The value of a statistical life: An economic assessment Methods, results, context[1]

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Summary

The choice of public policies relies ever increasingly upon "cost-benefit" analyses, designed to place the various possible options in some "order of priority". When these policies bring public health issues into play (e.g. reforms to the health care system, pollution abatement policies, etc.), it becomes necessary to determine the potential societal benefits brought about by improvements in the health of the individuals making up society (as a result of that policy being implemented). The state of health may be reflected by a number of health indicators such as quality of life and certain symptoms or pathologies, but also by the **number of deaths avoided** through the implementation of planned measures. It is therefore necessary to be in possession of the tools required to assess the potential benefits associated with an upward trend in health indicators. In this article, we review the economic assessment of benefits associated with a reduced number of (premature) deaths resulting from the implementation of public policies (road safety, air pollution abatement). We begin by analyzing the various methods defined by economic theory, insisting in particular on the contingent valuation method which has proven to be the only one to provide a full assessment of "what individuals are willing to pay in order to avoid the risk of premature death". We then present a summary chart of the main results obtained in various countries, using different methods. The last section is devoted to the particular instance of air pollution. What can be done to address the fact that deaths linked to air pollution affect an already weakened and often elderly group of people? How does context (air pollution) influence the assessment? Is it possible to transfer other results obtained in different contexts?

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1. Introduction

Because life is intrinsically priceless, the fact of assessing "the value of human life" may seem brutal from an ethical viewpoint. Although the ethical consideration is obviously very important, one cannot ignore the fact that by definition, every society has limited resources. Indeed, the money spent on a given investment project, such as the systematic detection of certain genetic diseases, does in fact limit the resources available for other equally or even more beneficial projects, in terms of public health. Projects are therefore selected or rejected by means of an arbitration process, even if, in the latter case, they would bring about improvements in public health. The question underlying this type of decision is the following: "how much should a community spend in order to save a human life?" In attempting to answer this question, decision-making tools are required not only in order to arrange projects in some order of importance but also to prioritize public policies.

Our use of the term "value of a statistical life" throughout the text is simply a concise way of signifying an anonymous individual's "willingness to pay in order to avoid the risk of premature death". The term does not directly denote "the value of life" as that is limitless, but rather refers to what each individual is willing to pay to avoid the **risk** of premature death. It is on the basis of willingness to pay that the "value of a statistical life" is then inferred.

The "value of a statistical life" is an important parameter in a large number of public investments, even if it is not always explicitly assessed. Plans for a new section of motorway, for instance, require the consideration of several elements such as infrastructure costs, of course, as well as potential benefits in terms of business growth, time gains and the number of accidents avoided. Intuitively, it goes without saying that the investment of a few thousand francs in a project designed to avoid a certain number of deaths, is a good thing. Let us consider, for instance, the construction of a traffic island at a dangerous intersection, which would significantly reduce the number of accidents occurring at this spot. In this case, the investment is generally welcomed (even requested by the public) and does not require an assessment of all the pros and cons of the project associated with such a project. By a similar rationale, in the opposite case of a very large investment (several hundred million francs) in order to prevent a very small number of accidents, rejection of the project would not give rise to any particular disagreements. But between the two extremes lie the majority of cases, where it is difficult to make a decision without conducting a preliminary assessment taking into account all the pros and cons, and in particular the consequences for public health. This is particularly valid in the case of road infrastructures, public health policies or policies to combat air pollution[3]. That is why we must be able to rely on indicators designed to assess the impact of these policies, especially with regard to the number of deaths avoided.

[3] In both cases, the term "accident" is not appropriate as it is not a question of reducing the number of accidental deaths but rather the number of premature deaths due to a lack of policy ("status quo").

The aim of this article is to present the techniques currently applied in the economic assessment of the "value of a statistical life", which often plays a predominant role in the establishment of public policies. Decisions directly associated with public health (creation of new health-care facilities, establishment of policies for the detection of certain pathologies, health-care system improvements), share the stage with other projects which could have positive or negative repercussions on public health (construction of new road infrastructures in urban areas, establishment of collective transport facilities, protection of natural environments, etc.). Hence the importance of utilizing common assessement criteria in order to select the most appopriate policy.

In the first section, we present the various methods advocated by economic theorists for assessing the "value of a statistical life", while paying particular attention to contingent valuation, the most widely used method in recent years. Section 3 is devoted to a presentation of the results obtained by this type of assessment, regardless of the chosen method and context. In the following section, we discuss the choice of relevant indicators in order to assess the impact of air pollution on mortality rates, followed by an in-depth analysis of the particular nature of "statistical life valuation" within the context of air pollution. Section 5 concludes the presentation.

2. Various methods advocated by economic theorists

Economists suggest two primary approaches for defining the "value of a statistical life". The first is based on an assessment of the deceased's productivity (generally in cases of premature death). This approach is referred to as the "human capital method" as it considers the individual in terms of productive value only, i.e. as physical capital (machines, tools, etc.). The method takes into account the individual's total expected income. This was the most frequently used method prior to the early nineties in most industrialized countries, and even if not designed for that purpose, it was also used to assess the benefits derived from improvements in air quality (Lave and Seskin [1971, 1977], Masson [1996]). The second approach advocates the use of the "willingess to pay" (WTP) concept, based on the surplus theory. Instead of being considered only as a link in the production chain, it is now the individual who determines, on the basis of his budget and preferences, what he is willing to pay to reduce the mortality risk. With this approach, non-market elements are factored into the assessment. The method used to determine WTP is that of contingent valuation (see § 2.2.2). This entails the use of a questionnaire to determine how much individuals are willing to pay to reduce the mortality risk, as a measurement of the "value of a statistical life". Contingent valuation leaves it up to the individual to assess what premature death means to him, by suggesting a hypothetical scenario: "how much would you be willing to pay for the establishment of such and such an infrastructure designed to reduce the likelihood of your death by X%?". In this case, the method is based on stated preferences. It is sometimes thought that methods based on revealed preferences ("hedonic method") can also be used to determine individual WTP. Indeed, the hedonic method (see § 2.2.1) uses an existing "market" in able to deduce from an individual's behaviour what he is willing to pay in order to reduce the mortality risk (wage differential between hazardous and non-hazardous jobs, purchase of "security" goods, etc.). In both instances, the approach is based on the preferences of individuals who arbitrate between their budget and the risk they are subjected to (or think they are).

2.1. The "human capital" method

The "human capital" method was the first method used to assess the "value of a statistical life", since the first texts referring to this type of approach date back to the 19th century (Farr [1876]). However, it was not before the twentieth century and the late sixties that this method was really utilized in assessments designed to establish public policy (Rice [1967], Weisbrod [1971]). In the standard "human capital" method, an individual's "social" value is measured according to his potential future productivity, based on the present value of his expected working income. There are a number of variations on the aggregate used to assess the social loss incurred by an individual's demise; Weisbrod [1971] suggests the net expected income from the individual's consumption (by analogy with physical capital, where upkeep expenditure must be deducted from the profits made with this capital), while others use GNP per capita or even net loss in terms of consumption (Sommer et al. [1999]), which has the advantage of factoring in the entire population and no longer just those individuals directly involved in production. In all other instances, the "human capital" method is implicitly based on the individual's maximized present and future social value (i.e. the individual's social worth).

While the main advantage of this method resides in the simplicity and transparency of the calculations performed (loss of production or consumption), it is also fraught with many drawbacks. These include the failure to take into account intangible consequences such as the pain or grief suffered by the victim's relatives, the discount rate in the event of premature death such as that caused by road accidents (Cropper et al. [1994]), or even the fact of considering the entire population on the same scale, without taking into account each person's individual perceptions.

The "human capital" method has now been almost completely abandoned for methods based on individual preferences, which take into account all losses incurred by death, including intangible ones. In numerous countries, however, government bodies still use values based on the former approach, which is easier to implement.

2.2. Individual preference method

2.2.1. Hedonic method (revealed preferences)

This much less popular method is used to deduce the "value of a statistical life" by observing the individual's behaviour in existing markets. The underlying hypothesis surmises that individuals reveal their mortality risk preferences through their behaviour on "real" markets[4] such as the job market (wage differential approach) or the consumer goods market (approach based on the purchase of

[4] As opposed to "hypothetical markets" used in the contingent valuation method.

goods). The necessary information is obtained by identifying situations in which individuals make an implicit or explicit choice between their wealth (wage or budget) and a physical risk.

Most studies of this type are based on wage differentials (Moore & Viscusi [1990], Lanoie et al [1995]). In this case, one assessess the premium associated with a greater mortality risk incurred by a certain job type; the wage differential between two jobs incurring different degrees of risk indicates what the individual is prepared to accept in order to "bear" the risk. This risk premium is deduced by regressing the wage over the mortality risk incurred by the job in question, thus making it possible to factor in other elements having an impact on people's wages. The premium, if it exists, indicates that arbitration does occur between the wage and the physical risk (mortality risk in our case), and may subsequently be used to deduce the "value of a statistical life". The wage differential approach is based on two assumptions. Firstly, workers must be fully informed of the risks they run in the course of their job. If they are not informed, this implies that the premium does not fully reflect the mortality risk, in which case it becomes necessary to base the study on the risk perceived by the individual and not on the statistical risk of a given job, as individuals base their wage demands on perceived risk rather than on objective risk measurements[5]. The second hypothesis surmises that the job market is a perfect one and that individuals may change jobs at no cost. If this is not the case, they may be forced to accept lower rates of pay than those matching their optimal choice, i.e. a wage that does not reflect what they are prepared to accept in terms of risk. This could lead to the appearance of biases, which in turn could result in an under-estimation of the "value of a statistical life" deduced from these studies. Another type of problem inherent in the method is that an assessment can only be made on the basis of certain professions or jobs (not all professions involve a risk) and that furthermore, some people sidestep this type of profession because of its hazardous nature (risk avoidance). Both these phenomena make it difficult, or even impossible, to extrapolate a value based on the entire population[6].

Another approach, far less frequently used, but with the advantage of basing itself on a more representative sample, is that of revealed preferences on the consumer goods market. The hypothesis also surmises that individuals reveal their preferences through their consumer expenses. Although the method has very seldom been used, it is still worth mentioning the Blomquist study [1979] which infers the "value of a statistical life" from observing the purchase of safety belts[7], or the Dardis study [1980] which does the same by using data on the purchase price of smoke detectors and their effectiveness in reducing mortality risks. The principle is exactly the same, the only difference lying in the various devices used to reveal individual preferences (consumer goods in this instance, or a risk premium in the case of wage differentials). Contrary to wage differential studies however, consumer

[5] The same problem is encountered in the contingent valuation method, where statistical risks do not necessarily reflect individual "beliefs". We will come back to this in the following section.

[6] Individuals affected by occupational hazards constitute a particular sample of the population, generally male and often fairly young. In this case, how can the values obtained be extrapolated?

[7] This is just one example that is difficult to replicate because at present, safety belts are compulsory in most countries.

expenditure studies have not been repeated several times by different authors, thus limiting their ability to produce credible estimates of the "value of a statistical life". Moreoever, it would appear even less possible to link the mortality risk to the purchase of a consumer item than to the choice of a hazardous job, given that buyers rarely possess quantitative information on the risk reduction liable to be associated with the product, and that the purchase of a consumer item is driven by several other reasons.

The main advantage of "revealed preference" approaches lies in the fact that they are based on observable individual behaviour (as opposed to contingent valuation which we discuss in the following section) and that they rely on individual preferences (as opposed to the "human capital" method).

2.2.2. Contingent valuation method (stated preferences)

The third[8] group of methods used to define the "value of a statistical life" is that of contingent valuation. This method is based on the creation of a hypothetical market in which individuals are asked to reveal their willingness to pay for a given variation of their risk level or mortality risk. A typical question in this type of survey would be: "How much would you be willing to pay for a means of transport that would reduce your mortality risk from 2 in 100 000 to 1 in 100 000 for a particular destination?" or "What portion of your wage would you be willing to sacrifice for a less hazardous job?" The main advantage of this approach lies in the almost total control of the researcher over the design of the survey. It is actually he who decides what information to give the respondents, what risk reduction to suggest, or even what means of payment to use. The contingent valuation method also has an advantage over the wage differential method as it is based on a representative sample of the general population, whereas the wage method only takes into account persons with a certain type of (hazardous) job. However, the major drawback with this type of method is the hypothetical nature of the scenario created by the researcher. The method is therefore based on the intention to pay, rather than on actions. As a result, special care has to be taken when designing the scenario in order to ensure maximum credibility so that the individual's stated willingness to pay truly reflects the value he attaches to the item being evaluated, this being the reduced likelihood of death in our case. The more credible the suggested scenario, the more relevant the findings. At the present time, most contingent "statistical life valuations" are based on a change in accidental death hazards in the transport sector (Desaigues & Rabl [1995], Jones-Lee et al. [1985, 1998]); these are conducted at the request of the Ministries of Transport of various countries.

The primary objections to the use of surveys for the purpose of getting individuals to reveal their willingness to pay (WTP) for a reduced mortality risk revolve around three points (Hanemann [1994]):

[8] We have deliberately omitted the method based on life-cycle models (Linneroth [1979], Crooper & Sussman [1990]), which has very seldom been used and, like the "human capital" method, has the major disadvantage of only taking into account the individual's expected consumption levels and failing to account for the relatives' pain or grief following his death.

vulnerability of answers to the conditions of the survey, creation of values through the expedient of the survey and the lack of means for checking results. Indeed, the actual design of the questionnaire is very important and can result in a number of biases. Small changes in the way questions are worded or the sequence in which they are asked can imply significant variations in the results. Even if some of these biases can be identified and checked (such as question sequence), others, such as comprehension problems, are more difficult to manage. Indeed, when the researcher designs the questionnaire, he has a precise idea not only of the information he wishes to obtain, but also of the degree of information he wishes to give the respondents. In spite of this, it is often difficult to control the degree of information as knowledge of the subject in question varies according to the individual. Let us take, for instance, the context in which questions are put; if individuals are questioned on their WTP for a reduced mortality risk without an explanation being given for this reduction, some may perceive the question as forming part of a road safety survey, while others might perceive it as forming part of a hospital care survey, for example. The difference in interpretation is not neutral, because even if the same probability is at issue, it will be interpreted differently by the respondents. The issue is one of risk perception (see § 4). The second problem associated with this type of assessment lies in value construction. Indeed, within the scope of mortality risk, respondents have no defined value for this type of good before being confronted with the questionnaire. The question then arises as to whether the answers actually reflect the respondent's preferences, or whether the choice was made "on the spur of the moment" without reflecting the individual's true behaviour in such a situation (a new environment tax which would reduce the effects of air pollution on health by diminishing pollution levels, for instance). Whatever the case may be, Willinger [1996] concludes that even if preferences are developed in the course of the questionnaire, this does not call the method *per se* into question as it only indicates a lack of preferences among the respondents. Hanemann's last criticism [1994] regarding the validity of findings is still applicable, given that in the specific area of economic assessment of a reduced mortality risk, the number of available studies is quite low, particularly in Europe. That is why this type of survey needs to be developed in order to produce a set of values for purposes of comparison and discussion.

In addition to the objections regarding the use of the contingent valuation method, there are a certain number of proven biases that should be factored into the compilation of the questionnaire. We will not discuss these biases in depth, but we will mention the five most significant ones (Willinger [1996]).

- The researcher's bias is present in any survey, regardless of the discipline in question. It is explained by the fact that during a face-to-face encounter, some answers may be given in order to please the researcher.
- Instrumental bias resulting from the chosen means of payment may cause the respondent to "cling" to the first proposad value. This can be easily avoided by using the referendum method.

- Strategic bias ("free rider") is due to the fact that some respondents may have predicted how their answer will be used, causing them not to reveal their "true" preferences. On the basis of some results, it seems that this bias does not have a major effect in practice.

- Hypothetical bias is based on the fact that respondents are not brought face-to-face with a "real" market. This bias can be reduced if special care is taken to make the scenario credible in the scenario design phase.

- Inclusion bias is essentially the most significant. Indeed, in certain studies (Hammit and Graham et al. [1999], Krupnick et al. [2000]), it is shown that WTP remains practically unchanged regardless of mortality risk variations. Respondents are insensitive to changes in mortality risk variations. This phenonenon is summed up in the following sentence: "a drop in the mortality risk is a good thing, regardless of the degree of variation". When applying the contingent valuation method, it is therefore very difficult to grasp the impact of various public policies acting on the same indicator but with different variation levels for this indicator.

All these various biases can be reduced (aside from the last one maybe, which is intrinsic to the valuation method) either while designing the contingent valuation questionnaire or while processing it.

3. The "value of a statistical life" in recent studies

In this section, we present a few "statistical life valuation" results in order to give an idea of the the value's magnitude. The choice of results is based on how representative the studies are in terms of method and context. Indeed, we have tried to put together a sample comprising the various available methods ("human capital", "hedonic" and "contingent valuation") as well as the various study contexts in which "statistical life valuation" should be conducted.

Researchers	Country of study	Risk type	Method used	Implicit value of a statistical life
Gerking et al. (1988)	United States	Industrial accidents	Contingent valuation	4.2 million $ (1)
Viscusi et al. (1991)	United States	Road accidents	Contingent valuation	3.3 million $ (2)
Le Net (1994)	France	Road accidents	Human capital	0.7 million $
Desaigues, Rabl (1995)	France	Road accidents	Contingent valuation	1.1 million $ (3)
Lanoie et al. (1995)	Canada	Road accidents	Hedonic method (wage differential)	15.4 to 17 million $
USEPA (1997, 1999)	United States (4)	(4)	(4)	5.9 million $
ExternE (1995)	Europe (5)	(5)	(5)	2.7 million $
Jones-Lee et al. (1998)	United Kingdom	Road accidents	Contingent valuation	1.6 to 2.6 million $
Krupnick et al. (2000)	Canada	Not contextualized	Contingent valuation	1.2 to 3.8 million $
Cifuentes et al. (2000)	Chili	Not contextualized	Contingent valuation	0.2 to1 million $

(1) Value based on mean

(2) Value based on median
(3) Mean value for a program saving 1,000 lives
(4) Value used by the *Environmental Protection Agency* (USA) based on 26 studies (21 using the hedonic method (wage) and 5 using the contingent valuation method)
(5) Value defined in the ExtenE project ("External Costs of Energy") funded by the European Commission. This value is the weighted mean of 15 European studies (hedonic and contingent valuation) available at the beginning of this project.

Various results for "statistical life value" (in millions of $1999)

As shown in this table, there are wide discrepancies between the values. These can firstly be explained by the survey location, because even if the majority of studies are American (Viscusi et al. [1991], Gerking et al. [1988], USEPA [1997, 1999]), others are Canadian (Lanoie et al. [1995], Krupnick et al. [2000]), French (Le Net [1994], Desaigues and Rabl [1994]) British (Jones-Lee et al. [1998]) or Chilean (Cifuentes et al. [2000]). However, it is difficult to have a clear understanding of how each country's specific characteristics affect "statistical life valuation". The wide discrepancies among the various results can be explained by other phenomena: the method used ("hedonic", "human capital", "contingent valuation"), the survey method (interview or postal survey), type of risk assessed, i.e. context, the amount by which the mortality risk is reduced, risk perception, and econometric models used in the analysis (linear or semi-logarithmic). It is clear that failing a common protocol, results are extremely sensitive to the various choices made by the people conducting these studies.

4. "Statistical life valuation" in the context of air pollution

The majority of currently available studies, with few exceptions (Krupnick et al. [2000]), are based on an economic assessment of mortality associated with road accidents. The question therefore arises as to the possibility of transferring this type of value to death caused by air pollution. The question targets two distinctive aspects. The first concerns the chosen indicator: Is "the value of a statistical life" relevant within the context of air pollution? The second concerns the factors to be considered when transferring values from one context to another.

4.1. "Value of one year of life" or "value of a statistical life"

Within the context of air pollution, the question may arise as to the choice of indicator representing the impact of air pollution on mortality. Indeed, one may feel that there is not much sense in identifying air pollution as a cause of death. Pollution is virtually never the main cause of an individual's death; it simply aggravates illnesses which subsequently result in the affected person's death. Recent studies follow this rationale, as they seek to determine the number of years of life lost when an individual is exposed to high pollution levels for a very long period of time. This new perception has totally altered the design of contingent valuation surveys (see § 2.2.2). In this instance, it entails an assessment of the value that individuals assign to an increase in their life expectancy, ranging from a few months to a few years according to the proposed scenario. It goes without saying that the concepts of "the value of one year of life" and the "value of a statistical life" are connected, since a reduced mortality risk results in increased life expectancy. However, there is currently no evidence to prove that both approaches result in similar values. In one of the few studies conducted on "the value of one year of life" (deduced from the individual's WTP for increased life expectancy), Johannesson and Johansson [1996] show that the "value of a statistical life" reflected by their results ranges from 30 000 to 110 000 $, significantly lower than the other values (see § 3). Both these "values" are related if respondents are aware of the link between mortality risk and life expectancy. This is seldom the case and numerous studies show that generally speaking, individuals find it easier to assess a "present" risk than a future variation in their life expectancy. In spite of this, a number of questions remain unanswered. Can "the value of one year of life" be calculated from the "value of a statistical life", using the appropriate discount rate? How can the fact that pollution is almost never the main cause of death, be addressed? What is the most relevant indicator for assessing the impact of air pollution on mortality?

Part of the answer may be found in a study conducted by Krupnick[9] et al. [2000]. Here, the approach is based on the reduced likelihood of dying. The researchers question individuals of 40 years and older, presenting them with two scenarios where the likelihood of dying is reduced; the one concerns the next 10 years, while the other concerns the period ranging from 70 to 80 years[10]. This dual assessment is designed to analyse the behaviour of individuals in terms of present value and has the advantage, even if the context is not explicitly stated, of relating to air pollution (survey of individuals aged 40+ years and reduced future mortality risk). This approach does involve deducing from the individual's WTP for a reduced mortality risk, a "statistical life value" that may subsequently be used within the context of air pollution. To our knowledge, this is the first study of its kind.

4.2. Factors influencing the "value of a statistical life"

Jones-Lee et al. (1998) identify four main factors which influence the determination of values associated with reduced mortality risks, according to the field of study (air pollution, road accidents, etc.). These are contextual factors (voluntary participation, control, responsibility), income, age and state of health[11].

- Contextual factors

Some studies have shown that the risk perceived by the individual depends on a certain number of elements, such as whether or not the risk is voluntary, whether it can be controlled, whether it is familiar (to potential victims or experts), whether it is a phobia, whether it is certain that the risk results in death or whether it is immediate. Savage [1993], for instance, shows that WTPs differ considerably according to reduced mortality risks within four different contexts: road accidents, plane accidents, domestic fires and stomach cancers. These differences are due to the way in which the risk is perceived, and more particularly, to the respondent's familiarity with the risk. The study shows that the less the individual knows or understands about the risk, the less willing he is to pay. Jones-Lee et al. [1998] consider that by comparison with road accidents, the "value of a statistical life" should be revised upwards by 50% in the case of subway accidents because the individual thinks that the risks he

[9] This study has been adapted to the French context by BETA and the survey will be conducted in 2001.
[10] Naturally, if the respondent is already 70 years old, both scenarios will be identical and the interviewer will only suggest a a risk reduction.
[11] The various factors influencing the value of human life will be analyzed with a view to transferring road safety values to the context of air pollution. Indeed, given the number of currently available studies in the area of road safety, the defined values may be considered as "reliable".

runs in travelling by subway are involuntary (in the sense that he has no other transport options), beyond his control, and the responsibility of the public authorities. By the same rationale, the researchers believe that the “value of a statistical life” should be revised downwards by 25% in the case of domestic fires (by comparison with road accidents) insofar as these risks greatly depend on the behaviour of the individual concerned. They conclude that by comparison with road accidents, individuals consider mortality risks associated with air pollution to be largely involuntary, beyond their responsibility, uncontrolable and insidious. Furthermore, their effect on weakened individuals is even more serious. For all these reasons, Jones-Lee considers that a “statistical life value” of 1.5 to 2 times higher than that applied to road accidents (without income, age or health adjustments) is not an unrealistic hypothesis in the case of air pollution.

- Income

The majority of studies (Miller and Guria [1991], Persson et al. [1995]) have highlighted the positive effects of income on WTP for a reduced mortality risk. In view of the fact that air pollution affects individuals aged 65 years and older in particular, and that according to national statistics, these individuals receive a lower-than-average income, consideration could be given to adapting (downwards) the “value of a statistcial life” associated with road accidents to the air pollution context. Even if it may seem logical, this adjustment is not necessarily required because considered from the perspective of public policy, there is no reason to factor in the income of the individuals concerned. Indeed, policies to combat air pollution are not designed for the exclusive benefit of the 65+ age-group, but for the entire population; the policy does not differentiate between income brackets and as a result, it is not necessary to adjust the “value of a statistical life” according to income levels.

- Age

All the above-mentioned studies (Jones-Lee et al. [1993], Desaigues and Rabl [1995], etc.) show that there is a decreasing relationship between age and WTP, from a certain age onwards (approx. 60 years). However, there is no evidence to illustrate its magnitude. It seems likely that from 65 years onwards, an adjustment factor of 0.5 to 0.85 can be applied to the average population. Given that air pollution particularly affects the elderly, as mentioned above, the value must be adjusted in order to distinguish it from the value applied in the road safety context.

- State of health

Even if it seems obvious that air pollution affects weakened individuals, whereas deaths on the road normally involve people in reasonably good health (average age of approx. 35-40 years), there is currently no evidence pointing to a possible adjustment. In view of the studies conducted to date, it is not possible to link an individual’s state of health to his WTP. As a reminder, our point of view is based on the individual’s preferences (contingent valuation) and not on those of society. As a consequence, there is no evidence to indicate that an unhealthy person would be more or less willing to pay in order to reduce his mortality risk than a healthy one. Consequently, there is no means of accurately establishing whether adjustments can be made for a person's state of health.

For the time being, even if some links have been established between WTP and certain contextual variables (risk perception, age, income), it is difficult to decide whether or not to transfer the "value of a statistical life" established for road safety to the context of air pollution. Indeed, no study is currently available concerning the WTP for a reduced mortality risk due to a drop in pollution levels. Without this type of study, it is difficult to validate the adjustments described above, even if these are based on a certain mumber of available results. How can we be sure that the suggested adjustments truly reflect the individual's choice with regard to air pollution policy, without a specific study having being conducted in this area?

5. Conclusion

As described above, neither the human capital method, which only considers the individual as a means of production, nor the revealed preferences method, which only looks at a sample of specific individuals, provides all the guarantees required for determining a value which could be used in cost-benefit analyses of public policy. Even if both methods provide very significant indications of potential magnitudes, they are gradually being replaced by the contingent valuation method which, under certain conditions (Arrow et al. [1993]), can be used to define the "value of a statistical life" that is consistent with the respondent's preferences. The contingent valuation method has been increasingly applied since the early nineties in order to assess reduced mortality risk, albeit within the context of road safety in the vast majority of cases. Even if some decontextualized studies (Krupnick et alli [2000], Cifuentes et al. [2000],) can be applied to the particular case of air pollution (see § 4.2.), no specific studies have been carried out on (premature) deaths associated with air pollution. In view of the fact that a large number of studies on the overall assessment of air pollution's effects on health show that mortality-related effects constitute the greater part of the benefits[12] assessed[13] (ECOPLAN [1994], Masson and Willinger [1996], Rabl [1999], Sommer et al. [1999], Chanel [2000]), consideration should be given to confirming these results by means of surveys designed to have individuals reveal their WTP for a reduced mortality risk due to a drop in pollution levels. In addition to providing a means of validating or invalidating the influence of context in assessments of this kind (death at an advanced age, risk perception, environmental sensitivity, etc.), this would confirm the possibility or impossibility of transferring values from one context to another.

[12] Benefits insofar as averted costs are assessed when pollution drops below its current level.
[13] These studies use the "value of a statistical life" transferred from other contexts (road accidents in general) and more often than not, opt for a "conservative" approach by only referring to the lower limits of these studies.

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