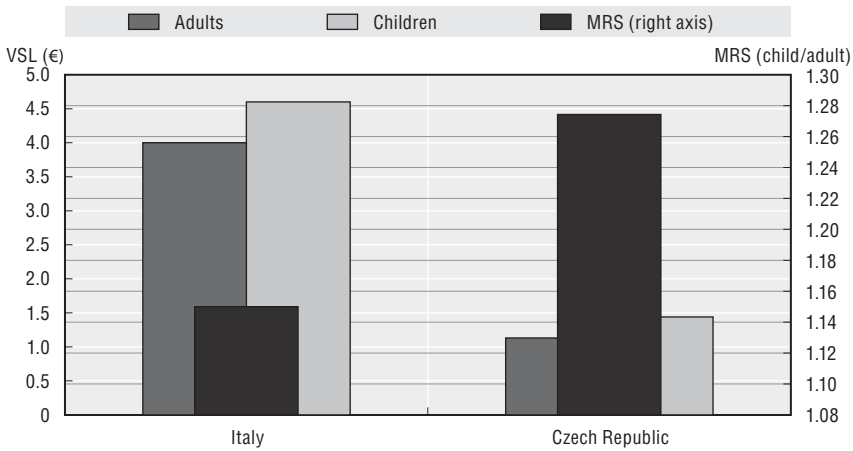
Is the VSL for children greater than for adults?

While the project generated a number of policy-relevant results which related to the valuation of mortality risks more generally, the principal policy-relevant objectives of the VERHI project was to determine whether, the value of risk reductions for children was greater than for adults – *i.e.* is the

marginal rate of substitution of risk reductions for children to adults greater than unity? As noted, the estimated "adult" VSL obtained in the VERHI study is derived from a sample of parents only. As a consequence, the VSL for all adults (all those above 18 years of age) could be different than that obtained in the study, resulting in a different estimated "premium" for child VSL.

At the aggregate level, the results are somewhat ambiguous. In the case of the conjoint choice experiment implemented in Italy the VSL for an adult (EUR 4.0 million) is not statistically different from a child (EUR 4.6 million). In the Czech Republic the values are statistically different at the 10% level, with values of CZK 24.5 million for the child and CZK 19.2 million for the adult. Figure 5.1 presents these figures,[5] alongside the marginal rate of substitution *i.e.* the ratio of these two values).

Figure 5.1. **VSL and MRS in Italy and Czech Republic Based on CCE**



Using the chaining exercise, the estimated values of risk reductions for children and adults are markedly different. We can first compare responses to the CV question in which respondents are asked what they would be WTP in order to avoid a poor health state. For a temporary poor health state, the MRS is 1.8, and for a permanent poor health state, it is 2.16. Given life expectancy, it is hardly surprising to find that the ratio is higher for the permanent health state, than the temporary one. As noted above, these values can then be "chained" with the standard gamble (SG) question to obtain a VSL. On this basis, the "best" estimate (*i.e.* using a single chain) for a child VSL in the United Kingdom is GBP 342 323, which is significantly greater than that of an adult GBP 121 411. The difference in the Czech Republic is less pronounced (EUR 128 736 and EUR 81 892), but statistically significant at the 5% level. However, there are concerns that there may be "double-counting" associated

with the chaining exercise, with the premium for child risk reductions applied twice. As such, in Figure 5.2 below the MRS is presented when the parents' own standard gamble response is applied to both themselves and children. However, the Czech values when the adult SG response is applied are not statistically different for children and adults.

The person trade-off exercise allows for direct estimation of the marginal rate of substitution, which is just ratio of adult persons to child persons stated by each individual in respective PTO consequent questions. From Table 5.1 below we see the distribution of individual MRS's is skewed; the MRS ranges between 3.4 to 6.2 for means, but the MRS derived from medians ranges between 1.7 to 2.2.

The MRS derived from the means in this case is 1.58 for the least severe illness outcome, T, whereas the MRS is around 2.0 for P and premature death. The MRS derived from geometric means are substantially larger; 1.91 for T, 2.6 for T and 2.67 for illness terminated in death. Each reported statistic confirms the parents prefer to treat ill children or save children if the decision in public context needs to be taken between children and adults.

In general, the results from VERHI are consistent with the literature, finding qualified evidence of a MRS greater than unity. However, this is by no means always the case. For example, the cancer VSL figures in Italy and the

Figure 5.2. **MRS for VSL based on the Chaining Exercise in UK and CZE**

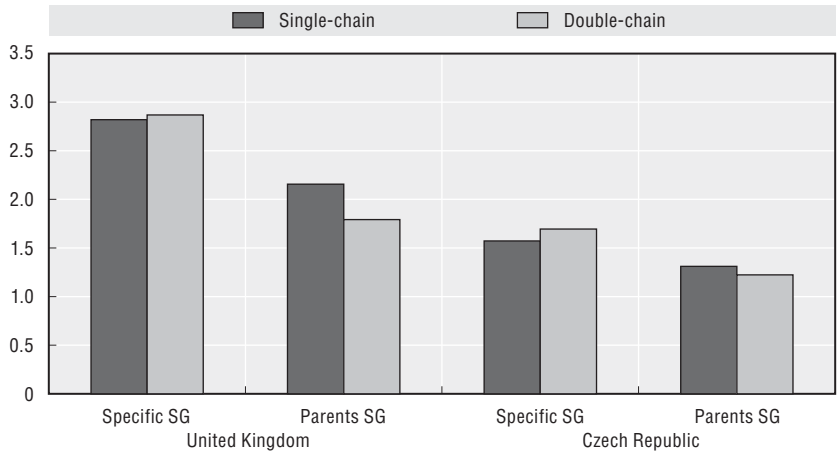


Table 5.1. **MRS derived from PTO means**

	Mean	Median	Geometric Mean
PTO1(T)	1.58	1.67	1.91
PTO2(P)	2.00	2.22	2.61
PTO3(death)	1.97	2.00	2.67

Czech Republic based on the conjoint choice experiments are higher for adults, raising the question whether the context or the baseline risk matter.

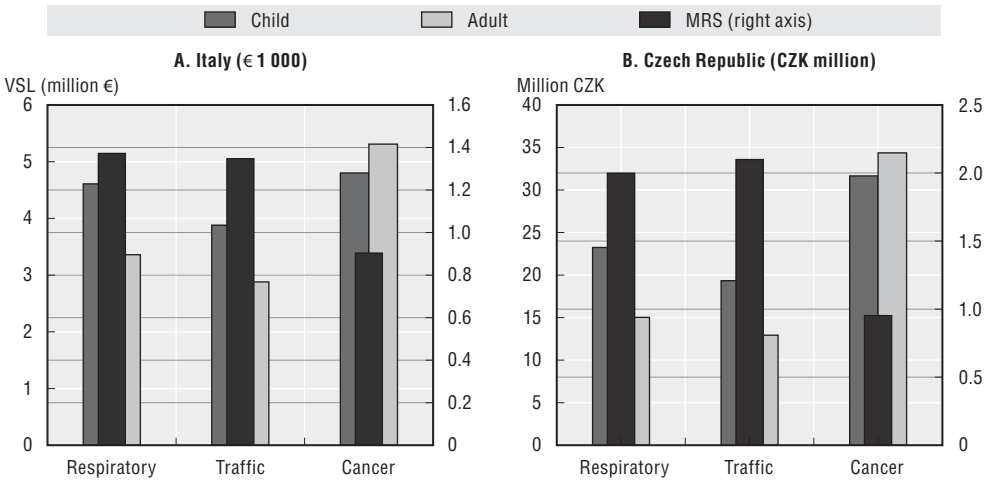
Why might values be different for similar risks?

The principal reason for the (qualified) finding that the MRS is greater than unity is likely attributable to general social preferences for risk reductions for children relative to adults, irrespective of the nature of the risk. It is also possible that the greater life expectancy of children (in general) relative to adults (in general) have a positive impact on the MRS for mortality risks.

A related risk factor, which may be particularly important for children, is that of latency. On the one hand, if the duration of latency exceeds the life expectancy of some adults, the VSL will be lower for the same reasons stated above. On the other hand, in the child valuation context, latency has particular implications when exposure is incurred in childhood, but the health impacts are realised much later as an adult. If risk preferences differ between children and adults, do these differences relate primarily to differences associated with exposure or with response? As such, latent impacts, which can manifest themselves long after the point of exposure, raise particular complications for the researcher (and policymaker).[6]

There is considerable empirical support for the view that context has an effect on VSL. Moreover, findings from VERHI indicate that relative VSLs for adults and children differ markedly by context (see Figure 5.3) While the MRS is actually less than one in Italy for cancer, it is in region of 1.3-1.4 for respiratory disease and traffic accidents. In the case of the Czech Republic, a similar pattern holds, but with relatively higher MRS (approximately 2) for the latter two contexts.

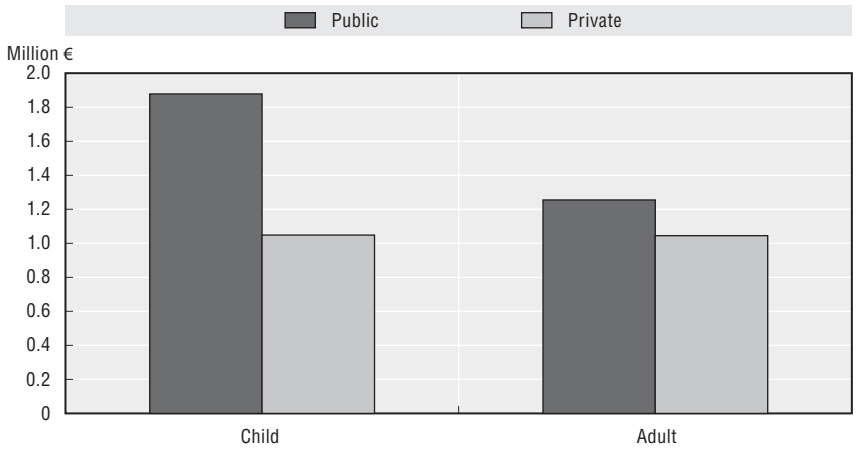
Figure 5.3. **VSL and MRS by Context Based on CCE**



In addition, the degree of "voluntarism" of a given risk may mean something very different for a 6-year old from for an adult. While respondents to a survey may perceive the risks associated with traffic to be voluntary for adults, the very same risks may be perceived as involuntary for children. Similarly, a risk, which is perceived as "controllable" for an adult, may be seen as uncontrollable for children. Even if a defensive expenditure is undertaken as a means to reduce risk, the parent may feel that they have "imperfect control" over it is to protect their child from a given risk.[7] This might explain some of the difference in MRS by context presented in Figure 5.4.

Of course, both of these factors correlate with the distinction between private and public risk reductions. However, the difference in WTP for children under the two cases (private and public) may be somewhat different than for adults. Most importantly, the relatively greater difference between the VSL associated with a public programme relative to a private activity for children may be attributable to the relatively more important component of paternalistic altruism in total WTP for children than adults. Adults may not trust other parents to protect their children. This may also be due to the nature of the substitute private risk reduction, and the degree of control that they believe that they can exercise. If their control is relatively more imperfect for children than for themselves, public risk reductions will be preferred relatively more to a private alternative for children than for adults, even in the absence of altruism.

Figure 5.4. **VSL According to Private/Public Interventions in CZE based on CCE**



Implications for public policy

While it is clear that there is no single MRS, there is some evidence – from VERHI and the literature more generally – that the VSL for a child is greater than that of an adult. This result is not unequivocal, however, not even within the VERHI project. Moreover, while there is a growing empirical case for the use of a differentiated VSL for children in cost-benefit analysis, it must be recognised that the use of age-differentiated VSL (in general) in policy analysis is the exception and not the rule. Indeed, adjustments of any kind to a central value are not commonly applied, except in sensitivity analyses.

For instance, the US Environmental Protection Agency's recommended central estimate is USD 7.4 million (2006), to be used in all benefit analyses regardless of age, income or other population characteristics.[8] The only recommended adjustments that are made are due to expectations of increased income over time, latent impacts, and inflation.

In the European Commission DG Environment's "Recommended Interim Values for the Value of Preventing a Fatality in DG Environment Cost Benefit Analysis" (2000)[9] three values are provided – a best estimate of around EUR 1 million (2000), with a lower estimate of EUR 0.65 million and an upper estimate of around EUR 2.5 million. It is suggested that these should be adjusted for latency, carcinogenic pollutants (due to dread) and age. However, the specific case of children is not mentioned.[10]

In the more recent *Impact Assessment Guidelines* of the European Commission, it is indicated that "research undertaken in the past has resulted in values of 1 – EUR 2 million for VOSL and 50 000 – EUR 100 000 for VOLY in Europe. These ranges should be used for the purpose of an Impact Assessment if no more context specific estimates are available". No mention is made of adjustments to this value for age, much less children.

In those cases where age-differentiated VSLs have been applied in sensitivity analyses, there has sometimes been considerable controversy about their use. For instance, in the United States the use of age-differentiated weights in an EPA analysis of the Clear Skies Initiatives resulted in a spate of newspaper articles.[11] Specifically, a 37% lower VSL was applied for those over 65. Health Canada also commissioned a study (related to cigarette regulation) in which a lower VSL was applied for older members of the population (Hara Associates 2002).

It is likely that the introduction of a "premium" for children would raise less controversy than a "discount" for seniors. Since "children" were not included in those studies, which are usually used to determine baseline, VSLs, the "premium" could be simply added to the baseline estimate. Moreover, there is a stronger political case. While the interests of children are usually defended by parents (and other caregivers), policymakers in OECD governments

have always had a special role in protecting the interests of children with respect to risks in general. In some cases (*i.e.* negligence or abuse), this role may supersede that of their parents.[12] As such, there is, at least, a distinct obligation with respect to children's risks to determine whether or not a premium should be applied.

However, the costs associated with undertaking valuation studies prohibits their implementation for each and every policy proposal.[13] As a consequence, for practical purposes it is important to identify cases in which it is particularly important to undertake mortality risk valuation studies. The EPA's *Children's Health Valuation Handbook* (2003) gives three examples of rules which have been analysed in the past and for which it would have been particularly helpful to have had specific values for children available:

- In the case of the Heavy – Duty Engine/Diesel Fuel Rule, a CBA used adult VSL values even when some of the impacts valued (*i.e.* acute bronchitis, lower respiratory problems, upper respiratory problems) focussed on children.
- The Food and Drug Administration's analysis of regulations related to the "safe and sanitary processing" of fruit and vegetable juices used the same COI values for adults and children. Since COI, values are derived from medicine and treatment costs, as well as productivity losses it is unlikely that an adult COI would be equal to a child COI.[14]
- In a cost-effectiveness analysis of the National Highway Traffic Safety Administration standards for airbags, the total number of fatalities are summed – *i.e.* the effectiveness of the regulation is expressed in terms of lives saved per USD million, with no distinction made between whether the lives are of children or adults.

Are there general rules, which can be applied to determine cases in which children-specific values would be most helpful? The EPA (2003) notes that a separate analysis of children's VSL is not required for CBA if the household rather than the individual is the relevant unit of analysis. This would be the case if the policy intervention in question mitigates a bad to which the whole household is subject. For instance, this would be the case for a hedonic property price model related to hazardous waste siting. The opposite case, where such an estimate is particularly important, would be in the presence of intra-household externalities. An example of such a case would be health effects for second-hand smoke from tobacco consumption.

More generally, in cases where the policy intervention particularly affects children due to nature/scope of policy (*e.g.* pesticides in school grounds) or because children are particularly vulnerable to this particular hazard (*e.g.* lead in drinking water), then child-specific values are likely to be helpful in ensuring that resources and policy efforts are allocated efficiently.

In conclusion, the VERHI project has provided a large body of evidence on the conditions under which the VSL for children is likely to be most different from that for adults. For instance, it is clear that context matters, but it plays a different role in the case of children and adults. There is less variation across context for children than for adults. Conversely, private interventions and public programmes are valued differently, with a premium placed on the latter for children relative to adults. Exploring such issues in future work is important for efficient policymaking.

Notes

1. In Article 1 of UNICEF's Convention on the Rights of the Child (*www.unicef.org/crc*) it is stated that "a child means every human being below the age of eighteen years unless, under the law applicable to the child, majority is attained earlier". The qualifying clause is in fact of some practical importance. A study by Melchiorre (2004) compares the age at which children can be employed, married, leave the education system, and be taken to court in different countries. It is interesting that there is wide variation, even within OECD countries (*www.right-to-education.org/sites/r2e.gn.apc.org/files/age_new.pdf*).
2. Recent projects include "The German 'Environmental Survey for Children'" (GerES IV), which surveyed almost 1 800 children aged 3 to 14 years of age – obtaining values on environmental exposure and health burdens. In addition, Sweden implemented a national survey of environment-related health issues amongst 30 000 children aged 8 months, 4 years and 12 years. While exposures and burdens were not measured directly, the survey sought perceptions of exposure from the respondents themselves. In the US, the National Children's Study will examine the effects of environmental influences on the health and development of more than 100 000 children across the United States, following them from before birth until age 21. (*www.nationalchildrensstudy.gov/about/overview/Pages/default.aspx*).
3. "The obligations and concerns of others in society toward children are different than those toward other adults" (Hoffmann 2007).
4. In legal parlance, this is referred to as parens partriae. See Hoffmann (2007).
5. Czech values obtained on basis of purchasing power parity exchange rate of 16.9 CZK/EUR.
6. There may be a significant interaction effect between length of latency and age of child, which is not reflected in the estimates of one or the other variable. This can be tested.
7. Interestingly, Dickie and Gerking (2006) argue that one of the reasons why the literature on inter-household financial transfers to adults does not find evidence of paternalistic altruism may be that they do not have control over the consumption decisions of older children.
8. *http://yosemite1.epa.gov/ee/epa/eed.nsf/pages/MortalityRiskValuation.html*.
9. *http://ec.europa.eu/environment/enveco/others/pdf/recommended_interim_values.pdf*
10. Adjustments based upon health status are not suggested given continued uncertainty in this area. Interestingly adjustments for differences in average income across member states are not recommended for both methodological

(uncertainty) and political (subsidiarity) reasons. However, lower values can be used for what were Accession States at that time.

11. See Viscusi and Aldy (2007) for a discussion.
12. In legal parlance, this is referred to as parens partriae. See Hoffmann (2007).
13. Agee and Crocker (2004) discuss the very restrictive conditions under which values might be transferred from adults to children.
14. Indeed, given the widespread use of COI methods in policy evaluation it would be interesting to know if the difference is likely to be greater or less than any difference there might be for WTP figures.

References

European Commission (2009), *Impact Assessment Guidelines* available at (*http://ec.europa.eu/governance/impact/commission_guidelines/docs/iag_2009_annex_en.pdf*).

United States Environmental Protection Agency (2003), *Children's Health Valuation Handbook*. Washington DC, EPA.

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Valuation of Environment-Related Health Risks for Children

Anna Alberini, Ian Bateman, Graham Loomes and Milan Ščasný

Is the value of reducing environmental risk greater for children than for adults? If so, what does this mean for policy makers? This report, the final output of the Valuation of Environment-Related Health Impacts (VERHI) project, presents new research findings on these key environmental policy questions.

The authors estimate a "VSL" (Value of a Statistical Life) for children and adults based on new methodological approaches for valuing children's health. The survey work is distinguished by its international dimension (surveys were conducted in the Czech Republic, Italy and the United Kingdom) and by the extensive development efforts undertaken.

The result: Two new survey instruments based on different methodological approaches; new estimates of the VSL for adults and children; analysis of the effects of context and other factors on risk preferences; presentation of novel ways to communicate risk, including a variety of visual aids; and insights that identify interesting paths for further study.

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