UPDATE OF THE MONETARY VALUE OF A STATISTICAL LIFE IN SPAIN

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Executive summary

- This report presents updated estimates of the Value of a Statistical Life (VSL) and the Value of Preventing a Fatality (VPF) in Spain, in the context of traffic accidents. The study conducted serves to refresh the initial research conducted by the DGT more than ten years ago, thereby satisfactorily fulfilling the provisions established with regard to road infrastructure evaluation in Royal Decree 345/2011, of 11 March, on the road safety management of infrastructure within the State Road Network.

- The methodology employed to obtain the VSL is essentially equivalent to that applied in the study presented in 2011. It thus follows what is known as the 'Contingent Valuation/Standard Gamble (CV/SG) chained method', proposed by Carthy et al. (1999), as previously used to estimate the value which is here updated. To complement this approach, this report brings in methodological developments set out in the Appendices, to enrich the main analysis by offering additional perspectives.

- The data required to conduct the VSL estimates presented here were obtained by means of a survey conducted with a representative sample in terms of geography, age group and sex, from the general Spanish population (N = 2,050). The fieldwork was conducted by the company Sigma Dos, which was awarded the corresponding lot by tender. The questionnaire employed in the survey was programmed in a computerised interface to be administered by means of computer-assisted personal interviews (CAPI) conducted at the homes of the sample participants.

- As the end result of the whole process described, we calculate the ***VSL*** to be a figure of **1.9 million euros**, 46% higher than the 2011 estimate (1.3 million). This increase is consistent with the rise in nominal per capita GDP seen in Spain since that date, amounting to approximately 24.5%, although it should not be overlooked that the estimated value corresponds to the preferences stated by the Spanish population, which irrespective of the increase in the standard of living which has occurred, may likewise reflect greater concern with road accidents.

- If we first of all add to the aforementioned figure of 1.9 million euros (VSL) the estimated value of the net output lost as a result of the premature death caused by traffic accidents, and then the medical and emergency service costs, the estimation of the ***VSL*** rises to ***2 million euros***. It should be pointed out that the methodology presented in this report to approximate the net loss of output resulting from a traffic accident fatality (estimated at 43,135 euros) refines the method used more than ten years ago, offering a more precise estimate.

- As demonstrated by the valuations obtained, which are clearly higher than those estimated in 2011, in order to prevent the current estimates from rapidly becoming obsolete, we must proceed once again to revise the figures within the next decade. It should not be overlooked that the loss of human life, the monetary scale of which is represented by the VSL, is unquestionably by far the most significant component of the social costs of road accidents.

1. Introduction

Directive 2008/26/EC established a mandatory requirement for member states of the European Union (EU) to conduct a road safety prior impact assessment for infrastructure projects. This Directive was transposed into Spanish law by means of Royal Decree 345/2011, of 11 March 2011, on the safety management of roadway infrastructure within the State Road Network, article 6 of which reads as follows:

"*The road safety impact assessment for infrastructure projects must set out the relevant safety considerations for the choice of the solution proposed in the information study. It must furthermore provide the necessary information to conduct a cost-benefit analysis of the different options examined*".

This was the principle that prompted the Spanish Directorate-General for Traffic (DGT) to conduct the corresponding tender, hiring the University of Murcia to produce the study to determine the value of a statistical life (VSL) bythe working group who authored this explanatory report. The values estimated by the team were reflected in a report (Abellán et al., 2011a) delivered to the DGT, and have since then been used to quantify the social costs of road accidents in Spain and to conduct the corresponding cost-benefit analyses in the area of road safety. In line with the recommendations of the working group included in the aforementioned report, every year the DGT has updated the original values in line with changes in nominal per capita GDP. In accordance with the suggestions made by the same team, we must now also consider the need to revise the estimated values, as ten years have elapsed. This is the fundamental aim of the contract tendered by the DGT via the open procedure subject to harmonised regulation (file no. 3DGT6A000059), Lot 1 of which (*Definition of the survey methodology and sourcing of the Statistical Values of a Life and a Non-Fatal Injury*) was awarded to the research team at the University of Murcia.

Following completion of the tasks indicated in the contract, and in fulfilment of the provisions of the "Deliverables" subsection of the set of technical conditions, this final report is presented, describing the methodologies used, showing and analysing the results of the study, and offering the main conclusions derived from it, as well as indicating possible future lines for improvement.

2. Background

2.1. The components of the social costs of traffic accidents

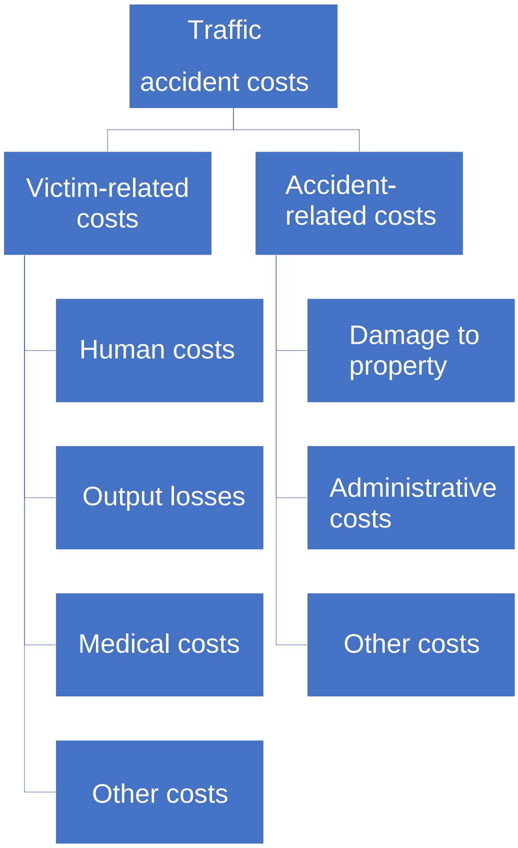
According to the most recent figures available for Spain (DGT, 2023), 2022 saw a total of 129,576 road accident victims. Under current legislation, a traffic accident with victims is where one or more people are killed or injured.[1] This is the typical definition in most Western countries (United Nations, 2017). Similarly, the standard criterion in Europe for defining a road accident fatality (Eurostat, 2019), which is applied in Spain, is anyone who dies as a consequence of a traffic accident, either in the act or within the next thirty days.[2] Fatalities on Spanish roads during 2022 amounted to 1,746 deaths, returning to practically the same figure of deaths as in 2019, before the numbers fell as a result of the decrease in road traffic due to the pandemic.[3]

Traffic accidents clearly have numerous consequences on very different levels, from damage to vehicles and infrastructure to the loss of human life, which is unquestionably the most significant and traumatic of all the costs resulting from road accidents. A recent study (Wijnen et al., 2019a) conducted within the context of the European SafetyCube project (Wijnen et al., 2017)[4] estimates for a sample of 31 European countries that the total costs of traffic accidents as a proportion of national GDP range from 0.4% (in Ireland) to 4.1% (in Latvia). According to the same project, with regard to these total costs, in countries where what is known as the 'willingness-to-pay approach'[5] is used to estimate the human costs (which, as we will see shortly, include deaths and injuries), they represent between 34% (in Finland) and 91% (in Croatia).

Although numerous methodological guides have been drawn up by different international institutions and countries to classify the costs and how they are estimated, Wijnen et al. (2017) -along with the authors of this report in the study conducted for the DGT in 2011- prefer the guidelines established in the European COST313 project (Alfaro et al., 1994), with the data and estimations thus being matched to the cost structure obtained in the COST313 initiative.[6] Figure 1 shows this structure, distinguishing among six main cost components, grouped into two major categories: costs directly related to accident victims, whether fatalities and injuries; and costs related to the accidents.[7] It should in this regard be noted that an accident may have more than one victim.

[1] The definitions of all data concerning traffic accidents with victims which must be sent by traffic surveillance and control officers to the National Register of Traffic Accident Victims are established in Order INT/2223/2014, of 27 October 2014, governing the notification of information to the National Register of Traffic Accident Victims.
[2] This definition excludes confirmed cases of natural deaths or where there is evidence of suicide.
[3] In 2019, 1,755 people died in traffic accidents. A year later this indicator dropped by 22% as a result of the mobility restrictions imposed under the state of emergency in force between 15 March and 21 June 2020. However, the trend was reversed in 2021, and even more so in 2022, when the increase compared to 2020 amounted to almost 27.5%.
[4] Project funded by the European Union Horizon 2020 Framework Programme.
[5] This is the methodological approach recommended by institutions (Alfaro et al., 1994; Bickel et al., 2006; ECMT, 1998) and experts (Jones-Lee & Spackman, 2013), used by most European countries (18 of the 31 analysed in the SafetyCube project).
[6] European Cooperation in the field of Scientific and Technical Research.
[7] Another European project, HEATCO (Bickel, 2006), distinguishes between direct economic costs such as medical treatment and administrative expenses, indirect costs resulting from the loss of productivity caused by accidents, and finally intangible losses, corresponding to the human costs in Figure 1.

Figure 1. Classification of traffic accident costs.



Source: Wijnen et al. (2017).

Human costs represent the intangible costs caused by the pain, suffering, sadness and loss of quality and years of life of the victims and their relatives (Evans, 2001). Although, given their intangible nature, these costs are not reflected in economic transactions, and therefore have no market price, it is essential to estimate them so as to properly represent all losses caused to social well-being as a result of road accidents. A distinction may be made within these human costs between two major categories: those caused by fatalities (the estimation of which is the main purpose of this report), and those resulting from injured victims (the focus of attention in a second report produced by the research team and accompanying this document).[8]

Focusing on the value of the human costs of fatalities, this would be given by the result of subtracting the potential consumption lost as a consequence of premature death from the Value of a Statistical Life (VSL). As explained in detail in Abellán et al. (2011a), the VSL is the monetary value society gives to the fact of avoiding the death of one of its members. The concept of "statistical life" suggests that this is an ex ante or anonymous valuation, not the value attributable to the loss of life of a specific person. Ultimately, what is valued is a reduction in the risk of death across society as a whole. However, as Wijnen et al. (2009: p. 327) specify:

"The VSL has two parts: one tangible and another intangible. The intangible part (everything that does not have a market price) represents the loss of joy of living and the value of pain, affliction and suffering of the victims and their relatives, also known as 'human losses'. The tangible part, which comprises all utility which can be acquired by means of market transactions, comprises the loss of consumption during the years sacrificed: 'not being able to consume for longer'".

[8] In accordance with the definition provided for human costs, a third item should be included, representing the losses of well-being resulting from accidents with victims for the friends and relatives of the victims themselves.

The VSL thus covers not only intangible or human losses, but also the tangible losses represented by the present value of the potential consumption lost as a consequence of premature death.

The preceding clarification is significant with regard to the calculation of the next component of the victim-related costs: production losses. These losses arise because accident victims are unable to continue working, either permanently (deaths and serious injuries which prevent them from working), or temporarily (those who are injured and resume work after being treated).[9] The victims' inability to work thus means that society loses out on the market and non-market (e.g. domestic work) output which could have been generated if the accident had not occurred.[10] It should be added that fatal victims not only permanently cease to produce, but also to consume, and a distinction must therefore be made between gross production losses (which include consumption losses) and net production losses (which exclude them). Therefore, in order to avoid counting consumption losses twice, when calculating the total costs of accidents with victims, they are either deducted from the VSL, giving rise to the human costs, or are otherwise subtracted from the gross production losses to give the net production losses[11]. Meanwhile, as indicated in the estimate of the Value of a Statistical Non-Fatal Injury (VoSI) conducted by Abellán et al. (2011b), and reaffirmed in the update of this estimate presented in the other report, in the case of those injured, there are no consumption losses to be deducted from the gross production losses.

Medical costs refer to the healthcare costs received by accident victims, including those who are treated in hospital and die. The most significant elements comprising this class of costs include those resulting from ambulance and helicopter transport to the hospital, the assistance given by emergency services, the costs of hospital admission, and the cost of outpatient treatment given in the case of injured victims.

Lastly, the "Other costs" item with regard to accident victims is of entirely residual significance, being confined essentially to the difference between the present costs of the funeral of the deceased, and its future costs if they did not die in the accident.

Having arrived at this point, it should be noted that, as previously done by Abellán et al. (2011a), this study will likewise present the results of the new estimates of what is known as the Value of Preventing a Fatality (VPF). This concept is identified with the sum total of all costs derived from traffic accidents which can be directly attributed to a fatality. In practice, this summation comprises the three major victim-related costs shown in Figure 1 (human costs, production losses and medical costs) although as previously explained, this is based on the VSL, and so net production losses and medical costs are added to this. The VPF is therefore a very approximate estimate of victim-related costs.[12]

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[9] With regard to injury victims, the classification used in Order INT/2223/2014 distinguishes between those who are injured and hospitalised for more than 24 hours (referred to prior to the entry into force of this standard as "serious injuries"), and those who are injured and receive healthcare for 24 hours or less (previously referred to as "minor injuries").

[10] Although it is comparatively minor, an additional loss results from what are known as friction costs, i.e. costs incurred by employers to recruit and train new workers to replace the victims, and costs of the professional reassignment of the victims.

[11] In this regard, in their review of the most recent estimates of the social costs of traffic accidents, Wijnen & Stipdonk (2016) found that in the 17 countries selected (10 high-income and 7 medium- and low-income countries), all except two (Belgium and Switzerland) deduct consumption losses from the VSL, resulting in the human costs. Consumption losses are thus included in the gross production losses. On the basis of this evidence, Wijnen et al. (2017) recommend such an approach, arguing that it offers an estimation of the human costs separated from the VSL. Having said that, it should be noted that in the selection of countries by Wijnen and Stipdonk, there are only 6 European states, and that in any event, as Spackman et al. (2011) suggest, human costs are not directly observable, and can only be calculated once the VSL is known. For this reason, the HEATCO project recommended that EU countries should calculate net production losses, deducting consumption losses from the gross figure, and adding the resulting figure to the VSL. This was the procedure followed in Abellán et al. (2011a) and which will also be used in this report.

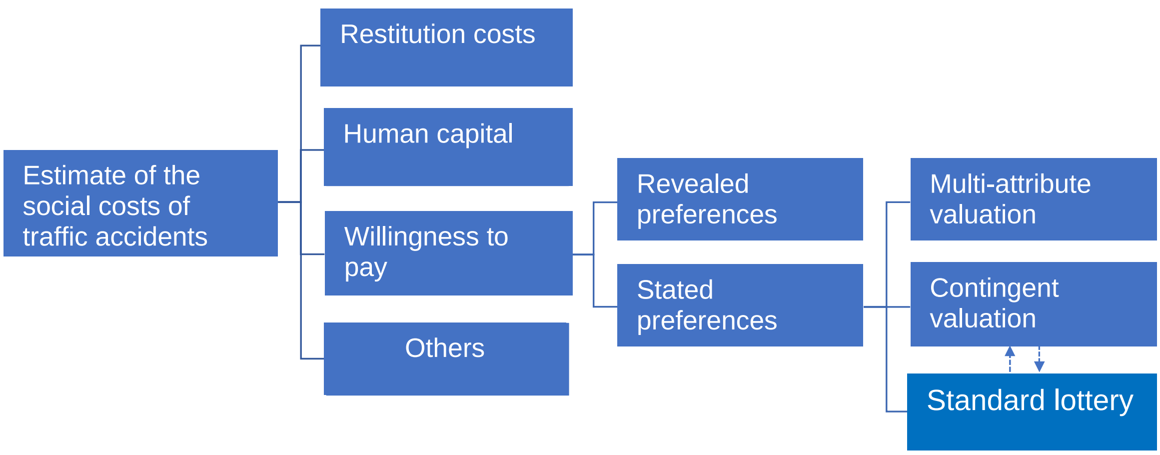
[12] The VPF thus calculated is a monetary appraisal used in the United Kingdom to evaluate the impact public policies, programmes and projects have on human life (HM Treasury, 2022). The value currently used is based on

Lastly, accident-related costs essentially comprise damage to property (vehicles, infrastructure, and occasionally private property) and the administrative costs linked to police, fire brigade and civil protection services, insurance and the justice administration. Other costs which could be added to those above include those resulting from highway congestion caused by road accidents (essentially lost time), and the unavailability of a vehicle if it is damaged in the accident.

2.2. Estimation methods

There are three main methods to estimate the social costs of traffic accidents (Alfaro et al., 1994; Wijnen et al., 2017): the restitution cost approach, which may be understood to be included within a broader approach referred to as the 'reproduction-and-resources-costs' method (Krupp & Hundhausen, 1984); the human capital approach (Mushkin & Collings, 1959) and what is known as the 'willingness-to-pay' approach (Mishan, 1971). While the logic of the first two approaches (restitution costs and human capital) is essentially based on the idea of quantifying the material damage caused by road accidents to the national economy, the logic of the willingness-to-pay (WTP) approach goes further, aiming to quantify the intangible losses which, as has already been seen, are included in the VSL. The first two methods are therefore on occasion referred to as 'cost-damage' methods (Bahamonde-Birke et al., 2015). Figure 2 sets out a synopsis of the methods stated, detailing the different methodologies used in the WTP approach, together with a fourth additional category ("Other"), which is residual in nature. Given its limited importance, we refer interested readers to Nankunda & Evdorides (2023), where a brief description is given. We will therefore henceforth focus our attention on the first three approaches.

Figure 2. Classification of road accident cost estimation methods



Source: Produced by the authors based on Nankunda & Evdorides (2023).

The restitution cost approach is thus named because it focuses on all the expenses required to restore the situation to the state prior to the accident occurring, including medical, administrative and vehicle repair costs.[13] We thus see that in principle this approach serves to approximate the scale of the costs related with the accidents shown in Figure 1.

In turn, the human capital approach measures the production losses caused by road deaths and injuries. These losses, which as discussed in the case of fatalities may be either gross or net depending on whether or not the consumption losses caused by premature deaths are deducted, are estimated by

the study conducted by Carthy et al. (1999), whose methodology was previously employed by Abellán et al. (2011a), and is now utilised again for this new estimate of the VSL and VPF.

[13] According to Bahamonde-Birke et al. (2015), the 'reproduction-and-resources-costs' method adds the costs of the resources representing the productivity losses caused by the loss of health or life of the victims to the restitution (or reproduction) costs. As will be discussed, the latter costs are comparable with those estimated by means of the human capital approach.

calculating the present discounted value of the future flow of earnings not received by the deceased. This takes into account economic and demographic indicators such as monthly salary income and life expectancy at different ages. Clearly, this method is only capable of capturing material losses, and thus ignores the value which society attributes per se to the human loss from road accidents, i.e. the VSL.

According to international recommendations (Alfaro et al., 1994) and the principles of the welfare economy (Boardman et al., 2006), the VSL should be estimated by means of what is known as the 'willingness-to-pay' (WTP) approach (Wijnen et al., 2017). According to this approach, an intangible good such as life, which has no market price, is valued on the basis of the monetary sums people are willing to pay to reduce the risk of dying. Although the COST313 project distinguishes between individual WTP and social WTP, depending on the origin of the (private or public) preferences to pay in order to reduce the risk of road deaths, the fact is that, from the perspective of the welfare economy[14], the VSL can only be obtained by aggregating a great many people's willingness to pay for a small reduction in the risk of dying in a traffic accident. According to economic theory (Jones-Lee, 1974) this trade-off between WTP and risk of death obtained for each individual constitutes what is known as the 'marginal rate of substitution' (MRS) between wealth and risk of death, denoted as m_d:

$$m_d = \frac{\Delta DAP}{\Delta p} \qquad [1]$$

where **Δ*WTP*** represents the amount an individual is prepared to reduce their income by in order to reduce their risk of death by a magnitude **Δp**.

Adding together the individual MRSs obtained as the mean value will provide the monetary value which society attributes to preventing any given person (a statistical life) from dying as a result of a traffic accident:

$$VVE = \frac{\sum m_d}{n} \qquad [2]$$

The social WTP is instead defined as the amount society overall would be prepared to pay for a reduction in the risk. This amount may be inferred, for example, by the public expenditure decisions taken by administrations to prevent traffic accidents, a procedure known as the 'cost per life saved' method (De Blaeij et al., 2003). According to the underlying theoretical principles of the willingness-to-pay approach, this approximation does not therefore give rise to a true VSL, since it is not based on individual preferences, but insteadon the preferences of public administrations (Wijnen et al., 2009).

The preceding proviso having been made, there are two main approximations, or method classes, used to estimate the VSL. Firstly, revealed preference methods, which aim to identify the trade-off or rate of exchange between wealth and risk of death by studying the decisions individuals make on real markets, also known as parallel or subrogated markets, such as those for employment, housing, etc. (Pinto et al., 2003; Abellán, 2019). Revealed preference studies thus analyse market decisions on consumption or usage of goods and services entailing a risk to health and life (e.g. tobacco, dangerous jobs) or safety devices (e.g. fire detectors). Most of the studies included in this methodological branch have nonetheless focused on the employment market (Viscusi & Aldy, 2003; Viscusi, 2018), and this is also the case in Spain (see Martínez & Méndez, 2009, for example). These studies estimate the VSL based on analysing existing salary differences between different occupations, or 'risk premiums' demanded by workers as compensation for performing dangerous tasks such as mining.[15]

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[14] The welfare economy is the branch of economics which judges the desirability of social changes based on a series of value or normative principles consistent with economic theory. The seminal contributions made by ground-breaking authors such as Schelling (1968), Mishan (1971) and Jones-Lee (1974, 1976) laid the foundations for using the willingness-to-pay approach as a procedure to estimate VSL in the scope of cost-benefit analyses, one of the methodologies developed within the context of the welfare economy. According to these underlying theoretical principles, the VSL is the aggregation of the individual WTP values, since according to the normative principle known as 'consumer sovereignty', each individual is the best judge of their own welfare.

[15] The revealed preference studies conducted in the labour market are known as wage-risk, hedonic wage or compensating-wage differential studies, and presume that if a person accepts a job with a higher than average risk, they will normally also demand a higher than average salary in compensation (Abellán et al., 2011a). Hedonic models apply a regression to the equilibrium wage observed on the market with regard to the risk of mortality,

Revealed preference methods have various limitations, some of which are cross-cutting or general, affecting all contexts one might wish to extrapolate the estimated valuations to, while others are specific to the field of road accidents. Therefore, one general limitation is that this approach is based on fairly unrealistic suppositions as to how markets function, since they are far from being perfectly competitive. Another generic limitation is that precisely because the estimations obtained are based on decisions observed in real markets, this method cannot offer altruistic valuations, or those for the non-use of intangible goods.[16] Revealed preference methods likewise face problems which call into question their relevance for estimating the VSL within the specific sphere of traffic accidents. With regard to studies focused on the labour market, although one could conceive of a private market for occupational safety, expressed in terms of bonuses paid for performing more dangerous jobs, it is hard to imagine the same in the case of road safety improvements, above all taking into account that the purchase and usage of many safety devices such as seat belts are mandatory (Wijnen et al., 2009). A second limitation stems from the fact that this type of study only provides estimates of the VSL for a particular population segment, comprising those of working age (Lindhjem et al., 2010), and often only for men (Cropper et al., 2011). Furthermore, most people covered by the studies based on employment markets face higher risks in their jobs than on the road (Dionne & Lanoie, 2004), which apparently seems to lead to higher VSL values in the former case than the latter (Elvik, 1995).

Thereare also declared preference methods which aim to obtain the trade-off ratio (or marginal rate of substitution) between money and risk of death, based on responses by the population to surveys that recreate hypothetical or simulated markets. This second approach has been used mainly in the context of risks to health, and within the sphere of road safety and environmental risks (Viscusi and Masterman, 2007), and was that used in the previous estimate of the VSL for the DGT (Abellán et al., 2011a). It will likewise be the reference approach in the estimates presented in this report.

While declared preference methods may suffer from what is known as 'hypothesis bias'[17] given the inherently hypothetical nature of the questions asked in the survey, of which the respondents have no market experience, and that it may also prove difficult for the interviewees to internalise their budgetary restriction when declaring their WTP, on occasion leading them to overestimate their capacity to pay (Lindberg, 1999), such methods do offer various advantages compared to revealed preference methods. The main advantage lies specifically in their greater applicability, thanks to the flexibility offered by the use of questionnaires. Recreating simulated road safety markets allows us simultaneously to evaluate different aspects of road accidents (e.g. fatalities and non-fatal injuries), without depending on the availability of statistical data on the amounts of money people actually invest in safety (Schoeters et al, 2022). Furthermore, declared preference methods offer the opportunity to explain the meaning of small reductions in risk and ascertain whether in fact respondents interpret them correctly, contrary to the implicit supposition in revealed preference methods, which assume that individuals properly understand the very small changes in risk associated with their market decisions (De Blaeij, 2003; Freeman et al., 2014).

There are two major method types in the declared preference approach: contingent valuation (CV) methods and multi-attribute valuation (MV) methods. A third category can be added to these two traditional major categories (illustrated in Figure 2 through the association between the CV and the procedure known as 'standard gamble'), based on the combination or chain of responses to a series of non-monetary choices or exchanges made using the aforementioned preference measurement technique known as the standard gamble, which will be explained below,[18] and the WTP and WTA

thereby revealing the trade-off between the prevalent wage rate and the level of incremental risk of death, from which the VSL is deduced (Cropper et al., 2011).

[16] These valuations represent the value society attributes to the mere existence of the good in question, even if not actually benefiting from it (Abellán, 2019).

[17] Hypothesis bias qualifies the phenomenon where what respondents say is different from what they actually do (Abelson, 2008; Hausman, 2012).

[18] In its traditional version (Torrance et al., 1972), the term 'standard gamble' refers to a distribution of probability with two possible outcomes: 'normal health' on one hand, and 'death' on the other hand. This gamble is compared to the certainty of remaining in state of health ***i***, worse than normal health, so the interviewee, by making successive choices between the two alternatives for different probabilities of normal health and death,

declared by the interviewees in response to CV questions. This third VSL estimation method was previously used by Abellán et al. (2011a), and has again been chosen by the authors of this report to update the value in the context of this study.

CV techniques are used to obtain monetary valuations both for public goods[19] such as air quality or natural spaces, and for non-market or intangible private goods, as in the case of risks of mortality and illness (Mitchell & Carson, 1989; Hammitt & Herrera-Araujo, 2018). To obtain these valuations, CV studies use a survey to recreate the contingency of a simulated or hypothetical market where the interviewer represents the supply side and the interviewee the demand side, and in the context of traffic accidents with fatalities the price[20] is determined by the maximum amount of money the interviewee is willing to pay to reduce the risk of death. This WTP represents the sum of money that would have to be taken from the individual to maintain their level of welfare (or utility) prior to that improvement. Alternatively, the interviewee could be asked for the minimum sum of money they would be willing to accept as compensation for being exposed to a risk of death. This willingness to accept (WTA) represents the monetary amount the subject would have to be given to retain their utility after the proposed improvement. The WTP for a positive change (avoiding an increase in the risk of death) and WTA for a negative change (exposure to an increased risk of death), as demonstrated by Hicks (1943), are simply monetary valuations of changes in the consumer's surplus.[21] According to Hicksian theory of welfare, in a context free of uncertainty and with perfect information, the WTP and WTA values should be similar, and so no major differences would be expected in the responses that the same interviewees give to each type of question (Hammit, 2015).

Although CV methods have undeniable advantages such as allowing prospective analyses and enabling valuation of the components of non-use of intangible goods (Abellán, 2019), as well as being able to show information about road accidents in a manner that is relatively easy for the population to process (Boardman et al., 2017), it is equally true that the estimates obtained are subject to different problems of inconsistency as a result of phenomena such as the insensitivity of interviewees' WTP/WTA to small changes in the risks of dying in a traffic accident[22], as well as the typical finding that the WTA is greater than the WTP declared by the same subjects.[23]

In theory, multi-attribute valuation (MV) methods serve to mitigate some of the inherent biases of the CV approach by obtaining the WTP in a more indirect or less explicit manner, since the interviewees only have to order (or score) a series of scenarios, or successively choose between 2 of them (Bahamonde-Birke et al., 2015). As indicated by their name, MV methods describe the good to be valued by means of its characteristic attributes or dimensions (typically no more than 8), with each of them taking different levels. For example, Schoeters et al. (2022) recently estimated the VSL for four European countries (Belgium, France, Germany and the Netherlands), using an MV method. To that end, each interviewee had to choose between 2 or 3 alternatives (over the course of a total series of 8), where each alternative represented a hypothetical car route characterised by 4 attributes: travel time, risk of having a fatal accident, risk of being seriously injured, and travel cost. The choices made by the interviewees can be used to identify the MRS existing between the different attributes, including

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ultimately determines the maximum risk of death they would be willing to accept to avoid aforementioned health problem ***i***. This risk is attained when the subject declares their indifference between the two options.

[19] Public goods have the characteristic that their benefits are consumed indivisibly or jointly, making it difficult to exclude those who do not pay for them. CV studies are therefore undertaken to estimate their "price".

[20] Known as the 'shadow price' as opposed to the market price, which does not exist for the good in question.

[21] Technically speaking, they constitute the compensated change in income that maintains constant utility for the individual.

[22] This is in general known as 'scope insensitivity' or 'scope effects' (Carson, 1997), a preference anomaly which forms part of a more general phenomenon known as 'embedding effects', and which, together with the scope problems, covers biases such as ordering effects, effects of the visible choice set and 'part-whole' effects (Bateman et al., 2004, 2006, 2007).

[23] The most comprehensive review conducted to date as to the discrepancy or gap between WTA and WTP is the meta-analysis conducted by Tunçel & Hammitt (2014). These authors estimated a WTA/WTP ratio of 3.28, although their study covers a wide range of data for all manner of goods. The first systematic review of this phenomenon in the field of health was published recently (Rotteveel et al., 2020). In this review, the authors identified 13 papers with WTP and WTA estimates derived from 19 experiments and subgroups. The estimated WTA/WTP ratio ranged from 0.60 to 4.01.

(due to the inclusion of attributes such as the travel cost and the risk of dying in an accident) the MRS between wealth and risk of death, used to determine the VSL.

The type of task required in MV studies allows these methods to be classified into two major groups (Abellán 2019): combined analysis and choice experiments (also known as 'discrete choice experiments'). Combined analysis asks survey respondents either to order (contingent ordering) the set of selected alternatives from highest to lowest preference, or to give a points score (contingent scoring) to each alternative, on a scale. Discrete choice experiments present a series of choices between two or more alternatives. When the choices are dichotomous, as in the study by Schoeters et al. (2002), the task is referred to as a comparison or paired choice task.

Despite the advantages apparently offered by MV methods, they are not without problems, such as the greater cognitive effort which may be required of interviewees when forced to compare numerous attributes (van den Berg et al., 2005), or the presence of different biases to those registered in CV exercises, like the existence of lexographical responses. In fact, the percentage of interviewees in MV studies who tend to systematically evaluate the alternatives from the choice sets based on one single attribute (e.g. always choosing the shortest car route) is no less than 30% (Iragüen & Ortúzar, 2004; Hojman et al., 2005; Veinstein et al., 2013; Schoeters et al., 2022). Finally, it should be pointed out that only discrete choice experiments are fully consistent with the idea of using a questionnaire to emulate consumer behaviour in markets, since this is what consumers do in a market: choose. Therefore, overall analysis techniques would be questionable from this perspective (Pinto et al., 2003).

As previously indicated, a third group of declared preference methods may be identified, based on the combination of a series of non-monetary exchanges, conducted with the standard gamble procedure with a monetary metric based on the WTP and WTA. The standard gamble method was used for the first time in the context of road safety by Jones-Lee et al. (1993, 1995) to estimate the value of preventing non-fatal victims in road accidents in the United Kingdom.[24] The standard gamble used by Jones-Lee et al. was formulated in its traditional version (Torrance et al., 1972), thereby asking interviewees to determine the probability *p* that would leave them indifferent between definitely experiencing a non-fatal health problem (an injury derived from a traffic accident) and receiving a medical treatment that could completely cure it with probability 1-*p*, but which could also kill them with probability *p*. This gives the relative value of the injury compared to normal health, or in other words the utility of experiencing the injury on a scale 0-1, where 0 is the value of death and 1 that of good health. The relative value of each injury was then combined with the VSL estimated years earlier for the United Kingdom (Jones-Lee et al., 1985) to give the Value of a Statistical Non-Fatal Injury.

However, Jones-Lee et al. (1995) detected two problems over the course of his study. First of all, with a different sample to those who responded to the questions with the standard gamble, who were presented with the valuation by means of a CV exercise for different risk reductions, he found that there was a serious problem of insensitivity to the size of these reductions. Meanwhile, in the standard gamble task, particularly in the case of more minor injuries, many of the interviewees were unable to accept any risk of death in exchange for potentially being entirely cured.

The first of the problems described (insensitivity to the range or size of the risk reductions) has been repeatedly corroborated thereafter (Beattie et al., 1998; Hammitt & Graham, 1999). In theory, it was expected that the individuals' WTP values would be proportional to the size of risk reduction. However, what typically happens is that the WTP values are much less than proportional when the reductions in the risk of death are small (Søgard et al., 2012; Andersson et al., 2016). This gives rise to VSL estimates which change with the size of the risk reduction used in the questions included in the surveys (Jones-Lee et al., 1995; Dubourg et al., 1997). As for the problem of interviewees' reluctance to accept exchanges between risk of death and health, this corresponds to a phenomenon known as the 'certainty effect' (Kahneman & Tversky, 1979), which has likewise been extensively documented, and is thus named precisely because of the observation of how interviewees tend to excessively overvalue the certain alternative (the injury) as opposed to the gamble (the treatment). At its extreme,

[24] This has also been used in Japan for the same purpose of obtaining monetary valuations of traffic accident injuries (Koyama & Takeuchi, 2004).

this overvaluation of certainty leads to an outcome where there is no probability of death that is sufficiently small for the two alternatives to be considered equivalent.

To overcome or at least reduce the two problems mentioned, Carthy et al. (1999) developed what is known as the 'Contingent Valuation/Standard Gamble (CV/SG) chained approach'. The termchainedrefers to the fact that with this method, the VSL is estimated by combining ('chaining') the responses to two types of question: CV questions and questions based on the modified standard gamble method, which we will hereinafter refer to simply as SG, adopting the same approach as Carthy et al. (1999).

As we have seen, if the traditional standard gamble compares an injury or non-fatal state of health i, which certainly occurs, with a treatment with uncertain outcomes, the modified standard gamble (SG) replaces the certain option with another gamble, so that state i is no longer certain but merely probable. As has been demonstrated empirically (Abellán-Perpiñán et al., 2012), this change mitigates the certainty effect bias, encouraging the desired trade-off between health and risk.

In the chained approach, interviewees must specifically respond to the following questions: (1) WTP in exchange for the certainty of completely recovering from a non-fatal injury or state of health i; (2) WTA in exchange for indefinitely enduring that state of health i; and (3) an SG question comparing two gambles: one with normal health and death as the possible outcomes, and another with state i and death as possible outcomes.

The authors use the responses to (1) and (2) to estimate the marginal rate of substitution (MRS) between wealth and the risk of suffering i (m_i). The advantage compared to the direct contingent method is that as no monetary value is placed directly on the reduction in the risk of death, there is no need for recourse to very small probabilities, as in the traditional method. The responses to question (3) serve to estimate what is referred to as the 'relative utility loss' which, when multiplied by m_i, gives an estimate of the MRS between wealth and risk of death (m_d), and hence the VSL).

The results of Carthy et al. (1999) proved promising in various aspects. Firstly, they did not experience the problem which typically affects the traditional CV method, that a non-negligible number of subjects reject paying any amount of money, or are willing to pay the same to reduce the risk of experiencing health consequences of differing seriousness. In other words, the WTP and WTA values obtained by Carthy et al. (1999) did not have the problem of scope insensitivity for the benefit. Secondly, the responses to the SG questions also verified the theoretical validity criterion, in that participants proved willing to assume greater risks of death in the treatment that would allow them to recover their health, the more serious the state of health avoided by such treatment was. For these reasons, many researchers have considered this approach to be the best available method for estimating VSL (Nellthorp et al., 2001; Spackman et al., 2011). It was this chained method which was used to estimate the official VSL for the United Kingdom (DETR, 1998; Jones-Lee & Spackman, 2013), and it was also chosen in the 2009 study estimating the official VSL for Spain in the context of traffic accidents (Abellán et al., 2011a; Sánchez-Martínez et al., 2021).

We must nonetheless point out that the CV/SG chained method is not without its problems. Its main limitation is connected to the problem of internal consistency which proponents of the method highlighted when testing a theoretically equivalent version called the 'indirect chained method' which, despite the theoretical expectation, led to very different results from those obtained with the original direct chained method. The indirect method provided very high, implausible values for the VSL for a small group of participants in the study (around 10%), causing the mean values to be multiplied by 15 or even 30 times the estimates obtained by direct chaining. Even when these subjects were excluded, the VSL estimates were clearly higher with the indirect method. This prompted some authors to question the internal consistency of the method (Thomas & Vaughan, 2015), triggering a debate as to its validity (Chiltern et al., 2015; Jones-Lee & Loomes, 2015; Olofsson et al., 2019; Balmford et al., 2019).

2.3. International evidence

The results of the aforementioned SafetyCube project (Wijnen et al., 2017) offer the most recent comparison of official figures for road accident costs used in European countries. The countries initially covered by the study were the 28 countries of the European Union (EU) plus 4 European countries not belonging to the EU.[25] The aim of the project was to review and systematise traffic accident cost figures in these 32 countries, including estimates of total costs and their components, per fatality and per accident, the identification of the methods used to estimate them, and an analysis of the differences in estimates between different countries. Likewise, in order to complete the components of costs in some countries that were absent or estimated in a manner diverging from the recommendations according to the COST313 project guidelines, what is known as the 'value transfer' approach is applied in order to standardise the unit costs of all countries and also obtain homogeneous estimates of the total costs of traffic accidents in all of them.[26]

The cost data reported by the researchers (Wijnen et al., 2017; 2019a) are the product of the information collectedon the number of accidents, their victims and the associated costs, based on a bibliographical search of reports and publications, together with the information obtained from the responses by 29 of the 32 experts contacted in the countries selected, who were sent an Excel questionnaire. Romania was the only country that did not provide any data, and the definitive sample was thus limited to 31 countries. Furthermore, the information provided by experts in Lithuania and Portugal was disregarded, although in both cases it proved possible to replace this information with that available from other sources. In total, official cost figures were obtained from 30 countries.[27]

As mentioned several pages ago, according to the original values of the official costs in the 31 countries (without adjustment by the value transfer method), they ranged from 0.4% in Ireland to 4.1% in Latvia once they were adjusted for GDP. Spain is in twenty-fifth place, with a percentage slightly under 1%, practically on a par with Norway (slightly higher than Spain), and the United Kingdom (slightly lower). An analysis of these data shows two fundamental reasons which explain such a substantial variability in the sample of countries selected. First of all, in terms of the seriousness of the accidents, all the countries include accidents with victims (whether fatalities, serious injuries or minor injuries) in their estimates of total costs, but 12 of them do not include accidents that cause damage only to property (without victims) in their costs. Since two countries (Luxembourg and Serbia) do not explicitly clarify whether they include this type of accident in their estimates or not, 44% of the remaining 29 countries do not consider this type of accident in their total costs. Although the unit cost for this type of accident is very small in comparison with the cost per fatality for example, as a great many such accidents occur, their cost may ultimately represent a far from negligible percentage of the total costs. This isthe case in Germany and Finland for example, where they account for as much as 50% of the total. Meanwhile, in Spain, Greece, Belgium and other countries they are not taken into account, which could in some cases lead to a considerable underestimation of the total costs.

The other explanation lies in the method used in each country to estimate the costs per victim. Specifically, focusing on the cost per fatality in the 18 countries that estimate human costs by means of the WTP approach, they have total costs per fatality[28] far higher than the other countries that estimate human costs by the human capital approach (3) or the restitution cost method (2). It is not known

[25] It should be clarified that reference is made to the grouping of 28 member states, since the project analysis was conducted prior to the United Kingdom leaving the EU on 31 January 2020. The 4 non-EU countries included in the study were: Iceland, Serbia, Norway and Switzerland.

[26] In the case which concerns us here, this procedure essentially involves transferring the cost values from the group of countries whose estimates are consistent with the international recommendations to other countries that lack consistent estimates, or have no estimates whatsoever.

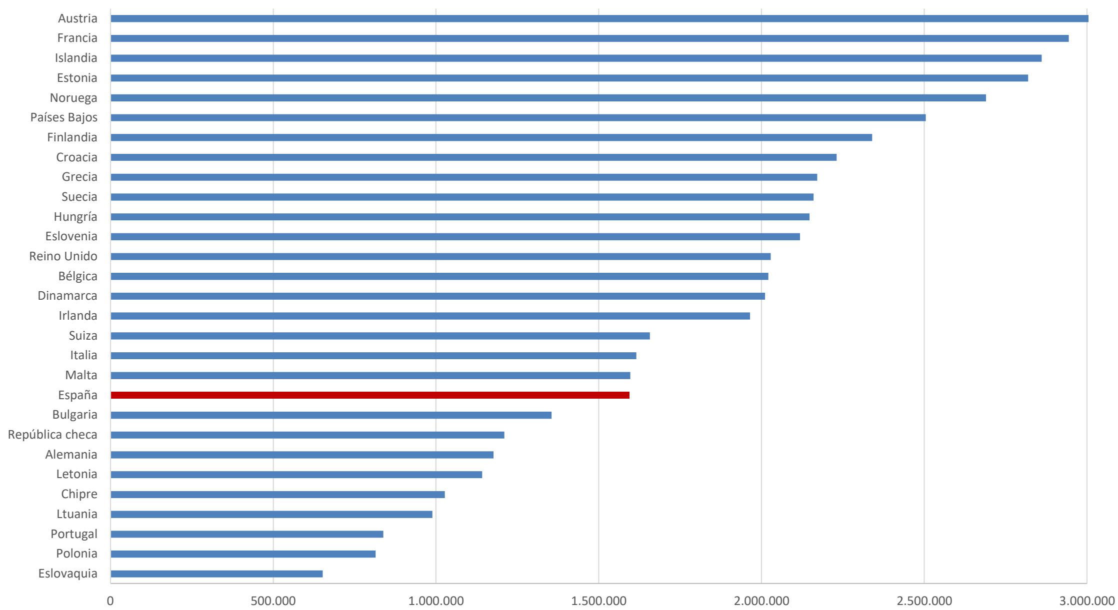
[27] 26 of the EU-28 countries (all except for Romania and Portugal), plus the aforementioned 4 non-EU countries.

[28] By total costs per fatality or death we refer not only to the human costs (or VSL), but to all costs connected with the fatality (which would be the VPF), and even costs connected with accidents imputed to the deceased (in the corresponding proportion, depending on the number of victims per accident). In other words, provided that data are available, the total cost per fatality breaks down into each of the components of the costs described in Figure 1.

what method the other countries making up the total of 29 considered in this case[29] use to estimate human costs. The proportion of human costs in countries that use the WTP approach out of the total cost per fatality ranges from 54% to 94%.

Figure 3 shows the cost per fatality in each of the 29 usable countries, in 2015 prices adjusted for Purchasing Power Parity (PPP).[30]. As can be observed, Austria is the country which attributed the highest value to a road fatality, representing slightly over 3 million euros. Approximately half of the countries represented (15) have a total cost per fatality in excess of 2 million euros. This group is followed by the central group of the distribution which includes Spain, with costs ranging from 1.7 million in Ireland to just over 1 million in Cyprus. Spain's cost per fatality stands at almost 1.6 million euros.[31]. Four countries have figures below one million euros: Lithuania, Portugal, Poland and Slovakia, with the latter having the lowest value of the entire sample at approximately 652,000 euros.

Figure 3. Costs per fatality (2015 euros, PPP)



Source: produced by the authors, based on Wijnen et al. (2017).

In order to offer as uniform a comparison as possible, also taking into account per capita income, Table 1 shows the per capita GDP and costs per fatality as the original figures (in other words based on the same information as in Figure 3), and adjusted by means of the 'value transfer' procedure applied by Wijnen et al. (2017) to complete the cost components which were absent or estimated with methods other than those recommended in COST313 for the 19 countries in the sample belonging to the Eurozone.[32] The baseline data of the report by Wijnen et al., expressed in 2015 euros adjusted for PPP have been updated to 2022 using the GDP deflators and PPP values for that year provided by the Eurostat database.[33] The mean cost per fatality was also estimated in the 19 countries, weighted by the demographic importance of each country out of the total aggregate population.

[29] Luxembourg and Serbia were excluded, given the lack of data as to the cost per fatality.
[30] In order to provide a uniform comparison of the costs per fatality in different countries, Wijnen et al. (2017) first updated them to 2015 prices, using the corresponding GDP deflators. The costs of countries not belonging to the Eurozone were then converted into euros using 2015 exchange rates. Lastly, all the costs were adjusted for the differences in purchasing power, using the relative price indices for 2015. All the data were drawn from the Eurostat database.
[31] Cost per fatality presumably based on the VPF estimated for the DGT by the research team in 2011, which at the time (in euros without PPP adjustment) stood at 1.4 million euros (Abellán et al., 2011a).
[32] The only country in the Eurozone not included in Table 1 is Luxembourg, for which there are no original data on cost per fatality (nor for non-fatal injury victims).
[33] https://ec.europa.eu/eurostat/databrowser/view/prc_ppp_ind/default/table?lang=en

Table 1. Costs per fatality and per capita GDP (2022 euros, PPP).

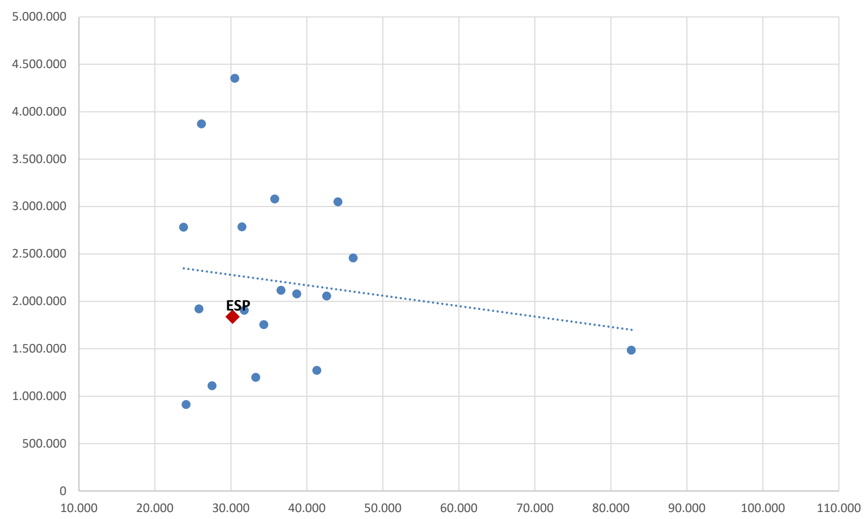
	GDPpc	Cost per fatality (original values)	Cost per fatality ('value transfer')
Germany	41,319	129,078	2,474,264
Austria	44,097	385,799	3,062,748
Belgium	42,612	312,613	2,562,638
Cyprus	33,272	158,208	2,648,982
Croatia	26,136	503,367	4,704,060
Slovakia	24,111	198,094	3,086,430
Slovenia	31,458	325,540	2,657,294
Spain	**30,241**	**293,609**	**2,487,677**
Estonia	30,527	1,480,264	3,502,807
Finland	38,678	596,443	2,082,441
France	35,769	384,884	2,373,276
Greece	23,790	323,260	2,656,344
Ireland	82,704	170,515	1,456,640
Italy	34,347	230,220	2,851,418
Latvia	25,811	47,459	3,818,479
Lithuania	31,782	173,086	4,373,880
Malta	36,609	270,158	2,827,674
Netherlands	46,093	264,123	2,458,149
Portugal	27,523	180,734	3,007,722
Weighted average	**36,770**	**2,030,020**	**2,601,611**

Source: produced by the authors, based on Wijnen et al. (2017) and Eurostat.

Looking first of all at the original cost values in Table 1, the first figure to highlight is that approximately half of the countries (10) have a higher than average cost per fatality. The remaining 9, including Spain, have a cost per fatality lower than the mean. The country with the highest cost per fatality is Estonia at more than 4 million euros, followed by Croatia, France and Austria. At the opposite end of the scale is Slovakia with a cost of less than 1 million euros. Spain is in 13th place, with a cost calculated at 1,835,061 euros. If we now look at the column with the cost figures adjusted by the 'value transfer' method, and compare them with the original figures (in other words, the official numbers), we find that only 6 countries have a lower value than the original figure following the adjustment. It should be highlighted that the only state registering no change in its value is the Netherlands, with this country, according to Wijnen et al. (2017), serving as the example for how to accurately calculate costs per fatality. It is impossible to conduct a proper appraisal of the value judgment implicit in the results generated by the SafetyCube project with nothing more than the information provided in its own deliverable. In any event, the differences observed probably indicate that, for example, as Wijnen et al. (2019a) suggest, there are many countries which include victim-related costs (human costs, production losses and medical costs) in costs per fatality, but do not do this for accident-related costs (damage to property, administrative costs and other costs), which by increasing the former through the addition of the accident costs (or more precisely the median value) from countries which do include them, will necessarily lead to a higher adjusted value. This problem of missing cost elements is also underlined by Wijnen & Stipdonk (2016) in their review of the published estimates of traffic accident costs in 17 countries, showing that there are various items which are typically not calculated, such as non-market production losses, tangible damage to infrastructure, costs of firefighting services and costs of traffic congestion.

It should finally be noted that there is weak negative correlation between the original figure of the cost per fatality and per capita GDP, which may be seen at first glance in Figure 4. This negative correlation is accentuated when the costs adjusted by the 'value transfer' procedure are considered.

Figure 4. Costs per fatality and per capita GDP (2022 euros, PPP).



Source: produced by the authors, based on Wijnen et al. (2017) and Eurostat.

The most recent review of the publications offering estimates of the social costs of traffic accidents[34] is probably that undertaken by Bougna et al. (2022). In their study, the authors conducted a systematic review of estimates published between 1983 and 2016, with the distinctive feature that one of the inclusion criteria employed to screen the initial batch of studies identified was that they had used either the human capital approach or the WTP method to calculate the VSL. Having constructed their final database (comprising 95 observations from 75 articles), they also embark on an econometric analysis to determine to what extent the use of each estimation method (human capital or WTP) could explain the differences in the total cost figures, and in these figures compared to GDP.

The most interesting results of the review by Bougna et al. (2022) are as follows. First of all, the human capital method is applied in almost 60% of the studies selected. This approach is used mainly in medium- and low-income countries, while the WTP approach is mainly used in high-income countries.[35] The variability range in the estimates corresponding to the 48 countries covered by the publication selected is considerable, with the road accident cost value ranging from 0.3% of GDP in Vietnam, to 6.7% of GDP in Iran. In Spain, the proportion of GDP attributed is 1%, with the year of publication of the study from which the data are drawn cited as 2015. However, this study is not among the bibliographical references in the article by Bougna et al. (2022).[36] The most significant results generated by the regression analysis conducted by the authors for the final model, which controls for population, income, and for a set of variables connected with road safety policies, are that studies using the WTP approach offer estimates of road accident costs which are on average 1 GDP point higher than those utilizing the human capital approach. Where the total cost value is used without adjusting for GDP as a dependent variable in the regression, this difference represents a factor of 0.9. Therefore, the impact of the estimation method used to calculate the VSL is important, and can ultimately explain

[34] Estimates covering not only studies which give rise to new official cost values, but also any type of study reporting traffic accident costs.

[35] This distinction among countries, based on their levels of per capita income, corresponds to the four-part classification used by the World Bank Group. This body classifies national economies as: low-income, lower-middle-income, upper-middle-income and high-income countries.

[36] We may nonetheless assume that the publication in question is the article by Martínez et al. (2015). This paper summarises the main results of the study by Abellán et al. (2011a), with the VPF figure estimated in that study being mentioned. What the aforementioned article does not show is any calculation of the weight of the social costs of traffic accidents as a percentage of GDP.

more than a third of the variance observed in the costs compared to GDP, and more than 79% of the heterogeneity in the absolute costs. Finally, it should be highlighted that the fact none of the low- and middle-income countries in the sample analysed by Bougna et al. (2022) used the WTP approach means their estimates are significantly lower than those quantified for high-income countries, as also noted by Wijnen & Stipdonk (2016).[37]

Next, we focus specifically on the latest studies providing the information on available VSL estimates. Moving from the general to the particular, we must begin with the systematic review conducted by Keller et al. (2021), who conducted a systematic search in the main databases of studies reporting VSL estimates, published between 2009 and June 2019. The main aim of the authors is to successfully identify the different methodologies used, and their frequency of use over the course of the different scopes of application of VSL estimates. This review is thus not confined solely to VSL estimates in the road safety sector[38], but instead contextualises these values with regard to figures for other sectors, specifically the environment, health, employment market and safety (e.g. accidents at nuclear plants or caused by natural disasters).

Table 2 summarises the most significant findings of the review, which 120 studies were ultimately selected for. However, this number does not match the figure shown in brackets in the "All sectors" categoryof the table because 3 of the studies selected did not contain VSL estimates, but simply the Value of a Year of a Statistical Life, and so are not included in the table. Likewise, the total number of studies considered does not match the sum total of the studies for each of the sectors because some of them report estimates for more than one sector.

Table 2. Median midpoint of VSL estimates (USD, PPP, 2019).

	Total	Developed countries	Developing countries	DP studies	RP studies	HD studies
Environment	1,062,630 (6)	5,146,850 (2)	680,489 (4)	1,381,201 (5)	ND (0)	744,058 (1)
Health	6,770,534 (33)	8,989,328 (21)	580,663 (12)	6,770,534 (33)	ND (0)	ND (0)
Labour market	8,740,231 (35)	11,784,289 (22)	1,430,105 (13)	ND (0)	8,740,231 (35)	ND (0)
Safety	3,010,740 (9)	7,075,108 (5)	409,110 (4)	3,010,740 (7)	2,942,773 (2)	ND (0)
Road safety	5,335,248 (41)	7,075,108 (28)	403,798 (13)	5,335,248 (37)	5,383,706 (4)	ND (0)
All sectors	5,716,830 (117)	8,342,027 (73)	858,599 (42)	5,185,402 (74)	7,940,006 (41)	744,058 (1)

Note: the number given in brackets corresponds to the studies which the calculation of the median midpoint is based on in each case. NA means 'Not Available'. DP Studies means 'Declared Preference Studies'; RP Studies means 'Revealed Preference Studies'; HC Studies means 'Human Capital Studies';

Source: Keller et al. (2021).

As can be observed in Table 2, one interesting contribution of this review is that it serves to clarify the methodologies that lie behind the frequently mentioned 'WTP approach'. Thus 63% of the studies selected (n=76) applied declared preference methods, while 36% (n=32) used revealed preference methods. Only 1 study, estimating the VSL in Russia, applied the human capital focus. In the words of the authors themselves, the 76 studies that used the declared preference approach are distributed in approximately equal parts between CV studies and discrete choice experiment studies.

As for the valuation figures recorded in Table 2, the midpoint median for all the VSL estimates included in the study amounts to some 5.7 million dollars, with the road safety sector specifically giving the closest estimate to this value summarising the whole sample, with a VSL of 5.3 million. As can be observed, the estimated VSL figures vary significantly across the different sectors considered. The higher value estimated for the labour market sector (8.7 million dollars) compared to other sectors may be due to the known propensity to use revealed preference methods in this sector, typically expressing higher VSL estimates than those obtained by means of declared preference methods. As

[37] After correcting for the underreporting of victims in traffic accidents, both in high-income countries (10 in their sample) and in low- and middle-income countries (7 in total), Wijnen & Stipdonk (2016) obtain a mean total cost in the former standing at 3%, while in the latter it ranges from 1.1% to 2.9%.

[38] Referred to in the article as "Transportation safety".

revealed by various studies, this also tends to be a constant in the sphere of road safety, such as the figure estimated on the basis of labour market studies for the US Department of Transport (9.2 million dollars), which Viscusi & Gentry (2015) consider appropriate for the valuation of transport-related fatalities. Also in the United States the figure of 6.6 million dollars was recently suggested in the context of evaluating the costs of the Covid-19 pandemic (Viscusi, 2020). However, as can be observed in Table 2, in this case the estimates considered in the road safety sector are very similar, irrespective of whether they were obtained by means of one approach or the other.

Finally, the study by Keller et al. (2021) also serves to judge the quality of the selected studies, by using the modified version of the CHEERS checklist[39], which consists of 21 items, each scored with a value of 0 or 1. Studies with a score below 12 are considered to be low quality, those between 12 and 16 are judged to be moderate quality, while those with a score above 16 are classified as high quality. The overall quality of the studies ranged from 5 to 21, with a mean of 18.40 and a median of 19, indicating that they were generally of good quality. However, the quality of the revealed preference studies was on average higher (19.14 vs. 17.97) than the declared preference studies, although they both share the same median score (19). In any event, while only 1 revealed preference study was considered to be of moderate quality, as many as 20% (n=15) of the declared preference studies were of low or medium quality. Having said that, and as specified by the authors themselves, the CHEERS checklist cannot adequately value the methodological quality of the studies, but essentially the quality of the manner in which the results obtained are reported.

Schoeters et al. (2022) recently published the results of the simultaneous VSL estimation in four European countries (Germany, Belgium, France and the Netherlands).[40] These estimates form part of the VALOR project (Schoeters et al., 2021), the result of a joint initiative by three European institutions to develop a standard methodology to calculate road accident costs in Europe: the Belgian Road Safety Institute (Vias Institute), the German Federal Highway Research Institute (BASt) and the French Institute of Transport, Development and Network Science and Technology (IFSTTAR, since 2020, Université Gustave Eiffel). Following a preparatory study (Wijnen et al., 2019b) where different methods were evaluated for the monetary valuation of non-market goods, the researchers decided to use a declared preference method rather than a revealed preference method, specifically conducting a discrete choice study as opposed to using CV methods.

As previously explained, by illustrating the declared choice or MV methods with the experimental design used by Schoeters et al. (2022), the researchers conducted a discrete choice experiment, with each participant in the survey thus making 7 choices between each two hypothetical scenarios, representing two car journey routes. The survey was completed by an online panel of 8,002 adults, equally distributed across the 4 countries, providing a representative sample of each in terms of age, sex and region. Having said that, the sample which ultimately proved usable was 31% smaller than the initial sample, being limited to 5,527 participants. This substantial difference between the initially defined sample and the sample analysed was above all the result of the many respondents who presented lexicographical preferences, i.e. subjects who throughout the 7 choice sets always chose the alternative which was best according to one single criterion (e.g. the cheapest or quickest route). Specifically, more than 2,000 individuals behaved in this way, representing 25.3% of the initial sample. The percentage was in fact higher, since a total of 2,513 people behaved in this manner (no fewer than 33.3% of the entire sample), although the authors "redeemed" 483 of these individuals, since additional questions allowed them to conclude that their lexicographical preferences were not the result of a simplifying heuristic, but that their preferences were extreme, which meant that they were not represented by the levels of attributes used in the scenarios. In any event, it is evident that a highly significant part of the initial sample was ultimately discarded.

Table 3 sets out the VSL estimates in 2020 prices obtained by Schoeters et al. (2022), together with the official values in force in each of the 4 countries involved. As can be observed at first glance, the VALOR project estimates are far higher than the figures for the official values. The estimate for the sample as a whole (as if it were one single country) amounts to almost 6.3 million euros, a figure

[39] Consolidated Health Economic Evaluation Reporting Standards.

[40] In truth, Schoeters et al. (2022) not only estimate the VSL in these four countries, but also the value of a serious injury, in addition to the value of time. In this report we refer only to the results concerning the VSL.

significantly higher than that currently in force in any of the four countries, and in fact higher than any European country. This can be confirmed simply by looking at Table 1, which sets out both the official costs and the adjusted costs per fatality (which is thus a broader concept than the VSL), with a weighted mean for the 19 countries considered (including the 4 in the VALOR project) which ranges from 2 to 2.6 million euros. Meanwhile, no country in this table has a cost per fatality anywhere near 6 million euros. The highest value is for Croatia, with an adjusted cost of 4.8 million euros.

If we analyse the differences country by country, the greatest discrepancy occurs with Germany, which, if it were to update its official VSL, would see the figure rise to 7.3 million euros, almost 7 times higher. However, as Schoeters et al. (2021) argue, the new value is not directly comparable in the case of Germany, since the official value used in this country is the result of applying a combination of cost restitution and human capital methods[41]. The comparison would be appropriate in the case of the Netherlands, since according to the authors' arguments, the VSL adopted by the Dutch state since 2001 was also estimated by means of a discrete choice study (De Blaeij, 2003; Wesemann et al., 2005).[42] However, despite the methodological similarity indicated, the new estimated VSL is more than twice that used to date in the Netherlands, increasing the figure by 125%. The increases in Belgium and France are likewise very substantial, registering relative increases of 119% and 56% respectively.[43] The authors acknowledge the considerable increase that their estimates entail compared to the official values for the 4 countries, but justify this mainly by indicating that citizens' preferences as to road safety have changed over the course of the last 20 years. We will return to this matter in the Conclusions section of this report.

Table 3. VALOR project estimates and official values (million €).

	Official VoSL	VoSL VALOR
Netherlands (2018)	2.8	6.3
Germany (2018)	1.1	7.3
Belgium 2020)	2.7	5.9
France (2019)	3.4	5.3

Note: the years in brackets indicate the date of the updated official VSL figures, as shown in the report by Schoeters et al. (2021).

Source: Schoeters et al. (2021).

To conclude, let us briefly discuss the very recently published review by Nankunda & Evdorides (2023), which focuses exclusively on the area of road accidents. The authors conducted a systematic review of the literature on traffic accident costs, distinguishing between the different methodologies used to estimate the figure, covering the period between 2001 and 2022. A total of 102 articles were ultimately selected, including that published by the authors of this report, based on the VSL estimate conducted for the DGT in 2011 (Sánchez-Martínez et al., 2021). 55% of the studies included in the review used the WTP approach, 29% the human capital approach, and 11% the restitution cost method. The remaining 5% applied other methods. As already seen, if we examine the results of Bougna et al. (2022), the WTP approach is used more frequently by high-income countries, while low- and middle-income countries turn to the human capital approach for their estimates. Meanwhile, if the source of the studies is analysed, it becomes clear that high-income countries make most use of social

[41] As mentioned in the previous section, this combination is what is known as the 'reproduction-and-resources-costs' method (Krupp & Hundhausen, 1984).

[42] A summary of the study may be found on the website of the Road Safety Research Institute (SWOV) in the Netherlands (https://swov.nl/nl/publicatie/de-waardering-van-bespaarde-verkeersdoden). The VSL originally recommended by this body to evaluate road safety projects stood at 2.2 ± 0.3 million euros (2001 prices). Updated to 2020 prices, this figure would be 3 million euros.

[43] As explained by Schoeters et al. (2021), in the case of France, the comparison between the estimate generated within the context of the VALOR project and the official value also proves appropriate, since the VSL used in France is derived from the transfer of VSL estimates contained in OECD data.

cost valuations for traffic accidents, accounting for 49% of all the studies reviewed. By contrast, only 4% of the studies were undertaken in low-income countries.

2.4. The evidence in Spain

Very few attempts have been made in Spain to estimate the VSL in the context of traffic accidents (and, in general, in any context). The background to the study conducted by Abellán et al. (2011a), which gave rise to the official VSL estimate used since then by the DGT to quantify the social costs of road accidents, includes a handful of papers which share the characteristic that their estimates were not based on the preferences of the population. As we have had the opportunity to observe, this contravenes the recommendations made by European projects such as COST313 or HEATCO, which advise using the WTP approach as the basis for estimating the human costs generated by road accidents. Thus, López-Bastida et al. (2004) approximate these costs by calculating the value of working time, Lladó & Roig (2007) use the human capital approach, estimating the value of production losses, FITSA (2008) turns to the compensation method and calculation of average values based on VSL estimates derived from other countries, as was also previously the case in Aparicio et al. (2002).

The only precedent in Spain for a study based on the WTP approach, and, more specifically, applying declared preference methods[44] within the context of road accidents, was conducted by Martínez et al. (2007), who nonetheless did not use a territorially representative sample of the whole nation.[45] It was following this precedent that Abellán et al. (2011) applied the 'contingent valuation/standard gamble (CV/SG) chained method', proposed by Carthy et al. (1999) to estimate the VSL and also the VPF, a result of adding the costs associated with lost production and medical and ambulance costs to the VSL, which have since then been used by the DGT.

The VSL obtained in the study by Abellán et al. (2011a) was estimated at 1.3 million euros, which, once production losses and medical and ambulance costs were added, resulted in a VPF of 1.4 million euros. The VPF thus obtained was equivalent to some 2 million 2009 dollars in purchasing power parity terms, which was consistent with the official values used in countries in the economic context of Spain. The figure was higher than that used in countries such as France and Germany, but lower than for the United Kingdom and United States. Likewise, the VSL estimated on the basis of the CV/SG method was clearly lower than previous estimates for Spain based on revealed preferences, in the context of the labour market (Martínez & Méndez, 2009), which range between 2.8 and 8.3 million euros.

As regards methodological questions, the study reached similar conclusions to those found by Carthy et al. (1999). By replicating their methodology, with some minor modifications, similar results were obtained both in terms of the positive findings of the original study (the advantage of the chained method in terms of sensitivity and the lower number of individuals reluctant to pay and/or accept risks), and in those that are less encouraging (the disparity between the estimates resulting from the direct VC/SG method and its indirect variant, which these same authors proposed in order to verify the consistency of the methodology).

In addition, in the 2009 study for Spain, an indirect chained method which was an alternative to the Carthy et al. (1999) version was trialled, and although it did not succeed in completely eliminating the discrepancies between direct and indirect chaining procedures, it did substantially reduce their scale (Sánchez-Martínez et al., 2021). Our study also served to confirm the influence of the chosen probability base (*n* out of 1000, *n* out of 10000) on the final results, thereby ascertaining that the estimated VSL depends on the non-fatal state of health used in the estimation procedure. All these learnings drawn from the 2009 study served to improve the methodological design of this VSL update study.

[44] As indicated some pages ago, Martínez & Méndez (2009) determine the VSL in Spain by means of a revealed preference study based on labour market data.
[45] It should also be noted that the sample size (n=360) was much smaller than both that used in the study by Abellán et al. (2011a), and that conducted here.

We are only aware of two new attempts to estimate the VSL for Spain in the context of road safety subsequent to the study by Abellán et al. (2011). As far as we know the first has not been published, and is referenced as a presentation given at a conference on the review conducted by Bahamonde-Birke et al. (2015) regarding different VSL estimation methodologies. Its authors are González et al. (2012), with the estimated value amounting to almost 32 million dollars, prompting Bahamonde-Birke at al. to deem this "implausible" in the general context of the other estimates made with discrete choice methods (n=13) selected in their review.

More recently, an article published by González et al. (2018) presented a VSL estimation also conducted through a discrete choice experiment. The study sample (477 people, following exclusion of inconsistent subjects from an initial sample of 513 individuals) was not representative of national territory (all the surveys were conducted in Santa Cruz de Tenerife in 2010) and almost all the interviews (n=390) were personal and computer-assisted. The remainder (n=87) were self-completed online. Each participant made 9 binary choices, with each scenario representing an alternative route along the TF5 motorway. The scenarios were characterised by a combination of 6 attributes (travel cost, travel time with highly congested traffic, travel time with moderately congested or free-flowing traffic, car occupant fatalities per year, car occupant serious injuries per year, pedestrian serious injuries or fatalities per year) and 3 levels per attribute. The VSL estimated in this manner amounted to no less than 10.63 million euros, which the authors themselves acknowledge as being a relatively high value, even taking into account the upper ends of the confidence intervals of the estimations of other studies covered by Bahamonde-Birke et al. (2015). The authors offer a series of explanations as to why the estimate is so high, including, as previously seen in the case of the study by Schoeters et al. (2022), a high percentage of subjects with lexicographical preferences (23% of the total), who were not discarded from the analysis leading to the VSL estimate. All these reasons set out by González et al. (2018) amply illustrate the limitations and biases of discrete choice studies.

3. Methods

3.1. Sample selection

The sample design was conducted by the research team with support from the company Sigma Dos which was responsible for the fieldwork. The nationwide sample (including the island provinces and excluding Ceuta and Melilla), was conducted on the basis of a population universe comprising the population resident in Spain aged 18 years and over, with a sample size of 2000 observations.

Stratified multistage sampling was conducted, selecting the primary sampling units (autonomous regions and municipalities) and individuals by means of random routes and sex and age quotas. The sample was stratified at the initial stage in proportion to the population size of each autonomous region, while within each of them, the distribution established was proportional to the size of the population resident in each census section (6 strata). The surveys were conducted by means of 200 routes.

Table 4 presents the percentage quotas by autonomous region and habitat size. The quotas by age group are shown in Table 5, with the composition by sex being: 49% men and 51% women.

Table 4. Quotas (%) by habitat size (thousands of inhabitants) and autonomous region.

	Less than 2	Between 2 and 10	Between 10 and 50	Between 50 and 100	Between 100 and 500	More than 500
Andalusia	0.6	2.9	5.2	2.6	3.9	2.7
Aragon	0.5	0.4	0.4	0.1	---	1.5
Asturias	0.1	0.3	0.6	0.3	1.1	---
Balearic Islands	---	0.4	1.0	0.2	0.9	---
Canary Islands	0.1	0.5	1.7	0.7	1.9	---
Cantabria	0.1	0.4	0.3	0.1	0.4	---
Castile and Leon	1.4	1.0	0.7	0.7	1.6	---
Castile-La Mancha	0.7	1.3	1.2	0.8	0.4	0.0
Catalonia	0.8	2.3	4.6	1.8	3.5	3.6
Valencia	0.5	1.5	4.1	1.6	1.6	1.7
Extremadura	0.5	0.7	0.5	0.3	0.3	---
Galicia	0.4	1.5	2.0	0.8	1.4	---
Madrid	0.1	0.7	1.2	2.1	3.2	7.1
Murcia	---	0.1	1.3	0.4	1.4	---
Navarre	0.2	0.4	0.4	---	0.5	---
Basque Country	0.3	0.7	1.7	0.3	1.9	---
Rioja	0.1	0.2	0.2	0.0	0.3	---
Total	**6.0**	**14.7**	**26.5**	**12.6**	**23.9**	**16.4**

Table 5. Quotas (%) by age group.

	%
18 to 24 years old	8
25 to 34 years old	14
35 to 44 years old	18
45 to 54 years old	20
55 to 64 years old	17
65 or over	24
Total	**100**

3.2. Health states

To apply the direct chained VSL estimation method, which represents the basic or reference approach of the study, and is described below in section 3.5, participants evaluated a scenario or state of health labelled as "State X". The interviewees also evaluated another scenario, referred to as "State Y", which was more serious than state X. Both health states are shown in Figure 5. Alongside other auxiliary or complementary analyses outside the main purpose of the study (the direct chained method), the inclusion of state Y allowed the VSL to be estimated by means of the indirect chained method. The main results concerning this indirect procedure are summarised in Appendix I.

Figure 5. Descriptions of health states X and Y.

State X	State Y
In hospital • Two weeks in hospital • With moderate pain	**In hospital** • More than 4 weeks, possibly several months • Moderate to severe pain
After hospitalisation • The pain gradually disappears • Difficulties working or performing leisure activities, which gradually reduce • Full recovery experienced after 18 months, without sequelae	**After hospitalisation** • Continued chronic pain for life • Major, permanent, lifelong difficulties in working and performing leisure activities • Some major scars may remain for life

As can be seen, state Y involves a longer period of hospitalisation, with more pain, and also chronic pain after being discharged, along with permanent difficulties to work and enjoy leisure (in state X these difficulties gradually disappear), and lifelong sequelae in the form of scarring. In other words, state Y is objectively worse than state X, and the two states can therefore be logically ordered.

3.3. Methods to source preferences

Contingent valuation: willingness to pay and willingness to accept

The chained method chosen to estimate the VSL requires two types of state of health preference measurements. The first uses money as the numerical value, and aims to ascertain the monetary value that the respondents place on an improvement (loss) in their health which results in avoiding (experiencing) a hypothetical state of health. This methodology, which involves assigning a monetary value to a good for which there is no market, based on the responses by a population sample to questions concerning hypothetical scenarios, is known as contingent valuation (CV), as already explained some pages previously. CV studies aim to estimate the monetary value of goods by asking subjects how much they would be willing to pay (Willingness to Pay, WTP) to enjoy a good and/or how much they would demand as compensation (Willingness to Accept, WTA) for losing a good (or for experiencing harm, as in the case of an illness).

The WTP and WTA questions are asked in this study by means of a mixed procedure, where subjects are first shown a series of cards with a wide range of monetary amounts ("payment card"). In the case of the WTP questions, the respondent must answer for this amount whether they "would certainly pay", "would certainly not pay" or "are not sure whether they would pay or not" to avoid experiencing the state of health being valued (state X). For the WTA questions, the participant must respond for the amount on each card whether it "would certainly be sufficient", "would certainly be insufficient" or they "are not sure whether it would be sufficient or not" to compensate for experiencing state of health X.

Once the interviewees' responses to each of the figures and the payment card have been obtained, and the internal consistency of the responses has been assured (by allowing the respondent to revise possible inconsistent responses where necessary)[46], an open question is asked to determine the maximum value they would pay to avoid experiencing state X (in the WTP question), and the minimum value that would constitute sufficient compensation for experiencing that state (in the WTA question). Respectively, these values lie within the intervals defined by the maximum amount they would certainly pay and the minimum amount they would certainly not pay (WTP), and the maximum amount they would consider insufficient and the minimum that would certainly be sufficient (WTA).

Modified standard gamble: individual relative value

The second method to obtain preferences is a "modified standard gamble" (SG) or "double gamble", a technique to measure the utilities of health states[47] which aims to obtain the value participants assign to the relative loss involved in experiencing a particular state of health compared to another (better) state. The utilities thus measured can be interpreted as indices or weights of health-related quality of life, and are defined on a scale where the values 0 and 1 are identified with death and perfect health respectively. Participants must choose between two hypothetical scenarios, identified with two medical treatments with uncertain results. The two treatments differ in the results that would arise from the (successful or unsuccessful) outcome of the treatment, and also the respective probabilities of success (or risks of failure).

Three questions are asked in this second evaluation procedure, involving both state X and state Y. The first two are intended to obtain the relative loss involved in experiencing states X and Y compared to a normal or good health scenario. The third question explores the value assigned to the relative loss involved in experiencing Y compared to X. As mentioned previously, the second and third questions are asked in order to perform indirect chaining, a complementary approach to the main direct method approach.

For example, in order to obtain the value of state X, interviewees are asked to choose between treatments A and B, both subject to some risk of death. For the former, the risk of a fatal outcome is 1 in 1000, while in the other cases (999 out of 1000) the patient experiences the consequences described in state X (see Figure 1). Meanwhile, if treatment B is successful, this allows them to recover normal health, but the risk of death is greater (p_x). The interviewee must state what

[46] Inconsistency is deemed to exist if the interviewee asserts that they are certain they would pay a particular amount of money to avoid the state of health, but are nonetheless certain they would not pay (or do not know whether or not they would pay) a lower amount. Similarly, it is inconsistent for an interviewee to claim that certain monetary compensation in exchange for experiencing a health problem is more than sufficient, but then to respond that a higher level of compensation is insufficient, or that they do not know whether it is sufficient or not.
[47] There are different techniques to measure utilities (Pinto et al., 2016, 2020), the most commonly used being the time trade-off and the standard gamble.

risk of death with treatment B (i.e. what p_x value) would make them indifferent between the two treatments (so they would not know which to choose). Formally speaking, the choice is presented in the following terms:

$$A: (0.001, Death; State\ X)\ vs. B: (p_x, Death; Normal\ health)$$

The indifference value $\overline{p_x}$ is not the result of asking the interviewee a direct question based on the scenario described, but is instead obtained following a sequence of choices in which the value of p gradually changes following an iterative process in light of the participant's responses. The first choice is put to the respondent in the following terms:

Treatment A	**Treatment B**
999 state **X**/1 dies	500 recover/500 die

If the respondent chooses treatment A, they are presented with a second choice in which the number of fatalities with treatment B is lower (specifically half)[48]:

Treatment A	**Treatment B**
999 state **X**/1 dies	750 recover/250 die

If they again choose treatment A, the risk of death in B is once again halved:

Treatment A	**Treatment B**
999 state **X**/1 dies	875 recover/125 die

If in this case the subject switches preference and chooses treatment B, the frequency with which treatment B leads to a fatal outcome is increased:

Treatment A	**Treatment B**
999 state **X**/1 dies	825 recover/175 die

The search algorithm is gradually developed until it delimits a range for the value of p_x (frequency of death under treatment B) with an amplitude of 25. Once this range has been delimited, the subject is asked for the precise value of the risk of death with treatment B that would make it difficult for them to choose between treatments, which we will note down as $\overline{p_x}$. For example:

You said that you would prefer treatment A to treatment B when the risk of death in B was 175, while if the risk of death with treatment B was 150, you would prefer this treatment to treatment A. What is the lowest risk of dying with treatment B that would make you unsure whether the treatment was better or worse than treatment A?

This same procedure is conducted with state Y, which then replaces state X in the chained choices presented to the participants, with the following alternatives (treatments) being chosen:

$$A: (0.001, Death; State\ Y)\ vs. B: (p_y, Death; Normal\ health)$$

The search algorithm is the same as that described in the example, upon conclusion of which the open question is asked to determine the new indifference value $\overline{p_y}$.

The third question using the SG method directly compares the two health states being valued: X and Y. In other words, state X once again occupies the best outcome in treatment A, while state Y (objectively worse than X) replaces death as the worst outcome of the two treatments. One important difference in the framing used in this measurement of the relative value of Y (as opposed to X) is that it

[48] As the value offered as a stimulus in each choice is the result of dividing in half the interval containing the indifference value, this search procedure based on iterative choices is known as the bisection method.

uses a base of 100 rather than 1000 to express the risks in the form of frequencies. The choices presented in this third question are thus of the following type:

$$A: (0.01, Death; State\ Y)\ vs. B: (p_{x/y}, Death; State\ X)$$

The first choice would be as follows:

Treatment A	**Treatment B**
99 State **X**/1 state **Y**	50 recover/50 state **Y**

The successive choices gradually change the distribution of probabilities for treatment B in accordance with the responses by the participants, following the aforementioned procedure, before ending with the open question which sets the risk of experiencing Y with treatment B which means the interviewee is indifferent to the two treatments ($\overline{p_{x/y}}$).

"Person trade-off" (PT): relative social value

In addition to the two valuation procedures (CV and SG) required to estimate the VSL by following the chained method, the survey also included a third preference measurement method, which together with the recently described SG approach also aims to establish a relative value measurement for certain health states compared to others, but is distinguished from the latter in that it assumes a social rather than individual perspective.

The method in question is a variant of what is known as the "person trade-off" (Nord, 1995), the essence of which involves comparing health outcomes for groups of people or populations of differing sizes, in order to detect the extent to which individuals are willing to trade off major health gains for a few people, against small health gains for many. As indicated previously in connection with the indirect chained method, the analysis of the possible differences between the individual values (derived from the SG) and the social values (obtained by means of the person trade-off) is summarised in Appendix II of this report.

Participants are specifically asked to choose between two possible road safety plans which reduce the number of fatalities and non-fatal injuries, but differ in the specific distribution of their effects. Thus, while one of them (plan A) avoids one fatality more than the other (plan B), the latter prevents 100 more non-fatal injuries than the former, with the non-fatal injuries being identified with the descriptions of states X and Y.

As in the case of the double gamble, after the first choice:

Plan A	**Plan B**
Prevents one more fatality	Prevents 500 additional injuries (state X)

The number of injured victims avoided by plan B is gradually modified upwards (downwards) if the respondent chooses plan A (plan B). The search procedure is similar to that described for the previous method, as is the open question at the end which serves to establish the indifference value, i.e. the number of additional injuries avoided with plan B that would cause the individual to be indifferent between this and plan A, which avoids one additional fatality.

This same task is considered replacingstate X with state Y, the first choice being as follows:

Plan A	**Plan B**
Prevents one more fatality	Prevents 500 additional injuries (state Y)

A third question sets the two states representing non-fatal injuries against one another, now labelled as "minor" (state X) and "serious" (state Y). In this case, the first choice in the indifference value search process is:

Plan A	**Plan B**
Prevents one additional serious injury (state Y)	Prevents 50 additional minor injuries (state X)

As already stated, the indifference value search procedure in the methods intended to obtain the relative individual value (SG) and the relative social value (person trade-off) follows an iterative algorithm which gradually leads the participant to delimit a range within which their preference is positioned. On the basis of the evidence obtained in previous studies, for some of the groups the sample was divided into, a modification was included in the form of administering the questions corresponding to these methods, intended to conceal the iterative nature of the procedure from the participants (in other words, to make the sequence in pursuit of the indifference value less transparent). Our hypothesis is that this opaque procedure, which aims to make individuals see their choices as isolated decisions rather than part of a convergence process, reduces violations of a widely accepted supposition of rationality, known as the invariance procedure[49] supposition, thereby helping to make the VSL estimates less volatile. Specifically, this opacity is brought into the two stated methods by alternating the choices corresponding to the questions for valuation of state X and state Y (the first two questions in each method). Thus, after the first choice in the question valuing state X in the double gamble:

Treatment A	**Treatment B**
999 state **X**/1 dies	500 recover/500 die

The first element in the state Y valuation sequence will be presented as follows:

Treatment A	**Treatment B**
999 state **Y**/1 dies	500 recover/500 die

This will then be followed by the next for state X (assuming that the subject chose A):

Treatment A	**Treatment B**
999 state **X**/1 dies	750 recover/250 die

And then the second choice with state Y (assuming that they chose B):

Treatment A	**Treatment B**
999 state **Y**/1 dies	250 recover/750 die

And so on successively, until arriving at the respective open questions which close the iterative procedure. This same strategy, which involves alternating choices involving state X with choices on state Y, is also used in some sample groups with the question on relative social value (PT).[50]

[49] As the name itself indicates, this supposition establishes that logically equivalent preference measurement procedures should lead to analogous results (Tversky et al., 1988). One of the most frequent violations of this normative principle is the phenomenon of 'preference reversals', where opposing preferences are obtained with similar methods (Lichtenstein & Slovic, 1971). As subsequent studies have demonstrated (Pinto et al. 2018), concealing or obscuring the iterative process from the interviewees whose preferences you are aiming to measure means that they declare their indifference between the two opposing alternatives, mitigating such preference reversals and so leading to greater consistency in the responses given.

[50] The procedure described, alternating choices between the two health states, was used by Pinto et al. (2018), generating more consistent results than those obtained by other iterative systems. It represents an adaptation of the method originally proposed by Fischer et al. (1999).

3.4. Questionnaire

The questionnaire, divided into a five-part structure[51], was programmed in a computerised interface to be administered by means of computer-assisted personal interviews (CAPI) conducted at the homes of the sample participants. The structure of the questionnaire is essentially the same for all interviewees, although 8 versions of the interface were designed, each with a different number of questions in the parts containing the preference valuation methods, and the way in which these questions are set. For example, there are questionnaire models which, in the part dedicated to the contingent valuation exercise, ask about willingness to pay (WTP) and willingness to accept (WTA), invoking a strictly personal perspective, while other models appeal to a more inclusive perspective, taking into account the repercussions their responses could have on their family. Likewise, there are models where, both to infer the individual relative value and the social value, an opaque procedure is structured to arrive at the indifference value of the interviewees, while other models use a fully transparent iterative procedure. These and other differences served to characterise the 8 versions of the questionnaire, which were randomly assigned to the interviewees.

Part 1. Introduction.

This first part, common to all the questionnaire models, begins by presenting the study, its purpose and the institutions involved, after which the participants are given an explanation that the objective of the questionnaire is to record their freely expressed opinions on some situations, mostly hypothetical, requiring a degree of reflection on their part before they respond.

This presentation is followed by a battery of questions intended to ascertain the relationship the interviewees have with vehicle use and motorway travel: whether or not they drive; how frequent their journeys are; number of kilometres covered per year; means of transport used; current driving licences, etc. Next, in order to familiarise the respondents with the concept of risk, in the sense of the likelihood of something bad happening, examples of different risks were presented, conveyed in the form of a percentage and natural frequency ("one per cent" vs. "one in a hundred"), with the support of visual aids. In order to evaluate the interviewee's capacity to properly interpret risks expressed in this manner, two questions are set which served to verify the interviewees' numerical skills.[52]

The participant is then informed of the risk of having a traffic accident in Spain, and the likelihood of that accident resulting in fatal and non-fatal injuries. The text shown to the participants (and read by the interviewer) is as shown in Figure 6:

[51] As will be explained below, 8 versions or models of the same questionnaire were used, one for each of the 8 subgroups of participants the sample was randomly divided into. In models 7 and 8, the questionnaire comprises only 4 parts, rather than the 5-part structure of the questionnaire in the other six models.

[52] According to various research projects (Cokely et al., 2012; 2014), people's ability to interpret and calculate proportions, percentages or probabilities correctly (such as risk of death by traffic accident) is one of the main determining factors in numerical illiteracy (Paulos, 1988) and the inability to understand statistical risks, and arithmetic rules more generally. The inclusion of questions regarding numerical skills in our questionnaire thus intended to ascertain whether a lack of numerical skills could significantly influence the estimates generated.

Figure 6. Communication of road accident risks and their consequences for health.

In Spain in 2021 there were almost 90,000 traffic accidents involving victims, 1,533 deaths, 7,784 serious injuries and 110,378 minor injuries. The annual risk associated with these traffic accidents is as follows:

- **3 people die per 100,000 population.**
- 16 people are seriously injured per 100,000 population.
- 233 people suffer minor injuries per 100,000 population.

In order to put the risk of fatality in traffic accidents in context, the next graph I will show you represents the **annual risks associated with the different causes of death or groups of people per 100,000**. For example:

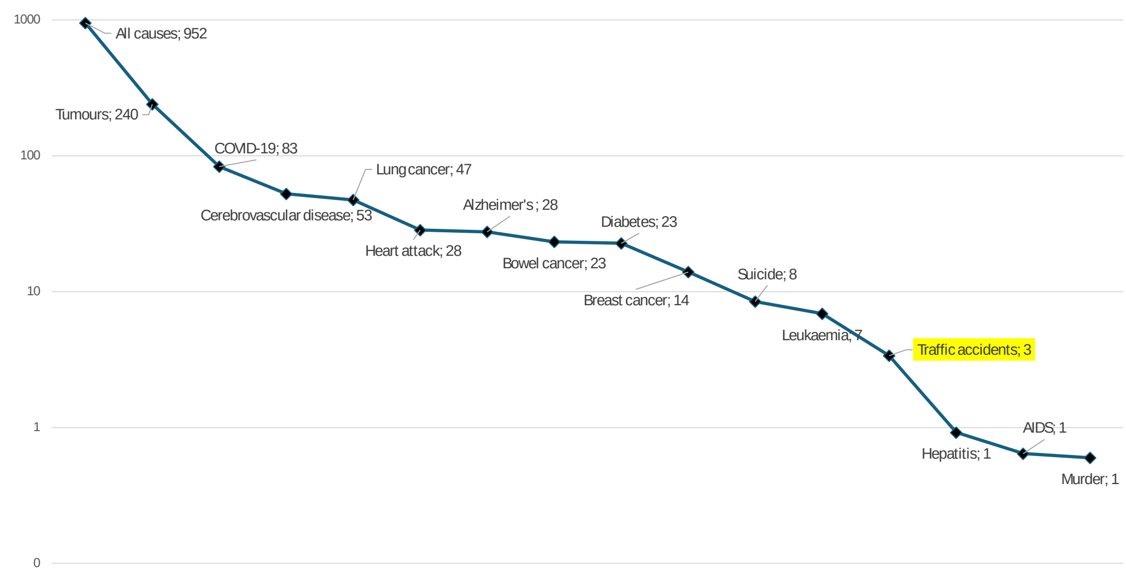
Interviewer shows: P8 card and show examples

"All causes: 952". This figure tells us that in Spain, 952 people die per year out of every 100,000 population (for any reason and at any age).

"Diabetes: 23". This figure tells us that in Spain, 23 people per 100,000 population die each year as a consequence of diabetes

The risk of dying in a traffic accident is also presented graphically, placing it in context compared to the risks of dying for other reasons, as shown in Figure 7.[53]

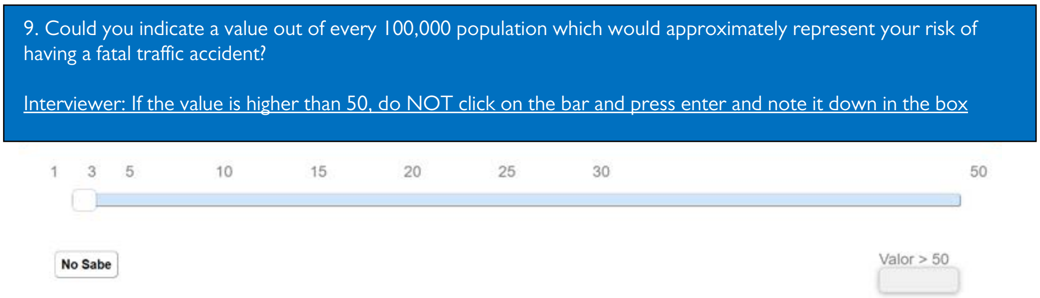
Figure 7. Risks of death (per 100,000 population) from different causes in Spain.



Next, in light of the average risk of dying in a traffic accident in this country (3 per 100,000), the interviewee is asked to reply whether, given their characteristics and travel habits, they believe they face a risk equal to, above or below the average. If their response is above or below, they are asked to specify approximately what the risk would be, with the help of a scale such as that shown in Figure 8.

[53] This part of the questionnaire applies the strategies that have proven most effective in the communication of risks, according to Gigerenzer (2002), Yamagishi (1997), Pailin (1997, 2003), Mitchell & Carson (1986), Hammitt (1986, 1990) & Corso et al. (2001), among others.

Figure 8. Question on subjective perception of risk of death in traffic accident.



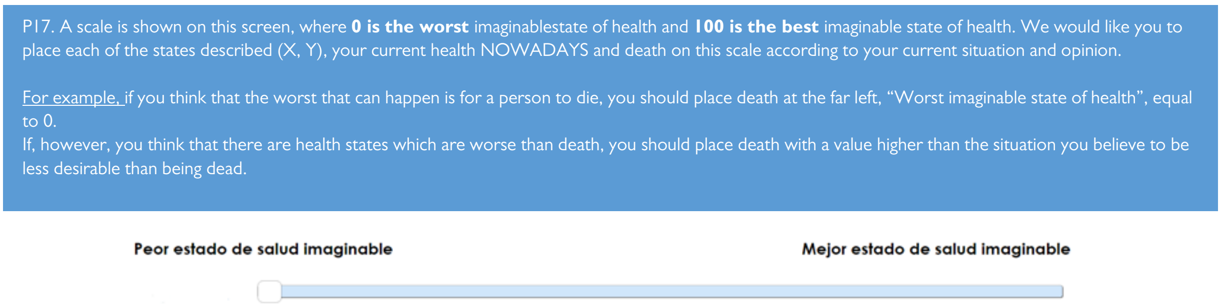
At the end of this introductory part, participants had to complete the SF-6D health questionnaire, where they are asked to reflect the degree to which their state of health causes them to be affected in six different dimensions or attributes of their quality of life (physical function; role limitations; social function; pain; mental health and vitality) at the time the survey was conducted.

Part 2. Visual scale

In the second part of the questionnaire, also shared by all eight models, a first health preference measurement method was used, although the purpose of this task is not so much to obtain valuations to use when estimating the VSL, but to train the participants, so as to gradually familiarise them with the health problems they will subsequently need to evaluate by means of the methods described in the previous section.

In this part the respondents were presented with the two hypothetical health states (X and Y) that will feature in the central parts of the questionnaire. Once the participants have read (and/or listened to) the description of each of the two states, they are asked to order these two hypothetical states according to their preference, together with their current state of health, and death, and once they have ordered them, to give them a score on a visual scale with minimum and maximum values of 0 and 100, respectively identifying the "worst imaginable state of health" and "best imaginable state of health", as shown in the description in Figure 9.

Figure 9. Visual analogue scale.



Part 3. Contingent valuation

As of part 3, differences start to emerge between the eight questionnaire models. All the interviewees, except for those responding to models 7 and 8, faced questions based on the contingent valuation (CV) methodology, i.e. questions as to willingness to pay (WTP) to avoid experiencing state X, and willingness to accept (WTA) or be compensated in exchange for experiencing that state. Nonetheless, the specific wording of the questions varies slightly among the different questionnaire models, some of which include an additional question, as explained below.

The first question in this part of the questionnaire, VC1, focuses on ascertaining how much the interviewee is willing to pay (WTP) to avoid state X. They are asked to imagine that after having a traffic accident, they are in the situation described in state X. They are then asked to imagine that they were offered a novel treatment not covered by the public health service, thanks to which they could achieve prompt recovery, avoiding the problems associated with state X (see Figure 10).

Figure 10. Scenario of the willingness to pay (WTP) question.

WITH NORMAL TREATMENT (state X)	WITH NOVEL TREATMENT
In hospital • Two weeks in hospital • With moderate pain **After hospitalisation** • The pain gradually disappears • Difficulties working or performing leisure activities, which gradually reduce • Full recovery experienced after 18 months, without sequelae	**In hospital** • One day in hospital **After hospitalisation** • In 4 or 5 days they will recover their state of health prior to the accident • There are no sequelae

As explained in section 3.3, the WTP is not obtained directly with an open question, but by means of a blended format, through which participants respond whether they would or would not pay (or if they are not sure whether they would) various monetary amounts shown to them at random, and they then specify the maximum amount they would pay within the range delimited by their previous responses. The values that make up the "payment card", i.e. the figures successively presented to the interviewee for them to state their willingness or not to pay these amounts in exchange for the novel treatment, are shown in Figure 11.

Figure 11. Payment card (figures in euros) for the question on willingness to pay (WTP).

50	100	300
500	1,000	3,000
10,000	30,000	100,000

The respondent sees the payment cards one by one and in a random order, and replies "definitely would pay", "definitely wouldnot pay", or "unsure whether would pay or not" for that amount, being advised at all times that their reply should take into account their level of yearly income and expenditure. Figure 12 shows an example.

Once the interviewee has replied whether or not they would pay each of the amounts on the payment card, they are shown the distribution of their responses, as shown in Figure 13. This example indicates that the respondent displayed an inconsistency in their responses (asserting that they " would certainly not pay" €50 or €300, while nonetheless stating that they "would certainly pay" €500 or €1000). In such situations, the respondent is invited to review and correct their responses.

Figure 12. Example willingness to pay (WTP) question.

VC1b. Bearing in mind your level of yearly income and expenditure, indicate whether you would be prepared to pay the amount I will now read to you for the novel medical treatment.

Bear in mind that before indicating the option which on each occasion you see as the money you state you would be prepared to pay for the novel treatment, this would no longer be available for other possible uses, either for you or your family.

Interviewer: Read amount and response options

Certainly would pay this amount
Certainly would not pay this amount
Unsure whether would pay this amount or not

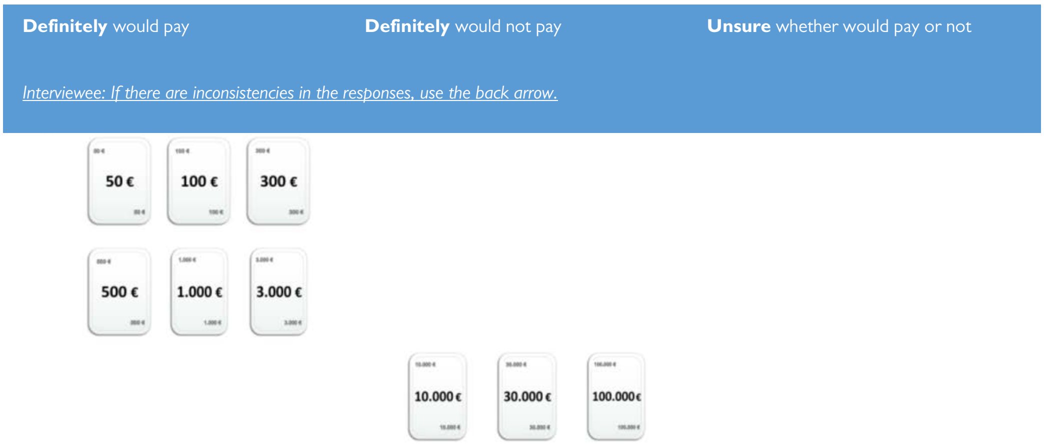
Figure 13. Example distribution of responses to question VC1 (WTP).

Definitely would pay | **Definitely** would not pay | **Unsure** if would pay or not

Interviewee: If there are inconsistencies in the responses, use the back arrow.
Confirm the range; once you move on, you can no longer go back

Once a response distribution free of inconsistencies has been obtained, a range is defined, within which we must find the precise value which is the maximum the interviewee would be willing to pay for the novel treatment to prevent them from experiencing status X. In the examplegiven below in Figure 14, this range has a lower bound of €3,000 (the highest amount they would certainly pay) and an upper bound of €10,000 (the lowest amount they would certainly not pay). The final open question would therefore be: "Between €3,000 and €10,000, how much would you be prepared to pay?".

Figure 14. Example distribution of responses to question VC1 (WTP).



The second question in this part also focuses on obtaining the monetary value associated with the loss of health resulting from state X, except that in this case, rather than doing so by asking about willingness to pay to avoid state X, they are asked about the amount of money that would compensate the interviewee for having to experience that state, in other words the "willingness to accept" (WTA).

The following scenario is designed to this end: the interviewee is asked to imagine that as a result of having had a traffic accident, they will experience the consequences described in state X, but that the same day they were lucky enough to win a lottery prize. Following the same procedure as described in the WTP case, the interviewee must this time respond whether a particular amount of money (each of those contained on the payment card) is or is not sufficient for them to consider that, despite the accident and its consequences, "the day would after all have been neither good nor bad".

As in the case of WTP, the cards with the amounts of money are presented one by one, in a random order. The participant responds in each case whether "the money would be more than sufficient", "the money would not be sufficient" or "they are unsure whether it would be sufficient or not". The range is delimited (correcting for any possible inconsistencies), and they are asked what minimum amount within that range they would consider sufficient to feel that the consequences of the accident are offset by the lottery prize.

The above descriptions of the WTP and WTA questions are common to all six groups that include the contingent valuation part. However, in three of the questionnaire models (3, 5 and 6), before the respondent sees the cards with the amounts of money and decides whether or not they would pay each of these amounts (in the case of WTP), or whether they would or would not be sufficient as compensation (in the case of WTA), they are given the following warning:

"*Before indicating the option you choose on each occasion, bear in mind that the money you state you would be prepared to pay for the novel treatment would no longer be available for other possible uses, either for you or your family.*" (WTP)/"*Before indicating the option you choose on each occasion, bear in mind that the money you state you would be prepared to accept as a prize will compensate for the consequences of the accident not only for you, but also for your family*" (WTA).

The purpose of including this variant is to use the results obtained to test whether appealing specifically to the family, in other words encouraging the interviewee to adopt an inclusive perspective (them and their family) in their response, rather than a strictly individual view, could influence their responses.

Furthermore, in the aforementioned groups 3, 5 and 6, a third question is added after the WTP and WTA questions, asking the respondent to think how the accident with the consequences described in state X would affect their life (work and leisure) and their family life, recording their responses on a scale from "Very little" to "A great deal". Table 6 summarises the questions in this Part 3 included in each of the questionnaire models.

Table 6. Part 3 (Contingent Valuation) questions in each questionnaire model

Model	Questions/tasks	Observations
1, 2, 4	• WTP and WTA – State X	
3, 5 and 6	• WTP and WTA – State X • Likely impact of the accident on work, leisure and family	The family perspective is raised in the WTP and WTA
7 and 8	---	---

Part 4. Losses of utility/relative values: SG and "person trade-off"

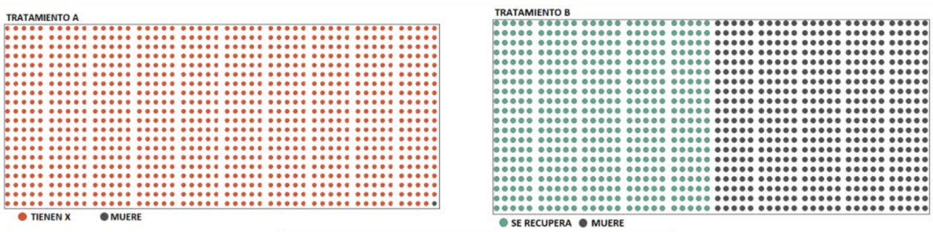
Part 4a. Individual relative value ("modified standard gamble", SG)

Part four contains the questions intended to obtain relative values for the health states of interest, or in the terminology specific to economic evaluation, to measure the utilities of these states. In this study, the methodology of which is based on prior work by Carthy et al. (1999), the chosen option is to use a "modified standard gamble" (SG) or "double gamble", as explained in detail in Section 3.3. All participants, irrespective of the questionnaire model randomly assigned to them, respond to the three questions formulated with this method, as described in the aforementioned section: a first question intended to measure the utility of state X, a second serving to elicit the utility of state Y, and a third to obtain the relative value of state Y compared to state X. Figure 15 shows an sample description of the scenario accompanied by the first choice that the respondents must make.

Figure 15. Modified standard gamble with state X. Scenario and first choice.

Imagine that you have a serious traffic accident, and that if you do not receive medical care, you could die. There are two medical treatments which could in principle be applied in your case: treatment A and treatment B.
Suppose that with treatment A: 999 out of every 1000 people treated respond well to the treatment, thereby achieving a situation like state X, while 1 in every 1000 people treated die.
With treatment B: 500 out of every 1,000 patients recover their health completely, while 500 of every 1,000 die.

VRI.1_1 What treatment would you choose to receive: A or B?
Interviewer: Show and maintain state X card

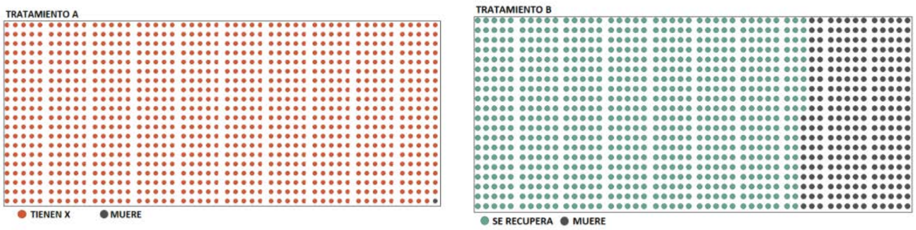


A – 999 X/1 dies
B – 500 recover/500 die

As explained in the previous section, depending on the subject's response, the next choice will increase or decrease the likelihood of recovery, and conversely the risk of death with treatment B. In the event that the respondent chooses treatment A when faced with this first choice, the next would then be that shown in Figure 16.

Figure 16. Modified standard gamble. 2nd choice (assuming they choose A the first time).

VRI1_2. And if the situation were as follows, what treatment would you choose?



A – 999 X/1 dies
B – 750 recover/250 die

As can be observed, the likelihood of success (recovery) with treatment B is now 750 out of 1000, and the risk of death is halved to 250 out of 1000. This bisection search procedure continues until it has defined the range containing the interviewee's indifference value, at which point an open question is asked, as seen in Figure 17.

Figure 17. Modified standard gamble. Final indifference value question.

You said that you would prefer **treatment A** to treatment B in the following situation:

A. 999 X; 1 dies/B 925 recover; 75 die

While in this other situation you said that **you would prefer treatment B:**

A – 999 X; 1 dies/B 950 recover; 50 die

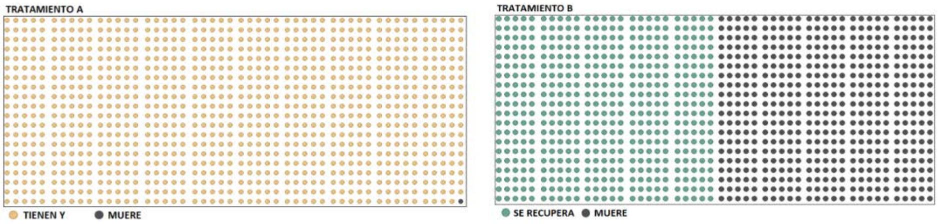
In other words, you would prefer treatment A if the risk of dying with treatment B is **75**, but would opt for treatment B if the risk of dying with that treatment was **50.** Between **75** and **50**, **what is the lowest risk of dying with treatment B that would make you unsure whether the treatment was better or worse than treatment A?**

The procedure is repeated, switching state X for state Y. Figure 18 shows the scenario and the first choice with state Y where a different colour has been used in the visual aid associated with the state. This is significant, and the variations introduced to some questionnaire models regarding how these questions are asked will therefore be discussed below.

Figure 18. Modified standard gamble with state Y. Scenario and first choice.

Imagine that you have a serious traffic accident, and that if you do not receive medical care, you could die. There are two medical treatments which could in principle be applied in your case: treatment A and treatment B.
Suppose that with treatment A: 999 out of every 1000 people treated respond well to the treatment, and thereby obtain a situation like that in **STATE Y**, while 1 in every 1,000 people treated die. With treatment B: 500 out of every 1,000 patients recover their health completely, while 500 of every 1,000 die.

VRI2_1 Which treatment would you choose to receive: A or B?
Interviewer: Show and maintain state Y card



A – 999 Y/1 dies
B – 500 recover/500 die

In section 3.3 it was shown that in order to make the process of eliciting the relative values less transparent in the standard gamble method (and also with the person trade-off), in some questionnaire models the choices corresponding to the questions valuing state X and state Y that make up the iterative indifference search algorithm are progressively alternated (first choice with X, first choice with Y, second choice with X, second choice with Y, etc.). This was specifically applied in models 4, 5, 6 and 8. The use of different colours for states X and Y on the visual aid is intended to remind the interviewee that the successive choices they face refer to different health states. In this part of the questionnaire, for models 4, 5, 6 and 8, the skill of the interviewer in maintaining the participants' attention at all times will be fundamental.

After the first two tasks based on the SG method (administered consecutively in models 1, 2, 3 and 7, and following the non-transparent format in the four other models cited), the subject is asked about the element(s) of the scenarios used in these two tasks that most influenced their decisions or most drew their attention when choosing between treatment A and treatment B. **¡Error! No se encuentra el origen de la referencia.**The interviewee can choose to highlight as many elements as they wish from the options shown in the following figure, and may also add other reasons not specified on the list.

Figure 19. Question about elements most influencing choices for the SG.

VRI.3. We would now like you to tell us which element or elements of those represented in the two previous questions you took into account most when choosing between treatment A and treatment B. Specifically, choose from the following options (you may choose more than one) which best explain(s) how you reached your choices between the two treatments. Therefore, in order to reach your decisions, you considered above all:
Interviewer: Show card VRI3 and mark the aspects indicated by the interviewee. Bear in mind the "others" option

The whole of treatment A.
That 999 out of every 1000 people treated would end up in state (X, Y) with treatment A.
In state X, Y with treatment A.
That 1 in every 1,000 people treated would die with treatment A.
That you could die with treatment A.
The whole of treatment B.
The number of patients per 1,000 who would recover their health with treatment B.
The number of patients per 1,000 who would die with treatment B.
That health would be completely recovered with treatment B.
That you could die with treatment B.
Another reason
Specify

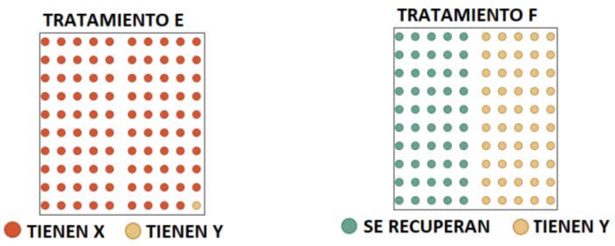
The respondents then face a third round of questions structured with this same method, although in this case the worst outcome in both treatments, which in the previous questions was identified with a fatal result, is now state Y, whereas in the event of success, treatment A leads to state X, and B to full recovery of health, as in the first question of this part of the questionnaire. The aim here is to obtain the relative value of Y compared to X, or the relative loss of utility represented by experiencing Y rather than X. The scenario and initial choice are shown in Figure 20, where, as indicated in section 3.3, it can be seen that the probability base is not 1,000, as in the previous two questions, but 100.

The indifference value search algorithm is similar to that mentioned for the first two questions, and once the range has been delimited, the final open question is asked, as shown in Figure 21.

Figure 20. Modified standard gamble: state Y vs. state X. Scenario and first choice.

Imagine that you have a serious traffic accident, and that if you do not receive medical care, you could die. There are two medical treatments which could in principle be applied in your case: treatment E and treatment F.
Suppose that with **treatment E**: 99 out of 100 people treated respond well to the treatment, and end up in a situation as in state X, while 1 out of every 100 people treated end up in a situation as described in state Y. With **treatment F**: 50 out of every 100 people treated recover their health completely, while 50 out of every 100 are left in state Y.

VRI4_1 Which treatment would you choose to receive: E or F?
Interviewer: Show state X and state Y card



E – 99 X/ I Y
B –50 S/50 Y

Figure 21. Modified standard gamble. Final indifference value question. X vs. Y.

You said that you **would prefer treatment E** to treatment F in the following situation:

E . 99 X; 1 Y/F 32 recover; 68 Y

While in this other situation you said that **you would prefer treatment F:**

E – 99 X; 1 Y/F 35 recover; 65 Y

In other words, you would prefer treatment E if the risk of experiencing state Y under treatment F was **68**, but would opt for treatment F if the risk of experiencing Y with this treatment was **65.** Between **68** and **65**, **what risk of experiencing Y with treatment F would leave you unsure whether this treatment is better or worse than treatment E?**

Following this last sequence of choices, interviewees are also asked about which element(s) of the decision scenario most influenced their responses, which brings this first block of part 4 of the questionnaire to an end. Table 7 summarises the questions in part 4a, and the questionnaire model variations.

Table 7. Questions in Part 4a (Individual relative value) in each questionnaire model

Model	**Questions/tasks**	**Observations**
1, 2, 3, 7	• SG – State X (vs. death) • SG – State Y (vs. death) • Point of reference question • SG – State X (vs. State Y) • Point of reference question	The three choice sequences in the SG method are presented separately: first SG(X), SG(Y), and lastly, SG(X/Y).
4, 5, 6, 8	• *SG – State X (vs. death)* • *SG – State Y (vs. death)* • Point of reference question • SG – State X (vs. State Y) • Point of reference question	The first two choice sequences in the SG method with state X and state Y are administered in a non-transparent manner, alternating choices corresponding to each algorithm.

Part 4b. Relative social value ("person trade-off", PT)

The second block of part 4 is also intended to ascertain the relative value respondents assign to the two health states being valued, but in this case the aim is to elicit a social, rather than individual, perspective. In the choices making up the questions in this block, interviewees do not choose between hypothetical medical treatments for themselves, but between health plans for population groups, as explained in section 3.3.

In order not to make the survey overly long, to obtain the relative value of preventing health states X and Y from a social perspective, i.e. by applying the person trade-off method, the valuations were distributed among the different questionnaire models. Participants assigned model 1 or model 4 thus answered one single question with this method, in which the state involved was state of health X. In models 2 and 5, this question was asked with a social perspective for state Y, and in models 3 and 6, the relative social value of Y compared to X was measured with this method. Lastly, as models 7 and 8 did not include the contingent valuation part in their respective versions of the questionnaire, it was possible to include all three questions with the person trade-off method (state X, state Y, state Y vs. X). In addition, in the case of model 8, the choice sequences comprising the first two questions (relative social value of X and relative social value of Y) were alternated, as explained in section 3.3, so the convergence procedure would not be fully transparent for the participants.

Figure 22. Person trade-off with state X. Scenario and first choice.

Imagine that the government needs to choose between two road safety plans that reduce traffic accidents, and asks for your opinion. The first plan, plan A serves to avoid **1 more death** then plan B, while plan B is capable of preventing **500 more injuries** than plan A. Suppose that all the additional injury victims in plan B would end up in a situation like that in **state X**

VRS1_1. And if the situation were as follows, which plan would you choose?

Interviewer: Show the card describing state X, keeping it visible to the interviewee throughout the process of question choices).

A – Prevents one additional fatality	
B – Prevents 500 additional injuries with state X	

Figure 22 shows the description of the scenario and first choice corresponding to the valuation of state X, with a social perspective. As can be seen, the respondents must decide whether they would support a road safety plan that would avoid one additional fatality or one that would prevent 500 non-fatal injuries, with the consequences described in state X.

Similar to the description given for the case in the SG method, depending on the participant's response to this choice and those which follow, the number of non-fatal injuries associated with plan B gradually rises or falls to define a range containing the value for which the subject would be indifferent between the two plans. This value is obtained by means of a final open question, as shown in Figure 23.

Figure 23. Person trade-off. Final indifference value question.

You said that **you would prefer plan A** to plan B in the following situation:

A – Avoids 1 more fatality/B – Avoids 650 additional injured victims with state X

While in this other situation, you said that **you would prefer PLAN B:**

A – Avoids 1 more fatality/B – Avoids 657 additional injured victims with state X

In other words, you would prefer plan A if the additional number of injuries avoided by plan B is **650**, but would choose plan B if the number were **675**. Between **650** and **675**, what is the number of additional injuries avoided with plan B that would leave you unsure whether this plan was better or worse than plan A?

Table 8 summarises the questions in part 4b and their distribution depending on the questionnaire model.

Table 8. Questions in Part 4b (relative social value) in each questionnaire model

Model	Questions/tasks	Observations
1, 4	• PT – State X (vs. death)	
2, 5	• PT – State Y (vs. death)	
3, 6	• PT – State X (vs. State Y)	
7	• PT – State X (vs. death) • PT – State Y (vs. death) • PT – State X (vs. State Y)	The three choice sequences in the PT method are presented separately: first PT(X), then PT(Y) and lastly, PT(X/Y).
8	• PT – State X (vs. death) • PT – State Y (vs. death) • PT – State X (vs. State Y)	The first two choice sequences in the PT method with state X and state Y are administered in a non-transparent manner, alternating choices corresponding to each algorithm.

Part 5. Sociodemographic and other questions

The last part of the survey, common to all the questionnaire models, contains an extensive battery of questions focused on characterising the interviewee as precisely as possible, beyond their age and sex (which was obtained at the start of the questionnaire), to control for the representativeness of the sample with regard to these two parameters. In part 5, interviewees are asked about their marital status, household size, and the existence of dependent children or adults. This final part also records information on the interviewee's level of completed studies, employment status and level of monthly household income (within one of six suggested income bands).

The interviewees' experience of road accident situations is collected by a question such as that indicated in Figure 24, differentiating between whether it was their own experience or that of someone in their close or more distant circle, and according to the seriousness of the accident. Following this question, others are included on healthy and unhealthy lifestyles (tobacco consumption; alcohol consumption; physical exercise), experiences of motorway risk (driving under the effects of alcohol or narcotics; with the respondent themselves or another person at the wheel; with the interviewee travelling as passenger), driving attitudes or habits (sounding the horn; shouting or gesturing at other drivers; flashing their headlights), as well as weight and height.

Figure 24. Question on past road accident experiences.

SD11. Please indicate in the following table whether you or people in your circle have suffered any type of **traffic accident**, and its seriousness.

If you have had more than one accident, you can tick several options

You	Minor	Serious	Fatal	No accident	Not applicable
Spouse/Partner	Minor	Serious	Fatal	No accident	Not applicable
Father/Mother	Minor	Serious	Fatal	No accident	Not applicable
Child	Minor	Serious	Fatal	No accident	Not applicable
Other relative	Minor	Serious	Fatal	No accident	Not applicable
Friend	Minor	Serious	Fatal	No accident	Not applicable
Acquaintance	Minor	Serious	Fatal	No accident	Not applicable

The final questions in part 5 record firstly the subjective survival expectations of the subject ("What probability between 0 and 100 do you give to being alive at the age of 75 years old/85 years old/95 years old?"); and also the degree to which they are satisfied and happy with their life, for which they must respond to the questions shown in Figure 25. Lastly, participants are asked how difficult they found it to answer the questionnaire, on a scale from 0 (not at all difficult) to 10 (extremely difficult).

Figure 25. Life satisfaction question

SD23 – You will now see five statements with which you may agree or disagree. Please indicate your level of agreement, where 1 means **"Completely disagree"** and 7 **"Completely agree"**.

Interviewer: Remind them of the scale, and avoid them always tending towards extremes.

	Completely disagree	Disagree	Tend to disagree	Neither agree nor disagree	Tend to agree	Agree	Completely agree
In most respects, my life is close to my ideal	○	○	○	○	○	○	○
The circumstances of my life are excellent	○	○	○	○	○	○	○
I am satisfied with my life	○	○	○	○	○	○	○
I have so far achieved most things that are important for me in life	○	○	○	○	○	○	○
If I were born again, I would change hardly anything in my life	○	○	○	○	○	○	○
In general I am happy	○	○	○	○	○	○	○

3.5. Calculation of the value of a statistical life

As mentioned in chapter 2 of this report, the results obtained with the different estimation methods trialled in the 2009 study prompted us to choose the CV/SG chained method to estimate the VSL. This method, proposed by Carthy et al. (1999), divides the procedure for calculating this value into three phases or stages, the specific application of which to this study is described below.

The individual MRS values between income and risk of experiencing a non-fatal injury (state X in our study) are estimated within the range defined by the two values declared by the interviewee in part 3 of the questionnaire, i.e. the maximum amount they would be willing to pay to avoid experiencing state of health X (WTP) and the minimum amount required as compensation in exchange for experiencing this state (WTA).

The estimate for MRS (m_x) is contingent on the functional form assumed for the utility function $U(w)$. In the 2009 study, like that done previously by the authors of the British study, four different types were considered for the utility function: Negative Exponential, Homogeneous, Logarithmic and Nth Root. This same approach is followed in this study. Although some of the functional forms require a certain number of observations to be discarded[54], the absence of a criterion allowing just one of them to be chosen prompts us to make estimates under these four different suppositions before finally obtaining a mean value. The Methodological appendix shows the expressions used to calculate m_x with each of the utility functions.

The SG method, developed in part 4a of the questionnaire, serves to estimate the relative loss of utility represented by experiencing a state of health or non-fatal injury compared to death, which constitutes the second stage of the chained method. This relative loss of utility is generally determined in accordance with the following expression (see Methodological appendix):

$$\frac{m_d}{m_i} = \frac{1-\theta}{\Pi-\theta} \qquad [3]$$

In the design chosen for the SG, the risk of dying with treatment A (the value of θ) is set at 0.001, with 0.999 being the probability of successful treatment, $(1-\theta)$, resulting in a situation like that described in state X. The risk of dying with treatment B (the probability Π), and also the probability of recovering normal health with this treatment $(1-\Pi)$ are gradually modified during the elicitation process, to the point at which the interviewee shows indifference between receiving this treatment and treatment A (the best outcome of which is state X). If we designate this indifference probability as $\overline{p_x}$, equation [3] can be rewritten as follows to express the relative loss of utility associated with state X:

$$\frac{m_d}{m_x} = \frac{1-0.001}{\overline{p_x}-0.001} \qquad [4]$$

By chaining the MRS values between income and experiencing state X (m_x) and the relative loss of utility associated with that state (m_d/m_x), the VSL is obtained:

$$m_d = \frac{1-0.001}{\overline{p_x}-0.001} \cdot m_x \qquad [5]$$

3.6. Calculating the value of preventing a fatality

The value of avoiding or preventing a death or the "value of preventing a fatality" (VPF) as a consequence of a traffic accident is a broader concept than the VSL[55], including all the costs derived from an accident which can be directly attributed to a fatality. These costs are typically known as internal, i.e. borne by the victims and their families, and external costs borne by the rest of society.
In this study, the VPF is estimated as the sum of three components: the VSL, estimated in accordance with the methodology described in the previous section; the value of the net production loss; and healthcare costs (medical and ambulance costs).

[54] In cases where WTP=0, WTA=0, or WTA<WTP, some of the functional forms are not defined, which forces us to discard the valuations of those subjects whose responses to the contingent valuation method follow these patterns.
[55] As previously in the study by Abellán et al. (2011a), we follow the convention used by Wijnen et al. (2009), for instance, designating the VSL as the component based on the WTP of the VPF (in the VC/SG method, in our case), while in the latter also including other components not based on the WTP.

Calculating the production losses associated with fatalities needs an estimation method to be selected based on plausible suppositions, since there are no individualised micro data which can be used to calculate the flow of income that a person killed in a traffic accident would cease to generate. Therefore, taking the human capital theory as our reference point, we can draw on information on salaries by sex and age to approximate the flow of income (or of value added generated) interrupted at the time the person dies. This is the approach followed in Abellán et al. (2022), whose data we use in this study, and whose methodologies described below.

Firstly, observed salary data are used for each Spanish region, sex and age group derived from the Salary Structure Survey produced annually by the Spanish National Statistics Institute (INE). Secondly, since not all those killed in traffic accidents are part of the employed population (either because they are inactive, i.e. aged under 16, retired, students or homemakers; or because they are unemployed), these salary data are adjusted in accordance with occupancy rates or employment rates (likewise specific to each sex, age group and Spanish region), derived from the Active Population Survey produced quarterly by the INE.

Meanwhile, productivity losses are monetary flows which extend over time into the future, and are thus subject to some degree of uncertainty. This requires a series of simplifying assumptions to be made, so as to obtain a plausible updated estimate of the value of these flows.

The first supposition is that the likelihood of being employed in the future will remain constant for each age group. For example, this means that to estimate the salary a person who died at the age of 20 would have had at the age of 50, we assume that their probability of being employed at the age of 50 corresponds to the current employment rate for workers in that age group. Regarding salary levels, in the interests of simplicity it could be assumed that they also remain constant (in real terms). However, the estimate assumes a positive productivity growth rate (and hence an increase in salary). Thirdly, a discount rate is used to calculate the present value of these lost production flows, which is a standard procedure in any estimate of the present value of a future flow of costs or benefits.

Three alternative scenarios are considered in the estimate: one in which productivity does not rise and the discount rate is zero; another in which productivity rises by 1% per annum and the discount rate is set at 3%; and a third scenario in which productivity rises by 3% and the discount rate is 1%. The second of these scenarios is assumed to be the central estimate, while the other two perform the function of sensitivity analysis, to observe the impact of these suppositions on the estimated production losses associated with a traffic accident fatality. As the original estimates correspond to the year 2019, they are updated to 2022 figures with the INE income update tool (December 2019-December 2022).

Lastly, the lost production estimated in this manner corresponds to the losses in gross terms. However, in the case of a traffic fatality, it is necessary to adjust this estimate in order to obtain the value in net terms, i.e. subtracting lost consumption. Part of the income that the deceased no longer generates would have been used for consumption, and since, unlike in the case of a non-fatal victim, the flow of consumption is also interrupted at the moment of death, the future consumption value must also be deducted. The assumption for this purpose is that consumption represents 80% of total gross production, this value being approximately the average consumption propensity observed for the Spanish economy as a whole during the last decade.

With regard to healthcare and transport costs (medical and ambulance costs), the figures used will be those published by the insurance business association (UNESPA, 2020).

3.7. Theoretical validity, calculation of income elasticity and imputation of income

The theoretical or construct validity of the results is analysed based on the confirmation that the WTP values (and hence the VSL estimates) behave as predicted by standard economic theory (Bateman et al., 2002). One commonly accepted minimum theoretical validity requirement is the existence of positive (and significant) correlation between the WTP declared by the interviewees and their capacity to pay, typically measured by means of their income.

This study compares the theoretical validity of the results by means of an ordinary least squares (OLS) regression analysis. This analysis serves to establish whether the declared WTP values and VSL estimates reveal a statistically significant relationship with the expected sign, not only with individuals' income, but also with a series of selected explanatory variables. The model is expressed as follows:

$$LnY = \alpha + \beta_i \cdot X_i + \varepsilon_i \quad \mathrm{i} = 1, 2, \ldots \mathrm{n} \qquad [6]$$

Where Y is the WTP or VSL, depending on the model, α is a constant, β_i the coefficients estimated, X_i the explanatory variables, and ε_i a disturbance with a normal distribution of mean 0 and variance σ^2. The monetary variables undergo a logarithmic transformation before being entered in the model, serving to immediately obtain the income-elasticity based on the coefficient estimated for the representative variable of the interviewee's earnings.

4. Results

4.1. Characteristics of the sample

Although the initial plan was to conduct 2,000 interviews, and the sample design was conducted for this figure, ultimately a total of 2,050 complete observations were available, distributed by autonomous region and habitat size as shown in Table 9.

Table 9. Composition of the sample by size of habitat (thousands of inhabitants) and Spanish region (%).

	Less than 2	Between 2 and 10	Between 10 and 50	Between 50 and 100	Between 100 and 500	More than 500
Andalusia	0.4	2.9	5.3	2.6	3.7	2.5
Aragon	0.4	0.4	0.5	---	---	1.5
Asturias	---	0.5	0.5	0.5	0.5	---
Balearic Islands	---	0.7	1.7	---	2.0	---
Canary Islands	---	0.5	1.5	0.6	2.1	---
Cantabria	---	0.5	0.5	---	0.5	---
Castile and Leon	1.4	0.8	1.0	0.5	1.1	---
Castile-La Mancha	0.5	1.5	1.0	0.4	0.6	---
Catalonia	0.5	2.0	4.4	2.0	3.5	3.9
Valencia	0.5	1.6	4.2	1.5	1.5	1.5
Extremadura	0.5	0.5	0.5	0.5	0.5	---
Galicia	0.5	1.2	2.2	1.0	1.4	---
Madrid	0.5	0.5	1.0	2.0	2.9	6.5
Murcia	---	---	1.0	0.5	1.5	---
Navarre	---	0.5	0.5	---	0.4	---
Basque Country	0.5	0.5	1.0	0.5	1.9	---
Rioja	---	---	---	---	0.5	---
Total	**5.7**	**14.6**	**26.7**	**12.4**	**24.7**	**15.8**

The distribution shown in the table reveals slight differences compared to the initial design, although the deviations are only small. Table 10 presents the sample distribution by sex and age quota, matching the expectations in the sample design and demonstrating the representativeness of the sample on a nationwide scale, according to these two dimensions.

Table 10. Sample composition by sex and age group (%).

	Male	Female	Total
18 to 24 years old	5.0	4.3	9.3
25 to 34 years old	6.7	7.0	13.8
35 to 44 years old	8.7	8.6	17.3
45 to 54 years old	9.6	10.3	19.9
55 to 64 years old	8.3	8.2	16.5
65 or over	10.5	12.8	23.3
Total	**48.8**	**51.2**	**100.0**

As set out in the previous section, those included in the sample were assigned at random to different subgroups, and were given different versions of the questionnaire. Table 11 presents the respective sample sizes associated with each of these questionnaire versions or sample subgroups, together with information on the mean duration of the interviews.

Table 11. Distribution of the sample by subgroup (questionnaire model) and mean duration of the interviews.

Model	Observations	%	Mean duration
1	295	14.4	39.70
2	300	14.6	39.65
3	298	14.5	39.65
4	295	14.4	39.67
5	298	14.5	39.65
6	297	14.5	39.66
7	132	6.4	37.88
8	135	6.6	37.80
Total	**2,050**	**100.0**	**39.43**

As can be observed in the table, the average interview duration was 39.43 minutes, with slightly shorter durations recorded where the questionnaire administered was 7 or 8. This is explained by the fact that these versions did not include part 3 (contingent valuation), so part 4b (social relative value) was extended instead, which ultimately took less time.

Information on the main sociodemographic characteristics of the study participants is presented in Table 12 (marital status; educational level; employment status; stated level of income and household characteristics). With regard to marital status, 53% of our sample comprises people who are married or have a civil partner, 30% are single, slightly under 10% are separated or divorced, and 7.6% are widowed. The sample composition quite closely approximates the overall Spanish population aged 16 and over, according to the Active Population Survey (EPA) for the third quarter of 2023, with a slightly higher presence of married and separated/divorced respondents in the sample compared to the general population, and a slightly lower representation of single people, which is in part explained by the fact that the study target population does not include the 16-17 year age band. Almost 30% of the sample had not completed any level of education beyond primary education, representing a slight over-representation of this group compared to the Spanish adult population; 41% of the sample had completed secondary studies, and 29.4% higher education (in both cases, the proportions are slightly lower than those seen in the population as a whole).

Table 12. Marital status, educational level, employment status, level of income and household characteristics of the sample participants.

Marital Status	**%**
Single	30.0
Married or Civil Partner	53.0
Separated or Divorced	9.5
Widowed	7.6
Level of Education	**%**
No education	2.8
Primary	26.8
Secondary	41.0
Higher	29.4
Employment Situation	**%**
Temporary private sector employee	8.4
Permanent private sector employee	32.0
Civil Servant	5.0
Non-civil servant public employee	2.6
Self-employed	6.7
Business owner	0.8
Unemployed	6.6
Retired/Pensioner	22.3
Homemaker	7.5
Student	6.3
Others	1.7
Level of income	**%**
Under 900 euros	10.3
Between 900 and 1,200 euros	17.3
Between 1,200 and 1,500 euros	21.8
Between 1,500 and 2,000 euros	20.9
Between 2,000 and 2,500 euros	15.0
Between 2,500 and 5,000 euros	12.3
Over 5,000 euros	2.4
Household characteristics	
Households with dependent children (%)	30.8
Average number of children	0.5
Households with dependent senior citizens (%)	7.8
Average number of senior citizens	0.1
Average household size	2.7

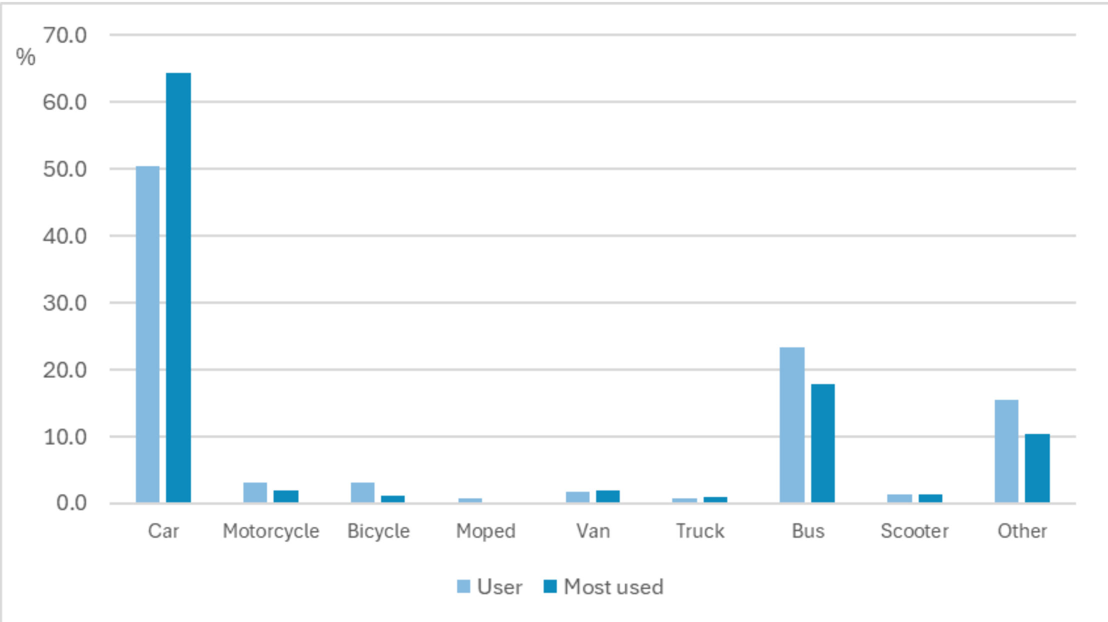
As for the employment status of the interviewees, 55.6% of the sample are part of the employed population: 40.4% are private sector employees, mostly with a permanent contract, 7.6% are public sector employees (5% civil servants), and 7.5% are self-employed or business owners. At the time the survey was conducted, 135 of the participants were unemployed (6.6% of the total). As for inactive population groups, the largest proportional category in the sample corresponded to retired people/pensioners, representing 22.3% of the total, followed by homemakers (7.5%) and students (6.3%). This population structure according to their relationship with the labour market is very similar to that recorded in the most recent EPA series. Only the self-employed, and to a greater extent retired people or pensioners, are somewhat over-represented in the sample. The only significant deviation between the share present in the sample and the proportion of the Spanish adult population they represent is in the case of business owners.

The level of household income declared shows that almost half of the interviewees (49.4%) live in households with monthly income equal to or less than 1,500 euros. A slightly lower percentage (48.2%) lie within the range from 1,500 to 5,000, and just 2.4% of the sample declare household income above that threshold. These data differ significantly from those given by the official statistics for the national population as a whole. Thus, according to the Family Budgets Survey, people in households with 1,500 euros' income or less accounted for 22% of the total population, while those living in households with monthly income between 1,500 and 5,000 euros were 71% of the population. This discrepancy typically occurs when asking for declared income data in surveys where the main purpose is not a study into the levels of income or expenditure of the population, and it does not represent a limitation as regards the analysis since the significant element for studying the theoretical validity of the subjects' responses is the relative difference in income between individuals, rather than the absolute values.

The final rows of Table 12 provide information on the characteristics of the households which the interviewees belong to. In 30.8% of cases, the respondent lives in a household where there are dependent children, while 7.8% of interviewees care for elderly people. The average household size is 2.7 members (similar to the general Spanish population), with an average of 0.5 children and 0.1 elderly people per household.

As for road travel habits and vehicle use patterns, Figure 26 shows that slightly more than 50% of interviewees regularly use a car as a means of transport. Buses represent the second most commonly used form of transport in the sample, with 23% of respondents stating that they use the bus. Motorbikes and mopeds are used by 3.6% and 1.2% of the sample respectively, while 2.3% drive a van, and 0.5% a truck. As for the use of more sustainable vehicles, 3.5% of the sample state that they use a bicycle, and 1% a scooter.

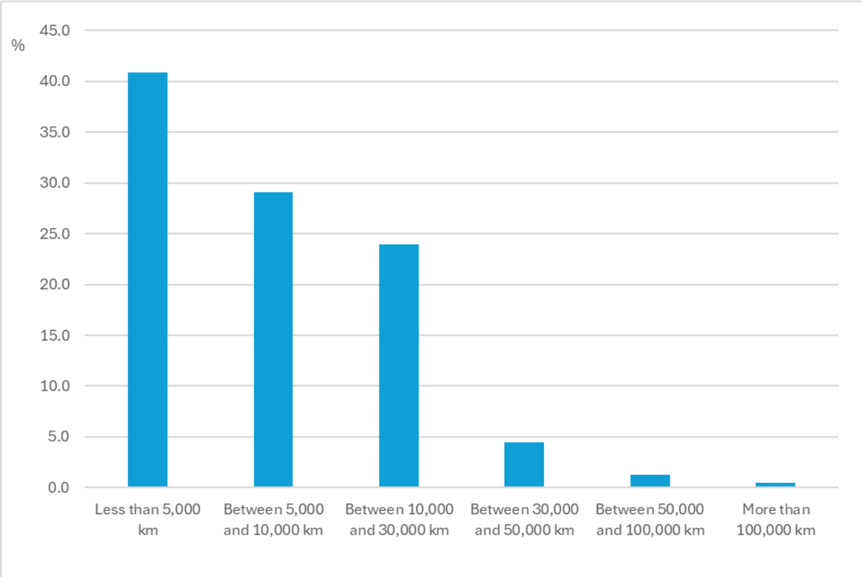
Figure 26. Use of means of transport and most typical means of transport (%).



If we consider the means of transport most used by each of the interviewees (including cases where only one is used), the order is similar to that above, with cars standing out above all others, at 64.3%. This is followed in terms of frequency by exclusive or majority use of buses (19.2%), with motorcycles (2.2%) and vans (2.1%) much further behind. The bicycle is the only or majority means of transport for 1.8% of respondents, and scooters for 0.7% of them.

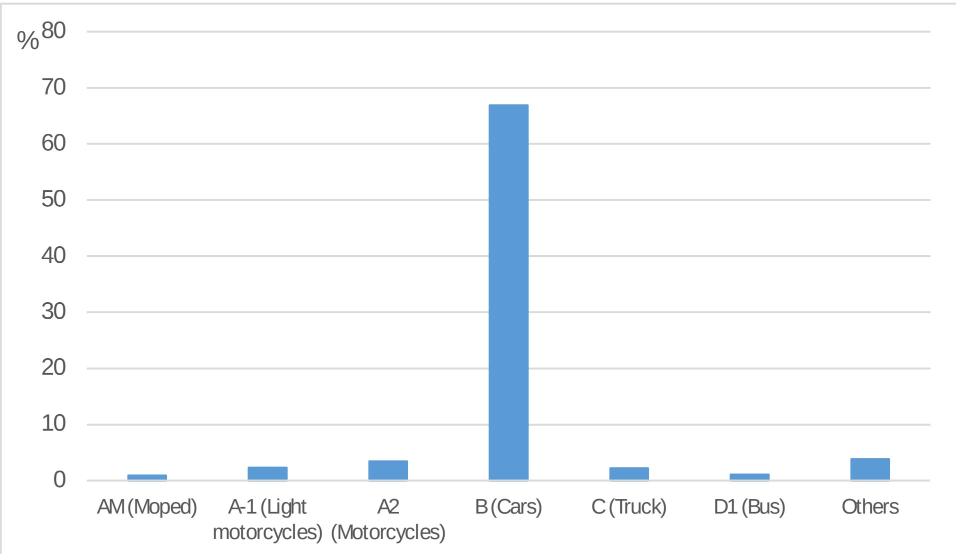
The intensity of use of means of transport among the sample participants, measured by means of the approximate number of kilometres covered per year, is represented graphically in Figure 27, revealing that more than 40% of the interviewees said that they cover at least 5,000 kilometres by road, irrespective of the means of transport used. 30% declared that they cover between 5,000 and 10,000 kilometres per year, and 21% between 10,000 and 30,000. The remaining respondents (7%) state that they cover more than 30,000 kilometres per year by various means of road transport.

Figure 27. Number of kilometres travelled per year.



69% of study participants state that they hold a driving licence. By far the most common was the class B (car) licence, held by 67% of interviewees, as seen in Figure 28. Almost 6% of the sample declare that they have a motorcycle licence: 2.4% hold an A1 licence (lightweight motorcycles), and 3.5% an A2 licence. As expected, other licences are in the minority in this sample.

Figure 28. Driving licences declared by the sample participants.



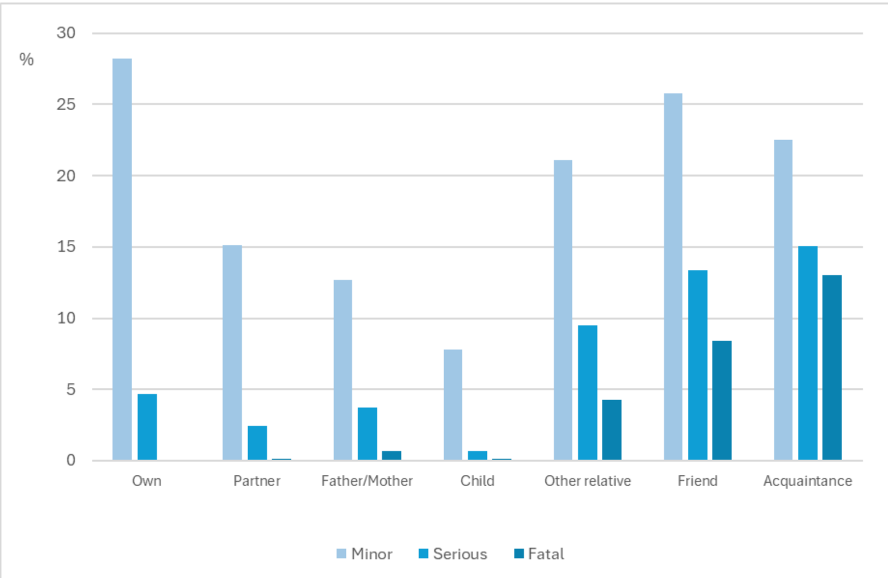
Those who stated that they a vehicle driving licence were asked about the number of points they had on their licence. The responses to this question are summarised in Table 13, according to which more than three quarters of the sample have all the points on their driving licence, and almost 90% have 12 or more, with barely 0.4% stating that they have lost all their driving licence points.

Table 13. Declared points on driving licence.

	Number	%
0 points	5	0.4
Between 1 and 7 points	21	1.5
Between 8 and 11 points	51	3.6
Between 12 and 14 points	170	12.0
15 points	1,097	77.6
DNK/DNR	75	5.3
Total	**1,414**	**100.0**

With regard to respondents' risk perception, the vast majority stated a subjective risk of death by traffic accident equal to (43.4%) or lower than (43.8%) average, with just 6.3% saying that they perceived their subjective risk of dying in an accident as being above average. Figure 29 shows the data on interviewees' prior experience of road accidents.

Figure 29. Prior direct experience of traffic accidents by seriousness and person affected. (% of total).



33% stated they had had a traffic accident, which in most cases was minor (28.2%, compared to 4.7% serious accidents). The more distant the relationship between interviewee and victim, the greater the indirect experience of more serious accidents becomes. Therefore, the percentage of respondents whose partner had had a serious traffic accident was 2.4%; this was 3.7% if the victim was a parent, 9.5% for other relatives, 13.4% for friends, and 15.1% for acquaintances. Similarly, 4.3% of survey participants had lost a relative in a traffic accident, 8.4% a friend and 13% an acquaintance (the percentages were 0.15% in the case of a partner or child, and 0.68% had lost a parent in an accident).

Table 14. Healthy and unhealthy habits.

	I have never smoked	Ex-smoker	Occasio-nal smoker	Daily smoker	
Tobacco consumption	46.2	21.1	7.7	24.9	
	No	**Occasio-nal**	**Week-ends**	**Several times a week**	**Daily**
Alcohol consumption	35.7	32.4	19.5	7.7	4.7
	None	**Occasio-nal**	**Modera-te**	**Several times a week**	**Daily**
Physical exercise	34.3	24.0	11.5	18.6	11.6

Table 14 shows the summary of the responses to questions about unhealthy (tobacco and alcohol consumption) and healthy (physical exercise) habits. One in four respondents stated that they were regular smokers, while a further 7.7% smoke occasionally. Almost half the sample (46.2%) have never smoked, and 21.1% consider themselves to be ex-smokers. As for alcohol consumption, just over a third of the sample declared that they had not drunk alcohol in the past month. Although fewer than 5% stated that they consumed alcohol daily, more than 30% had consumed alcoholic beverages regularly over the past month (weekends, several days a week or daily). The remaining third consume alcohol occasionally. As regards physical activity, 34.3% of respondents stated that they do not engage in any type of physical exercise, and 24% only occasionally. More than 40% of the sample engage in physical activity at least once a week, with 11.6% of the total engaging in physical exercise every day.

Table 15. Attitudes towards risk on the road and behaviour behind the wheel (% of total).

					Yes
Has driven under the effects of alcohol					18.3
Has driven under the effects of narcotics					4.1
Has been a passenger of someone driving under the effects of alcohol or other drugs					36.3
	Always	**Almost always**	**Someti mes**	**Only once**	**Never**
Beep the horn in frustration	0.6	1.1	14.3	23.6	60.4
Insult or shout	0.5	1.2	9.0	17.8	71.5
Flash headlights	0.4	1.7	14.9	22.9	60.1
Make hand gestures	1.0	2.0	13.3	20.9	62.9

The final part of the questionnaire also gathered information on risk attitudes in travel by road and behaviour behind the wheel. The data declared by the interviewees are summarised in Table 15. Emphasis must be placed on the disturbing statistic from the first part of the table that more than a third of the survey participants (36.3%) state that they have travelled in a vehicle whose driver was under the effects of alcohol or other substances. 18.3% of interviewees admit having got behind the wheel after consuming alcoholic beverages, and 4.1% under the effects of narcotics. As for attitudes which could be categorised as uncivil or lacking in solidarity towards other drivers, although this type of behaviour does not prove typical among the respondents (with the sum total of those always, almost always or occasionally engaging in such actions in no case amounting to 20%), as many as 40% have used their horn as a sign of frustration or inappropriately flashed their headlights on occasion. A slightly lower percentage (37%) have made hand gestures at other drivers, and 28.5% admit having sometimes insulted or shouted at the occupants of other vehicles.

Table 16 sets out the responses to different types of questions intended to characterise the study participants. In terms of the biometric characteristics of the respondents, the average declared weight was 73.6 kg, average height 168.6 cm, and body mass index (BMI) is thus estimated at 25.9. A quarter of the sample revealed a degree of numerical illiteracy, in that they were unable to correctly answer the control questions asked on understanding frequencies and probabilities. Lastly, 82.7% of participants stated that they expected to be alive at the age of 75; this percentage falls to 63.9% when the survival threshold is put at 85 years, and goes down to 35.1% for a life expectancy of 95 years.

Table 16. Biometric characteristics, numerical skills, survival expectations.

Weight (kg)	73.6		
Height (cm)	168.6		
Body mass index (BMI)	25.9		
	%		
Numerical skills (numerical illiteracy)	25.0		
	At age 75	**At age 85**	**At age 95**
Survival expectation (%)	82.7	63.9	35.1

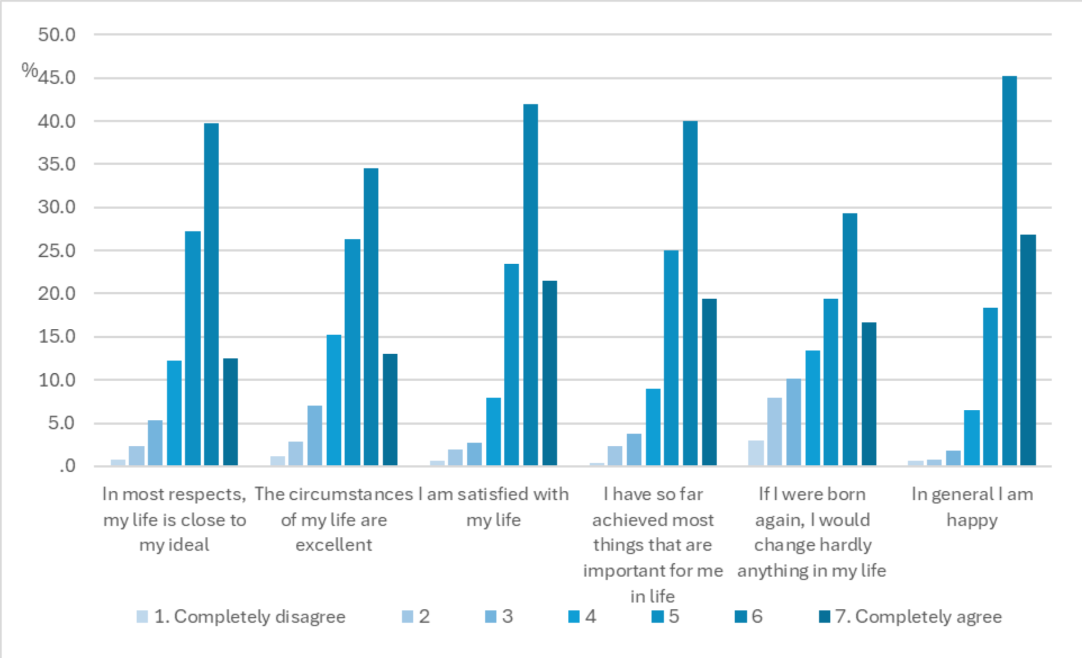
The questionnaire gathered information on the state of health perceived by the interviewees themselves, using the multi-attribute SF-6D descriptive system, comprising 6 dimensions (physical function; role limitations; social function; pain; mental health and vitality); each of which may amount to between 4 and 6 different levels of seriousness. Table 17 shows the distribution of the states most frequently declared by the participants. The numerical code indicates the level of seriousness, from the most minor (1) to the most serious (4, 5 or 6), according to the dimension, with each digit corresponding to one of the six dimensions. State 111111 is thus identified with a situation of perfect health, in that all six attributes are at their lowest level of seriousness ("no problem or symptom"). State 211222 , for example, reveals a slight impact on the physical function, pain, mental health and vitality dimensions.

Table 17. Declared state of health according to the SF-6D descriptive system.

State SF-6D	%
111111	19.4
111122	9.6
111112	9.2
111121	4.9
111222	2.1
111123	2.0
211122	1.7
211222	1.6
111212	1.6
111132	1.3
222222	1.3
Other	45.4

As seen in the table, almost one in every 5 respondents declared that their state of health would be described as 111111. Only 11 of the SF-6D states were needed to describe the state of health for over half of the participants (only 30 states are required to describe the health condition of two thirds of the sample).

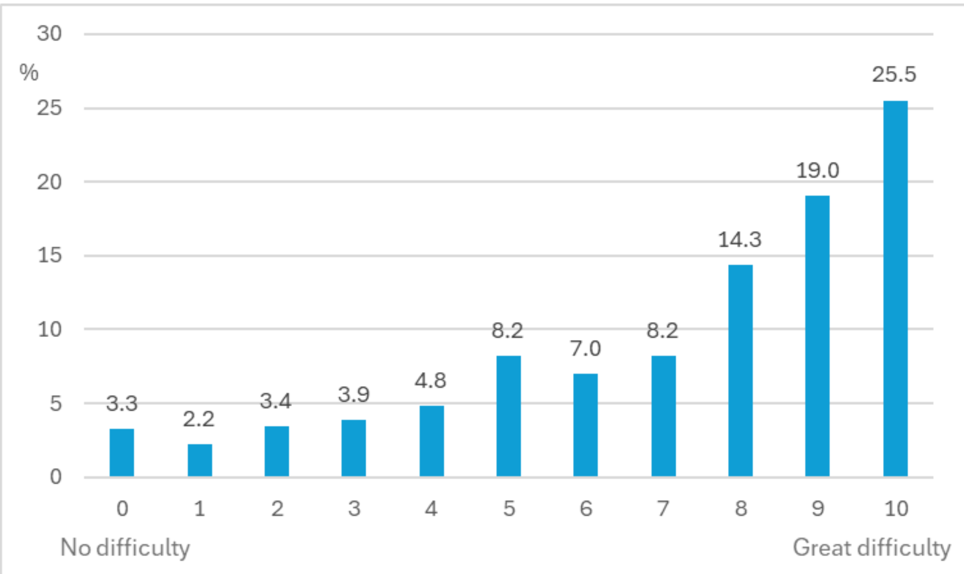
Figure 30. Degree of life satisfaction. Distribution of the responses (%).



Information was likewise obtained as to the interviewees' degree of satisfaction with their own life, through a set of 5 questions, the responses to which are summarised in Figure 30. In light of these responses, the conclusion drawn is that the participants in the study are in general satisfied with their life and consider themselves to be happy. The sum totals of the responses with values of 5 or higher on the scale ("Tend to agree", "Agree", "Completely agree") amount to at least 65%, and are over 85% for some of the statements. In all cases the mean score on the scale from 1 to 7 is above 5 (except for the statement "If I were born again, there is practically nothing I would change in my life", for which the mean score stands at 4.9). The phrase "In general I am happy" receives the highest mean score of all (5.8), with 72% of the respondents stating that they "agree" or "completely agree".

To conclude this section focused on characterising the profile of the study participants, Figure 31 presents the distribution of the responses to the question on the degree of difficulty they experienced when answering the survey, on a scale from 0 to 10. A quarter of the interviewees gave the survey the highest degree of difficulty, with as many as 74% of participants responding with a value of 6 or higher. The mean degree of difficulty stood at 7.3 (the median value was 8.0).

Figure 31. Degree of difficulty of the questionnaire.



4.2. Ordering the states and scores on the visual analogue scale

In the first appraisal task, participants had to order and score the two health states (descriptions of the consequences of a non-fatal traffic accident) used in the study, together with their state of health at the time of the interview, and death, on a visual analogue scale (VAS). Table 18 presents the respective scores for these four states on the VAS. Both the mean and median values correspond to expectations in ordinal terms: Own state > State X > State Y > Death. Individually, this ordering was recorded for 1,900 participants (92.7% of the sample).

Table 18. Scores for the health states on the Visual Analogue Scale (VAS).

	State X	State Y	Own state	Death
Mean	62.6	31.6	86.1	6.1
Standard Deviation	21.0	20.8	14.4	11.5
Median	64.0	30.0	90.0	1.0

As the situation described as state X does not involve any particularly significant detriment to health (two weeks in hospital with moderate pain and complete recovery after 18 months, with gradual disappearance of pain and difficulties in daily activities), it is perfectly plausible that some respondents would rate this state of health as being subjectively better than their own (or at the same level), which occurs in the case of 109 participants (5.3% of the sample). It is less likely, although also possible, that this would occur with regard to state Y, with just 6 participants responding in this way. As for where the option "immediate death" would be positioned on the scale, the expectation is that this would always be in last place, either at the far end of the scale (a score of 0), or else above a value of 0, if the respondent imagines possible situations that would be worse than death. A total of 2018 participants (98.4%) position death strictly below the other three states (there are another 25, giving a total of 99.7%, who gave the lowest score to death and to one of the other three states). None of the respondents position state X or their own state of health in last place, and just 7 (0.3%) assign this position to state Y.

As for the order of states X and Y, only 9 participants responded inconsistently by placing state Y above X on the visual scale, giving the former a higher score. We would categorise these responses as inconsistent, because as indicated above, state Y is logically worse than X (more weeks spent in hospital and similar or worse symptoms which last longer, some of them being chronic).

4.3. Contingent valuation: willingness to pay and accept

The results of part 3 of the questionnaire are presented below, registering the values obtained by CV, i.e. the WTP to avoid state X and the WTA in exchange for experiencing this state. As shown in chapter 3, the individual MRS values m_X are estimated using these two values.

Table 19 shows the basic descriptive statistics of the WTP values to avoid X in each of the questionnaire models or groups (remember that groups 7 and 8 did not include the contingent valuation part). The size of each subgroup does not match the totals for the questionnaire models shown in Table 11, since 37 respondents (a maximum of 8 in subgroups 3 and 6, and a minimum of 3 in group 2) responded "I donot know whether I would pay or not" for all of the amounts on the payment card, which made it impossible to determine the value of their maximum WTP. The mean WTP to avoid state X for the entire sample is 6,944 euros. The WTP values for each model or subgroup range from 5,834 for model 2, to 8,879 for model 3. The median amounts to 1,000 euros for the entire sample, with this same value in all the groups except for model 2, where the median drops to 650 euros.

Table 19. Descriptive statistics for the Willingness-to-pay (WTP) values declared to avoid state of health X.

Model	Mean	Median	Standard deviation	Observations	WTP=0	
					No.	%
1	6,040	1,000	14,385	289	24	8.3
2	5,834	1,000	14,657	297	27	9.1
3	8,879	650	59,977	290	27	9.3
4	6,398	1,000	15,414	288	25	8.7
5	6,244	1,000	12,278	293	23	7.8
6	8,300	1,000	18,799	289	18	6.2
Total	**6,944**	**1,000**	**28,114**	**1,746**	**144**	**8.2**

Table 20. Descriptive statistics for the Willingness-to-accept (WTA) values in exchange for experiencing state of health X.

Model	Mean	Median	Standard deviation	Observations
1	129,399	25,000	218,745	286
2	126,694	30,000	193,742	291
3	140,050	25,000	222,241	290
4	130,067	15,000	212,792	281
5	133,858	30,000	207,363	290
6	125,413	25,000	206,664	287
Total	**130,929**	**25,000**	**210,180**	**1,725**

The same information regarding the WTA values in exchange for experiencing state X is presented in Table 20. In this case 58 values are lost as a result of the interviewees' responses to all the amounts on the payment card being "unsure whether it would be sufficient or not". The mean WTA for the sample as a whole stands at 130,929 euros; by subgroup, the minimum mean WTA corresponds to model 6 (125,413 euros) and the maximum to model 3 (140,050 euros). The median for the sample as a whole stands at 25,000 euros, with a minimum of 15,000 in subgroup 4 and a maximum of 30,000 in the groups given questionnaire models 3 and 5.

The major differences observed between the WTA and WTP valuations shown in the preceding tables are consistent with the finding typically reported in CV studies of a gap between the WTA and WTP (Oliva et al., 2023). There are various explanations given for this discrepancy, such as income effects[56] (Hanemann, 1991), loss aversion[57] (Kahneman et al., 1991) and commitment costs[58] (Zhao & Kling, 2001).

[56] These effects result from the fact that interviewees are subject to a budgetary restriction when stating the maximum amount of money they would be willing to pay, while there is no such restriction when asked as to the minimum WTA.

[57] In other words, the psychological phenomenon which involves giving greater importance to a loss than to a gain, even if it is of the same magnitude. This bias is described by what is known as prospect theory, initially proposed by Kahneman & Tversky (1979). One implication of this phenomenon is known as the endowment effect, according to which we attribute greater value to losing something we already have than gaining something that does not form part of our endowment (Thaler, 1980): the WTA may be greater than the WTP for this reason.

[58] The fact that respondents are required to estimate how much they would be willing to pay for a good with which they are not familiar, within a limited time, means that the costs of "committing" to paying a certain amount are greater, which may give rise to the discrepancy between WTA and WTP.

4.4. Individual relative value: probabilities of indifference in the two gambles

In this section the results obtained in part 4a of the questionnaire, i.e. participants' responses to the questions under the modified standard gamble (SG) method and the individual values derived from them, are presented and discussed.

First of all, Table 21 shows the indifference probabilities for the first two elicitation processes under the SG method ($\overline{p_x}$, $\overline{p_y}$). In these first two questions from part 4a, the health states (X and Y, respectively) constituted the best outcome from treatment A, with the best outcome from treatment B being normal health, and the worst outcome from both treatments being death.

For the sample as a whole, in the case of state X, the mean risk of death that is the maximum respondents are willing to accept to avoid experiencing state X is 0.063.[59] This mean value ranges from 0.054 (groups 1, 2 and 3) to 0.008 (groups 5 and 6). The median for all interviewees is 0.005, with the value ranging from 0.004 in groups 1, 3 and 7, to 0.010 in groups 4 and 6.

Table 21. Indifference probabilities in the modified SGs. State X and state Y. Maximum risk of death assumed in the gamble (p_i, Death; Normal health)

Model	State X ($\overline{p_x}$)			State Y ($\overline{p_y}$)			Observations
	Mean	Median	Standard deviation	Mean	Median	Standard deviation	
1	0.054	0.004	0.164	0.218	0.030	0.319	295
2	0.054	0.005	0.160	0.204	0.028	0.305	300
3	0.055	0.004	0.158	0.219	0.030	0.313	298
4	0.054	0.010	0.144	0.180	0.025	0.282	295
5	0.080	0.005	0.210	0.183	0.025	0.301	298
6	0.080	0.010	0.190	0.222	0.025	0.318	297
7	0.055	0.004	0.160	0.192	0.025	0.298	132
8	0.073	0.008	0.181	0.189	0.025	0.279	135
Total	**0.063**	**0.005**	**0.172**	**0.203**	**0.025**	**0.304**	**2.050**

In the case of state Y, the indifference probability for the whole sample, i.e. the maximum risk of death they are willing to accept to avoid experiencing state Y, rises to 0.203.[60] The minimum for the subgroups is 0.180 (model 4), and the maximum 0.222 (model 6). The median for the aggregate sample is 0.025. This value coincides with the median values of groups 4 to 8, while the maximum of the subgroup medians is 0.030 (models 1 and 3).

The outcomes in the table show how the probabilities are related to the differing seriousness of the two health states. The mean risk of death accepted with state Y is thus three times higher than the mean corresponding to state X. Similarly, the median probability of indifference for Y is five times higher than the median value for state X.

4.5. Value of a statistical life

As explained in section 3, the VSL is calculated by "chaining" the MRS between income and state X (m_x) and relative loss of utility of X (m_d/m_x), obtained by the SG method. The m_X values are estimated on the basis of the individual WTP and WTA values, the statistics for which were presented in Table 19 and Table 20 respectively. The relative utility losses are calculated from the probabilities

[59] It should be recalled that the choice is presented in the following terms:

$$A: (0.001, Death; State\ X)\ vs. B: (p_x, Death; Normal\ health)$$

[60] In this case, the choice is presented in similar terms:

$$A: (0.001, Death; State\ Y)\ vs. B: (p_y, Death; Normal\ health)$$

obtained in the SG with state X, which was shown in aggregate terms in the first columns of Table 21. The values resulting from this training operation are presented in Table 22.

Table 22. Values of a Statistical Life in euros, estimated by means of the CV/SG method (without excluding outliers)

	Mean	Median	Standard deviation	n
Logarithmic	4,523,799	371,460	28,916,378	1,583
Homogeneous	3,191,783	171,007	26,292,797	1,714
Nth root	5,684,492	483,837	31,487,654	1,583
Exponential	3,046,342	180,157	26,705,189	1,583

Depending on the functional form assumed to calculate the MRS, a different estimation for the VSL is obtained, as seen in the table. The minimum value of the means corresponds to the homogeneous function (3.2 million euros), while the maximum corresponds to the nth root function (5.68 million euros). The medians range from 171,007 euros to 483,837 euros, respectively, for these same two functional forms. As seen in the last column, the functional form requiring the fewest observations to be discarded is the homogeneous (1,714 individual values); the other three reduce the number of valid observations for estimating the VSL to 1,583.

However, the existence of some extreme individual values makes it advisable to discard some observations when calculating the aggregate value. Rather than applying an ad hoc threshold beyond which a value may be considered an outlier —as Carthy et al. (1999) did in the British study— and similar to the approach by the research team in the 2009 study, individuals were excluded from the calculation if their VSL was at least three standard deviations greater than the mean. This criterion in handling outliers minimises the number of observations discarded, with just 6 individuals being eliminated from the final sample. Although this represents just 0.35% of the total sample, it has a very significant impact on the estimate, as shown in Table 23.

Table 23. Values of a Statistical Life in euros, estimated by the CV/SG method (after excluding outliers).

	Mean	Median	Standard deviation	n
Logarithmic	3,363,711	364,955	9,992,100	1,577
Homogeneous	2,234,246	167,889	7,405,773	1,708
Nth root	4,353,860	481,723	13,044,256	1,577
Exponential	2,081,556	180,157	6,697,111	1,577

The elimination of these 6 outlying observations leads to a degree of compression in the range containing the estimates derived from the four functional forms assumed for the utility function. The VSL means are now between 2.2 million for the homogeneous function and 4.35 obtained with the nth root function.

As is to be expected, there are differences in the VSL figures estimated in each of the subgroups the sample was divided into, depending on the questionnaire model completed. By way of example, Table 24 shows the VSL figures estimated with the homogeneous function (which maximises the number of valid individual values) after applying the aforementioned criterion for handling outliers. As seen in the table, the VSL, estimated for the sample as a whole at 2.2 million euros, fluctuates between 1.8 million for the subgroup which was given model 3 of the questionnaire, and 2.5 million for the subgroup which completed model 5.

Table 24. Values of a Statistical Life in euros, estimated according to the CV/SG method and assuming the homogeneous function, after excluding outliers

Model	Mean	Median	Standard deviation	Observations
1	2,305,070	193,981	7,269,849	283
2	2,458,730	198,784	8,004,017	288
3	1,854,757	110,889	6,118,377	285
4	2,389,947	129,974	8,148,837	280
5	2,499,495	208,125	8,315,955	287
6	1,896,479	189,684	6,301,703	285
Total	**2,234,246**	**167,889**	**7,405,773**	**1,708**

According to the principles of the welfare economy, the mean values should be considered as representative of aggregate preferences. Returning to Table 23, the average of the four means amounting to 3 million euros (3,008,343 euros, to be precise) could be taken as the VSL. However, as Carthy et al. (1999) suggested, some weight should also be given to estimations based on the median. Following this suggestion, as in the 2009 study, we calculated the average from the lowest value of the medians, corresponding to the result of assuming the homogeneous function, and the maximum value of the means, corresponding to estimating the VSL with the nth root function, to give a result of 2.2 million euros.

Meanwhile, in determining the VSL by the chained method, it was implicitly assumed that income utility is independent from the individual's state of health. There is, however, evidence which questions this supposition. As in the 2009 study, here we decided to apply a reduction coefficient of 0.85 to the previous estimation, as a result of which the VSL would be set at 1.9 million euros (1,921,743 euros). This value will need to be increased by the costs associated with the production losses and the medical costs to determine the value of preventing a fatality (VPF), as shown below.

As indicated in section 3.7, the theoretical validity of the estimates is analysed by checking that the WTP values and the VSL estimates behave as predicted by standard economic theory: among other predictions, whether the estimated values correlate in a positive and significant manner to the capacity to pay, measured by means of earnings (declared income).

This involves performing the corresponding regression analyses by ordinary least squares (OLS), serving to ascertain not only the relationship of the WTP and VSL to the respondents' income level, but also to a series of selected variables. Introducing monetary variables to the model in the form of logarithms also allows us to immediately obtain the income-elasticity of the VSL. Beyond the main variable of interest, namely household income (in logarithms), the regressors included in the model are as follows:

- Sociodemographic characteristics of the interviewees: sex; age; region of residence in Spain; marital status; educational level; employment status; dependent children; dependent adults; household size.
- Healthy and unhealthy habits: smoking; consumption of alcoholic beverages; physical exercise
- Variables related to road use and accidents: subjective risk of having a fatal accident; vehicles used; kilometres travelled; driving licence; points on licence; experience of traffic accidents (own and social circle); risk attitudes behind the wheel (driving under the effects of alcohol and other substances, or travelling with a driver in such a state); aggressive attitudes behind the wheel.
- Other: Declared level of happiness or life satisfaction; expectations of survival at 75, 85 and 95 years old; numerical skills; perceived difficulty of the questionnaire and its duration.

Most of the explanatory variables are included in the model as dichotomous variables (e.g. sex; region of residence; whether the interviewee has dependent children or adults; smoking; risk attitudes behind the wheel, etc.). Others take the form of categorical variables (subjective risk of dying in an accident: above, equal to or below the mean; kilometres travelled; level of education; employment status, etc.). The age variable is incorporated as a continuous variable, as is age squared, in order to test a possible relationship between WTP (or VSL) and the quadratic age.

The first two columns of Table 25 show the regression coefficients which explain individuals' WTP based on the aforementioned variables. The efficient model identifies a few regressors with statistically significant coefficients. For the purposes of this regression analysis, it is worth emphasising that the results of estimating the model show the existence of a positive, statistically significant relationship between income declared by the participants and their WTP to avoid state of health X, which supports the theoretical validity of the contingent valuation study developed in part 3 of the questionnaire. Aside from this, the number of kilometres covered per year in road vehicles; holding all driving licence points; having intermediate or higher level education; declaring a greater level of happiness and having experienced an accident in the family (a serious accident, for parents, or minor, for a child) are associated with a greater WTP to avoid state X. Meanwhile, if respondents declare a subjective risk of death by traffic accident equal to the average; belong to the "Other" group in the employment status section; do not drink alcoholic beverages and engage in daily physical exercise, this is associated with a lower WTP.

Table 25. Results of the OLS regression analysis. Efficient models.

	Dependent variable			
	WTP		**VSL**	
	Coeffic.	Est. error	Coeffic.	Est. error
Ln Income	0.707***	0.0602	0.614***	0.148
Age			0.0141***	0.00406
Subjective risk = mean	-0.253**	0.105	-0.347***	0.128
Kilometres travelled	1.50e-05***	3.53e-06	1.09e-05**	4.56e-06
All driving licence points	0.326***	0.107		
Primary education	0.990***	0.379	-0.646**	0.326
Intermediate education	1.255***	0.383	1.471***	0.455
Advanced qualifications	1.251***	0.402	1.554***	0.471
Does not drink alcohol	-0.225*	0.115		
Exercises daily	-0.350**	0.159	-0.444**	0.215
Consider themselves happy	0.0230***	0.00880	0.0411***	0.0112
Numerical skills			0.340**	0.168
Slight accident to self			0.248*	0.145
Serious accident, parents	0.568**	0.238		
Serious accident, children	0.409**	0.201		
Serious accident, other relative			0.446**	0.201
Drives car			0.412**	0.184
Drives moped			0.700*	0.367
Drives van			-0.854***	0.310
Survey duration			0.101***	0.0295
Observations	1.602		1.583	

*** p<0.01, ** p<0.05, * p<0.1. Both models include dummy variables for the Spanish region where they live (17) and employment status (11 categories).

The two columns on the right in Table 25 present the results of the OLS regression analysis, in this case taking the individual VSL estimates as the dependent variable for the model. The results are qualitatively similar to those obtained in the previous model, although statistically significant coefficients are obtained for certain regressors which did not reveal this explanatory power in the WTP model. They include age, which shows a positive coefficient, while we also see positive, significant coefficients accompanying numerical skills, experience of the interviewee having had a minor accident or a relative having had a serious accident, car or mopeds used as their main vehicle, and interview duration. Statistically significant negative coefficients are observed for variables such as regularly driving a van, in addition to some of those previously mentioned in the regression with the WTP as the dependent variable (subjective risk equal to the mean, and regular physical exercise).

The VSL regression model also confirms the statistical significance of the (positive) coefficient accompanying the declared income variable. Since both the VSL and declared earnings (income) were entered in the model in logarithmic form, this coefficient may be interpreted as the VSL income elasticity. This elasticity is estimated at 0.6, a value similar to that obtained in the 2009 study (between 0.6 and 0.7 depending on the utility function used to estimate the MRS). The value 0.6 is also similar to those provided in a meta-analysis of studies focused on estimating the VSL through a declared preference approach. Specifically, for high-income countries the range observed in the literature is from 0.55 to 0.85 (Viscusi & Masterman, 2017). In any event, the income elasticity value in this study is lower than one, as in most studies conducted to date (Miller, 2000; Viscusi & Aldi, 2003).

4.6. Value of preventing a fatality

To calculate the value of avoiding a fatal victim, or the value of preventing a fatality (VPF) as a consequence of a traffic accident, the production losses and healthcare costs (medical and ambulance) must be added to the estimated VSL figures.

Table 26 shows the estimated values for the gross and net production losses. The table shows the results of the estimate for the three scenarios described in section 3.6. In the first scenario, both productivity growth and the discount rate are given the value 0; in the central scenario, productivity growth is assumed to be 1%, and a discount rate of 3% is applied; in the third scenario, productivity growth is assumed to be 3% per year, with a discount rate of 1%.

Table 26. Gross and net production losses associated with a fatality. Present value in 2022 euros.

Growth scenario	Total gross losses	Gross loss per fatality[(1)]	Net loss per fatality[(2)]
1. Null	513,466,063	294,081	58,816
2. Central	376,658,296	215,726	**43,145**
3. Maximum	705,644,560	404,149	80,830

[(1)] Total gross losses/number of accident fatalities (1,746 in 2022).
[(2)] Gross loss × 0.2 (consumption propensity=80%).

Assuming the central scenario, the net production loss as a consequence of a traffic accident fatality is estimated at 43,135 euros.

Furthermore, according to information published by UNESPA (2020),the mean medical and ambulance costs are estimated at around 650 euros, with this figure covering medical care and transport per traffic accident. According to this same study, the ninetieth percentile of the distribution of these costs stands at 962 euros. This value is similar to the figure imputed in the 2009 study, which was 1,000 euros, and we will therefore also assume this figure here.

The result of adding these costs to the VSL gives us a VPF of approximately 2 million euros (1,965,850 euros).

5. Conclusions

This report updates the estimates of the Value of a Statistical Life (VSL) and the Value of Preventing a Fatality (VPF) in Spain in the context of traffic accidents, these estimates having been made by the same research team more than 10 years ago at the request of the DGT, as is also the case for the study here described. This update was made possible by conducting a new survey with a broad sample representing the general Spanish population, comprising 2,050 participants.

The new VSL which is to replace the figure estimated in 2011, which has been updated yearly since then in line with the increase in Spain's per capita GDP at current prices, amounts to 1.9 million euros, a figure which lies within the range of the most recently reported costs per fatality for a total of 29 European countries (Wijnen et al., 2019a), ranging from 0.7 to 3 million euros (adjusted for Purchasing Power Parity and with reference to 2015). The estimated value is 46% higher than that obtained in 2011, which (although it shows positive correlation with the path followed by income per capita in Spain over the intervening years, where there has been a relative increase of 24.5%) remains a reflection of population preferences, apparently more sensitive to the human losses caused by traffic accidents.

As previously discussed at length in this report, the concept of cost per fatality is broader than the VSL, and, in light of the analysis made by Wijnen et al. (2019a), corresponds more approximately in the case of Spain to the concept of VPF. This metric is the result of adding the value of the net production losses caused by the motorway fatality, and the healthcare costs associated with accidents (medical and ambulance costs) to the VSL. If we consider the update to the VPF resulting from the study presented in this report, this would give us a valuation of almost 2 million euros. If we adjust this new value for Purchasing Power Parity[61], and repeat the analysis conducted in section 2.3 of this report, which compared the costs per fatality in 19 Eurozone countries (updated to 2022), Spain climbs two positions in the ranking, to be placed eleventh out of the 19 states considered, practically on a par with Belgium and Finland. This analysis confirms that the new VSL and VPF estimations conducted for the DGT are perfectly in line with the range of values across Europe.

As in 2011, the methodology used to estimate the VSL is once again that initially proposed by Carthy et al. (1999) based on chaining the responses to questions on willingness to pay for and willingness to accept certain states or conditions of health, corresponding to the contingent valuation (CV) approach, conducted using a technique referred to as the modified standard gamble (SG) by Carthy et al., with their methodological approach thus being referred to as the 'Contingent Valuation/Standard Gamble (CV/SG) chained approach'. As explored in detail by Sánchez-Martínez et al. (2021), and as confirmed in this study, this methodology avoids, or at least reduces, problems which are typical to CV studies, such as insensitivity to changes in the magnitude of the goods valued. For questions formulated with the SG, the individual relative values for each of the two health states used are sensitive to the seriousness of the same. The mean risk of death accepted with state Y (the more serious of the two) is more than three times the mean corresponding to state X (more minor). Similarly, the median probability of indifference for state Y is five times higher than the median value for state X.

The design structured within the study (the results of which are set out in this report) nonetheless incorporated methodological innovations concerning the complementary analyses at the heart of the study, involving the application of the chained approach by Carthy et al. (1999). Specifically, as described in Appendix 2 of the report, the different subgroups the overall sample was divided into considered questions presented using the "person trade-off" method, intended to obtain "relative social values", rather than just individual values, as inferred from the responses to the questions asked with the modified standard gamble. Taking account of the mean values from the responses to the person trade-off questions, the number of minor injury victims deemed equivalent to a fatality is 6.4 times higher than the number of serious injury victims corresponding to this same equivalence. In the case of the medians, the ratio is 1.8 to 1.

[61] The aforementioned adjustment gives a VPF of 2,049,659 euros PPP.

Having calculated the VSL, in order to obtain the VPF, it was necessary first of all to estimate the value of the net production losses caused by the road fatality, as well as the medical and ambulance costs. In the former case, taking the human capital theory as the reference point, the procedure involved approximating the flow of income (or value-added generated) interrupted at the time of a person's death, based on information on salaries by sex and age derived from the Salary Structure Survey produced yearly by the Spanish National Statistics Institute (INE). This is the approach followed in Abellán et al. (2022), the data from which was used in this study, representing a methodological improvement compared to the less precise approach adopted in 2011. Assuming the central scenario of the three considered in the report, net production loss as the consequence of a traffic accident fatality is estimated at 43,135 euros. Similarly, the medical and ambulance costs derived from the information published by UNESPA (2020) are estimated at 962 euros. Consequently, the VPF amounts to almost 2 million euros.

As with any empirical study, however sophisticated the methodology used, there are always limitations which should be discussed. This also applies to this study, without in any way undermining the validity of the results obtained. As previously experienced by Carthy et al. (1999), and also highlighted in the previous study by Abellán et al. (2011a), this study once again found that the more instances of chaining are performed to estimate the relative utility loss of a non-fatal state of health compared to death, the higher the figure will be for the VSL. Therefore, there is a notable discrepancy between the VSL estimated by means of the direct chaining method for state X and death, and the much higher figure estimated through indirect chaining by means of state Y, as shown in Appendix I of this report.

With regard to the limitations surrounding attempts to estimate the VSL, and as seen when discussing the different methodologies available, discrete choice methods are also affected by such factors. Abellán et al. (2011) indicated that the two most recent meta-analyses at that time (Lindhjem et al., 2010; Dekker et al., 2011) only identified two discrete choice studies in the context of traffic accidents. Subsequently, Bahamonde-Birke et al. (2015) identified 13 studies of this kind, undertaken between 2005 and 2013. For their part, in a systematic review of the studies published between 2009 and 2019, Keller et al. (2021) only managed to identify four in the road safety sector. As previously mentioned, the most recently published work to use this methodology to estimate the VSL in the context of road accidents is the study by Schoeters et al. (2022), estimating the VSL for 4 European countries (Germany, Belgium, France and the Netherlands). The values estimated in that study are much greater than those in force in the countries in question up to that time. Specifically in the case of the Netherlands, the figure is more than twice as high, catapulting the country into the leading positions in terms of social costs of traffic accidents in Europe. It would in fact seem that the institution responsible for road safety in the Netherlands (SWOV) accepted this estimate as official, since it published the figure for the social costs of road accidents in the country at 27 billion euros, a figure equivalent to 3% of Dutch GDP. Three quarters of all costs come from the corresponding weight of human costs, based on the new estimate.

Both the results obtained by Wijnen et al. (2019a) for the Netherlands and those described by González et al. (2018) for Spain (the latter study also using a discrete choice experiment to estimate the VSL), share comparatively high valuations. The authors of both studies are aware of this, as recognised in their articles, although in the former case Wijnen et al. (2019a) tend to explain this phenomenon mainly on the basis of a significant change in social preferences in favour of greater social safety. They also argue that although their estimate is high (6.3 million euros), it lies within the upper bound of the range of values identified by Bahamonde-Birke et al. (2015). Updated to 2020 prices, these values show a range from 548,000 to 7.3 million euros. Nonetheless, SWOV (2022) adds that the methodological differences of the new version compared to the 2001 study, which provided the basis for the cost figures used by the Dutch institution, may have affected the results, ultimately indicating that future research would be needed to clarify other possible explanations.

Meanwhile, González et al. (2018), although they do not see their VSL estimate for Spain of 10.63 million euros as implausible, underline different biases which may have distorted their results. Firstly they indicate that some interviewees seem to have underestimated the costs they would incur by using the route represented in the scenarios of the choice sets employed. Secondly, as mentioned previously, numerous participants always chose the option which described a lower road fatality rate. This phenomenon of lexicographical preferences affected 23% of their sample, and 1/3 of the sample in Wijnen et al. (2019a). Far from being negligible, these percentages are quite clearly significant, and represent a sizeable limitation on this type of study. Lastly, the authors also note that declared preference methods may tend to overestimate the influence of prices on choices, since no real payment has to be made.[62]

Placing our estimate in the context of the studies discussed, we believe that the higher value obtained for the new estimate unquestionably reflects greater social awareness as to motorway risks. In this respect, we agree with Wijnen et al. (2019). However, our opinion is that these authors do not address an element which distinguishes their study from the work performed in the Netherlands 20 years previously. Although they were both discrete choice studies, despite the differences indicated by SWOV (2022), it is equally true that the study carried out in the context of the VALOR project (Schoeters et al., 2021) was structured by means of an online panel. There is evidence in this sense within the sphere of preference measurement in the context of health (which is closely related to the context of road safety, since the scenarios are described in terms of fatality and illness) that data gathered in person with the help of an interviewer are of greater quality than those self-completed by respondents online (Norman et al., 2010). This fact, in combination with the extreme values reported by Wijnen et al. (2019a), leads us to believe that it is advisable to be cautious, before fully accepting that such figures are merely the reflection of genuine societal preferences. Greater nuance is observed in the arguments made by González et al. (2018), discussing the possible biases their study may have been exposed to. In their case, the majority of the surveys were face-to-face, structured by means of CAPI interviews, as in our study. Nonetheless, only 390 interviews were conducted in this way, and their study could therefore to some extent have been compromised by the sample size, which it is worth remembering would have been even smaller if the final usable sample had been filtered, by discarding the 23% of participants who revealed evidence of strategic behaviour guided by lexicographical preferences.

The study described in detail in this report represents an update to the initial research conducted for the DGT more than 10 years ago, serving to maintain satisfactory fulfilment of the forecasts regarding road infrastructure evaluation established in Royal Decree 345/2011, of 11 March, on road safety management of infrastructure in the State Road Network. It is worth bearing in mind that the human costs caused by traffic accidents represent between 34% and 91% of total costs in European countries (the majority) that apply the willingness-to-pay approach (Bougna et al., 2022). The compelling nature of these figures demands that the authorities responsible for road safety ensure that this fundamental element is not overlooked in estimations of the social costs of traffic accidents, while furthermore periodically updating the corresponding value. In light of the considerable variation seen in the preferences stated by citizens with regard to the Value of a Statistical Life since 2011, the authors of this report recommend that the current estimate be updated within the next decade.

Following from the discussion set out in this report regarding the pros and cons of discrete choice methods, when embarking on a further update to these estimates it would be of interest to obtain new valuations within the context of a single study by means of the 'Contingent Valuation/Standard Gamble (CV/SG) chained approach' used here, and also through an ad hoc discrete choice experiment. Similarly, following the analysis conducted by the SafetyCube project on differences in the cost components for several European countries, the authors believe that to coincide with the new update to the VSL and VPF figures, it would also be of interest to estimate the accident-related costs (damage to property, administrative and other costs), in order to obtain as accurate an estimate as possible of the unitary social cost of a fatality.

[62] Similarly, González et al. (2018) indicate that if the mean distance estimated for a route along the TF5 motorway was not entirely precise, this could have pushed the VSL figure upwards.

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Appendix I: The VSL estimated by means of the indirect CV/SG method

Methodology

As explained previously, the questionnaire included the tasks required to address the estimate of the VSL by following the double training procedure proposed by the research team in the 2009 study (Sánchez-Martínez et al., 2021).

This indirect method shares with the CV/SG method the part comprising an estimate of the MRS through contingent valuation, by obtaining the WTP and WTA figures associated with experiencing a minor impact on health (state X in our study). However, rather than directly combining these MRS values with the relative utility losses associated with this same minor impact on health, measured with one single SG, these utility losses are estimated by chaining the results of two "double gamble" questions: one valuing the loss of utility associated with a more serious state of health than X (state Y in our study), and another measuring the relative loss of utility for Y compared to X.

Therefore, in order to apply the indirect method, once the MRS values had been determined using the CV method, we first obtained the relative utility loss associated with state Y, in the same way as shown for state X:

$$\frac{m_d}{m_y} = \frac{1-0.001}{\overline{p_y}-0.001} \qquad [1]$$

Where $\overline{p_y}$ is the indifference probability obtained from the process of choosing between treatment A and treatment B, when the former offers a probability of 0.999 of leading to state Y and a probability of 0.001 of dying; and the second a p_y risk of dying and a $(1-p_y)$ probability of recovering health.

Secondly, the SG elicitation process in which state X is the best outcome of treatment A (and normal health the best for B), now replacing death as the worst outcome in both treatments with state Y, gives us the relative utility loss of Y compared to X, according to the following expression:

$$\frac{m_y}{m_x} = \frac{1-0.01}{\overline{p_{x/y}}-0.01} \qquad [2]$$

Where $\overline{p_{x/y}}$ is the indifference probability resulting from the sequence of choices applied in this SG question, where, as shown in the methods section, the probability base is 100, rather than 1000.

The VSL estimated by means of this indirect or double chaining method is calculated as follows:

$$m_d^{ind} = \frac{1-0.001}{\overline{p_y}-0.001} \cdot \frac{1-0.01}{\overline{p_{x/y}}-0.01} \cdot m_x \qquad [3]$$

Results

The main text of the report presented the WTP and WTA values for avoiding or experiencing state X, respectively, used as the basis to estimate the value of m_x (see Table 19 and Table 20). In addition, Table 21 showed the indifference probabilities (p_y), obtained with the procedure in which the individual relative value or "utility" of state Y was evaluated. Part 4a of the questionnaire included a third elicitation process based on the modified SG technique, in which the best outcome from treatment A was state X, the best outcome from treatment B was normal health, and the worst outcome from both was state Y, which allowed us to obtain the relative value of X compared to Y. The indifference probabilities resulting from this question ($\overline{p_{x/y}}$) are shown in Table 27.

Table 27. Indifference probabilities in the modified SG, X vs. Y. Maximum risk of death assumed in the gamble ($p_{x/y}$, State Y; Normal health)

Model	State X vs. state Y ($\overline{p_{x/y}}$)			Observations
	Mean	Median	Standard deviation	
1	0.183	0.030	0.293	295
2	0.169	0.040	0.265	300
3	0.160	0.020	0.262	298
4	0.169	0.020	0.288	295
5	0.173	0.020	0.272	298
6	0.155	0.020	0.246	297
7	0.176	0.020	0.285	132
8	0.175	0.030	0.291	135
Total	0.169	0.030	0.273	**2.050**

The result of chaining m_x with the relative utility loss of X compared to Y (m_y/m_x), and with the relative utility loss of Y, with reference to death (m_d/m_y), both obtained by means of the indifference values, is therefore the VSL estimated by means of the indirect CV/SG method, or double chaining procedure, as shown in Table 28. The values set out in the table are those obtained once the outliers have been eliminated by two different procedures. On one hand, the same approach was applied to detect outliers as for the direct method, i.e. by setting the limit at three standard deviations. On the other hand, the VSL was estimated by omitting the individuals who reveal themselves as non-traders, i.e. those who were unable to distinguish the seriousness of state of health Y compared to X in the double gamble.

Table 28. Values of a Statistical Life estimated according to the indirect CV/SG method based on two outlier elimination structures.

	Three deviations		Eliminating non-traders	
	Mean	Median	Mean	Median
Logarithmic	10,470,932	3,415,593	46,428,057	1,856,905
Homogeneous	7,146,013	1,940,639	31,694,128	956,802
Nth root	13,411,081	4,384,614	60,926,467	2,437,595
Exponential	6,296,068	1,474,858	27,984,094	855,446

As can be observed, the former procedure gives rise to mean values closer to those of the direct chained method, while the latter approach means that the medians obtained by the different functional forms are more similar. In any event, both approaches give rise to values that are substantially higher than those achieved with the direct method.

Appendix 2: Relative social value (results of the PT)

Part 4b of the questionnaire was designed to allow detection of the existence of any type of divergences between the strictly individual preferences revealed by the interviewees in the modified standard gamble tasks ("individual relative value") and the social preferences, which we aimed to measure by means of questions based on the person trade-off (PT) method, focused on obtaining "relative social values".

Table 29 shows first of all the indifference values for the first two elicitation processes under the PT method ($\overline{N_x}$, $\overline{N_y}$). In the first two questions of part 4b, the road safety plan offered as an alternative to that which avoids one additional traffic accident fatality served to prevent a certain number of minor or serious injuries (X and Y respectively). The table does not show the subgroups which were presented with models 3 and 6 of the questionnaire, since they only included the PT comparing minor injuries (X) to serious injuries (Y).

Table 29. PT indifference values: number of minor injuries (state X) or serious injuries (state Y) avoided, considered to be equivalent to avoiding one fatality.

Model	State X ($\overline{N_x}$)			State Y ($\overline{N_y}$)			Observations	
	Mean	Median	Standard deviation	Mean	Median	Standard deviation	X	Y
1	78,495	750	825,747	---	---	---	295	---
2	---	---	---	39,099	505	580,141	0	300
4	419,227	890	5,875,891	---	---	---	295	---
5	---	---	---	40,225	510	582,024	---	298
7	15,343	978	114,771	2,057	325	9,864	132	132
8	82,619	900	864,218	8,665	450	86,385	135	135
Total	**186,706**	**880**	**3,498,613**	**29,085**	**500**	**484,092**	**857**	**865**

First of all, for all the participants who responded to the social relative value questions with state X, the minimum number of minor injury victims (state X) avoided that was considered to be equivalent to preventing one accident fatality amounted to 186,706, in mean values. Meanwhile, the median stood at 880. There is a degree of variability by subgroup, with the mean values thus fluctuating between 15,343 (model 7) and 419,227 (model 4), and the medians between 750 (model 1) and 978 (model 7). As the indifference value had no upper bound, the existence of outlier responses explains the fact that differences are much greater for the means than for the medians.

With regard to state Y, the mean value of the number of serious injury victims (state Y) avoided, considered to be equivalent to preventing one fatality, was 29,085, with the median standing at 500. Once again, dispersion among subgroups is greater for the means (between 2,057 in model 7 and 40,225 in model 5) than the medians (minimum of 325 in model 7 and maximum of 510 in model 5).

As occurred with the individual relative values (the risks of death assumed in the modified SG), these values with a social perspective are sensitive to the seriousness of the state of health. If we focus on the means, the number of minor injury victims considered equivalent to one fatality is 6.4 times greater than the number of serious injury victims corresponding to this same equivalence. In the case of the medians, the ratio is 1.8 to 1.

If we limit the comparison to the intra-group scale, i.e. models 7 and 8 in which the same participant responded to the two PT tasks described, the ratio between the means corresponding to X and to Y is even greater: 7.5 in subgroup 7, and 9.5 in subgroup 8; and the ratio of medians is 3 and 2 for these two subgroups respectively.

Methodological appendix

1. The direct CV/SG method

The contingent valuation/standard gamble (CV/SG) chained method proposed by Carthy et al. (1999) divides the VSL calculation procedure into three phases or stages:

1. Estimate of the marginal rate of substitution (MRS) between income and risk of a non-fatal injury, based on the WTP and WTA figures for avoiding or experiencing the consequences of that injury (respectively), described as a "state of health".
2. Estimate of the relative utility loss associated with the state of health representing the non-fatal injury, by means of a modified standard gamble (SG).
3. Calculation of the VSL based on the two preceding estimates, as the MRS between income and risk of dying in a traffic accident.

The individual MRS figures between income and risk of non-fatal injury (state X, in our study) are estimated within the range bounded by the maximum amount that the respondent is willing to pay to avoid experiencing a non-fatal injury or state of health (i) (WTP), and the minimum amount demanded as compensation in exchange for experiencing that health condition (WTA). The theoretical basis is as follows:

Let us assume that an individual faces two possible natural states: to survive in perfect health, with probability $(1-\bar{q})$, and to survive with a minor health problem, with probability $\bar{q}$. The expected utility would be given by the following expression:

$$\overline{UE} = (1-\bar{q}) \cdot U(\overline{w}) + \bar{q} \cdot I(\overline{w}) \qquad (1)$$

Where $U(w)$ represents a cardinal income utility function in full health; $I(w)$ is that function in the event that the individual experiences the minor health problem; and $\overline{w}$ represents the initial level of income.

Let us imagine that the individual is offered a reduction in the risk of experiencing the state of health, so this goes from $\bar{q}$ to q, in exchange for a certain amount of money v. The new situation would be represented by:

$$\overline{UE} = (1-q) \cdot U(\overline{w}-v) + q \cdot I(\overline{w}-v) \qquad (2)$$

Differentiating the equation (2) and setting $q=\bar{q}$ would give us the marginal rate of substitution between income and risk of experiencing the minor health condition, m_i:

$$m_i \equiv \left|\frac{\delta v}{\delta q}\right|_{q=\bar{q}} = \frac{U(\overline{w})-I(\overline{w})}{(1-\bar{q})\cdot U'(\overline{w})+\bar{q}\cdot I'(\overline{w})} \qquad (3)$$

As this is a minor health condition, we may assume that the marginal income utility in the event of experiencing this state of health is approximately equal to the circumstance of enjoying good health, although the good health income utility is higher than that enjoyed if experiencing the state of health, however minor it might be:

$$I'(w) = U'(w) \qquad (4)$$

$$I(w) = U(w) - \alpha; \qquad \alpha > 0 \qquad (5)$$

By combining the expressions [3], [4] and [5], the following is obtained:

$$m_i = \frac{\alpha}{U'(\overline{w})} \qquad (6)$$

Lastly, it is supposed that more income is always preferred over less income, and that the individual is averse to financial risk, i.e.:

$$U'(w) > 0, \qquad U''(w) < 0 \tag{7}$$

As demonstrated by Carthy et al. (1999), if we accept the suppositions underlying expression [7], the MRS of each interviewee will necessarily be bounded by the WTP and WTA values declared in part 3 of the questionnaire. The specific estimate of this MRS will depend on the functional form assumed for the utility function $U(w)$. In this study, as in the 2009 estimate of the VSL for Spain and the original British study, four different forms were considered for the utility function: Negative Exponential, Homogeneous, Logarithmic and Nth Root.

The MRS value (m_i), with $\hat{x}$ and $\hat{y}$ being he WTP to avoid the state i and the WTA in exchange for experiencing that state, respectively, would be obtained as follows for each functional form:[63]

- *Nth root*:

$$m_i = \frac{\hat{x}[\ln(\hat{x}+\hat{y}) - ln\,\hat{x}]}{\ln 2} \tag{8}$$

- *Logarithmic*:

$$m_i = \left(\frac{\hat{x}\hat{y}}{\hat{y}-\hat{x}}\right) ln\,\frac{\hat{y}}{\hat{x}} \tag{9}$$

- *Homogeneous*:

$$m_i = \frac{2\hat{x}\hat{y}}{\hat{x}+\hat{y}} \tag{10}$$

- *Negative exponential*:[64]

$$m_i \approx \frac{x\,(1-2^{-\frac{\hat{y}}{\hat{x}}})}{\ln\left(2-2^{-\frac{\hat{y}}{\hat{x}}}\right)} \tag{11}$$

The second stage, i.e. the estimate of the relative utility losses, uses a modified standard gamble (SG) method. The SG method serves to obtain the utility associated with the non-fatal state of health or injury, on a scale of 0-1, and the relative loss of utility represented by experiencing the non-fatal state of health or injury compared to death, which constitutes the second stage of the chained method.

Let us now assume that, rather than two possible natural states – normal health and a minor health problem – there is a third state, namely the possibility that the subject dies. Assuming that the individual maximises their expected utility (and that the three states are mutually exclusive), we have the following expression:

$$\overline{UE} = (1-\bar{p}-\bar{q})\cdot U(\bar{w}) + \bar{p}\cdot D(\bar{w}) + \bar{q}\cdot I(\bar{w}) \tag{12}$$

Where $\bar{p}$ represents the probability of dying in the following period and $D(w)$ is the utility of the income conditional on the occurrence of death.

If the individual is offered a change in the probabilities of dying and of experiencing the minor health condition, as shown in stage 1, there will be a certain amount of money, v which will verify:

$$\overline{UE} = (1-\bar{p}-\bar{q})\cdot U(\bar{w}-v) + \bar{p}\cdot D(\bar{w}-v) + \bar{q}\cdot I(\bar{w}-v) \tag{13}$$

[63] The algebraic development to define the value is not shown in detail, for the sake of brevity and clarity of presentation. This development may be consulted for the different functional forms in the appendix to Abellán et al. (2011).

[64] This expression is valid in the event that $\hat{y} \geq 3\hat{x}$. For other cases, see the aforementioned appendix.

Differentiating the above expression with regard to p, individualising $p = \bar{p}$ and $q = \bar{q}$, and ultimately deriving with regard to q, we obtain:

$$\frac{m_d}{m_i} = \frac{U(\bar{w}) - D(\bar{w})}{U(\bar{w}) - I(\bar{w})} \qquad (14)$$

Finally, let us suppose that the subject is presented with the hypothesis that, as a consequence of a traffic accident, their situation requires them to receive medical treatment, and there are two alternatives, each of which leads to different outcomes with different probabilities. One of the treatments offers a probability $(1 - \theta)$ of experiencing a minor health condition i and a probability θ of dying. The second treatment presents a probability $(1 - \Pi)$ of fully recovering health and a probability Π of dying.

Assuming that the individual evaluates the two treatments (the two gambles) according to the expected utility paradigm, if we determine the level of probability Π which, for a given probability θ, means that the subject is indifferent between the two treatments, in other words between the two gambles $(\theta, Death; State\ i)$ and $(\Pi, Death; Normal\ health)$, it may easily be demonstrated that:

$$\frac{U(\bar{w}) - D(\bar{w})}{U(\bar{w}) - I(\bar{w})} = \frac{1-\theta}{\Pi - \theta} \qquad (15)$$

We would thus have estimated the quotient $\frac{m_d}{m_i}$, which is the objective of the second stage of the method, namely:

$$\frac{m_d}{m_i} = \frac{1-\theta}{\Pi - \theta} \qquad (16)$$

Finally, the VSL is estimated by chaining the results of stages 1 and 2, as follows:

$$m_d = \frac{1-\theta}{\Pi - \theta} \cdot m_i \qquad (17)$$

2. The indirect CV/SG method

The indirect method used in this study is a variation of the indirect procedure trialled by Carthy et al. (1999), but unlike their method, the double chaining is performed by means of a more serious (rather than less serious) state of health than state i.

This method shares with the CV/SG method the part which involves estimating the MRS through contingent valuation, by obtaining the WTP and WTA values associated with experiencing a minor health condition (i). However, rather than directly combining these MRS values with the relative utility losses associated with this same minor condition, measured with an SG, these utility losses are estimated by chaining two SGs: one which places a value on the utility loss associated with a more serious state of health than the previous one (k), and another measuring the relative utility loss between both non-fatal states.

Therefore, to apply the indirect method, once the MRS values have been determined using the CV method, firstly the relative utility loss associated with the more serious state of health (k) is obtained, in the same way as presented for the minor condition, i.e. by seeking the value of p_k which means that the individual is indifferent between the gambles or treatment $(q_k, Death; State\ k)$ and $(p_k, Death; Normal\ health)$. This loss of utility would be provided by the following expression:

$$\frac{m_d}{m_k} = \frac{1-q_k}{p_k - q_k} \qquad (18)$$

Secondly, the respondent is asked to choose between the gambles $(\Phi_i, State\ k; State\ i)$ and $(\Pi_i, State\ k; Normal\ health)$, until arriving at the value Φ_i which makes them indifferent between the two gambles or treatments. The relative loss of utility of k compared to i would be:

$$\frac{m_k}{m_i} = \frac{1-\Phi_i}{\Pi_i-\Phi_i} \tag{19}$$

Based on the combination of the equations (18) and (3) above, the VSL estimated by means of this indirect or double-chaining method is calculated as follows:

$$m_d^{ind} = \frac{1-q_k}{p_k-q_k} \cdot \frac{1-\Phi_i}{\Pi_i-\Phi_i} \cdot m_i \tag{20}$$

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