# UPDATE OF THE MONETARY VALUE OF A QUALITY-ADJUSTED LIFE YEAR (QALY) AND THE VALUE OF A STATISTICAL NON-FATAL INJURY IN SPAIN

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# Executive Summary

- This report presents updated estimates of the Monetary Value of a Quality-Adjusted Life Year (MVQALY), the Value of a Statistical non-fatal Injury (VoSI) and the Value of Preventing an Injury (VPI) in Spain, in the context of traffic accidents. The study, based on a survey of a broader sample representing the general Spanish population (n=2,027), serves to refresh the initial research conducted for 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 MVQALY is estimated by applying two complementary methodologies. The implicit value of the QALY is on the one hand obtained from the new estimate of the Value of a Statistical Life (VSL), in the same way as in 2011. Meanwhile, the explicit value of the QALY is obtained by combining QALY gains with the willingness to pay for such gains, by using an enhanced chained method. The estimates obtained by these two methods – implicit and explicit – are lastly harmonised, to derive a single MVQALY.

- The VoSI is estimated in three different forms, although only one of these is used to support the values recommended to the DGT, to approximate the human costs of minor and serious personal injuries in traffic accidents. This estimation involves combining the VSL with the relative values or relative utility losses derived from the responses presented by the modified SG. The other two estimates of the VoSI have a purely indicative value, in that they were obtained by combining the estimates of the VSL and the MVQALY for Spain with data regarding non-fatal victims and their QALY losses, according to the Maximum Abbreviated Injury Scale (MAIS) used in the USA.

- The MVQALY recommended to the DGT for use in its economic evaluations of road safety measures amounts to 78,814 euros, this figure being 47% higher than the value estimated in 2011 of 53,600 euros. The recommended value is the midpoint of the range between the explicit value (66,462 euros) and the implicit value (91,166 euros) of the QALY. The increase reflected in the new estimate is consistent with the increase in nominal GDP per capita registered in Spain since 2011 (approximately 24.5%), although it would also seem to reflect a greater concern with road accident rates.

- The minor VoSI recommended to the DGT is estimated in this study at 7,886 euros, while the serious VoSI is set at 354,630 euros. When these valuations are increased by taking into account medical and ambulance costs, as well as production losses, this results in a minor VPI of 8,506 euros, and a serious VPI of 385,480 euros. The new estimates of the VoSI for minor and serious injuries represent respective increases on the 2011 figures of 58% and 93%. Once again, we see an evolution of preferences in Spanish society towards greater awareness of the importance of preventing road accidents.

- As demonstrated by the valuations obtained, which are clearly higher than those estimated in 2011, to prevent the current estimates from rapidly becoming obsolete, we must proceed to revise the figures again within the next decade. It should not be overlooked that there can be no doubt that the human costs, some of which come from the health and quality-of-life losses of the persons injured, are by far the most significant component in the social costs of road accidents. Until such time as these estimates are revised, we recommend that they be updated annually in line with nominal per capita GDP growth.

# 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 Directorate-General for Traffic (DGT) to contract the University of Murcia, by means of the corresponding tender process and through the team authoring this explanatory report, to conduct a study to determine the monetary value of a statistical non-fatal injury and of a Quality-Adjusted Life Year (QALY) in Spain. The values estimated by the working group were set out in a report (Abellán et al., 2011b) presented 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 accordance with changes in nominal per capita GDP. Likewise in accordance with the suggestions made by the working group, we must now also consider the need to revise the estimated values, as ten years have passed since then. This is the fundamental aim of the contract tendered by the DGT via the open procedure subject to harmonised regulation (case 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, presenting and analysing the results of the study, and offering the main conclusions derived from it, also indicating possible lines for future improvement.

# 2. Background

## 2.1. The social costs of non-fatal traffic accidents

According to the most recent figures available for Spain (DGT, 2023), in 2022 there were a total of 129,576 road accident victims, most of whom were injured. Specifically, 98.7% of this total covers hospitalised injury victims[1] (8,502, representing 6.6% of all victims) and non-hospitalised injury victims[2] (119,328, or 92.1% of all victims, 93.3% of the overall figure for non-fatal victims). As seen with the volume of road fatalities, following the suspension of mobility imposed by the restrictions to contain the spread of coronavirus during the recent pandemic, the figures for accidents with non-fatal victims once again rose to pre-pandemic levels, above all in the most serious cases.

As we know, traffic accidents have numerous consequences, at very different levels from damage to vehicles and infrastructure, and the costs derived from healthcare for the victims, to losses of health and human life caused by injuries and premature death resulting from accidents with victims. A recent study (Wijnen et al., 2019a) conducted in the context of the European SafetyCube project (Wijnen et al., 2017)[3] estimates, for an initial sample of 32 European countries, that the monetary value of preventing a fatality in a traffic accident ranges from 0.7 million (Slovakia) to 3 million euros (Austria).[4] However, the cost corresponding to a serious injury victim varies in Europe between 28,205 euros in Latvia and 975,074 euros in Poland, with the median of the distribution of costs across the 29 countries[5] for which information was ultimately available to quantify the cost per serious injury victim at 254,777 euros. If these values are expressed relative to the cost of a fatality, the variation range among the 28 countries[6] for which the percentage can be calculated runs from 2.5% (Latvia) to 34% (Estonia). Similarly, the scale of the cost per minor injury victim also reveals considerable dispersion, fluctuating between 296 euros in Latvia and 71,742 euros in Norway.[7] If we express these costs in the same way as before, as a percentage of the cost per fatality, the range spans from 0.03% in Latvia to 4.2% in Bulgaria and Portugal.



As Wijnen et al. (2019a) indicate, this considerable variability range in the cost per serious and minor injury victim is explained above all by methodological differences in recording the victims and

[1] According to the definitions established in Order INT/2223/2014, of 27 October 2014, governing the reporting of information to the National Register of Traffic Accident Victims, hospitalised injury victims are those who as a result of a traffic accident require hospitalisation of more than 24 hours, unless they would be defined as a fatality, as set out in the same regulation. As indicated in the 'Update to the monetary value of a statistical life in Spain' report which accompanies this text, a fatality is understood as any person who, as a consequence of a traffic accident, dies in the act or within the next 30 days, with this definition excluding confirmed cases of natural death or those where there is evidence of suicide. Prior to the entry into force of Order INT/2223/2014, hospitalised injury victims were referred to as "serious injury victims".

[2] Non-hospitalised injury victims are those injured in a traffic accident who did not require hospitalisation for more than 24 hours and were treated by the corresponding healthcare services, unless they would be defined as fatalities or hospitalised injury victims, as seen in the previous note. Prior to the issuance and entry into force of Order INT/2223/2014, non-hospitalised injury victims were classified as "minor injury victims". The terms minor/serious and hospitalised/non-hospitalised injury victims will be used interchangeably hereinafter, as appropriate.

[3] Project funded by the European Union Horizon 2020 Framework Programme.

[4] Both these values relative to the cost of a fatality, and those subsequently shown with regard to the cost of serious and minor injury victims (all derived from the SafetyCube project) are expressed in 2015 euros, adjusted for Purchasing Power Parity (PPP). Wherever this is not the case, this will be explicitly stated.

[5] The initial sample comprised the 28 countries belonging to the European Union (EU) in 2016 plus Iceland, Norway, Serbia and Switzerland. The analysis conducted in the project thus predates the United Kingdom's departure from the EU on 31 January 2020. Of these 32 countries, the information required to estimate the cost per serious injury victim was not obtained for Luxembourg, Romania or Serbia, and the final sample thus comprised just 29 countries: 27 EU countries, and 3 non-EU countries.

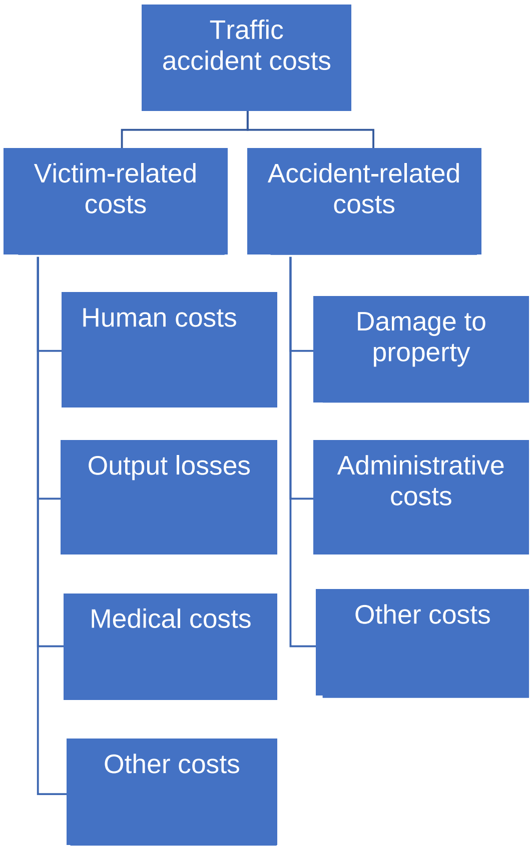
[6] Poland is now added to the previous exclusions of Luxembourg, Romania and Serbia, as the cost per serious injury victim in the country exceeded the cost per fatality (120%), which was deemed to be implausible, since the human costs are part of both the costs per fatality and the costs per serious injury victim.

[7] In this case, a sample of 28 countries was analysed, although it should be pointed out that this sample does include Poland, while Lithuania is excluded.

calculating the associated costs. In particular, the countries analysed use different definitions of injury victims. For example, whereas Spain applies the basic principle of more or less than 24 hours of hospitalisation as explained above, other states use definitions based on the type and seriousness of the injury or time limits other than 24 hours to categorise hospitalisation (Weijermars et al., 2018).[8] Similarly, there are differences in the components of the total costs (see Figure 1) included in the calculation of the costs of non-fatal injuries. Therefore, some countries attribute the corresponding proportion of the material costs connected with the traffic accident to the cost per non-fatal injury victim, while other countries do not. Lastly, a large part of the differences seen in the costs utilized in the different European countries is derived from the methodology used to estimate the human costs of non-fatal injuries, as occurs in the case of fatalities.

Figure 1 shows the structure of costs of traffic accidents with non-fatal victims, analogous to that shown in Abellán et al. (2023), distinguishing 6 main cost components, grouped into two major categories: costs directly connected to non-fatal victims of accidents, and costs connected with the accidents.

***Figure 1. Classification of traffic accident costs.***




Source: Wijnen et al. (2017).



[8] In 2013, the European Commission established a standard definition for serious injury victims in non-fatal traffic accidents, such as those with an injury level of MAIS3+. This definition is based on the injury seriousness score established on the Abbreviated Injury Scale (AIS), developed by the Association for the Advancement of Automotive Medicine (see https://www.aaam.org/abbreviated-injury-scale-ais/). This ordinary scale assigns an injury seriousness points from 1 to 6 (1 indicates a minor injury, and 6 is the maximum). An AIS score of 9 is used to describe injuries where there is not enough information available for a more detailed coding. The Maximum Abbreviated Injury Scale (MAIS) is the AIS score of the most serious injury suffered by a patient. For example, if a patient has one injury with an AIS score of 2 (moderate) and another with an AIS score of 4 (serious), then their MAIS score is 4. Patients with an MAIS score of 3 or more (MAIS3+) are considered to be clinically serious injury victims. However, methodologies to estimate MAIS3+ injury victims continue to differ considerably among European Union countries (Schoeters et al., 2020).

Beginning with the first of these two major categories (directly connected with non-fatal victims), it should be noted that human costs essentially represent the intangible costs caused by the loss of quality of life in the victims (Schoeters et al., 2017). These costs could be broadened to also include the pain, affliction and suffering caused by the accident to family and friends.

In a manner equivalent to the concept of the Value of a Statistical Life (VSL), representing the value assigned by society to avoiding the death of any fellow citizen (a statistical or anonymous life, in other words), this same notion of statistical value should also be transferred to the case of non-fatal traffic accident injury victims. The Value of a Statistical non-fatal Injury (VoSI) may therefore be defined as the value attributed by society to a specific reduction in the risk of being injured (experiencing the corresponding loss of quality of life) as the result of a traffic accident (Abellán et al., 2011b). The VoSI thus defined is equivalent to all the human costs represented by the deterioration in the health of those injured in traffic accidents. As is to be expected, the dimension of these human costs (and of all other costs in general) will vary depending on the seriousness of the injuries suffered, and so over the course of this report a distinction will be made between serious VoSI and minor VoSI.

The next item to consider in the costs of non-fatal injuries are production losses. These losses arise because accident victims are unable to continue working, either permanently (serious injuries which prevent them from working), or temporarily (those who are injured and resume work after being treated). The victims' inability to work therefore means that society loses out on both the market and non-market (e.g. domestic work) output which could have been generated if the accident had not occurred.[9] It is necessary to add that, unlike in the case of fatalities, who permanently cease not only to produce, but also to consume, injury victims do not have their flow of consumption interrupted, and so all the production losses to be considered are gross.[10]

Medical costs refer to the costs of medical treatments received by accident victims, administered by hospitals or other healthcare establishments. The most significant items recorded within this type of costs (Wijnen et al., 2017) are those derived from transportation to the hospital by ambulance and helicopter, the response provided by emergency services, costs resulting from hospital admission, as well as outpatient and home treatment costs, physiotherapy and rehabilitation.



Lastly, the "Other costs" item with regard to non-fatal accident victims is of entirely negligible significance, essentially comprising the cost of the time spent by people visiting accident victims at the hospital, and the costs of adapting the home to the needs of the injured person.

Similarly to the Value of Preventing a Fatality (VPF) cited to estimate the costs directly linked to traffic accident fatalities, in the case of those injured, the costs linked to them are approximated by means of the Value of Preventing an Injury (VPI). The VPI is thus a broader concept than the VoSI, since it not only includes the human costs derived from the accident, but also the production losses derived from the temporary or permanent inability of the accident victims to work, and also the healthcare costs (medical and ambulance costs). This thus corresponds to the sum total of all three main cost elements connected with victims, as set out in Figure 1. As with the VoSI, the dimension of production losses and medical costs incurred will depend on the seriousness of the injuries sustained in the accidents, and a distinction is thus made between serious VPI and minor VPI.

Lastly, the accident-related costs essentially comprise damage to property (vehicles, infrastructure, and potentially private property) and the administrative costs linked to police, fire brigade and civil protection services, insurance and the judicial administration. Other costs which could

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

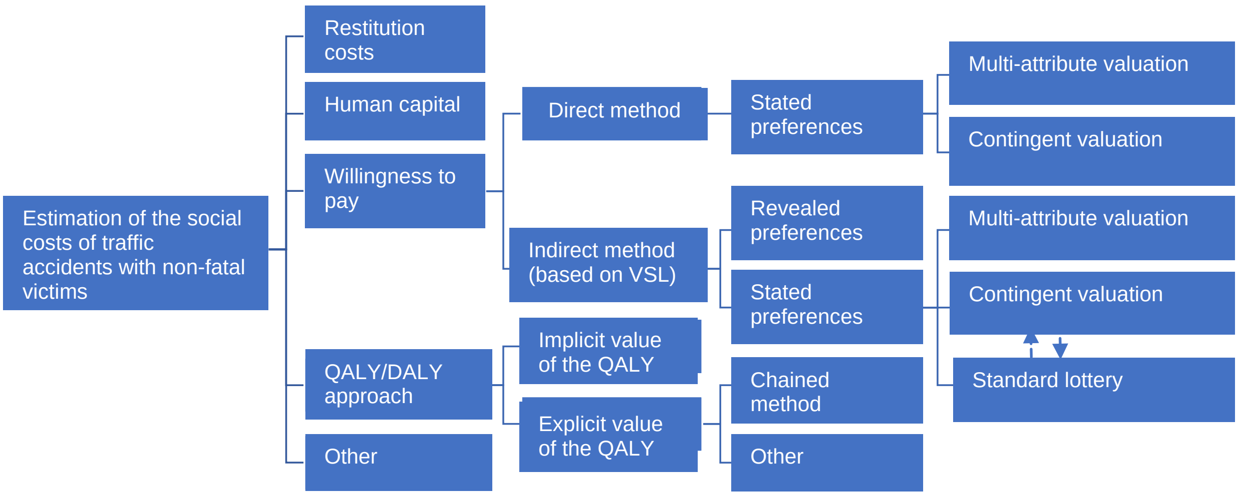
[10] It should be noted in this regard that, as explained in Abellán et al. (2023), in order to avoid counting consumption losses twice when calculating the total costs of accidents with victims, they are either deducted from the VSL, giving rise to the human costs, or are otherwise subtracted from the gross production losses, to give the net production losses. Meanwhile, in the case of non-fatal victims, as there are deemed to be no consumption losses, these do not need to be deducted from the gross production losses.

be added to those above include those resulting from highway congestion caused by road accidents (essentially lost time), and the unavailability of the vehicle if it is damaged in the accident.

## 2.2. Estimation methods

There are various methods for estimating the social costs resulting from traffic accidents with non-fatal victims. These methods are essentially identical to those used to estimate the VSL, as can be inferred by comparing Figure 2 of this report with the equivalent figure contained in Abellán et al. (2023). Therefore, we once again see that the preferred methods to quantify different components of the costs of road accidents include the restitution cost procedure, the human capital approach, and the willingness to pay approach, as the method recommended in international guides as the main approach to estimate the human costs of traffic accidents (Alfaro et al, 1994; Bickel et al, 2006; Schoeters et al., 2017; Wijnen et al., 2017). Nonetheless, as can be observed in the classification tree structure shown in Figure 2, this is more intricate than that depicted in the case of estimating the costs of fatalities. The specificities associated with quantifying the costs of traffic accident injuries are discussed below.

***Figure 2. Classification of the methods to estimate the costs of traffic accidents with non-fatal victims***




Source: Produced by the authors.

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, infrastructure and vehicle repair costs, as well as some other minor costs.[11] We thus see that this approach serves in principle to approximate the scale of the costs related with the accidents shown in Figure 1.

Meanwhile, the human capital approach measures permanent or temporary production losses resulting from the inability of the injury victims to participate in the employment market as a result of their injuries. These losses are estimated by calculating the discounted present value of the future production flow no longer provided by the injury victims while they are unfit for work, which in the case of more serious injuries, could be permanent. These potential production losses are typically approximated (Alfaro et al., 1994) by using economic and demographic indicators, such as monthly salary income and life expectancy at different ages. Furthermore, as the seriousness of the injuries varies, giving rise to varying amounts of sick leave, suppositions must be made as to the length of the period during which the injury victims cannot work.

Although the two methods described, referred to in highly graphical terms by some authors (Bahamonde-Birke et al., 2015) as 'damage-cost' approaches, are used by some countries to

[11] Such as friction costs or the costs of hiring and training new employees, as well as professional adaptation costs of the injury victim, if they have sequelae from the accident, or the costs of replacing the damaged vehicle and adapting their home.

approximate the value of the human costs[12], the fact is that an increasing number of states state that they utilize the willingness to pay (WTP) approach as the basis for estimating the losses of health and quality of life of those injured in road accidents. Therefore, in the study by Schoeters et al. (2017) within the European SafetyCube project, 15 of the 21 countries that provided a breakdown of information for the different components of the social costs of non-fatal injuries[13] estimate the human costs of serious injuries by means of the WTP approach. This methodology, together with the QALY/DALY approach also set out in Figure 2, is the only way of properly valuing the non-material or intangible losses represented by the health-related drop in quality of life caused by traffic accidents. As highlighted by the results of the SafetyCube project, an econometric analysis of the relationship between the human costs and the cost per serious injury, taking into account whether the WTP approach was used or not to estimate those costs, reveals that the variability fraction observed in the cost per serious injury among the different countries rises from 67% to 88%.[14] It is therefore quite clear that using other methods such as those indicated previously, instead of the WTP approach, tends to undervalue the social costs of traffic accidents.

In the case of fatalities, if this approach obtains the monetary valuation of a human life based on the aggregation of a large number of people's willingness to pay for a small reduction in the risk of dying on the road, when transferred to the context of non-fatal injuries, this also involves aggregating the willingness to pay of numerous individuals, but in this case to reduce the risk of being injured. The trade-off ratio between the WTP and the risk ($p_{Q_i}$) of a person suffering an injury $\mathbf{Q}_i$ as a result of a traffic accident is referred to as the marginal rate of substitution (MRS) between wealth and the risk of being injured, denoted as $m_{Q_i}$:

$$m_{Q_i} = \frac{\Delta DAP}{\Delta p_{Q_i}} \quad [1]$$

When small reductions in the risk of being injured, such as that represented by $\Delta p_{Q_i}$, are aggregated for a sufficiently large number of people (let us call this number *n*), are equivalent to avoiding an injury with certain sequelae $\mathbf{Q}_i$, then we can estimate the monetary value of a statistical victim of these characteristics (Jones-Lee, 1989) as the average of the MRS between wealth and the risk of experiencing state $\mathbf{Q}_i$:

$$VVnM = \frac{\sum m_{Q_i}}{n} \quad [2]$$

As indicated in the previous paragraph, the VoSI directly reflects the human costs resulting from losses in quality of life and the suffering of traffic accident injury victims. The VoSI is thus made up entirely of intangible losses, unlike the VSL which also included lost consumption. As indicated previously, a distinction can be made between the serious VoSI and the minor VoSI depending on the seriousness of the injuries which occur.

The estimation of the VoSI by means of the WTP approach can be addressed in two different ways, as set out in Figure 2. The more immediate or direct approach involves simply obtaining the WTP for a marginal reduction in the risk of being injured. This is referred to as the direct method, as it offers an absolute value (a monetisation) of a non-fatal injury with sequelae $\mathbf{Q}_i$. However, an indirect procedure could be followed instead, based on measuring the relative value represented by experiencing the health problem $\mathbf{Q}_i$ rather than dying. In other words, we may first calculate the ratio or quotient between the MRS of income and the risk of experiencing state $\mathbf{Q}_i$ ($m_{Q_i}$) and the MRS between income and the risk of dying ($m_d$), which represents the relative value of the injury $\mathbf{Q}_i$

[12] Specifically, according to Schoelters et al. (2017), in Germany and Latvia human costs are estimated by means of the restitution cost procedure, while in Portugal, the Czech Republic and Slovakia, they are estimated by applying the human capital approach.
[13] The 15 countries in question are Austria, Belgium, Croatia, Denmark, Slovenia, Spain, Finland, Ireland, Iceland, Malta, Norway, Netherlands, United Kingdom, Switzerland and Sweden. In the 6 remaining countries (Germany, Slovakia, Italy, Portugal, the Czech Republic and Serbia), the human costs have less of an impact on the total cost per serious injury than other components, mainly production losses and medical costs.
[14] Linear regression with an adjusted $R^2 = 0.8756$, $p<0.001$.

compared with death. If we have first estimated the VSL (which is simply $m_d$), from the product of this value times the relative value of the injury in question, aggregated for the *n* individuals from whom we have obtained their WTP, it is deduced that:

$$VVnM = \sum \left( \frac{m_{Q_i}/_n}{m_d/_n} \right) \times \left( \frac{\sum m_d}{n} \right) = VR_{Q_i} \times VVE \qquad [3]$$

As shown in Figure 2, applications of the direct method to estimate the VoSI are based on the declared preference approach. The methodologies used in this approach aim to obtain the MRS between money and risk of being injured, based on the population's responses to surveys that recreate hypothetical or simulated markets. The hypothetical nature of the scenarios presented, using a questionnaire as a simulacrum of a virtual market, distinguishes this approach from the other main approach used to value "intangible" or non-market goods, based on the revealed preferences of individuals in real markets. This second approach can also be seen in Figure 2, but in connection with the indirect method which, as we have just considered, infers the VoSI via the VSL.[15] Abellán et al. (2023) contains an in-depth discussion of the advantages and disadvantages of each of the two stated approaches (declared preferences and revealed preferences), and we therefore invite interested readers to consult the reference cited.

In the direct method for estimating the VoSI, two fundamental methodologies have been used: contingent valuation (CV) and multi-attribute valuation (MV). In the first case, the respondents are asked directly what maximum amount of money they would be prepared to pay for a specific reduction in the risk of sustaining an injury as a consequence of a traffic accident.[16] This WTP represents the sum of money that would be taken from the individual to maintain their level of welfare (or utility[17]) prior to that improvement. Although CV methods are consistent with the principles of the welfare economy (Jones-Lee, 1976), and provide useful values to conduct cost-benefit analyses of road safety measures (Boardman et al., 2017), they are not free of criticism, focused mainly on the liability of WTP to experience certain biases[18], which may give rise to significant variability in the results of the estimates obtained (Jones-Lee et al., 1995; Beattie et al., 1998).



The studies conducted in Sweden (Persson et al., 1995; 1999; Persson, 2004) to estimate VoSI are a prime example the application of CV methods. In the second of these studies (which was more complete), around 3,000 people completed a postal questionnaire, with slightly less than half of them responding to questions as to the WTP to reduce the risk of having traffic accidents with non-fatal consequences (the rest of the sample was used to obtain an estimate of the *VSL*). The respondents which took part in the study intended to estimate the monetary value of non-fatal injuries were in turn distributed among 16 sub-samples in order to compare the existence of different types of bias. In some

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[15] We refer readers with an interest in understanding the main characteristics of the revealed preference approach to the report by Abellán et al. (2023), which offers a detailed overview of this approach in connection with estimation of the VSL.

[16] The fact that the respondents are asked directly for their WTP does not necessarily mean that the question is asked in open format. There are different ways of obtaining the interviewees' WTP, such as by means of auctions, simple or double dichotomous questions, a payment card, etc. The characteristics of all these formats may be consulted in Pinto et al. (2003).

[17] The term 'utility' has various meanings in Economics. It is often understood as an ordinal index of preferences (Samuelson, 1938), and it thus makes no sense to interpret the difference between the utilities of two health states in terms of the intensity with which one state is preferred to another. In this report, meanwhile, we interpret the term 'utility' in a cardinal sense, measurable on an interval scale (a scale with predetermined origin and unit of measure), and it does make sense to compare the distance between the utilities of each state of health (see, in this regard, Torrance, 1986, for example). This is the typical interpretation within the field of what is known as utility-cost analysis, a methodology used to evaluate the social return of public programmes by comparing their incremental costs against their utility gains (Pinto et al., 2016).

[18] Essentially biases connected with the insensitivity of WTP to changes in the size of the reduction of the risk of being injured and the seriousness of the injuries. This lack of sensitivity, proportionality or scope forms part of a family of anomalies generically referred to as embedding effects, which also includes ordering effects, visible choice set effects and part-whole effects (Bateman et al., 2004, 2006, 2007).

of these sub-samples the subjects evaluated reductions in the risk of dying in an accident, as well as reductions in the risk of having non-fatal accidents.

The questionnaires included descriptions of 7 types of injury, 4 of them serious and 3 minor. Two of the serious injuries resulted in permanent disability, and the other two required a period of 1 year and 6 months respectively until full recovery was achieved. The three minor injuries were whiplash, a broken wrist and concussion. The initial risk levels were set on the basis of the data as to the real risks faced by motor vehicle users in Sweden, and were presented to the subjects with the support of visual aids. For each of the seven categories, the respondents were asked for their WTP for a reduction of 50% and for a reduction of 30% in the initial risk level.

The VoSI obtained from the WTP for the 30% reduction in the risk of sustaining various injuries, when related to the estimate of the VSL drawn from the same study (around 2.4 million euros), indicated that injuries causing permanent disability were valued at 40% of the VSL, while the serious injuries causing temporary incapacitation were valued at 13% of the VSL. Minor injuries were in turn valued at between 1% and 2% of the VSL. The mean weighted VoSI for serious injuries represented 16% of the VSL, while the figure for minor injuries was 1.5% of the VSL.

The Swedish study found evidence of insensitivity (embedding) in the WTP figures, both with regard to the size of the reduction of the risk of being injured, and the seriousness of the injuries. With particular reference to this second bias, the authors noted that respondents had difficulty in discriminating between the reduction in the risk of a certain injury and that of other related injuries. As previously mentioned, this problem of lack of sensitivity to the range of variation of the attributes to be valued by the respondents is one of the main anomalies detected in CV studies.

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 are only asked to order (or score) a series of scenarios, or otherwise successively choose between 2 of these scenarios (Bahamonde-Birke et al., 2015). The type of task required in MV studies is capable of classifying these methods into two major groups (Abellán 2019): combined analysis and choice experiments (also known as discrete choice experiments). Combined analysis asks the 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. Although they are effective, these experiments also face certain problems, including ambiguity in the descriptions (Collins & Vossler, 2009) and contextual biases (Beattie et al., 2000).

With regard to the use of MV methods to estimate the VoSI, Schoeters et al. (2022) recently published the results of the simultaneous estimation of the VSL and serious VoSI in four European countries (Germany, Belgium, France and the Netherlands). 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 CV methods.

In the discrete choice experiments conducted by Schoeters et al. (2022), researchers conducted a discrete choice experiment, with each participant in the survey (n=8,002) making 7 choices between each pair of hypothetical scenarios, representing two car journey routes. Each route was 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 respondents can be used to identify the MRS existing between the different attributes, including (thanks to the inclusion of attributes for travel cost and risk of suffering a serious injury) the MRS between wealth and risk of sustaining serious injury, used to determine the serious VoSI. The mean value attained for the four countries involved as a whole was

0.95 million euros (at 2020 prices). The values obtained for each of the countries and their comparison with the official values in force in those countries will be presented and discussed in the next subsection.

It should nonetheless be indicated at this point, in order to illustrate one of the problems commonly faced by discrete choice experiments, that no less than 33% of the sample in the study by Schoeters et al. (2022) revealed lexicographical preferences, in other words the respondents tended systematically to choose between the two hypothetical routes on the basis of one single attribute (e.g. always choosing the shorter car route). This bias is in fact a constant in most studies of this type, where the percentage of lexicographical preferences is typically no lower than 30% (Iragüen & Ortúzar, 2004; Hojman et al., 2005; Veinstein et al., 2013; Schoeters et al., 2022).

Without a doubt, the main exponent in Europe of the application of the indirect method (deducing the VoSI as a fraction of the VSL) is the study conducted by the Department of Transport in the United Kingdom in the early 1990s (Jones-Lee et al., 1993. 1995; O'Reilly et al., 1994). The fundamental aim of the study was to determine the value of the human costs represented by serious traffic accident injuries with reference to the VSL.

To this end, they interviewed two general population samples, using different methods to value 8 types of injury or state of health, anonymously labelled (from lesser to greater seriousness) as F, V, W, X, S, R, N and L.[19] As we will see below, these same states are also used in the study conducted by the research team to estimate the VoSI for Spain. In the first of the samples (n=414) the relative value was obtained for each of the health states with reference to death by means of the WTP for reductions in the risk of sustaining the injury in question, while in the other sample (n=404) the same relative values were inferred by using the standard gamble (SG) method.[20] They were subsequently combined with the VSL previously estimated in the United Kingdom (Jones-Lee et al., 1985), to give the VoSI.



The serious problems of lack of sensitivity of the WTP, both to the magnitude of the reductions in risk and to the seriousness of the healthstates [21], prompted the authors of the study to ultimately calculate the VoSI using the relative values derived from the second sample, i.e. the values inferred from the responses to the questions asked with the SG procedure. We will therefore only refer to the results derived from this second sample.

The SG used in the British study[22] asks respondents to determine the probability $p_i$ that would make them indifferent between definitely experiencing a state $i$ (corresponding to any of the aforementioned 8 states) and receiving medical treatment which could prove successful, and cure them completely with probability $1 - p_i$, but which could also go wrong, causing their death with probability $p_i$. This serves to obtain the relative value of each of the health states in comparison with normal health

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[19] As described in section 3 of this report (Methods), as one of the 8 health states (state F) does not involve hospitalisation of the accident victims, this opens up the possibility of distinguishing between estimates of the serious VoSI and the minor VoSI, as was done in the study by Abellán et al. (2011b).

[20] It should be noted that in fact the participants in both samples only directly valued four of the eight healthstates, specifically states R, S, X and W. The utilities of the other four states were obtained by interpolation based on the responses given by the subjects to a task with a visual analogue scale (a scale between 0 and 100 on which they were required to assign points directly to the healthstates).

[21] It should in this regard be mentioned that, for example, the mean WTP for a reduction in risk which was three times the other reduction proposed (12/100,000 vs 4/100,000), was just 20% higher. Similarly, 26% of participants stated that they were willing to pay the same sum of money to reduce the risk of experiencing a state of health (S) considered by 90% of the sample to be preferable to death, as to reduce the risk of dying in the accident by the same magnitude.

[22] The standard gamble is thus named because it is a probability distribution with two possible events or natural states. The type of standard gamble used in the British study corresponds to the traditional configuration (Torrance et al., 1972), where the gamble is compared against a certain event. Years later, also in the United Kingdom, Carthy et al. (1999) experimented with the use of a modified standard gamble, which was utilized by the research team to estimate the VSL. This study also uses a modified standard gamble or "double gamble", but with a different format to that proposed by Carthy et al., which is capable of more precisely capturing individual preferences with more serious healthstates. This double gamble variant was successfully used by Abellán et al. (2012) to estimate the algorithm to generate the utilities of health states SF-6D.

(NH), or in other words the utility of sustaining that injury on a scale 0-1, where 0 is the value of death (D) and 1 that of good health. This utility corresponds specifically to the probability of recovering normal health $1-p_i$. Once the utility of state $i$ has been obtained, the relative value of this state and death can be directly approximated as the quotient between the loss of utility represented by the injury and the loss of utility represented by death, i.e. as the "relative utility loss" of state $i$ compared with death. This relative utility loss will be equal to the probability $p_i$ of the treatment failing.[23] Ultimately, then, the VoSI of state $i$ will be a fraction $p_i$ of the VSL.

The relative value thus calculated for serious injuries as a whole was 0.095. In other words, the VoSI of a serious injury represented 9.5% of the VSL. Bearing in mind that in 1991 the VSL in the United Kingdom (at 1990 prices) amounted (when rounding) to 617,672 pounds, this means a VoSI for serious injuries of around 58,500 pounds. The relative values estimated on the basis of the WTP figures were between 1.5 and 10.5 times higher than the corresponding values obtained with the SG, depending on the seriousness of the state of health and the size of the reduction in the risk. In the opinion of the study researchers, these major differences between the valuations achieved via the two methods highlight the insensitivity problems of WTP, as previously discussed.

Although, as described in detail in section 3, we will over the course of this report present different estimates of the VoSI for Spain, the reference estimation, which is therefore recommended for use by the DGT in its calculations of the social costs of traffic accidents, is based on applying the indirect method which we have just explained. Specifically, as was the case in the 2011 study, the estimate is derived from the combination of the relative values of sustaining serious and minor injuries, respectively, obtained from the responses to questions presented by means of a modified standard gamble or double gamble, and the VSL reported in Abellán et al. (2023). The SG employed nonetheless presents a different format to that used in 2011, which, as explained below, offsets some of the problems detected with the double gamble used by Abellán et al. (2011b)[24].

The QALY approach (Schoeters et al., 2017) is named for the Quality-Adjusted Life Years metric typically used in evaluating the health outcomes of medical interventions when approving healthcare technologies and medicines, and also in studies into the social returns on investments in health and safety prevention measures (Miller, 2000). In the specific sphere of road safety, this approach makes sense when calculating the utility losses of injury victims as QALY losses. These losses can be monetised by applying the QALY "shadow" price or the Monetary Value of the QALY (MVQALY), which can in turn be estimated implicitly ("anchored" in the VSL), or otherwise explicitly (by determining its value based on aggregation of the instances of respondents "willingness to pay" for hypothetical health gains). This differentiation between the means of determining the MVQALY (implicit vs explicit) is used as the criterion in Figure 2 to group the different methods that will now be reviewed. Irrespective of the means used to estimate it, the MVQALY has two clear applications in the context which concerns us here. Firstly, the monetisation of QALY losses associated with traffic accident injuries gives us the VoSI, or human costs caused by the injuries. This value serves to evaluate the cost-benefit of road safety measures. Secondly, the MVQALY can be used as an efficiency threshold or maximum price per QALY gained with a road safety measure that the public authorities are prepared to pay to implement it. This second use of the MVQALY makes sense in the context of cost-utility analyses.[25]

Prior to this, it is helpful to offer a summary explanation of the concepts of QALY and its mirror image, Disability-Adjusted Life Years (DALY), the abbreviations for which are also included in Figure 2 to highlight the complementarity which exists between the two metrics.

[23] In formal terms, the relative value of avoiding a non-fatal accident compared with avoiding a fatal accident ("relative utility loss") estimated by means of the SG is given by this expression: $VR_i = \frac{U(SN)-U(i)}{U(SN)-U(M)} = \frac{1-(1-p_i)}{1-0} = p_i$, where, by convention, U(NH)=1 and U(D)=0.
[24] Which was identical to the modified standard gamble used by Carthy et al. (1999) in their chained CV/SG method.
[25] The fundamentals of the cost-utility analysis may be found in Pinto et al. (2016). Vallejo-Torres et al. (2016) can also be consulted for a summary of the main studies published where the value of the threshold cost per QALY has been estimated. We will return to this matter in subsection 2.4.

QALY is a health output measurement which assigns a utility or weight of quality of life of 1 to living a year in good health, and the utility of 0 to death.[26] The QALY number associated with a particular health problem is determined by its duration and seriousness. Thus, a given injury ***Q***, which reduces the quality of life of the victim compared with their normal health for a period ***T***, is equivalent to the following QALY number:

$$AVAC = U(Q,T) = V(Q) \cdot T, \qquad [4]$$

where $U(Q,T)$ is the total utility[27] associated with the sequelae of the accident and $V(Q)$ is the utility or weight of quality of life associated with the injury in question. As previously stated, this utility is measured on a scale where 0 represents death, and 1 is normal or full health.

Let us consider the practical interpretation of the QALY with an example. Suppose that a road accident victim is injured, causing them to experience a loss of quality of life compared with normal health of 25% for 1 year. According to the above equation, this means that their quality of life for that year will have a utility V(Q)=0.75 (=1-0.25), or in other words, 0.75 QALY.

As indicated previously, the mirror image of the QALY is the DALY, a metric of the output gap between full health and effective (and thus imperfect) health caused by illnesses. The concept was originally developed by the World Healthcare Organisation and the World Bank to estimate the 'Global Burden of Disease' (Murray & Lopez, 1996). This measurement is based on adding together the Years of Life Lost as a consequence of premature death and the Years Lived with Disability (YLD) as a result of the impaired quality of life caused by the illness. The YLD are calculated by multiplying the number of years ***T*** that the worse than normal state of health lasts, by the weight of disability or 'disutility' ***D(Q)*** or loss of quality of life represented by that state compared with normal health. Therefore, in this case, the disutility of **Q** is measured on a scale where 0 represents normal health and 1 death. Following the same example as before, a 25% loss of quality of life means a weight of disability of 0.25, which, as may immediately be confirmed, is equivalent to **1 –*V(Q)*** on the QALY scale. These two measurements are thus symmetrical. In fact, in recent years we have seen a succession of studies in different European countries estimating the YLD caused by traffic accidents with non-fatal injuries. Studies have been conducted in Sweden (Tainio et al., 2014), the Netherlands (Weijermars et al., 2016), Belgium (Dhondt, 2013) and France (Lapostolle et al., 2009), among other countries. Similarly, within the context of the SafetyCube project, YLD figures were calculated for six EU countries (Weijermars et al., 2016).

See below, by way of illustration of the approach leading to an implicit MVQALY, how the National Highway Traffic Safety Administration in the USA (NHTSA) estimates the VoSI for different types of traffic injury. This body conducts an economic evaluation of road safety measures intended to prevent highway accidents based on estimates of the volume of QALY lost as a result of injuries caused by traffic accidents (Blincoe et al., 2002; Blincoe et al., 2015; Spicer and Miller, 2010). These QALY losses are monetised by estimating the relative value that they represent with regard to the VSL (Blincoe et al., 2023), to give the VoSI of the different injuries. This process implicitly gives us the MVQALY as the quotient of this value and the corresponding QALY losses.

The QALY losses used by the NHTSA were originally derived from the work by Miller et al. (1995). The authors estimated the QALY losses on the basis of the *Injury Impairment Index* (*III*) instrument, originally developed by Hirsch et al. (1983) for clinical use. The index initially considered six dimensions: mobility, cognition, daily living, pain, sensory capacity and cosmetic aspects, each with four levels of seriousness. Subsequently, Miller et al. added a dimension referring to total or partial permanent unfitness for work. On the basis of a review of generic quality of life measurements, the authors associated quality of life weightings to each of the seven III dimensions, serving to obtain the QALY lost over a victim's lifetime as a consequence of the sequelae from the accident. The weightings

[26] Readers interested in a summary of the fundamentals and properties of QALY values may turn to subsection 2.2.5.2 of the 2011 study which led to the estimation of the monetary value of the QALY (Abellán et al., 2011b). Other more technical references, in English, are Pinto et al. (2016) and Pinto et al. (2020).
[27] This utility is simply the total number of QALYs linked to the health problem caused by the traffic accident.

were updated in further revisions by Spicer & Miller (2010) and Spicer et al. (2011), which laid the foundations for the QALY loss calculations used by the NHTSA in its report with 2010 data (Blincoe et al., 2015). These QALY losses are calculated as follows. Firstly:

$$AVACP_t = 1 - \prod_{i=1}^{7}(1 - III_i) \quad [5]$$

where $AVACP_t$ represents the loss of QALY in the period **t** and $III_i$ represents the utility loss (the disutility) predicted by the III instrument for each of the 7 dimensions.

Next, the total loss of QALY from an injury is estimated for three periods ($t = 1, 2, 3$) where $t = 1$ is the first year after the accident, $t = 2$ runs from the second to the fifth years, and $t = 3$ runs from the sixth year onwards. Indicating as $a,\ b$ and $c$, respectively, the sum total of years for each of the three stated periods, discounted at a specific discount rate $d$[28], this gives us the total number of QALY lost as:

$$AVACP(d) = a \cdot AVACP_1 + b \cdot AVACP_2 + c \cdot AVACP_3 \quad [6]$$

This allows us to go on to calculate the relative value or relative disutility factor resulting from a non-fatal accident as the following quotient:

$$FDR = \frac{a \cdot AVACP_1 + b \cdot AVACP_2 + c \cdot AVACP_3}{EVAC(d)} \quad [7]$$

Where $EVAC(d)$ is the quality-adjusted life expectancy $a + b + c$[29] discounted at a discount rate $d$ to the age when the accident occurs.

The aforementioned disutility factor multiplied by the VSL gives us the VoSI as a fraction of the VSL:

$$VVnM = FDR \times VVE \quad [8]$$

The relative values thus estimated are grouped in accordance with the maximum level of seriousness attributed to non-fatal traffic accident victims according to their injuries, based on the grading established in the Maximum Abbreviated Injury Scale (MAIS). As explained in footnote 8 of this report, this scale has six levels, the highest of which (level 6) corresponds to death. The levels of seriousness applicable to the injury victims range from 1 (minor injury) to 5 (critical injury). It should be remembered that non-fatal victims with an MAIS score of 3 or higher (MAIS3+) are considered to have clinically serious injuries.

Given that the *Injury Impairment Index* (*III*) instrument was developed 40 years ago, the NHTSA explored new ways of estimating QALY losses. It thus drew on what was known as the *VIBES* study (Gabbe et al., 2016), which empirically estimated the levels of disability that could be associated with different types of injury, with patient samples from five countries. However, as the sample sizes used in this study were small, allowing injuries to be distinguished only by diagnosis and demographics, the

[28] The means of discounting or estimating the present value of a future flow (in this case QALY) is to apply a factor or multiple to each coming year, which discounts or advances its value at a certain rate, known as the discount rate. This discount rate is greater than zero, which means that each year which passes is given a lower weighting (multiplied by a smaller factor), reflecting the behavioural phenomenon of impatience or positive temporal preference (see Abellán et al., 2011b, for a more detailed explanation of the discounted QALY method). According to the recommendations of the US Department of Transportation, with regard to the VSL this would be 4% (USDoT, 2011).

[29] The QALE at a given age x is life expectancy (the number of years of life expected in the future, at the prevalent mortality rates) adjusted for the impairment experienced in the quality of life of an individual over time. Section 3 of this report will set out a formal presentation of this concept, by explaining how this was calculated for use as an input in estimating the MVQALY which is subsequently presented.

NHTSA opted to maintain the III seriousness template, while estimating the QALY losses associated with each of the levels by combining the disutility fractions generated by the two systems (III and VIBES), to generate a hybrid estimation of these losses.[30] The relative values derived from this process, currently recommended by the US Department of Transportation, are as shown in Table 1.[31]

***Table 1. Relative MAIS disutility factor, (d=4%).***

| Maximum AIS level | Seriousness | Fraction of the *VSL* |
|---|---|---|
| MAIS 1 | Minor | 0.0049 |
| MAIS 2 | Moderate | 0.0434 |
| MAIS 3 | Serious | 0.1858 |
| MAIS 4 | Very serious | 0.3044 |
| MAIS 5 | Critical | 0.5160 |

*Source:* Blincoe et al. (2023).

The MAIS-based VoSI is calculated by multiplying the relative values from Table 1 by the magnitude of human costs per fatality, set by Blincoe et al. (2023) at 9,828,476 dollars (2019 values)[32]. Accordingly, as shown in Table 2, the VoSI with minor injuries (MAIS 1) amounts to 47,761 dollars, while the value corresponding to more serious injuries (MAIS 5) equals 5,071,911 dollars. These values can be divided by the associated QALY losses, which implicitly results in the monetary value or cost per QALY and, according to the figures from Table 2, stands at 575,438 dollars. As can be observed, the last row in Table 2 records for fatalities (MAIS 6) the VSL (cost per fatality) and the volume of QALY lost, which in this case represents the quality-adjusted life expectancy (QALE) at the date of death. Logically, the quotient of these two variables gives the same monetary value for the QALY: 575,438 dollars.



***Table 2. VoSI, VSL ($) and number of QALY lost according to MAIS, (d=4%).***

| Maximum AIS level | VoSI, VSL | QALY lost |
|---|---|---|
| MAIS 1 | 47,761 | 0.083 |
| MAIS 2 | 426,975 | 0.742 |
| MAIS 3 | 1,825,865 | 3.173 |
| MAIS 4 | 2,991,702 | 5.199 |
| MAIS 5 | 5,971,911 | 8.814 |
| MAIS 6 | 9,828,476 | 17.08 |

*Source:* Blincoe et al. (2023).

As discussed at length in Abellán et al. (2011b), the implicit estimation of the MVQALY, anchored in the VSL, requires that we accept two suppositions of debatable plausibility: first, that the MVQALY remains constant over time (Dolan & Edlin, 2002; Klose, 2003); and second, as a consequence of this, that the VSL declines at a uniform rate with age (Aldy & Viscusi, 2007). As explained at the time, Mason et al. (2009) offer a basis for calculating the MVQALY as a ratio between the VSL and the QALE, which makes it unnecessary to assume that this value would remain constant over time. Essentially, this basis involves seeing the MVQALY as the result of the aggregation of many instances of willingness to pay for small reductions in the risk of death. This will result in minor QALE

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[30] The specific details of how the III and VIBES disutility fractions were combined are described in Blincoe et al. (2023). We refer readers with an interest in understanding these specifics to the aforementioned reference.

[31] Blincoe et al. (2023) present estimates of the relative QALY loss values for different discount rates (0%, 2%, 3%, 4% and 7%). Table 1 shows the values calculated with a discount rate of 4%, which is the figure recommended by the US Department of Transportation (USDoT, 2011).

[32] This amount is lower than the VSL (10.9 million dollars), since Blincoe et al. (2023) are of the opinion that there are productivity losses inherently reflected in the VSL which are deducted, in order to be added separately together with the other components of traffic accident costs.

gains, which when added together will give rise to an aggregate WTP for 1 QALY. As in the 2011 study, in this report we once again assume the interpretation by Mason et al. (2009), such that the update for the estimation of the MVQALY anchored in the VSL which we present in section 4 may be interpreted in this way, as an aggregation of small QALE gains.

The explicit estimate of the MVQALY (i.e. not mediated via the VSL) has been addressed in two ways, as indicated in Figure 2. It can be seen that there is one approach, dubbed by Robinson et al. (2013) as the 'chained' approach, which coexists with 'Other' methods. Both means of estimating the MVQALY have two elements in common. Firstly, in both cases the resulting estimations are obtained by means of surveys (they are thus declared preference studies), and secondly, both methodologies are based on the combination of the utilities corresponding to hypothetical health gains and instances of willingness to pay declared for those same gains. The difference between the two approaches lies in how this combination is performed.

The estimates included in the 'Other' methods category are characterised in that rather than directly measuring the respondents' preferences (the utilities) on the proposed health gain scenarios, they directly impute to the health states involved, the utility pre-established in multi-attribute utility instruments such as EQ-5D (Gyrd-Hansen, 2003; Bobinac et al., 2010, 2012; Martín-Fernández et al., 2014), and thus simply obtain the WTP of the respondents. Similarly, there are studies (Shiroiwa, 2010) that directly ask for the WTP to gain 1 QALY.

The 'chained' method, meanwhile, to some extent emulates the underlying philosophy of the 'CV/SG chained approach' of Carthy et al. (1999), and involves breaking down the VSL calculation into two steps, rather than asking directly for the WTP for reductions in the risk of death, by directly measuring the preferences of the sample of respondents with regard to small gains in health, before chaining the utilities thus obtained with instances of their willingness to pay (Byrne et al. 2005; Pinto-Prades et al., 2009; Donaldson et al., 2010; Gyrd-Hansen et al., 2012). There are three direct utility measurement techniques typically used in the studies: the standard gamble (SG) method which has already been explained, what is known as the 'time trade-off' procedure, and the visual analogue scale (VAS) technique.[33] Of these three methods, the SG and the time trade-off techniques enjoy the greatest credibility from the health economy perspective, since they infer the respondent's utility based on their choices in response to successive comparisons of two alternatives.

Meanwhile, the VAS is in principle an introspective method, and is thus further removed from how consumers behave in the markets.[34]

Once the utility of the state of health representing the injury in question has been measured by one of the stated techniques, the QALY gain equivalent to avoiding that injury over time is then calculated, relative to the year when it is suffered (Pinto & Martinez, 2005):

$$\Delta AVAC_i = [1 - V_i(Q_I)] \cdot t', \quad [9]$$

where $\Delta AVAC_i$ represents the QALY gained, $V_i(Q_I)$ is the utility of the subject *i* attributed to the state $Q_I$ and t' is the time they remain in that state.

Each subject is then asked for their maximum WTP in order to be guaranteed the aforementioned QALY gain, and then by combining the two preceding steps, the MVQALY of the individual *i* is calculated as follows:

$$VMAVAC_i = \frac{\Delta DAP_i(Q_I)}{\Delta AVAC_i}, \quad [10]$$

where $\Delta DAP_i(Q_I)$ is the WTP to definitely avoid the health problem.

[33] Detailed explanations of these three methods may be found in Pinto & Sánchez (2003) and Pinto et al. (2004; 2016; 2020).

[34] This method is also considered to be less valid than the preceding approaches because of its considerable tendency to experience contextual effects (Bleichrodt & Johannesson, 1997; Robinson et al., 2001).

Lastly, the MVQALY for society as a whole is obtained by averaging (or using some other central trend measurement such as the median) their WTP and QALY gains, thus calculating the quotient of the two averages (or medians), to give a ratio of means or medians (Gyrd-Hansen et al., 2012).

There are two fundamental suppositions underlying the MVQALY calculation explained here in relation to obtaining instances of willingness to pay. First of all, we assume the validity of what is known as the 'linear QALY model' (Abellán et al., 2006), which means that the health valuations are proportional to their duration. For example, avoiding one month in a state of health $Q_i$ with a utility of 0.95 would be equivalent to 0.042 QALY, maintaining a constant monthly utility. However, Abellán et al. (2006, 2009) suggest that this linearity might not always be maintained. Secondly, it is presumed that the WTP is proportional to the gain in QALY. Thus, if a person pays 100 euros to avoid remaining in a state of health $Q_i$ with a utility 0.95, their WTP for one QALY is estimated at 25,000 euros. However, this proportionality is questioned because of the concurrence of factors including budgetary restriction[35], the presence of individuals who are not prepared to exchange risk of death for a potential health gain ('non-traders')[36] or disregard for negative utilities[37] (Pinto et al., 2009; Robinson et al., 2013; Vallejo-Torres et al. 2020). As presented later in this report, the research team offers an explicit estimation of the MVQALY, which will complement that based on the VSL, by applying a chained approach which we categorise as enhanced, to the extent that the procedure used to measure the utilities in principle minimises the biases cited immediately above.

Having concluded the explanation of the QALY/DALY, Figure 2 ends with a generic section of 'Other' methods. In the context of estimates of the costs of traffic accident injuries, these methods have a residual significance, although they constitute the basis for the human costs estimated by such major European countries as France and Germany. Both these countries specifically use compensation awarded to victims in the courts of law to compensate them for the non-material losses suffered (Schoeters et al., 2017).



## *2.3. International evidence*

The results of the aforementioned SafetyCube project (Schoeters et al., 2017; Wijnen et al., 2017) offer the most recent comparison of the official figures for non-fatal injury costs used in European countries. Of the 29 countries[38] for which the total costs per serious injury could be definitively calculated, they range from 0.04% of GDP in Ireland, to 2.7% of GDP in Poland. The mean percentage stands at 0.3%. This considerable variability is also found when expressing the costs of a serious injury relative to the costs of a fatality, marking a range that runs from 2.5% in Lithuania to 34% in Estonia.[39] Although this is a broad dispersion, approximately 75% of the countries analysed have a value of between 10% and 20% of the cost of a fatality. As the authors argue, these relatively low percentages are probably due to the fact that in many European countries the human costs associated with serious

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[35] In other words, the problem which arises because the respondents reach the limit of their capacity to pay. Although this phenomenon could partially explain some results reported in the published studies (e.g. Donaldson et al., 2008), the fact is that when attempts have been made to mitigate this problem by presenting the respondents with smaller health gains, budgetary restriction does not seem to be the main factor determining the lack of sensitivity or proportionality in the WTP (see, for example, Vallejo-Torres et al., 2020).

[36] Individuals who are not prepared to accept any risk of death in a standard gamble, but who are however prepared to pay a positive amount for a health improvement, give rise to an infinite MVQALY (Vallejo-Torres et al., 2020). This problem typically affects a non-negligible percentage of the samples, which leads to the dilemma of excluding them from the MVQALY calculation, or attributing arbitrarily raised utilities to them (Robinson et al., 2013).

[37]Negative utilities, because a fraction of the respondents consider some of the health states to be worse than death. In response to this phenomenon, the utility of these subjects is typically truncated at zero, which leads to an overestimation of their WTP for QALY (Robinson et al., 2013).

[38] It should be borne in mind that Luxembourg, Romania and Serbia provided no data in this regard (Schoeters et al., 2017; 2020).

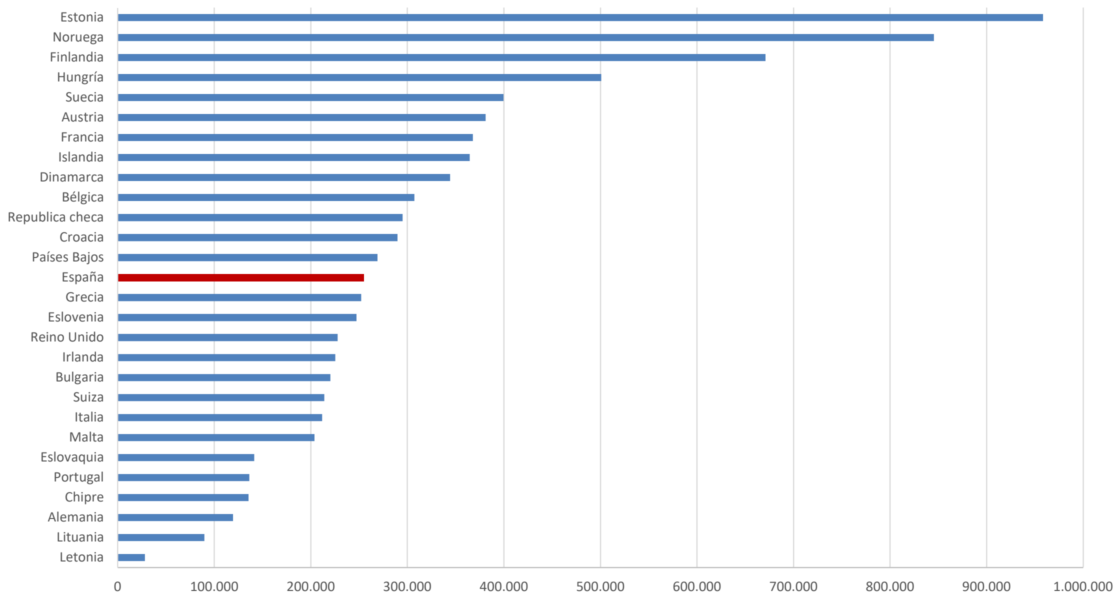
[39] In this case, and also when the relativised cost data correspond to minor injuries, Poland is excluded from the comparison, since the figures for the costs per injury supplied by the country were greater than those of the cost per fatality (Wijnen et al., 2017).

injuries are estimated simply by applying a standard percentage to the value of preventing a fatality, using such international sources as the HEATCO project (Bickel et al., 2006). However, among European countries (15 of the 21 that provided a breakdown of information for the different cost components in Figure 1)[40] that estimate the human costs of serious injuries (which would be the VoSI) by means of the 'willingness to pay' approach, these costs represent the larger percentage of the cost per serious injury, specifically between 51% and 91%. The cost per minor injury reveals even greater variability, fluctuating between 0.03% in Latvia to 4.2% of the cost per fatality in Bulgaria.

Figure 3 shows the cost per serious injury in each of the 28 usable countries, in 2015 prices, adjusted for Purchasing Power Parity (PPP).[41] As can be observed, Estonia is the country which attributed the highest value to a road fatality, with a figure representing almost 960,000 euros. Almost 2 thirds of the sample of countries have a cost per serious injury of less than 300,000 euros.

Spain stands right at the halfway point of the distribution in fourteenth position, with a cost of almost 255,000 euros[42], slightly higher than the median cost for the sample (253,527 euros). There are only two countries below the 100,000 euro figure: Latvia and Lithuania, with the latter having the lowest value of the entire sample at 28,205 euros.

***Figure 3. Costs per serious injury (millions of 2015 euros, PPP)***




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

In order to offer as uniform a comparison as possible, also taking into account per capita income, Table 3 shows GDP per capita and costs for serious injury for the 19 countries of the sample belonging to the Eurozone.[43] The baseline data of the report by Schoeters et al. (2017) expressed in 2015 euros adjusted for PPP have been updated to 2022, using the GDP deflators and PPP values for

[40] The 15 countries in question are Austria, Belgium, Croatia, Denmark, Slovenia, Spain, Finland, Ireland, Iceland, Malta, Norway, Netherlands, United Kingdom, Switzerland and Sweden. In the 6 remaining countries (Germany, Slovakia, Italy, Portugal, the Czech Republic and Serbia), the human costs have less of an impact on the total cost per serious injury than other components, mainly production losses and medical costs.

[41] 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 for 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.

[42] Cost per serious injury presumably based on the serious VPI 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).

[43] The only Eurozone country not included in Table 3 is Luxembourg, for which there are no original data as to the cost per non-fatal injury.

the year provided by the Eurostat database.[44] The mean cost per serious injury was likewise estimated in the 19 countries, weighted by the demographic weight of each country out of the total aggregate population.

An observation of the data in the table indicates that just 9 countries have a cost per serious injury lower than the mean. The remaining 10 countries, including Spain, have a higher cost per fatality. The country with by far the highest cost per serious injury is Estonia, at almost 1.5 million euros, followed a considerable way behind by Finland and Croatia, both of which have costs in excess of half a million euros. Latvia lies at the opposite end of the scale, with a cost of less than 48,000 euros. Spain is in ninth position, with a cost per serious injury calculated at 293,609 euros. Finally, it should be noted that there is a weak negative correlation between the figure of the cost per serious injury and per capita GDP, which can easily be seen in Figure 4.

***Table 3. Costs per person seriously injured and per capita GDP (2022 euros, PPP).***

| | GDPpc | Cost per serious injury |
|---|---|---|
| Germany | 41,319 | 129,078 |
| Austria | 44,097 | 385,799 |
| Belgium | 42,612 | 312,613 |
| Cyprus | 33,272 | 158,208 |
| Croatia | 26,136 | 503,367 |
| Slovakia | 24,111 | 198,094 |
| Slovenia | 31,458 | 325,540 |
| **Spain** | **30,241** | **293,609** |
| Estonia | 30,527 | 1,480,264 |
| Finland | 38,678 | 596,443 |
| France | 35,769 | 384,884 |
| Greece | 23,790 | 323,260 |
| Ireland | 82,704 | 170,515 |
| Italy | 34,347 | 230,220 |
| Latvia | 25,811 | 47,459 |
| Lithuania | 31,782 | 173,086 |
| Malta | 36,609 | 270,158 |
| Netherlands | 46,093 | 264,123 |
| Portugal | 27,523 | 180,734 |
| **Weighted average** | **36,770** | **266,128** |

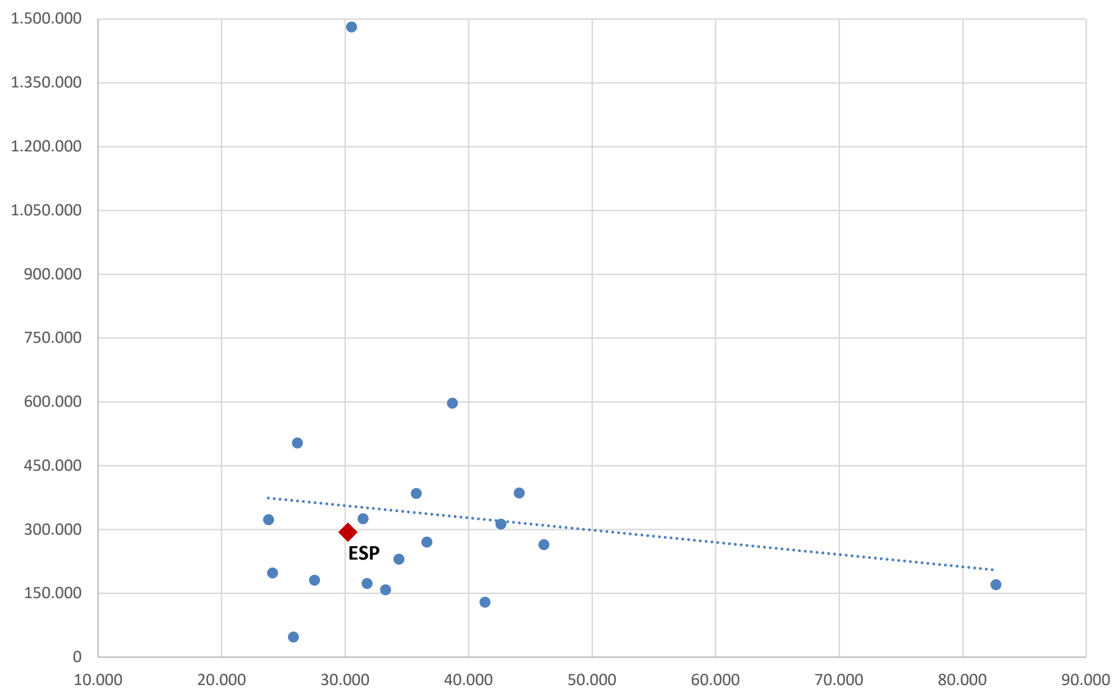
°Source: produced by the authors based on Schoeters et al. (2017) and Eurostat.

Wijnen & Stipdonk (2016) reviewed the estimate of the social costs of traffic accidents in 17 countries, 10 of which are high-income countries while the remaining 7 are middle- and low-income. Their review includes the costs of serious and minor injuries, emphasising that the costs of such injuries in the two groups of countries represent half of all costs, with two thirds corresponding to serious injuries. The main difference between the two sets of countries is the proportion of the costs per fatality out of the total costs, which is higher in middle- and low-income countries, because of the greater incidence of fatal accidents compared with those resulting in non-fatal injuries.



[44] https://ec.europa.eu/eurostat/databrowser/view/prc_ppp_ind/default/table?lang=en

***Figure 4. Costs per person seriously injured and per capita GDP (2022 euros, PPP).***




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

As previously explained, Schoeters et al. (2022) conducted a discrete choice experiment which allowed them to estimate the serious VoSI for Germany, Belgium, France and the Netherlands. Each participant in the survey made 7 choices between each pair of hypothetical scenarios representing two different 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. That said, the sample which ultimately proved usable was 31% smaller than the initial sample, being reduced 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, in other words subjects who throughout the 7 choice sets always chose the alternative that 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 employed on the scenarios. In any event, it is clear that a very significant part of the initial sample was ultimately discarded.

Table 4 sets out the VoSI 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 estimates of the VALOR project 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 1 million euros, a figure significantly higher than that currently in force in any of the four countries, and in fact higher than any European country. This may be ascertained simply by considering Table 4, which sets out the official costs per serious injury, with a weighted mean for the 19 countries studied (including the 4 covered by the VALOR project) which amounts to less than 270,000 euros. Meanwhile, no country in this table has a cost close to a million euros, except for Estonia, which is a complete outlier in the context of the Eurozone.

***Table 4. VALOR project estimates and official values (million €).***

| | Offcial VoSI | VALOR VoSI |
|---|---|---|
| Netherlands (2018) | 0.3 | 1.0 |
| Germany (2018) | 0.1 | 1.1 |
| Belgium (2020) | 0.3 | 0.9 |
| France (2019) | 0.4 | 0.8 |

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

Source: Schoeters et al. (2021).

If the differences are analysed country by country, the greatest discrepancy occurs with Germany, which would see its official VoSI rise by 1000% if it were to be updated. However, as Schoeters et al. (2021) argue, this new value is not directly comparable in the case of Germany, since as we have seen, the official value used in the country is the result of applying the law court 'compensation' method. However, the comparison is appropriate in the case of the Netherlands, because, as the authors argue, the VoSI adopted in this study from 2001 was also estimated with a discrete choice study (De Blaeij, 2003; Wesemann et al., 2005). However, as can be observed, despite the methodological similarity indicated, the new serious VoSI estimate is more than twice that used to date in the Netherlands, increasing the figure by 227%. The increases in Belgium and France are likewise very substantial, registering relative increases of 213% and 108%, respectively.[45] The authors acknowledge the considerable increase that their estimates entail compared with the official values in 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.



As indicated in our description of the QALY/DALY approach, in recent years studies have been undertaken in Europe with the aim of quantifying the burden of illness imposed on societies by non-fatal traffic accident injuries. Tainio et al. (2014) estimated that the mean Years Lived with Disability (YLD) in Sweden amounted to 14.7 for serious accidents with permanent consequences, and 0.012 for minor injuries. In fact, 96% of all YLD occurring as a result of traffic accidents originated in accidents with permanent consequences, although they accounted for just 2% of all accidents. Meanwhile, in the Netherlands Weijermars et al. (2016) estimated the mean YLD at 8.4 for accidents with permanent consequences, while in the case of minor injuries the figure was 0.2. As for types of injury, Lapostolle et al. (2009) and Tainio et al. (2014) highlight that intracranial injuries, spinal cord injuries and fractures make up the bulk of the illness burden as a consequence of traffic accidents.

Schoeters et al. (2017), using the estimates calculated by Weijermars et al. (2016) of the YLD caused by serious injuries in traffic accidents in 5 European countries, and the data compiled in the SafetyCube project as to the human costs in these same countries, all estimated with the WTP approach, calculate the cost per YLD for them all. This estimate has the virtue of being supposedly based on the official cost values in these countries. As can be observed in Table 5, the resulting YLD value varies from slightly over 66,000 euros in the United Kingdom, to 94,113 euros in Austria. Of the five countries considered, Spain would have the second-lowest YLD value.

[45] 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.

**Table 5. Serious VoSI, YLD through serious injury and YLD value (2015 euros).**

| | Serious VoSI (WTP) | YLD through serious injury | Value of YLD |
|---|---|---|---|
| Austria | 301,160 | 3.2 | 94,113 |
| Belgium | 239,171 | 2.7 | 88,582 |
| Spain | 223,450 | 3.2 | 69,828 |
| Netherlands | 208,560 | 2.4 | 86,900 |
| United Kingdom | 205,952 | 3.1 | 66,436 |

Source: Schoeters et al. (2017).

Likewise, Schoeters et al. (2017) compare these YLD values with those derived from the MVQALY estimates published in the academic literature. Specifically, with explicit estimates of the QALY value. These estimates, expressed in 2010 euros, are shown in Table 6.

**Table 6. Value of QALY (2010 euros).**

| Studies | Country | Value of QALY | | |
|---|---|---|---|---|
| | | Minimum | Maximum | Mean |
| **Gyrd-Hansen (2003)** | Germany | 11,892 | 14,121 | 13,007 |
| **Pinto-Prades et al (2009)** | Spain | 4,654 | 125,588 | 30,843 |
| **Bobinac et al (2010)** | Netherlands | 9,838 | 25,108 | 16,627 |
| **Zhao et al (2010)** | China | 3,671 | 5,693 | 4,760 |
| **Bobinac et al (2012)** | Netherlands | 1,213 | 21,959 | 9,389 |
| **Gyrd-Hansen & Kjær (2012)** | Denmark | 3,040 | 107,688 | 38,844 |
| **Pennington (2013)** | Denmark, France, Hungary, Netherlands, Norway, Poland, Spain, Sweden, United Kingdom | 6,266 | 23,049 | 12,210 |
| **Robinson (2013)** | Denmark, France, Hungary, Netherlands, Norway, Poland, Spain, Sweden, United Kingdom | 7,841 | 43,279 | 20,161 |
| **Shiroiwa et al (2013)** | Japan | 15,597 | 77,986 | 42,499 |
| **Bobinac et al (2014)** | Netherlands | 54,132 | 244,768 | 114,665 |

Source: Schoeters et al. (2017).

As can be seen, the great majority of the estimates set out in Table 6 present a broad range of values for most countries. For example, note the absolute difference between the minimum and maximum QALY values estimated by Pinto-Prades et al. (2009) for Spain: 120,934 euros. The range is even greater in the estimate by Bobinac et al. (2014) for the Netherlands, where it amounts to almost 191,000 euros. Meanwhile, if we focus on the mean values, we find that these are lower in all cases except for Bobinac et al. (2014), than the YLD costs shown in Table 5. It should nonetheless be pointed out that the comparison is distorted by inflation, and so if the MVQALY figures in Table 6 were updated according to the change in prices registered between 2010 and 2015, the difference between the two estimates would be smaller.

## 2.4. The evidence in Spain

The study undertaken by the research team in 2011 (Abellán et al., 2011b) estimated the VoSI of a traffic accident in Spain, distinguishing between victims with minor injuries and those with serious injuries (whether or not they required hospitalisation), according to the criterion employed by the DGT to classify accident injuries. The value for the health losses associated with a serious injury (VoSIS) was estimated at 183,500 euros, while the human costs for a minor injury (VoSIM) were set at 5,000 euros. Adding the productivity losses and medical expenses to the human costs gave us a Value of Preventing an Injury (VPI) in a traffic accident of 219,000 euros in the case of a serious injury victim (VPIS), and 6,100 euros in the case of a minor injury victim (VPIM).

Estimation of the VoSI involved the social preference measurements methods with the greatest bibliographical accreditation, in terms of both theoretical properties and their practical performance. The VoSI was anchored in the Value of a Statistical Life (VSL) which the same research team estimated in a prior study (Abellán et al., 2011a), used as the reference to calculate the relative values of non-fatal injuries, obtained with a combination of the contingent valuation and modified SG method, the latter procedure representing a methodological innovation in this sphere.



The study in question also calculated the MVQALY in the context of traffic accidents, which was estimated at 53,600 euros. This monetary value was obtained by means of a procedure which involved dividing the Value of a Statistical Life (VSL) by the QALY representing the expected lifespan of an average accident victim in Spain (known as the Quality-Adjusted Life Expectancy, or QALE), assuming a discount rate of 1.5%.

Aside from this precedent in the context of traffic accidents, there are various studies estimating the MVQALY in Spain, most of them in the context of healthcare intervention (Sacristán et al., 2020), and none of them by inference from the VSL, as was the case in the study by Abellán et al. (2011b). All the empirical estimates for Spain, i.e. those not derived from a bibliographical review[46], and based on general population data[47], are set out in Table 7.

[46] By bibliographical review, we refer to those works (Sacristán et al., 2002; De Cock et al., 2007) which reviewed the utility-cost studies published to a particular date, selecting those where the authors recommend funding the healthcare intervention evaluated.

[47] There are two studies conducted in Spain which estimate the MVQALY on the basis of patient surveys (Camps-Herrero et al., 2014; Dilla et al., 2016).

**Table 7. QALY value in Spain (euros).[48]**

| Reference | Method | Values/ranges proposed (euros/QALY) |
|---|---|---|
| Pinto Prades(2009) | Demand | 4.585-123.724 |
| Donaldson et al. (2010) | Demand | 92.488-171.476 |
| Abellán-Perpiñán et al. (2011b) | Demand | 53,600 |
| Martín-Fernández et al. (2014) | Demand | 7.626-41.558 |
| Vallejo-Torres et al. (2016) | Demand | 10.000-30.000 |
| Vallejo-Torres et al. (2018) | Supply | 22.000-25.000 |

Source: Sacristán et al. (2020).

As can be seen, the MVQALY estimate based on the VSL by Abellán et al. (2011b) is the only one offering a single-point threshold. In all other cases, the estimates are ranges. The value given by Abellán et al. (2011b) lies within the range of values estimated by Pinto-Prades et al. (2009) and is lower than the band determined by Donaldson et al. (2010). At the opposite end, the estimates by Vallejo-Torres et al. (2016, 2018) propose clearly lower figures. It should be noted in this regard, as Mason et al. (2009: p. 944) warned, that "the value of a QALY may differ depending on how the gain in that QALY occurs". This means that the MVQALY is context-dependent and not one single figure, on the basis of the differences that tend to exist between the values estimated in the field of healthcare and those obtained in the context of road safety.

Following a summarised review of the international and national evidence regarding the VoSI and MVQALY within the outlined panorama, we briefly contextualise the estimates by the research team itself, under the terms of the contract signed with the DGT, as presented in the following pages. As will be described in the next section, aside from the VoSI reference estimate based on the combination of the relative values obtained with the double gamble and the VSL determined by Abellán et al. (2023), we will present another two VoSI estimates based on relative values from Table 1 and QALY losses from Table 2. As will be emphasised, these estimates merely have the function of illustrating the calculations that could be made for Spain if information were available with a breakdown by MAIS, as in the USA An implicit estimate will also be presented for the MVQALY based on the VSL produced by Abellán et al. (2023), reproducing the procedure previously used in 2011. However, another novel feature of this study is the generation of an explicit estimate of the MVQALY, which is not therefore anchored in the VSL.



[48] The terminology used in the Method column of Table 7, distinguishing between Demand and Supply is based on Baker et al. (2011), and has the following meaning. The demand perspective typically draws on the contingent valuation methodology, and involves asking the population directly as to their willingness to pay for gains in health or QALY. The supply perspective is based on calculating the opportunity cost involved in displacing other interventions to adopt a new intervention within a fixed healthcare budget. It therefore derives the value of the marginal health expenditure threshold.

# 3. Methods

## *3.1. Sample selection*

The sample design was conducted by the research team with support from the company Sigma Dos, responsible for the fieldwork. The sample, which was nationwide (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 the 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 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 8 presents the percentage quotas by autonomous region and by habitat size. The quotas by age group are shown in Table 9, the composition by sex being: 49% men and 51% women.

*Table 8. 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 9. 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

The study uses 10 hypothetical descriptions, referred to generically as "healthstates", which will be valued by different preference measurement methods, as explained in the next section. These 10 valuation scenarios include, firstly, the two states described according to the SF-6D system[49] and anonymously labelled as "state C" and "state J", which are described in Figure 5. These two states are coded as 311112 and 412422, respectively, according to the SF-6D descriptive system.[50]

**Figure 5. Descriptions of the SF-6D health states (C, J)**

| State C | State J |
|---|---|
| **Quality of life:**<br>• Their health limits them a little in undertaking moderate effort (e.g. moving a table, vacuum cleaning or walking for more than 1 hour).<br>• They have no problems with their work or daily activities as a result of their physical health or emotional problems.<br>• Their health never hampers their social activities (such as visiting friends or family).<br>• They have no pain.<br>They never feel very anxious or despondent and depressed<br>• They almost always have plenty of energy | **Quality of life:**<br>• Their health limits them a great deal in undertaking moderate effort (e.g. moving a table, vacuum cleaning or walking for more than 1 hour).<br>• They have no problems with their work or daily activities as a result of their physical health or emotional problems.<br>• Their health only occasionally hampers their social activities (such as visiting friends or family).<br>• They have pain which moderately interferes with their regular work (in the workplace or at home).<br>• They only occasionally feel very anxious or despondent and depressed.<br>• They almost always have plenty of energy |

The other eight health states correspond to the descriptions of a series of hypothetical injuries and sequelae resulting from a traffic accident (injuries), which were used in the study conducted in 2009 (Abellán et al., 2011b), labelled as F, W, X, V, S, R, N, L. Figure 6 shows the detail of each of these injuries.

[49] The SF-6D multi-attribute system (Brazier et al., 2002) describes a state of health in terms of 6 dimensions, each of which may take on different levels of seriousness between 4 and 6, depending on the dimension.

[50] State C (311112) presents level 3 for dimension 1 (physical function) and level 2 for dimension 6 (vitality), without any limitation on the other dimensions. State J (412422) presents level 4 for the physical function and pain attributes; level 2 for social function, mental health and vitality; and no impact on the second attribute (role limitations).

***Figure 6. Descriptions of the health states (injuries) resulting from a non-fatal traffic accident***

| State F | State W |
|---|---|
| • No hospitalisation required; outpatient treatment.<br><br>**After treatment:**<br>• Mild to moderate pain for 1 week.<br>• Difficulties working or performing leisure activities, which gradually reduce.<br>• After 3 or 4 months, recovery is total without any sequelae. | **In hospital:**<br>• For 1 week<br>• Slight pain<br><br>**After hospitalisation:**<br>• Pain or discomfort for several weeks.<br>• Difficulties working or performing leisure activities, which gradually reduce.<br>• After 3 or 4 months, recovery is total without any sequelae. |
| **State X** | **State V** |
| **In hospital:**<br>• Moderate pain for 2 weeks<br><br>**After hospitalisation:**<br>• Pain gradually disappears.<br>• Difficulties working or performing leisure activities, which gradually reduce.<br>• After 18 months, fully recovery, without any sequelae. | **In hospital:**<br>• Moderate pain for 2 weeks<br><br>**After hospitalisation:**<br>• Moderate to serious pain for 1-4 weeks<br>• Pain then gradually eases, but reappears when performing certain activities<br>• Permanent, lifelong difficulties in working and performing leisure activities. |
| **State S** | **State R** |
| **In hospital:**<br>• Moderate to serious pain for 4 weeks<br><br>**After hospitalisation:**<br>• Moderate to serious pain for 1-4 weeks<br>• Pain then gradually eases, but reappears when performing certain activities<br>• Permanent, lifelong difficulties in working and performing leisure activities. | **In hospital:**<br>• More than 4 weeks, possibly several months<br>• Moderate to severe pain<br><br>**After hospitalisation:**<br>• Continued chronic pain for life<br>• Major, permanent, lifelong difficulties in working and performing leisure activities.<br>• Some major scars may remain for life. |
| **State N** | **State L** |
| **In hospital:**<br>• More than 4 weeks, possibly several months<br>• Inability to use legs and possibly arms due to paralysis or amputation.<br><br>**After hospitalisation:**<br>• Confined to a wheelchair for life<br>• Dependent on other people for many physical needs, such as dressing and washing | **In hospital:**<br>• More than 4 weeks, possibly several months<br>• Head injuries causing permanent brain damage.<br><br>**After hospitalisation:**<br>• Mental and physical capacity is hugely diminished for life.<br>• Dependent on other people for many physical needs, such as dressing and washing |



Although the overall set of health states consists of these 10 (the two SF-6D states and the 8 injuries adapted from the British study), each respondent is faced only with 3 or 4 of them, depending on the questionnaire model assigned to them, as explained subsequently.

## 3.3. Methods to source preferences

### Modified standard gamble: individual relative value

The first method used to obtain preferences to estimate the MVQALY and VoSI is the "modified standard gamble" (SG), a technique to measure the utilities of healthstates, intended to obtain the value that the participants assign to the relative loss involved in experiencing a particular state of health compared with 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 respectively identified with death and perfect health.

The SG format used in this study is as follows: participants must choose between two hypothetical scenarios, identified with two medical treatments which are uncertain. Both treatments differ in the results derived from the (successful or unsuccessful) outcome of the treatment, and the respective probabilities of success and failure. The probabilities are expressed in the form of natural frequencies with a base of 1,000.

To obtain the value of state $i$, the participants are asked to choose between two treatments, A and B, both with a certain probability of success, which result in full recovery of health. In the case of treatment A, the probability of success is set at 0.5 (500 of every 1,000 recover), while if the treatment fails, which occurs in another 500 out of every 1,000 cases, the individual would find themselves with state of health $i$ for the rest of their life. In the case of treatment B, success leads to them recovering their health, but failure of the treatment has a fatal outcome: the patient dies. The aim is for the respondent to identify the risk of death with treatment B ($p_i$) that would leave them indifferent between the two treatments (so they would not know which to choose). Formally speaking, the choice is presented in the following terms:

$$A: (0.5, Estado\ i;\ SN)\ vs. B: (p_i, M;\ SN)$$

Where $SN$ indicates recovery of "normal health" and $M$ denotes death.

The indifference value $\overline{p_i}$ is not derived from asking the respondent a direct question based on the scenario described, but is instead obtained following a series of choices in which the value of $p$ gradually changes, by means of an iterative process, in light of the participant's responses (a choice-based matching procedure). The first choice is put to the respondent in the following terms:

| **Treatment A** | **Treatment B** |
|---|---|
| 500 recover/500 State $i$ | 500 recover/500 die |

If the respondent chooses treatment A, they are then presented with a second choice in which the number of fatalities with treatment B is lower (specifically half)[51]:

| **Treatment A** | **Treatment B** |
|---|---|
| 500 recover/500 State $i$ | 750 recover/250 die |

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

| **Treatment A** | **Treatment B** |
|---|---|
| 500 recover/500 State $i$ | 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** |
|---|---|
| 500 recover/500 State $i$ | 825 recover/175 die |

The search algorithm is gradually developed until it defines a range for the frequency of death with 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 one treatment or the other, which we will divide by 1,000 and note down as $\overline{p_i}$. 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?*

[51] Because 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.

This procedure is conducted for each of the states which the participants are required to evaluate (a maximum of four per respondent), depending on the subgroup (questionnaire model) they are assigned to, as detailed below. The values obtained for states C and J (SF-6D health states) will serve for one of the approximations of the MVQALY (known as the "enhanced chained approach"). The relative values for states F, W, X, V, S, R, N and L (the injuries) will serve to calculate the VoSI, and to estimate the MVQALY by using the methodological approach anchoring this value in the VSL.

As stated, the procedure to ascertain the indifference value in this method follows an iterative algorithm, which gradually leads the participant to define an interval within which their preference lies. On the basis of the evidence obtained in prior 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 non-transparent procedure, which aims to make the individuals see their choices as isolated decisions rather than part of a convergence process, reduces violations of the supposition of invariance in the procedure, thereby helping to make the estimates of the MVQALY and VoSI less volatile. The way in which this opacity is incorporated in the two aforementioned methods specifically involves alternating the choices corresponding to the valuations of two different states. By way of example, the application of this non-transparent procedure in the SG valuation sequences of states C and J would begin with the first valuation question choice for state C:

| **Treatment A** | **Treatment B** |
|---|---|
| 500 recover/500 State **C** | 500 recover/500 die |

Following this, they are presented with the first valuation sequence for state J:

| **Treatment A** | **Treatment B** |
|---|---|
| 500 recover/500 State **J** | 500 recover/500 die |



This will be followed by the second choice in the sequence corresponding to State C (assuming that the subject chose treatment A):

| **Treatment A** | **Treatment B** |
|---|---|
| 500 recover/500 State **C** | 750 recover/250 die |

And next, the second choice with State J (assuming that the participant chose treatment B in the first choice):

| **Treatment A** | **Treatment B** |
|---|---|
| 500 recover/500 State **J** | 250 recover/750 die |

These alternating choices between the two iterative processes continue until the corresponding indifference ranges are defined, finishing with the respective open questions which mark the end of the procedure. This strategy, which involves alternating choices involving one state of health with choices about another, within the valuations by means of the SG method, is used in almost all the groups with different states, as detailed below in the section explaining the design of the questionnaire.

**Contingent valuation: Willingness to pay**

The contingent valuation (CV) method aims to assign values to goods for which there is no market, and which therefore have no price. In essence, the CV involves recreating a hypothetical market for respondents to assign a price (their maximum WTP) to the good whose value they wish to obtain. In this case, the aim is to ascertain the respondents' WTP in exchange for avoiding a health problem, of a particular seriousness and a certain duration.

In this study the WTP is obtained by means of a mixed procedure, according to which the subjects are first shown a series of cards with a wide range of monetary amounts ("payment card"). In the light of each of these amounts in euros, the participant must respond for that amount whether "they would certainly pay", "would certainly not pay" or "are not sure whether or not they would pay" to avoid experiencing the state of health being valued.

Once the interviewees' responses have been obtained for each of the figures on the payment card, and the internal consistency of the responses has been ensured (allowing the respondent to revise possible inconsistent responses where necessary), an open question is asked to determine the maximum value that they would pay to avoid experiencing the state of health being valued. This WTP will lie between the maximum amount that they would certainly pay and the minimum amount that they would certainly not pay.

The WTP technique is used to value four different health gains in total, involving the avoidance of experiencing two different states (state C and state J) for two brief alternative durations (1 month and 5 months).

## 3.4. Questionnaire

The questionnaire, divided into five parts, was programmed in a computerised interface to be administered by means of computer-assisted personal interviews (CAPI) conducted at the homes of the individuals comprising the sample. The structure of the questionnaire is essentially the same for all the interviewees, although 8 versions of the interface were designed, each with a different number of questions included in the parts containing the preference valuation methods, and the way in which these questions are set. Each of these 8 models was assigned to the interviewees randomly.

**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 with regard to 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 highway 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 are 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 the risks expressed in this manner, two questions are set which serve to verify the numerical skills of the interviewees.

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 7:

**Figure 7. 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 out of every 100,000 population suffer minor injuries.**

To put the risk of a fatal traffic accident into context, the next graph I will show you represents the **annual risks associated with different illnesses per 100,000 people**. For example:

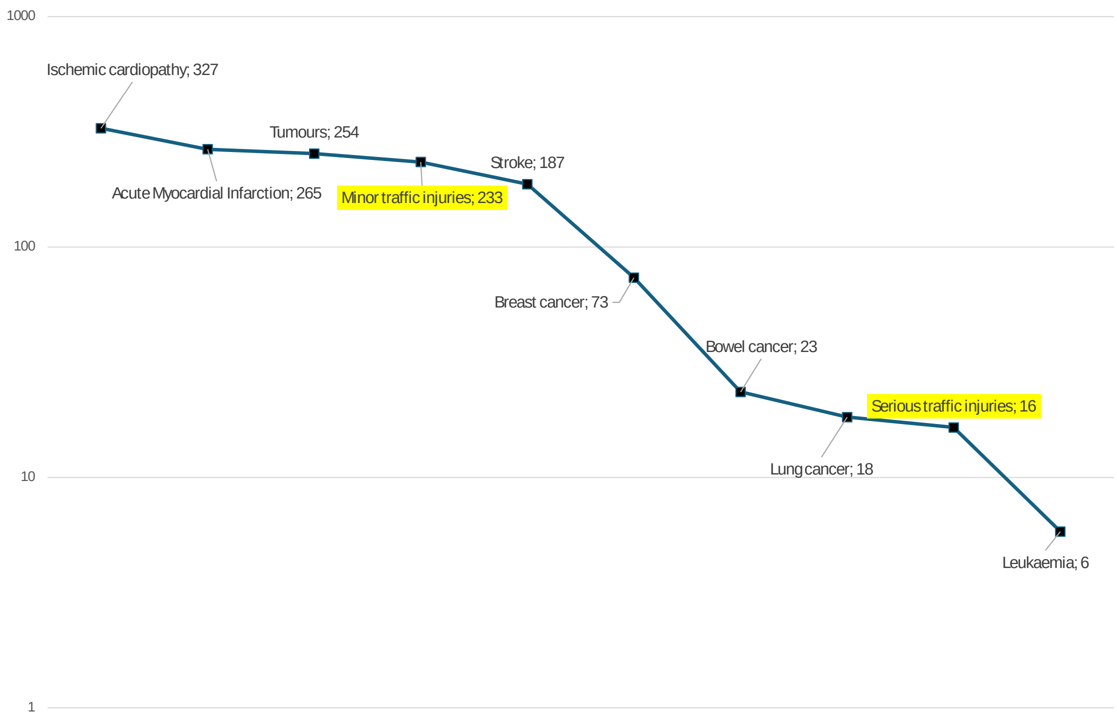
*Interviewer shows: P8 card and show examples*

"Tumours; 254". This value tells us that each year in Spain 254 people out of every 100,000 develop a tumour (for any reason and at any age).

"Bowel cancer; 23". This figure tells us that every year in Spain 23 people out of every 100,000 are diagnosed with bowel cancer

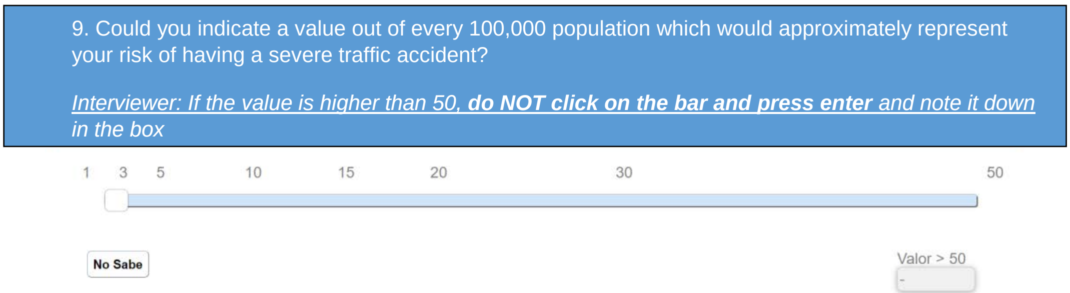
The risk of experiencing minor or serious consequences after a traffic accident is also presented graphically, placing it in context with regard to the risks of having some common illnesses, as shown in Figure 8, [52].

**Figure 8. Risks of death by different causes in Spain.**




Next, in light of the average risk of sustaining serious injury in a traffic accident in Spain (16 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 the one shown in Figure 9.

**Figure 9. Question as to subjective perception of risk of death in traffic accident.**




At the end of this introductory part, the 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 carried out.

## Part 2. Visual scale

In the second part of the questionnaire, a first health preference measurement method was used, although the purpose of this task is not to obtain valuations that will be used in estimating the MVQALY or the VoSI, 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.

From part 2 onwards, differences start to emerge among the eight questionnaire models, since the health states being valued are different in each of them, as shown in Table 10. The 3 or 4 states (SF-6D or injuries) are evaluated with the visual scale and modified standard gamble (SG), while only the SF-6D states are evaluated by means of the contingent valuation method: willingness to pay (WTP).



**Table 10. Health states included in each questionnaire model**

| Model | States valued | |
|---|---|---|
| | SF-6D. | *Injuries* |
| **1** | C | F, S |
| **2** | C, J | W, R |
| **3** | C | X, N |
| **4** | J, C | V, L |
| **5** | J | F, S |
| **6** | C, J | W, R |
| **7** | J | X, N |
| **8** | J, C | V, L |

(*) The choices corresponding to the sequences of these two states are gradually alternated (a non-transparent search procedure).

Each interviewee is shown the description of the 3 or 4 states they are to evaluate, as distributed in Table 10, in the terms shown in the previous Figure 5 and Figure 6. Once they have read (and/or listened to) the descriptions, they are asked according to their preference to put these three (or four) hypothetical states in order, 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 (0 and 100), respectively identifying the "worst imaginable state of health" and "best imaginable state of health", as shown in the description of Figure 10.

**Figure 10. Visual analogue scale (example states J, F, S).**

*Interviewer: Show them the tablet so that the interviewee can assess each situation. They need to do it by themselves, and we explain to them that:*

P17. This screen shows a scale, where **0 is the worst** state of health you could imagine, and **100 is the best** imaginable state of health. We want you to position each of the states described (J, F, S) with your state of health TODAY and death on the scale according to your opinion on current situation.

For example: if you believe that the worst thing that could happen is for someone to die, you will place death on the far left, "Worst imaginable state of health", equivalent to 0. If, meanwhile, you believe there are health states worse than death, you should give death a higher value than this situation that you see as less desirable than being dead


## Part 3. Losses of utility/relative values: modified standard gamble

In part 3, the interviewees face a series of tasks based on the modified standard gamble (SG) methodology, i.e. questions focused on ascertaining the relative value of the different health states, or in the specific terminology of economic evaluation, measuring the utilities of these states compared to death and perfect health. However, the format in which the questions are administered varies slightly among the different models of questionnaire, with all of them including an additional question of a reflexive nature, as indicated below.

The format chosen for this modified SG or double gamble was explained in detail in section 3.3. All participants respond to three or four tasks based on this method, depending on the model of questionnaire assigned to them at random. Each of these valuation tasks involves one of the 10 health states, distributed across the groups as shown in Table 10.



All the interviewees value two injuries (F, W, X, V, S, R, N, L), and at least one SF-6D state (C, J). In the case of the injuries, their description and symptoms include a time dimension (time spent in hospital, duration of the symptoms, possible permanent sequelae, etc.). In the case of the SF-6 states, in this part of the questionnaire the interviewees will be asked to assume that the situation described is lifelong, with this time dimension being included on the description card, as shown in Figure 11.

**Figure 11. Descriptions of the SF-6D health states (C, J) in part 3 questions (standard gamble)**

| State C | State J |
|---|---|
| **Quality of life:**<br>• Their health limits them a little in undertaking moderate effort (e.g. moving a table, vacuum cleaning or walking for more than 1 hour).<br>• They have no problems with their work or daily activities as a result of their physical health or emotional problems.<br>• Their health never hampers their social activities (such as visiting friends or family).<br>• They have no pain.<br>They never feel very anxious or despondent and depressed<br>• They almost always have plenty of energy<br><br>**For**:<br><br>• The rest of their life | **Quality of life:**<br>• Their health limits them a great deal in undertaking moderate effort (e.g. moving a table, vacuum cleaning or walking for more than 1 hour).<br>• They have no problems with their work or daily activities as a result of their physical health or emotional problems.<br>• Their health only occasionally hampers their social activities (such as visiting friends or family).<br>• They have pain which moderately interferes with their regular work (in the workplace or at home).<br>• They only occasionally feel very anxious or despondent and depressed.<br>• They almost always have plenty of energy<br><br>**For:**<br><br>• The rest of their life |

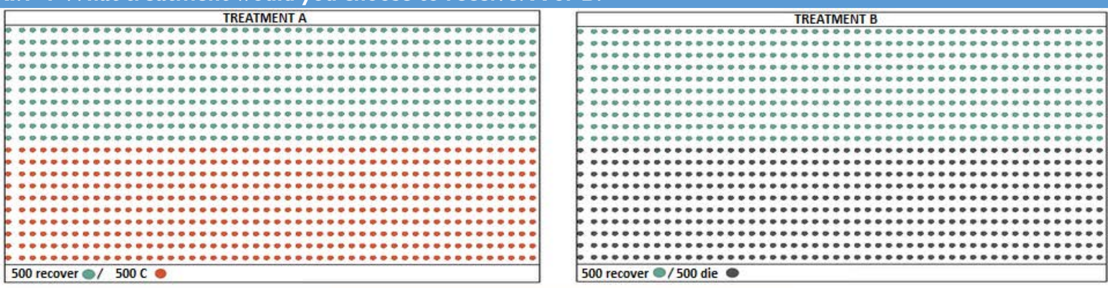
Likewise, in all the groups the sample is divided into according to the questionnaire model, except for those assigned models 5 and 7, two of the sequences of choices intended to obtain the indifference value in the modified standard gamble are administered in a non-transparent manner, by alternating choices from the algorithms corresponding to two states, as explained above. This occurs in the case of states F and S (model 1), states C and J (models 2 and 4), states X and N (model 3), states W and R (model 6) and states V and L (model 8).

Figure 12 shows an example of the description of the scenario together with the first choice that the interviewees must make, for the specific case of state C (SF-6D state 311112).

**Figure 12. Modified standard gamble with state C. Scenario and first choice.**

VR11. Imagine that you have a traffic accident and sustain relatively serious injuries. There are two medical treatments which could in principle be applied in your case: treatment A and treatment B.
Assuming that with treatment A, 500 of every 1,000 people treated respond well to the treatment, fully recovering their health, while 500 of every 1,000 end up in a situation like that in **STATE C**. (*Interviewer: Show the card describing **STATE C**, keeping it visible to the interviewee throughout the process of question choices*). With treatment B, 500 out of every 1,000 patients completely recover their health, while 500 of every 1,000 die.

**VR1.1 1 What treatment would you choose to receive: A or B?**



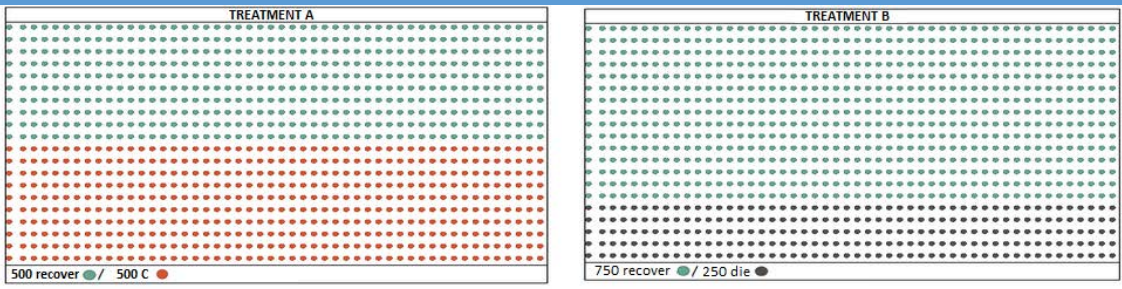

A – 500 recover/500 C

B – 500 recover/500 die

As explained in the previous section, depending on the subject's response, the next choice will raise or lower the probability of recovery, and conversely the risk of death with treatment B. In the event that the interviewee chooses treatment A in this first choice, they would next be shown the choice in Figure 13

***Figure 13. Modified standard gamble. 2nd choice (assuming they choose A the first time).***

VR11_2. And if the situation were as follows, what treatment would you choose?
**Interviewer: it is important to note whether the state gradually changes from one screen to another, and that the interviewee reads the corresponding state each time (focusing on the text and the colour of treatment A)**




A – 500 recover/500 C

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: 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 14.



***Figure 14. Modified standard gamble. Final indifference value question.***

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

**A 500 recover/500 C vs. B 825 recover/175 die**

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

**A – 500 recover/500 C vs. B 850 recover/150 die**

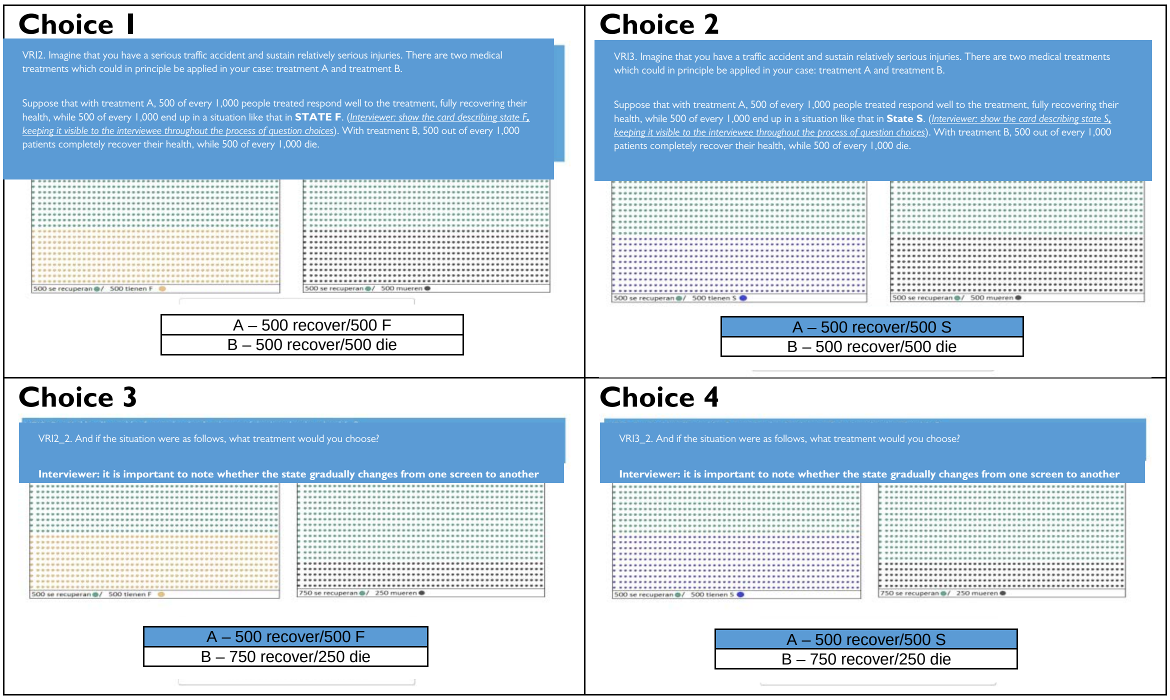
In other words, you would prefer treatment A if the risk of dying with treatment B is **175**, but would opt for treatment B if the risk of dying with that treatment was **150.** Between **175** and **150**, **what is the lowest risk of dying with treatment B that would make you unsure whether the treatment was better or worse than treatment A?**

The procedure is repeated for each of the health states assigned to each questionnaire model, as shown in Table 10. Although in each sequence of choices the interviewee is presented with a card showing the description of the state of health being valued, so that the respondents are aware that the health states are different in each sequence of choices, they are assigned a different colour in the visual aids.

As indicated previously, in order to make the process of selecting the relative values less transparent in the standard gamble method, in some questionnaire models the choices corresponding to the valuation questions that make up the iterative algorithm in pursuit of the indifference value are progressively alternated for two of the states. For example, in model 1 the task of valuing state C is conducted first, followed by the valuation of states F and S by means of this non-transparent procedure: first choice in the algorithm for state F, first choice in the algorithm for S, second choice with F, second choice with S, etc.).

Figure 15 shows the visual aids accompanying the start of this alternate or overlapping sequence of choices. They are initially presented with the first choice in the elicitation sequence corresponding to state F: (500 recover; 500 suffer F) vs. (500 recover, 500 die); next, the first choice in the sequence corresponding to state S (500 recover; 500 suffer S) vs. (500 recover, 500 die). Next, assuming that the interviewee chose treatment A in the first choice, they are presented with the second choice for state F: (500 recover; 500 suffer F) vs. (750 recover, 250 die); then, assuming that with state S they also chose treatment A, the second choice involving this state: (500 recover; 500 suffer S) vs. (750 recover, 250 die). This continues successivelyuntil the respective indifference ranges are defined, at which point the respective open questions are asked in order to establish the indifference value (the risk of death in treatment B that would make the respondent indifferent between the two treatments).

***Figure 15. Modified standard gamble with states F and S. First choices with the non-transparent procedure.***




As indicated, the use of different colours for each state in one single questionnaire model is intended to remind the interviewee that the successive choices they will be facing refer to different healthstates. In this part of the questionnaire, the skill of the interviewer in holding the attention of the participants at all times likewise proves fundamental.

After the three (or four) questions with the SG method, the subject is asked about the element or elements of the scenarios used in these tasks that most influenced their decisions or drew their attention in choosing between treatment A and treatment B. The interviewee can choose as many elements as they wish to highlight from the options shown in Figure 16, and may also add other reasons not specified on the menu.

***Figure 16. Question about elements most influencing choices for the SG.***

Q. We would now like you to tell us which element or elements of those represented in the two previous questions you took most into account when choosing between treatment A and treatment B. Specifically, choose from the following options (you may pick more than one) which best explain(s) how you made your choices between the two treatments. In order to reach your decisions, you considered above all:

| |
|---|
| The whole of treatment A. |
| 500 out of every 1,000 people treated would end up in state (C, F, S) with treatment A. |
| In state (C, F, S) with treatment A. |
| 500 out of every 1,000 people treated recover their health with treatment A. |
| With treatment A there is no risk of dying. |
| 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. |
| You could die with treatment B. |
| Other reasons |
| Please specify |

## Part 4. Contingent valuation (Willingness to pay)

This part of the questionnaire only uses the two health states described according to the SF-6D system, namely states C and J. The aim is to ascertain how much the interviewee is willing to pay (WTP) to avoid experiencing the situations that these states describe. Furthermore, unlike the scenarios presented in part 3 (modified SG), in this case the states are not presented with an indefinite duration, in other words as chronic conditions, but are associated with brief durations, specifically 1 and 5 months.



In half of the questionnaire models a value is only given to one of the two SF-6D states, and in the other half both states (the assignment by model coincides with that shown in Table 10). In cases where only one state of health (C or J) is valued, the WTP question is asked for both durations: 1 month and 5 months; in those subgroups where both states are valued, only one timeframe is used (1 month or 5 months). In short, all the interviewees respond to two WTP questions in this part of the questionnaire, because they either value the two states with a single duration, or evaluate one single state with two durations.

Figure 17 shows the cards used for each state in the case of the shorter duration; those corresponding to the longer duration are identical to these, replacing "1 month" with "5 months". Table 11 summarises the distribution of the contingent valuation tasks in the 8 subgroups, according to the questionnaire model.

**Figure 17. Descriptions of the SF-6D health states (C, J) in the part 4 questions (contingent valuation). 1-month duration example.**

| State C | State J |
|---|---|
| **Quality of life:**<br>• Their health limits them a little in undertaking moderate effort (e.g. moving a table, vacuum cleaning or walking for more than 1 hour).<br>• They have no problems with their work or daily activities as a result of their physical health or emotional problems.<br>• Their health never hampers their social activities (such as visiting friends or family).<br>• They have no pain. They never feel very anxious or despondent and depressed<br>• They almost always have plenty of energy<br><br>**For**:<br>• 1 month | **Quality of life:**<br>• Their health limits them a great deal in undertaking moderate effort (e.g. moving a table, vacuum cleaning or walking for more than 1 hour).<br>• They have no problems with their work or daily activities as a result of their physical health or emotional problems.<br>• Their health only occasionally hampers their social activities (such as visiting friends or family).<br>• They have pain which moderately interferes with their regular work (in the workplace or at home).<br>• They only occasionally feel very anxious or despondent and depressed.<br>• They almost always have plenty of energy<br><br>**For:**<br>• 1 month |

**Table 11. Part 4 (WTP) questions in each questionnaire model**

| Model | State | Duration |
|---|---|---|
| **1** | C | 1 month, 5 months |
| **2** | C, J | 1 month |
| **3** | C | 1 month, 5 months |
| **4** | J, C | 5 months |
| **5** | J | 1 month, 5 months |
| **6** | C, J | 5 months |
| **7** | J | 1 month, 5 months |
| **8** | J, C | 1 month |

The valuation scenario is as follows: the interviewee is asked to imagine that after having a traffic accident they find themselves in the situation described for the state in question (C or J), and will remain in that situation for a limited period (1 month or 5 months). They are next asked to imagine that they are offered a novel treatment, thanks to which they could achieve immediate recovery, avoiding the problems associated with state C (J). Figure 18 presents the scenario for the case of state J with a duration of 5 months.

It is explained to the interviewee that the treatment is not covered by the public health system, and they would therefore need to pay a certain amount of money to receive it. They are specifically informed that although the effect would be immediate, to avoid complications they would be required to take the treatment for 12 months and pay a certain fixed monthly amount throughout that year.

**Figure 18. Contingent valuation scenario. WTP to avoid state J for 5 months.**

Imagine that you have sustained injuries as the result of a **traffic accident**. With the standard medical treatment covered by the public health system, you would spend 5 months in a situation as described in state J, following which you would recover your health, without any type of after-effect.

Now imagine that you are offered a novel treatment, outside the public health system, thanks to which you would recover your health immediately, avoiding the 5 months spent in state J.

*Interviewer: Show card with state J, 5 months, and novel treatment*

**State J**

**Quality of life:**

- Their health limits them a great deal in undertaking moderate effort (e.g. moving a table, vacuum cleaning or walking for more than 1 hour).
- They have no problems with their work or daily activities as a result of their physical health or emotional problems.
- Their health only occasionally hampers their social activities (such as visiting friends or family).
- They have pain which moderately interferes with their regular work (in the workplace or at home).
- They only occasionally feel very anxious or despondent and depressed.
- They almost always have plenty of energy

**WITH NOVEL TREATMENT**

- **Immediate recovery**

ADVANCE

As explained in section 3.3, the WTP is not obtained directly by means of an open question, but through a blended format where participants respond whether they would or would not pay (or if they are not sure whether they would pay) various amounts of money presented to them at random, and they then specify the maximum amount they would pay per month for one year, in the range delimited by their prior 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 19.



**Figure 19. Payment card (figures in euros) for the question on willingness to pay (WTP).**

| | | |
|---|---|---|
| 5 | 10 | 30 |
| 50 | 100 | 300 |
| 1,000 | 3,000 | 10,000 |

The respondent sees the payment cards, one by one and in random order, and replies "definitely would pay", "definitely would not 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 20 shows an example.

***Figure 20. Example willingness to pay (WTP) question.***

VC1a. Although the effect of the treatment would be immediate, to avoid complications you would need to take it for **twelve months** (the treatment has no side effects). **Payment for the treatment would be** monthly so you would have to pay a fixed amount each month for one year. You **will now be shown different amounts of money.**

Bearing in mind your level of income and the expenses you have each month and at the end of the year, please **indicate** for each of these amounts whether **to access the novel medical treatment**...

*Interviewer: Read response options and amount*

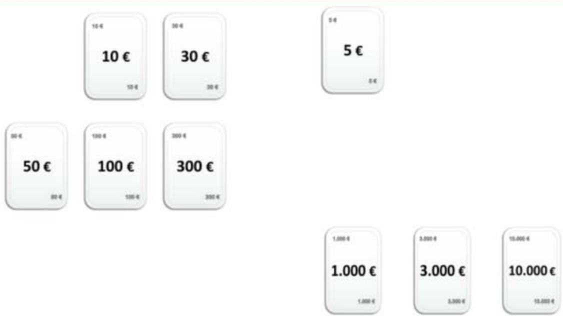

| |
|---|
| **You would certainly** pay that amount each month for one year |
| **You would certainly not** pay that amount each month for one year |
| **You do not know** whether you would pay that amount each month for one year |

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 presented in Figure 21. The example shown indicates that the respondent displayed an inconsistency in their responses (asserting that "they would certainly not pay" €5, while nonetheless stating that "they would certainly pay" between €10 and €300). In such situations, the interviewee is alerted to the inconsistency and invited to revise and correct their responses.

***Figure 21. Example of inconsistent distribution of responses to question VC1 (WTP).***

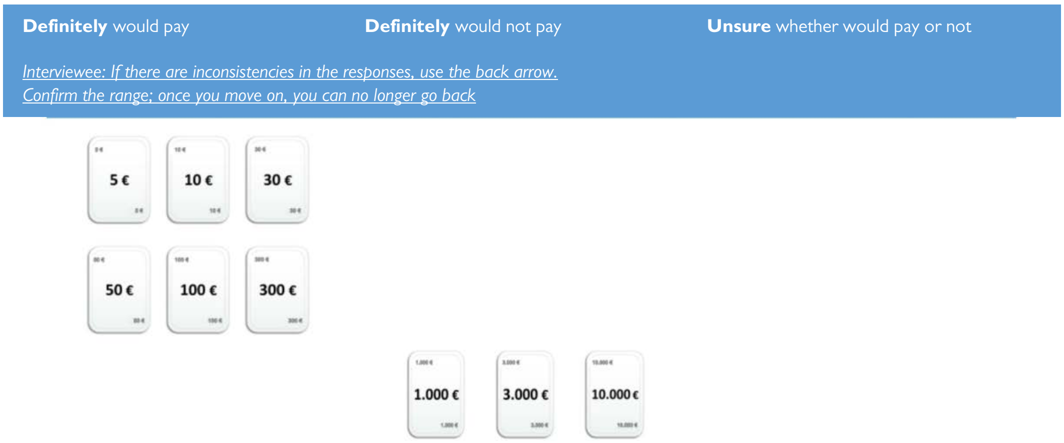
| **Definitely** would pay | **Definitely** would not pay | **Unsure** whether would pay or not |
|---|---|---|

*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 achieved, a range is defined, within which we need to find the precise value which is the maximum the interviewee would be willing to pay for the novel treatment to prevent them experiencing state X. In the example Figure 22 given below, this range has a lower bound of €300 (the greatest amount that they would certainly pay) and an upper bound of €1,000 (the lowest amount that they would certainly not pay). The final open question would therefore be: "Between €300 and €1,000, how much would you be prepared to pay?".

***Figure 22. Example of final distribution of responses to question VC1 (WTP).***




The aforementioned descriptions in the WTP questions are common to all eight groups (changing the states and durations, as indicated in Table 11). However, in four of the questionnaire models (2, 4, 6 and 8), before the interviewee begins to see the cards with the amounts of money and decide whether or not they would pay each of them, they are given the following warning:

"*Bear in mind, before indicating the option you choose on each occasion, 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.*"

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



Furthermore, in the aforementioned groups 2, 4, 6 and 8, after each of the WTP elicitation processes, another question is asked, where the interviewee is asked to think about how their life (work and leisure) and their family life would be affected by having an accident with the consequences described on the card in question (state C/state J; 1 month/5 months), setting out their responses on a scale from "Very little" to "A great deal".

**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. 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 via a question such as that indicated in Figure 23, differentiating between whether it was their own experience or that of a person in their closer 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 (such as sounding the horn, shouting or gesturing at other drivers, flashing their headlights), as well as weight and height.

***Figure 23. Question on past road accident experiences.***

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

If you have had more than one accident, you may mark different options
Use "not applicable" if the interviewee has no such relationship. For example, they have no children, are orphaned or do not have information about their father/mother

| | | | | | |
|---|---|---|---|---|---|
| Own | 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 likelihood between 0 and 100 do you give to being alive at the age of 75 years/85 years/95 years?"); and furthermore the degree to which they are satisfied and happy with their life, for which they must respond to the questions shown in Figure 24. Lastly, the 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 24. 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: Remember the scale, and avoid tending always 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 monetary value of the QALY*

### *3.5.1. Estimation of the MVQALY by means of the enhanced chained approach.*

As explained in section 2.2, the chained approach to estimate the MVQALY involves breaking down the process of obtaining the WTP for health gains measured in QALY, into two stages. The purpose of this approach, as with the 'CV/SG chained approach' proposed by Carthy et al. (1999) to estimate the VSL, is simply to offset the insensitivity problems of the WTP method, or in other words the lack of proportionality between the WTP values declared by the respondents and the magnitude of the health gains and/or the probabilities of occurrence of those gains (Beattie al., 1998).

However, the studies that followed the chained approach have not succeeded in dissipating the problems of lack of proportionality in the WTP, nor in reducing the volatility of the MVQALY estimates, for reasons such as those previously explained in section 2.2, such as the limit imposed by budgetary restriction, the reluctance of a significant number of interviewees to accept any risk of death ('non-traders') in exchange for a health gain, or the fact that negative utilities are frequently ignored.

The enhanced chained approach proposed in this study is based on the approach described, with a series of modifications made to take into account the aforementioned limitations of the chained approach in its practical application, and the lessons learned from the analysis conducted by the research team in the study by Abellán et al. (2011b). Specifically, the enhanced chained approach sets out to undertake the first two stages of the estimation procedure as follows:

1. The utility of two described healthstates is obtained by means of a multi-attribute classification system: the SF-6D (Brazier et al., 2002). This utility is obtained in two alternative ways:
    a. Directly, from the declared preferences of the interviewees, using a modified standard gamble or double gamble method (specifically that used by Abellán et al., 2012) to estimate the SF-6D algorithm for Spain.
    b. Indirectly, by applying to each state of health the utility corresponding to it according to this algorithm, namely the utility of the Spanish tariff for the same SF-6D instrument. The estimate resulting from this exercise will be shown in Appendix I, given that it is purely intended to illustrate the methodology which was included in the category 'Other' in Figure 2, in the explicit QALY value estimation approach.[52]
2. The WTP for the health gain associated with avoiding the two states selected for two brief periods (1 month and 5 months) is obtained in order to attenuate the impact of the budgetary restriction. The expectation is that the utilities of the health states derived from stage 1 will be lower than those that would have resulted from using the standard gamble technique, relying on this offsetting the problems of lack of proportionality in the WTP values.



The modified SG used in stage 1 of the procedure has two benefits compared with the traditional approach. First of all, avoiding the "certainty effect" (Kahneman & Tversky, 1979), given that there is no certain outcome in either of the two alternatives or treatments, mitigates the problem of non-traders (those refusing to accept any risk of death to improve quality of life), which is the why utilities very close to one are obtained. Furthermore, it is capable of obtaining utilities lower than zero (states considered "worse than death"), unlike in the case of the modified standard gamble format used by Carthy et al. (1999).

Furthermore, in some of the questionnaire models used in the study, a non-transparent iterative process is employed in order to search for the indifference value between the gambles for each participant. As Pinto et al. (2018) demonstrate, this type of non-transparent procedure leads to a significant reduction in violations of the invariance of the procedure, this being one of the specific reasons explaining the volatility of MVQALY estimates.

### *3.5.2. Obtaining the MVQALY anchored in the VSL.*

Aside from the aforementioned chained approach, this study replicates the approach to calculating the MVQALY trialled in the 2011 study, obtaining this value anchored in the VSL estimated on the basis of survey 1.

To do so, aside from the VSL, we need to calculate the "Quality-Adjusted Life Expectancy" (QALE), which is calculated by means of the "life tables"[53]normally used to estimate the life expectancy of the population (life expectancy at birth, life expectancy at age 65, etc.).

[52] Sometimes in the academic literature this form of estimate based on the utilities of some multi-attribute instrument, such as the SF-6D, is referred to as "indirect" (e.g. Nimdet et al., 2015).
[53] The life tables (see, for example, Chiang, 1976) are constructed by assuming that the probability of survival by sex and age group remains constant over time. In other words, it is assumed that the probability of survival of a person who is now aged 30, will in another 30 years' time be the same as that enjoyed by a person currently aged 60.

The life expectancy for the subjects belonging to the age group $x$:

$$EV_x = \frac{\sum_{i=x}^{s} L_i}{l_x} \qquad [11]$$

where $L_i$ represents the total number of years lived per cohort of individuals for ages between $x$ and $s$ (the last age band on the life table), and $l_x$ indicates the number of survivors at the start of the age group $x$.

The QALE for the subjects in the age group $x$is calculated as:

$$EVAC_x = \frac{\sum_{i=x}^{s} AVAC_i}{l_x} \qquad [12]$$

the numerator now being the years of life of the cohort of individuals with ages between $x$ and $s$, but "quality-adjusted":

$$AVAC_x = L_x \cdot \sum_{i=x}^{s} U_{Q_i} \cdot prev_{Q_x} \qquad [13]$$

where $U_{Q_i}$ represents the utility or "quality of life weighting" of the state of health $Q_i$ and $prev_{Q_x}$ indicates the prevalence of that state within the age group $x$. In order to estimate $U_{Q_i}$ we use the set of values or tariff of SF-6D utilities estimated for Spain (Abellán et al., 2012).[54]

Assuming that the QALE thus calculated is discounted at a certain rate $d$, the MVQALY is obtained as the quotient of the VSL and the discounted QALE of the individual representing those killed in a traffic accident. To identify this representative individual, the mean age at death in a traffic accident in Spain in 2021, by age group (imputing the mean value for each group range) was obtained.

$$VMAVAC = \frac{VVE}{EVAC\,(d)} \qquad [14]$$



## 3.6. Calculation of the monetary value of a statistical non-fatal injury

### 3.6.1. Calculation of the VoSI anchored in the VSL and based on relative utility losses.

The results obtained in part 3 of the survey, with the SG method for the eight injuries of differing seriousness, allows us to ascertain each of their relative values compared to death, i.e. the value given to avoiding each of these consequences in a traffic accident with regard to the value attributed to avoiding death as a result of an accident.

It should be remembered that the SG method employed in this study corresponds to the following framing:

$$A: (0.5, Estado\ i;\ SN)\ vs. B: (p_i, M;\ SN)$$

Where $Estado\ i$ is the state of health describing the consequences of a non-fatal traffic accident, $SN$ a normal state of health, and $M$ death. The result of the iterative search procedure is to obtain the value $\overline{p_i}$ which makes the respondent indifferent between the two treatments (A and B). Assuming that the participants behave in accordance with expected utility theory, this condition of indifference may be expressed as

$$0.5\ U(i) + 0.5\ U(SN) = \ p_i\ U(M) + (1 - p_i)\ U(SN) \qquad [15]$$

[54] Each age cohort is assigned the mean utility resulting from considering the distribution of SF-6D states among the population, according to the responses of the sample participants, representing the Spanish population by sex and age (n=2050), used to estimate the Value of a Statistical Life in Spain.

And assuming that $U(SN) = 1$ and $U(M) = 0$, the utility of the state of health $i$ is obtained as:

$$U(i) = \frac{1-p_i}{0.5} - 1 = 1 - 2\,p_i \qquad [16]$$

The relative value of avoiding a non-fatal accident compared to avoiding a fatal accident ("relative utility loss") is obtained as the quotient of the loss of utility associated with having a non-fatal accident and the loss of utility derived from dying in an accident:

$$VR_i = \frac{U(SN)-U(i)}{U(SN)-U(M)} = \frac{1-(1-2p_i)}{1-0} = 2\,p_i \qquad [17]$$

The VoSI will thus be a proportion of the *VSL*:

$$VVnM = 2\,p_i\,VVE,\ 2\,p_i\ \in (0,1) \qquad [18]$$

Since in our study we have the utilities for eight health states or injuries of differing seriousness, we calculate the VoSI for each of these eight non-fatal injuries based on the VSL, using their respective relative utility losses[55]. These eight VoSI values give us the minor VoSI, the serious VoSI and the VoSI, as a weighted mean of all or some of them, as explained below.

To aggregate the monetary values associated with each of the non-fatal injuries and obtain the different VoSI values (minor and serious) we will follow a methodology similar to that in the 2011 study (Abellán et al., 2011b). With regard to the minor consequences of traffic accidents, the DGT assigns this condition to cases where hospital admission is not required, or hospitalisation lasts under 24 hours, while all accident victims requiring hospitalisation greater than this threshold are classified as serious. According to this criterion, only the scenario labelled F in our study can be deemed as equivalent to the description of the consequences of a minor accident, since it is a state which does not entail any period of hospitalisation, while the next most serious (state W) already entails one week's hospitalisation.



Meanwhile, although state F was included with the other seven states in the British study, when calculating the serious VoSI, as we did in 2011, we draw upon the methodology followed in the United Kingdom to calculate the value of the human costs of slight injuries. In the absence of data on the prevalence of minor accidents with and without the need for medical care, or in general as to the factors associated with minor injuries caused by traffic accidents in Spain and their distribution, we assume, as in the procedure followed in the British study, that minor accidents with a degree of significance account for just 20% of the total, and are described by state of health F. We presume, then, that in all other cases the consequences are not significant for the victim's health, making it reasonable to consider their monetary valuation as insignificant, if not null.

As for aggregating the monetary values of the remaining health states to estimate the serious VoSI, in the absence of our own data as to the prevalence of each of the scenarios described in states W to L, as in 2011 we draw upon the frequencies observed in the United Kingdom. Since in this study, unlike the British one, the serious VoSI is calculated as the weighted mean of seven of the eight injuries evaluated (excluding state F), we need to re-weight those frequencies. The original and re-weighted frequencies are shown in Table 12.

[55] In the 2011 study, this procedure was not applied in the case of the two most serious states (N and L), because of the inability of the SG framing employed at the time to reflect the true preferences of the subjects in cases where the state of health was considered "worse than death"; nor was it used in the case of the most minor state (F), for which a double chaining approach was used. The framing chosen for the modified SG in this study does not suffer the limitations which affected the method used in 2011 (as proposed by Carthy, et al. 1999), and so the procedure described is applied in the same way to all eight injuries.

***Table 12. Prevalence of the different types of injury in the United Kingdom and re-weighting to calculate the serious VoSI in Spain.***

| | United Kingdom frequency | Re-weighted frequency |
|---|---|---|
| State F | 19.00 | --- |
| State W | 15.00 | 18.52 |
| State X | 31.50 | 38.89 |
| State V | 6.00 | 7.41 |
| State S | 13.00 | 16.05 |
| State R | 14.00 | 17.28 |
| State N | 0.75 | 0.93 |
| State L | 0.75 | 0.93 |
| **Total accidents** | 100.00 | 100.00 |

Source: O'Reilly et al. (1994) and produced by the authors.

### *3.6.2. Calculation of the VoSI anchored in the VSL and based on the relative values from the USA.*

As seen in section 2.2 of this report, it is possible to obtain the VoSI from the VSL. This is done by drawing on the relative values produced by the US Department of Transportation (Blincoe et al., 2023), as shown in Table 1 of section 2.2. The procedure simply involves multiplying the relative disutility factor associated with each maximum AIS level by the VSL. This will give us the monetary valuation derived from each of the different maximum AIS levels (MAIS1, MAIS2, MAIS3, MAIS4 and MAIS5).

To aggregate these values and obtain the monetary values of statistical non-fatal injuries (VoSI), for minor and serious accidents, the US Department of Transportation data are also used, for the last available year: 2019. Specifically, MAIS1 and MAIS2 are considered minor accidents, while MAIS 3, MAIS 4 and MAIS 5 are considered serious for the purposes of inclusion in the weighted means.

***Table 13. Frequency of victims according to MAIS in traffic accidents, USA, 2019.***

| Maximum AIS level | Absolute frequency (No. of individuals) | Relative frequency (%) |
|---|---|---|
| MAIS 1 | 3.875.265 | 85,99 |
| MAIS 2 | 427.119 | 9,48 |
| MAIS 3 | 141.167 | 3,13 |
| MAIS 4 | 19.285 | 0,43 |
| MAIS 5 | 7.187 | 0,16 |

*Source:* Blincoe et al. (2023).

### *3.6.3. Calculation of the VoSI anchored in the MVQALY and based on estimated QALY losses in the USA.*

The third approach to estimate the VoSI also draws on the US Department of Transportation data (Blincoe et al., 2023), except that in this case the VoSI is not anchored in the VSL as in the two previous approaches, but is based on the MVQALY estimated in that same study. In essence, once the MVQALY has been obtained, this value is applied as a shadow price to the average health losses (in

QALY) associated with each of the different MAIS levels. These losses correspond to those shown in Table 2 of subsection 2.2.

## 3.7. Calculating the value of preventing an injury in a traffic accident

The value of preventing an injury (VPI) in a traffic accident is a broader concept than the VoSI, since aside from this (representing the "human" or "health" costs of the accident), it also includes the production losses derived from the accident victims' temporary or permanent inability to work, as well as the healthcare costs (medical and ambulance costs).

Calculating the production losses associated with non-fatal injuries requires selecting an estimation methodology, based on plausible suppositions, since there are no individualised micro data which can be used to calculate the flow of income that a person injured in a traffic accident would cease to generate. Therefore, taking the human capital theory as our reference point, we can make use of information on salaries, according to sex and age, to approximate the flow of income (or of value added generated) interrupted when the person has the accident. This is the approach followed in Abellán et al. (2022), whose data we use in this study, and whose methodology is described below.

Observed salary data are first 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 injured in traffic accidents form 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 suppositions to be assumed, so as to obtain a plausible estimation of the value of these flows discounted to the present.



The first supposition is that the likelihoods of being employed in the future will remain constant for each age group. With regard to salary levels, in the interests of simplicity it can be assumed that they also remain constant (in real terms). However, the estimate assumes a productivity growth rate (and hence a salary increase) of 1%. Thirdly, in order to calculate the present value of these lost production flows, a discount rate of 3% was used, a standard procedure in any estimate of the present value of a future flow of costs or benefits.[56]

The aforementioned circumstances are common to those assumed to estimate the production losses associated with accident fatalities. In the case of non-fatal injuries, we furthermore need to adopt another set of assumptions, and must in particular determine the number of days that a minor and serious traffic accident victim will be unfit for work (with and without hospitalisation). In the former case (state F), the assumed duration of the period of sick leave is 10 days. Serious accidents which nonetheless do not result in sequelae (states W and X) give rise to between 30 and 90 days of work lost; those giving rise to permanent sequelae (V, S, R) will entail between 4 months and 2 years of labour inactivity, and lastly the most serious (M, L) will lead to permanent disability, and the timeframe of the production losses will therefore cover the rest of the accident victim's life. The weightings used to aggregate the production losses of the different health states are the same as those used to calculate the VoSI anchored in the VSL, in other words as shown in the Table 12.

In all cases the assumption is that a working life runs from the age of 16 to 65. As the original estimates correspond to 2019, the figures are updated to 2022 with the INE income update tool (December 2019-December 2022).

[56] These cases are relevant in the case of serious consequences of accidents which give rise to very long-lasting or even permanent periods of disability.

It should be emphasised that these estimates correspond to production losses in gross terms, and unlike the estimation of the production losses from a fatality, productivity costs must be considered in these terms in the case of non-fatal victims, since the flow of consumption is not interrupted at the time of the accident.

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).

# 4. Results

## *4.1. Characteristics of the sample*

The total number of complete observations was 2,027, distributed by autonomous region and size of habitat as shown in Table 14.

***Table 14. 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 | Total |
|---|---|---|---|---|---|---|---|
| Andalusia | 0.5 | 3.0 | 5.3 | 2.5 | 3.9 | 2.4 | 17.7 |
| Aragon | 0.5 | 0.5 | 0.5 | --- | --- | 1.5 | 3.0 |
| Asturias | --- | 0.5 | 0.5 | 0.5 | 0.5 | --- | 2.0 |
| Balearic Islands | --- | 0.6 | 1.3 | | 1.5 | --- | 3.4 |
| Canary Islands | --- | 0.5 | 1.5 | 0.5 | 2.0 | --- | 4.4 |
| Cantabria | --- | 0.5 | 0.5 | --- | 0.5 | --- | 1.5 |
| Castile and Leon | 1.5 | 1.0 | 0.9 | 0.5 | 0.9 | --- | 4.8 |
| Castile-La Mancha | 0.5 | 1.6 | 1.0 | 0.5 | 0.5 | --- | 4.0 |
| Catalonia | 0.5 | 1.9 | 4.3 | 1.9 | 3.4 | 3.9 | 16.0 |
| Valencia | 0.5 | 1.5 | 4.6 | 1.5 | 1.5 | 2.0 | 11.7 |
| Extremadura | 0.5 | 0.5 | 1.0 | 0.5 | --- | --- | 2.5 |
| Galicia | 0.5 | 1.0 | 1.8 | 1.0 | 1.5 | --- | 5.8 |
| Madrid | 0.5 | 0.5 | 1.0 | 2.0 | 2.9 | 6.8 | 13.7 |
| Murcia | --- | --- | 1.0 | 0.5 | 1.5 | --- | 3.0 |
| Navarre | --- | 0.5 | 0.5 | 0.0 | 0.5 | --- | 1.5 |
| Basque Country | 0.5 | 0.5 | 1.0 | 0.5 | 2.0 | --- | 4.5 |
| Rioja | --- | --- | --- | --- | 0.5 | --- | |
| **Total** | **5.9** | **14.6** | **26.8** | **12.4** | **23.6** | **16.7** | **100.0** |

The distribution shown in the table reveals slight differences compared with the initial design, although the deviations are only small. Table 15 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 15. Sample composition by sex and age group.***

| | Male | Female | Total |
|---|---|---|---|
| 18 to 24 years old | 4.4 | 4.4 | 8.8 |
| 25 to 34 years old | 6.9 | 6.9 | 13.8 |
| 35 to 44 years old | 8.4 | 8.5 | 16.9 |
| 45 to 54 years old | 10.0 | 10.4 | 20.4 |
| 55 to 64 years old | 8.8 | 8.6 | 17.4 |
| 65 or over | 9.7 | 13.1 | 22.8 |
| **Total** | **48.2** | **51.8** | **100.0** |

As set out in the previous section, those included in the sample were assigned at random to different subgroups, and were given versions of the questionnaire which differed in some aspects. Table 16 presents the respective sample sizes associated with each of these questionnaire versions or sample subgroups, together with information as to the mean duration of the interviews.

***Table 16. Distribution of the sample by subgroup (questionnaire model) and mean duration of the interviews.***

| Model | Observations | % | Mean duration |
|---|---|---|---|
| **1** | 256 | 12.6 | 33.66 |
| **2** | 249 | 12.3 | 35.53 |
| **3** | 250 | 12.3 | 33.60 |
| **4** | 255 | 12.6 | 35.54 |
| **5** | 246 | 12.1 | 33.72 |
| **6** | 270 | 13.3 | 35.39 |
| **7** | 250 | 12.3 | 33.83 |
| **8** | 251 | 12.4 | 35.60 |
| **Total** | **2,027** | **100.0** | **34.62** |

As can be seen in the table, the mean duration of the interviews was 34.62 minutes, with slight differences being recorded among groups. The minimum interview duration was 28.9 minutes, and the maximum 42.1 minutes.

Information on the main sociodemographic characteristics of the study participants is presented in Table 17 (marital status, educational level, employment status, stated level of income and household characteristics). With regard to marital status, 56.3% of our sample comprises people who are married or have a civil partner, 29.3% are single, 7.5% are separated or divorced, and 6.7% 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 have not completed any education beyond primary education, representing a slight over-representation of this group compared to the Spanish adult population; 42% of the sample have completed secondary studies, and 29% higher education (in both cases, the proportions are slightly lower than those seen in the population as a whole).

***Table 17. Marital status, educational level, employment status, level of income and household characteristics of the sample participants.***

| **Marital status** | **%** |
|---|---|
| Single | 29.3 |
| Married or civil partner | 56.3 |
| Separated or divorced | 7.7 |
| Widowed | 6.7 |
| **Level of education** | **%** |
| No education | 2.8 |
| Primary | 25.7 |
| Secondary | 42.3 |
| Higher | 29.2 |
| **Employment situation** | **%** |
| Temporary private sector employee | 7.9 |
| Permanent private sector employee | 33.0 |
| Civil servant | 4.6 |
| Non-civil servant public employee | 2.3 |
| Self-employed | 7.3 |
| Business owner | 1.1 |
| Unemployed | 8.0 |
| Retired/pensioner | 22.5 |
| Homemaker | 7.0 |
| Student | 5.1 |
| Other | 1.2 |
| **Level of income** | **%** |
| Under 900 euros | 10.4 |
| Between 900 and 1,200 euros | 16.6 |
| Between 1,200 and 1,500 euros | 19.9 |
| Between 1,500 and 2,000 euros | 21.6 |
| Between 2,000 and 2,500 euros | 15.9 |
| Between 2,500 and 5,000 euros | 13.6 |
| Over 5,000 euros | 2.1 |
| **Household characteristics** | |
| Households with dependent children (%) | 31.4 |
| Average number of children | 0.5 |
| Households with dependent senior citizens (%) | 7.4 |
| Average number of senior citizens | 0.1 |
| Average household size | 2.7 |



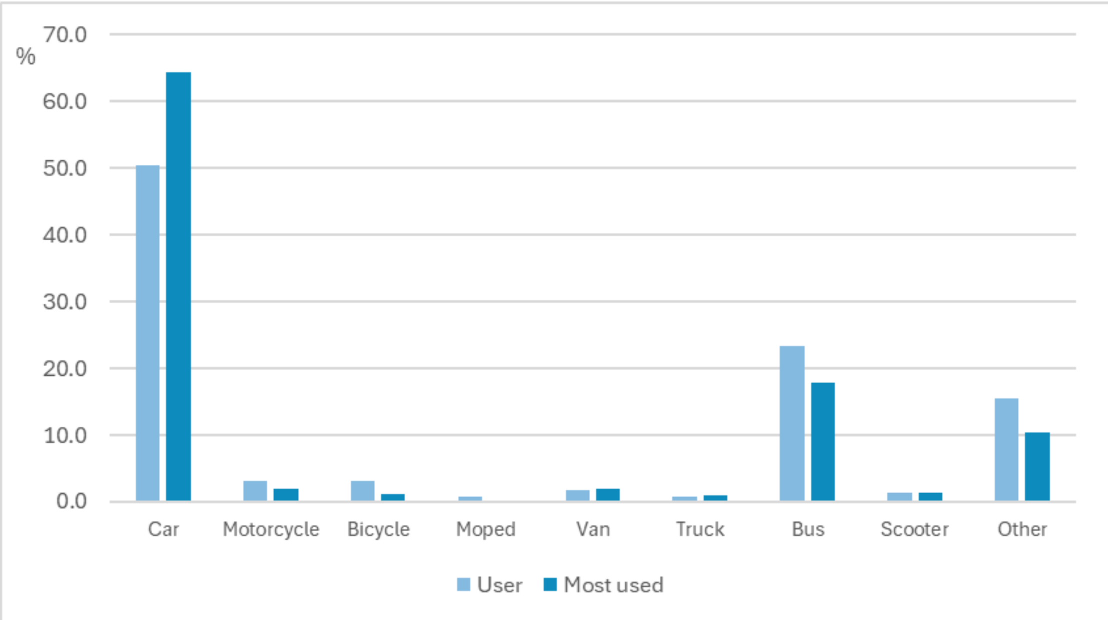
As for the employment status of the interviewees, 56.2% of the sample are part of the employed population: 40.9% are private sector employees, mostly with a permanent contract, 7.9% are public sector employees (4.6% civil servants), and 8.4% are self-employed or business owners. At the time the survey was conducted, 163 of the participants were unemployed (8% of the total). As for inactive population groups, the largest proportional category in the sample corresponded to retired people/pensioners, representing 22.5% of the total, followed by homemakers (7.0%) and students (5.1%). 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, while in the case of students, civil servants and homemakers, there is a significant negative deviation between the proportion present in the sample and their share in the Spanish adult population.

More than half of the interviewees (51%) declared a household income of between 1,500 and 5,000 euros. A slightly smaller percentage (47%) live in households with monthly income equal to or less than 1,500 euros, and just 2.1% of the sample declared household income of more than 5,000 euros. These data differ significantly from those presented 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 of income or less accounted for 22% of the total population, while those living in households with monthly income of 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 regard 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 17 provide information on the characteristics of the households which the interviewees belong to. In 31.4% of cases, the respondent lives in a household where there are dependent children, while 7.4% 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 25 shows that slightly more than 50% of the interviewees regularly use a car as a means of transport. Buses represent the second most commonly used form of transport among the sample, with 23.4% of respondents stating that they use the bus. Motorbikes and mopeds are used by 3.1% and 0.7% of the sample respectively, while 1.7% drive a van, and 0.8% a truck. As for the use of more sustainable vehicles, 3.1% of the sample state that they use a bicycle, and 1.4% a scooter.

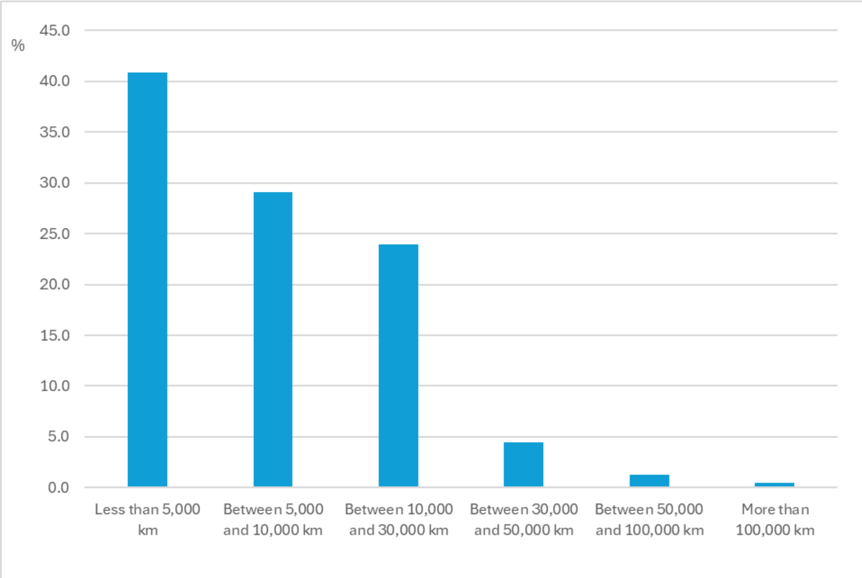
***Figure 25. Use of means of transport and most typical means of transport (%).***




If we consider the means of transport most used by each of the interviewees (including those cases where only one is used), the order is similar to the above, with cars standing out above all others at 64.3%. This is followed in frequency by exclusive or main use of the bus (17.9%), with motorcycles and vans much further behind (both at 1.9%). The bicycle is the only or majority means of transport for 1.2% of the respondents, and scooters for 1.3% of them.

The intensity of use of means of transport among the members of the sample, measured by means of the approximate number of kilometres covered per year, is represented graphically in Figure 26, which reveals that almost 41% of the interviewees state that they cover at least 5,000 kilometres by road, irrespective of the means of transport used. 29% state that they cover between 5,000 and 10,000 kilometres per year, and 24% between 10,000 and 30,000. The remaining respondents (6%) state that they cover more than 30,000 kilometres per year by various means of road transport.

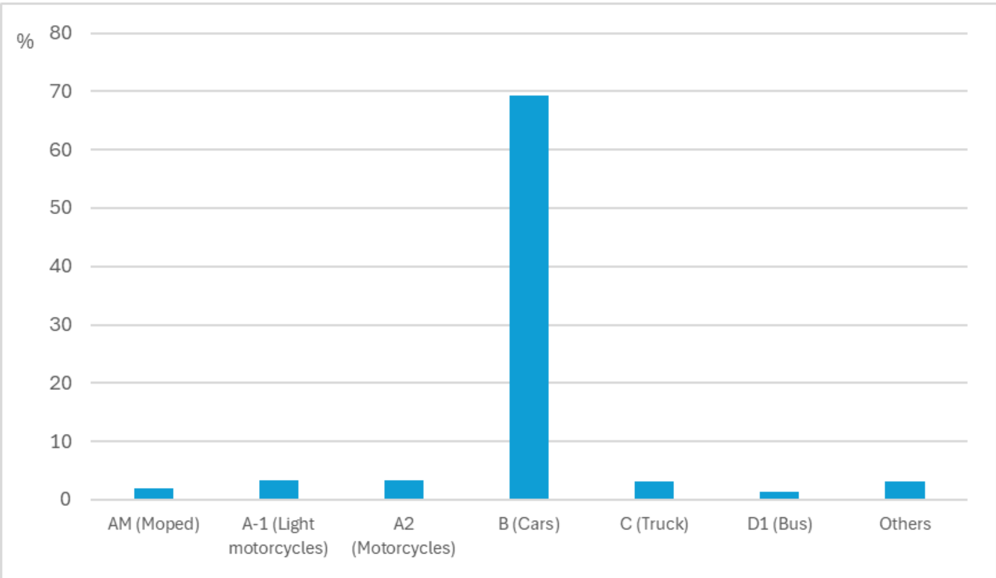
**Figure 26. Number of kilometres travelled per year.**




70.5% of study participants stated that they held a driving licence. By far the most common was the class B (car) licence, held by 69% of interviewees, as can be observed in Figure 27. 6.6% of the sample stated that they had a motorcycle licence: 3.3% an A1 licence (light motorcycles), and an almost identical percentage the A2 licence. As expected, other licences are in the minority in this sample.



**Figure 27. Driving licences declared by the sample participants.**



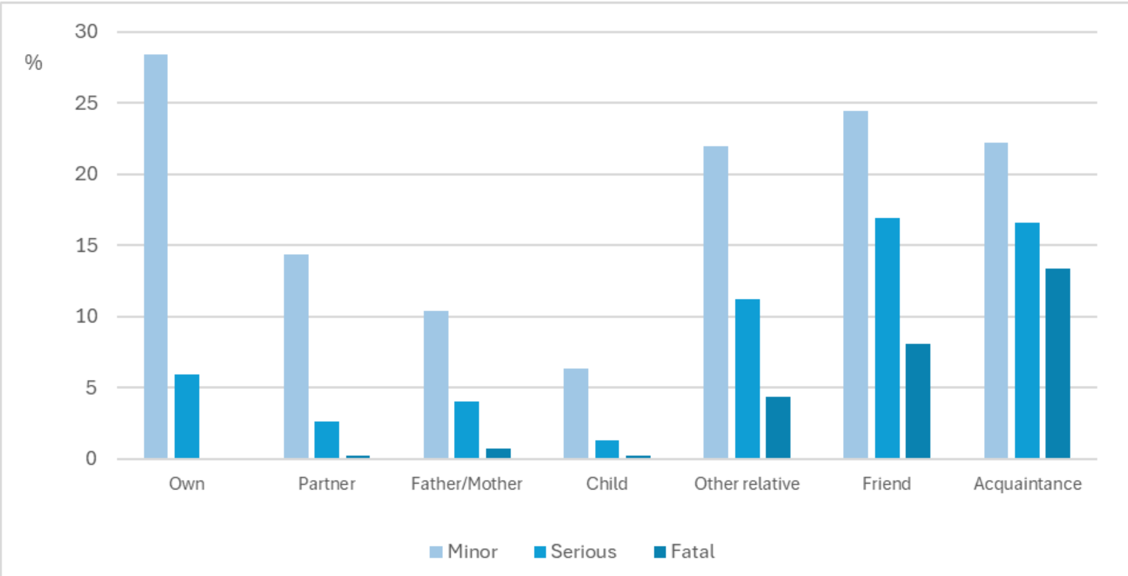

Those who stated that they had some type of vehicle driving licence were asked about the number of points they had on their licence. The responses to this question are summarised in Table 18, according to which 81.6% of the sample have all the points on their driving licence, and more than 90% have 12 or more points, with just 0.4% stating that they have lost all their driving licence points.

**Table 18. Declared points on driving licence.**

| | Number | % |
|---|---|---|
| 0 points | 1 | 0.1 |
| Between 1 and 7 points | 14 | 1.0 |
| Between 8 and 11 points | 44 | 3.1 |
| Between 12 and 14 points | 138 | 9.7 |
| 15 points | 1,165 | 81.6 |
| DNK/DNR | 67 | 4.7 |
| **Total** | **1,428** | **100.0** |

With regard to the interviewees' risk perception, the vast majority declared a subjective risk of having a serious traffic accident equal to (40.9%) or lower than (47.9%) the mean, with just 7% stating that they perceived a risk of sustaining serious injury as a consequence of an accident which was higher than the mean. Figure 28 shows the data on interviewees' prior experience of road accidents.

**Figure 28. Prior direct experience of traffic accidents by seriousness and person affected. (% of total).**




34% stated they had had a traffic accident, which in most cases was minor (28.4%, compared with 5.6% serious accidents). The indirect experience of more serious accidents increases the more distant the relationship between interviewee and victim. Therefore, the percentage of respondents whose partner had had a serious traffic accident was 2.6%; this was 4.1% if the victim was a parent, 11.2% for other relatives, 16.9% in the case of a friend, and 16.6% for acquaintances. Similarly, 5.5% of survey participants had lost a relative in a traffic accident, 8.1% a friend and 13.4% an acquaintance (the percentages were 0.25% in the case of a partner or child, and 0.698% had lost a parent in an accident).

**Table 19. Healthy and unhealthy habits.**

| | I have never smoked | Ex-smoker | Occasional smoker | Daily smoker | |
|---|---|---|---|---|---|
| Tobacco consumption | 44.9 | 21.7 | 7.8 | 25.6 | |
| | **No** | **Occasional** | **Weekends** | **Several times per week** | **Daily** |
| Alcohol consumption | 33.8 | 32.9 | 20.4 | 8.1 | 4.3 |
| | **None** | **Occasional** | **Moderate** | **Several times per week** | **Daily** |
| Physical exercise | 30.9 | 19.4 | 12.4 | 22.7 | 14.6 |

Table 19 shows the summary of the responses to questions about unhealthy (tobacco and alcohol consumption) and healthy habits (physical exercise). One in four respondents stated that they were regular smokers, while a further 7.8% smoke occasionally. Slightly under half of the sample (46.2%) have never smoked, and 21.7% consider themselves to be ex-smokers. As for alcohol consumption, only 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, 28.5% 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, 31% of respondents stated that they do not engage in any type of physical exercise, and 19% only occasionally. The proportion of the sample who regularly engage in physical activity amounts to almost 50%, with 14.6% of the total taking physical exercise every day.



**Table 20. Attitudes towards highway risk and behaviour behind the wheel (% of total).**

| | | | | | Yes |
|---|---|---|---|---|---|
| Has driven under the effects of alcohol | | | | | 19.3 |
| Has driven under the effects of narcotics | | | | | 5.1 |
| Has been a passenger of someone driving under the effects of alcohol or other drugs | | | | | 37.6 |
| | **Always** | **Almost always** | **Sometimes** | **Only once** | **Never** |
| Beep the horn in frustration | 0.4 | 1.8 | 13.6 | 24.1 | 60.1 |
| Insult or shout | 0.5 | 1.5 | 9.8 | 15.6 | 72.6 |
| Flash headlights | 0.3 | 1.5 | 14.6 | 22.5 | 61.1 |
| Make hand gestures | 0.7 | 1.7 | 12.2 | 22.2 | 63.1 |

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 20. Emphasis must be placed on the disturbing statistic from the first part of the table that more than a third of the survey participants (37.6%) state that they have travelled in a vehicle whose driver was under the effects of alcohol or other substances. 19.3% of interviewees admit having got behind the wheel after consuming alcoholic beverages, and 5.1% 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 conduct does not prove to be typical among the respondents (with the sum total of those engaging in such actions always, almost always or occasionally in no case amounting to 20%), as many as 40% have used their horn as a sign of frustration; 39% have inappropriately flashed their headlights on occasion; a slightly lower percentage (37%) have made hand gestures at other drivers, and 27.4% admit having occasionally insulted or shouted at the occupants of other vehicles.

Table 21 sets out the responses to other questions of different types, intended to characterise the study participants. In terms of the biometric characteristics of the respondents, the average declared weight was 73.5 kg, the average height 168.2 cm, and the body mass index (BMI) is thus estimated at 25.9. A quarter of the sample revealed a certain degree of numerical illiteracy, in that they were unable to correctly answer the control questions asked regarding understanding frequencies and probabilities. Lastly, 84.4% of participants stated that they expected to be alive at the age of 75; this percentage falls to 65.4% when the survival threshold is put at 85 years, and down to 34.6% for a life expectancy of 95 years.

***Table 21. Biometric characteristics, numerical skills, survival expectations.***

| | | | |
|---|---|---|---|
| Weight (kg) | 73.5 | | |
| Height (cm) | 168.2 | | |
| Body mass index (BMI) | 25.9 | | |
| | **%** | | |
| Numerical skills (numerical illiteracy) | 25.5 | | |
| | **At age 75** | **At age 85** | **At age 95** |
| Survival expectation (%) | 84.4 | 65.4 | 34.6 |

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 22 shows the distribution of the most frequent states 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, in the aforementioned order. 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.

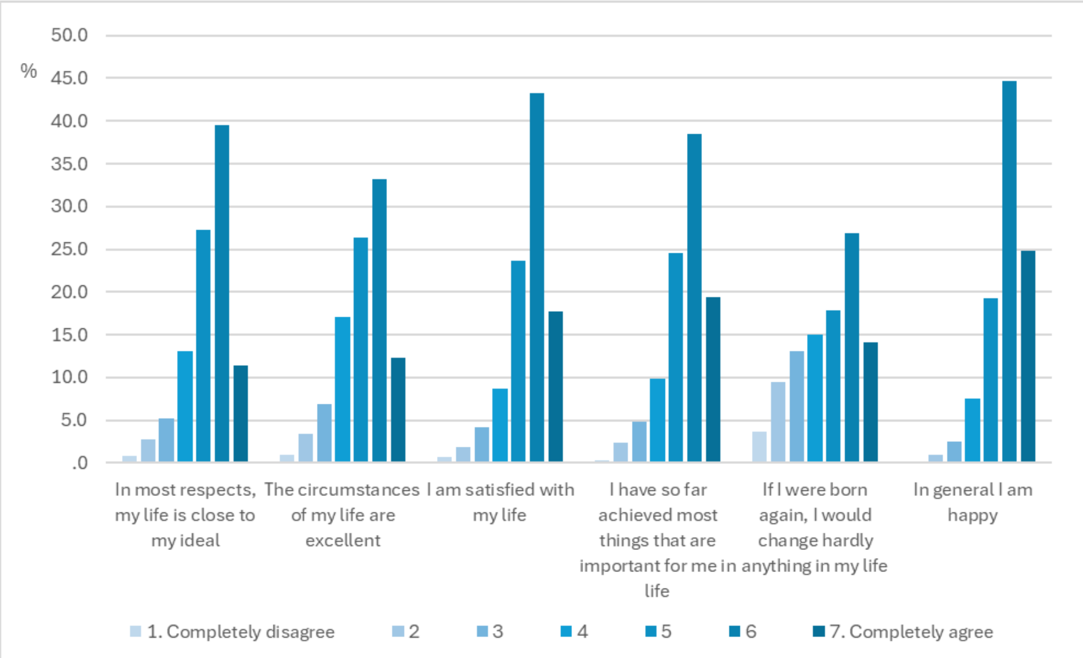
***Table 22. Declared state of health according to the SF-6D descriptive system.***

| State SF-6D | % |
|---|---|
| 111111 | 16.3 |
| 111122 | 6.6 |
| 111112 | 6.1 |
| 111121 | 2.0 |
| 121122 | 2.0 |
| 111222 | 1.5 |
| 222222 | 1.4 |
| 111123 | 1.3 |
| 111212 | 1.1 |
| 121112 | 1.1 |
| 111133 | 1.0 |
| Other | 59.4 |

As can be observed in the table, one in every 6 of the respondents stated that their state of health would be described as 111111. Only 11 SF-6D states are needed to describe the state of health of over 40% of the participants (and just 25 states are required to describe the health condition of half of the sample).

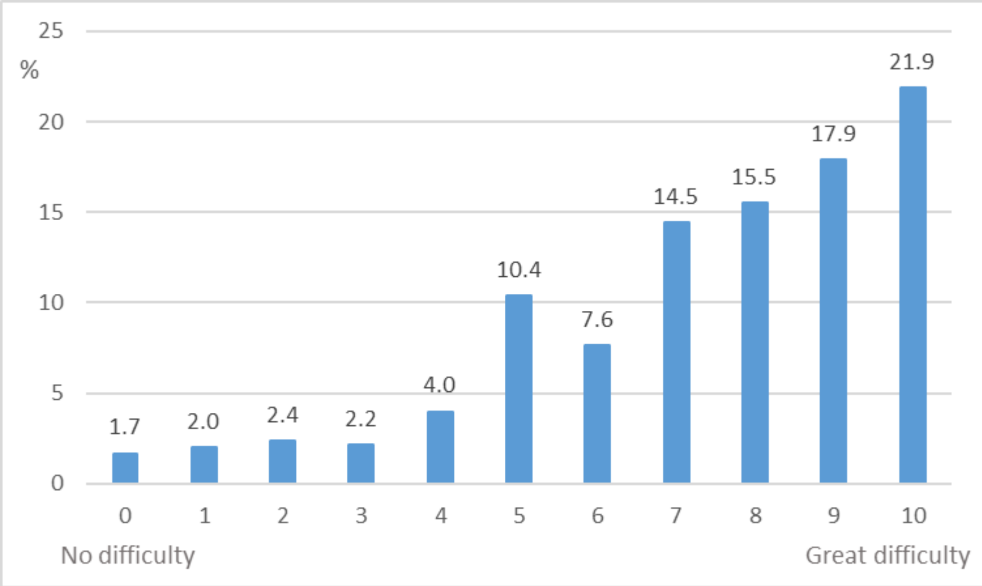
Information was also obtained as to the interviewees' degree of satisfaction with their own life, by means of a set of 5 questions, the responses to which are summarised in Figure 29. In light of these responses, the conclusion which may be drawn is that the participants in the study are in general satisfied 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 a minimum of 59%, and for some of the statements more than 88%. 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 4.7). The phrase "In general I am happy" receives the highest mean score of all (5.8), with 70% of the respondents stating that they "agree" or "completely agree".

***Figure 29. Degree of life satisfaction. Distribution of the responses (%).***




To conclude this section focused on characterising the profile of the participants in the study, Figure 30 presents the distribution of the responses to the question on the degree of difficulty they experienced in answering the survey, on a scale from 0 to 10. 22% of interviewees gave the survey the highest degree of difficulty, with as many as 77.4% of the 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 30. Degree of difficulty of the questionnaire.**




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

In the first appraisal task, the 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 23 presents the respective scores for these four states on the VAS. Both the mean and median values correspond to expectations in ordinal terms. The score assigned to their own state of health is the highest, and that assigned to death the lowest (mean 5.25; median 3.00). The two SF-6D states (C and J) receive scores in accordance with their logical order: the means and medians are higher for C than for J.

**Table 23. Scores for the health states on the Visual Analogue Scale (VAS).**

| | C | J | Own state | Death |
|---|---|---|---|---|
| **Mean** | 71.37 | 55.31 | 85.42 | 5.25 |
| **Standard Deviation** | 19.06 | 18.79 | 15.19 | 7.95 |
| **Median** | 75.00 | 55.00 | 90.00 | 3.00 |
| | **F** | **W** | **X** | **V** |
| **Mean** | 67.59 | 62.67 | 64.16 | 40.32 |
| **Standard Deviation** | 19.68 | 21.22 | 20.15 | 17.91 |
| **Median** | 70.00 | 64.00 | 65.00 | 40.00 |
| | **S** | **R** | **N** | **L** |
| **Mean** | 33.43 | 26.08 | 13.70 | 10.65 |
| **Standard Deviation** | 17.47 | 16.68 | 13.39 | 10.48 |
| **Median** | 30.00 | 24.00 | 10.00 | 8.00 |

As for the other 8 states (the injuries), in aggregate terms they also reveal scores on the visual scale consistent with the relative seriousness of each of them. An inconsistency in terms of the means (and medians) is detected only between states W and X, since X is objectively worse than W (longer time in hospital and longer recovery period, with similar symptoms), and one would expect this score to be lower than the figure for W. The fact that these two states were evaluated by different subsamples (the VAS task does not match in any of the subgroups, and so they could not be evaluated in comparative terms), and the similarities in the seriousness of the symptoms and sequelae described (but not in the times) could explain the similar score given to both (in fact, statistical tests concluded there are no significant differences between the scores for these two healthstates).

## 4.3. 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.

Table 24 shows the aggregate values of the probabilities of indifference, i.e. the risk of death with treatment B ($p_i$, *D*; *NH*) which makes the subject indifferent between this treatment and treatment A (0.5 *State* $i$; *NH*). The number of observations is three times higher in the case of states C and J, since the study design indicated established that most interviewees would evaluate these two SF-6D states, which will be used to estimate the MVQALY by means of the chained method.

**Table 24. Probabilities of indifference in the modified SG. Maximum risk of death assumed in the gamble ($p_i$, Death; Normal health).**

| | SF-6D. | | Injuries | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | J | F | W | X | V | S | R | N | L |
| **Mean** | 0.023 | 0.047 | 0.010 | 0.022 | 0.022 | 0.101 | 0.104 | 0.282 | 0.331 | 0.441 |
| **Standard deviation** | 0.072 | 0.112 | 0.040 | 0.069 | 0.063 | 0.186 | 0.178 | 0.347 | 0.350 | 0.374 |
| **Median** | 0.004 | 0.009 | 0.002 | 0.008 | 0.005 | 0.020 | 0.015 | 0.100 | 0.180 | 0.400 |
| **Observations** | 1,530 | 1,520 | 502 | 519 | 500 | 506 | 501 | 519 | 500 | 505 |



The indifference probabilities of state J are higher than those for state C (more minor than the former): 0.047 compared with a mean of 0.023; 0.009 compared with a median of 0.004. On an aggregate scale, the differences in the means are statistically significant (p=0.000). As for the other health states evaluated (the injuries), although a clear relationship is observed between the seriousness of the state of health and the risk of death which respondents are prepared to accept to avoid it, this relationship is not fulfilled in all cases. Thus, while the mean risk accepted rises with seriousness (except for states W and X, which have identical means), the median values reveal certain inconsistencies: the median for X is lower than for W (the latter being slightly more serious than the former), and the median for V is higher than for S (which describes more minor injuries than V). The tests of the means for all observations of each state reject the equality hypothesis at 95%[57] for all comparisons between injuries, except for these last two pairs: W vs. X (p=0.892) and V vs. S (p=0.769).

Table 25 presents the statistics of the indifference probabilities in the SG by questionnaire model/group for the two SF-6D states (C and J). The mean risk of death accepted with state C (more minor) varies between 0.015 (group 2) and 0.031 (group 8). In the case of state J, the mean risk ranges from 0.025 (group 5) to 0.078 (group 7). The medians are between 0.003 (groups 3, 6 and 8) and 0.006 (group 2) for state C, and between 0.005 (group 5) and 0.015 (group 2) for state J. According to Bonferroni's test, the differences do not prove significant between any of the groups for state C, while for state J there are significant differences between models 7 and 8, on one hand (but not between them), and models 2, 4, 5 and 6, on the other hand. The Kruskal Wallis test does identify statistically significant differences among various groups, for both state C and state J.[58]

[57] The null hypothesis is rejected at 99% in all comparisons accept R vs. N (p=0.024).

[58] In the case of C, the test reveals a value of p<0.05 for the comparisons between model 1 and models 3, 6 and 8, and the comparisons between the latter three and model 2. In the case of state J, statistically significant differences are found in the comparisons of 2 against 4, 5 and 8; 4 against 6 and 7; and 5 against 6, 7 and 8.

**Table 25. Indifference probabilities in the SG modified by group. States SF-6D (C, J).**

| Model | State C | | | | State J | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Standard Deviation | Median | n | Mean | Standard Deviation | Median | n |
| **1** | 0.025 | 0.083 | 0.004 | 256 | --- | --- | --- | --- |
| **2** | 0.016 | 0.041 | 0.006 | 249 | 0.039 | 0.066 | 0.015 | 249 |
| **3** | 0.024 | 0.067 | 0.003 | 250 | --- | --- | --- | --- |
| **4** | 0.020 | 0.056 | 0.004 | 254 | 0.034 | 0.081 | 0.007 | 254 |
| **5** | --- | --- | --- | --- | 0.025 | 0.072 | 0.005 | 246 |
| **6** | 0.023 | 0.081 | 0.003 | 270 | 0.034 | 0.095 | 0.009 | 270 |
| **7** | --- | --- | --- | --- | 0.078 | 0.126 | 0.012 | 250 |
| **8** | 0.031 | 0.093 | 0.003 | 251 | 0.075 | 0.179 | 0.007 | 251 |
| **Total** | **0.023** | **0.072** | **0.004** | **1530** | **0.047** | **0.112** | **0.009** | **1520** |

Table 26 presents the same information for the eight health states valued with the SG (the injuries). Each respondent only valued two of these injuries, in addition to 1 or two SF-6D states, which is why for each of them values are only available for around 500 respondents (two sample subgroups). The differences between the values from each of the two groups which rated each injury prove statistically significant according to the Bonferroni test for state N (p = 0.049), with respective means of 0.362 (group 3) and 0.301 (group 7).

**Table 26. Indifference probabilities in the SG modified by group. Injuries (F, W, X, V, S, R, N, L)**

| Model | State F | | | State S | | | n |
|---|---|---|---|---|---|---|---|
| | Mean | Standard Deviation | Median | Mean | Standard Deviation | Median | |
| **1** | 0.013 | 0.043 | 0.002 | 0.107 | 0.189 | 0.015 | 256 |
| **5** | 0.008 | 0.036 | 0.002 | 0.101 | 0.166 | 0.020 | 245 |
| **Total** | **0.010** | **0.040** | **0.002** | **0.104** | **0.178** | **0.015** | **501** |
| **Model** | **State W** | | | **State R** | | | **n** |
| | **Mean** | **Standard Deviation** | **Median** | **Mean** | **Standard Deviation** | **Median** | |
| **2** | 0.021 | 0.075 | 0.008 | 0.303 | 0.378 | 0.100 | 249 |
| **6** | 0.024 | 0.063 | 0.007 | 0.263 | 0.315 | 0.098 | 270 |
| **Total** | **0.022** | **0.069** | **0.008** | **0.282** | **0.347** | **0.100** | **519** |
| **Model** | **State X** | | | **State N** | | | **n** |
| | **Mean** | **Standard Deviation** | **Median** | **Mean** | **Standard Deviation** | **Median** | |
| **3** | 0.024 | 0.062 | 0.005 | 0.362 | 0.370 | 0.228 | 250 |
| **7** | 0.020 | 0.063 | 0.005 | 0.301 | 0.326 | 0.150 | 250 |
| **Total** | **0.022** | **0.063** | **0.005** | **0.331** | **0.350** | **0.180** | **500** |
| **Model** | **State V** | | | **State L** | | | **n** |
| | **Mean** | **Standard Deviation** | **Median** | **Mean** | **Standard Deviation** | **Median** | |
| **4** | 0.104 | 0.194 | 0.018 | 0.448 | 0.375 | 0.400 | 254 |
| **8** | 0.098 | 0.178 | 0.025 | 0.434 | 0.374 | 0.380 | 251 |
| **Total** | **0.101** | **0.186** | **0.020** | **0.441** | **0.374** | **0.400** | **505** |

Based on the indifference probabilities, and applying the formula from the following equation:

$$U(i) = 1 - 2\,p_i \qquad [19]$$

the utilities of the health states are obtained. The result is shown in Table 27 for the aggregate, in other words for all the observations for each state of health in the sample. This same information is presented by group in Table 28 for the SF-6D states (C, J), and in Table 29 for the other eight states (injuries).

***Table 27. Utilities of the health states for all the observations by state.***

| | **SF-6D.** | | ***Injuries*** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | J | F | W | X | V | S | R | N | L |
| **Mean** | 0.953 | 0.905 | 0.979 | 0.955 | 0.956 | 0.798 | 0.791 | 0.436 | 0.337 | 0.118 |
| **Standard deviation** | 0.145 | 0.224 | 0.079 | 0.138 | 0.125 | 0.371 | 0.355 | 0.693 | 0.700 | 0.748 |
| **Median** | 0.992 | 0.982 | 0.996 | 0.984 | 0.990 | 0.960 | 0.970 | 0.800 | 0.640 | 0.200 |
| **Observations** | 1,530 | 1,520 | 502 | 519 | 500 | 506 | 501 | 519 | 500 | 505 |

***Table 28. Utilities of the SF-6D health states (C and J) by group.***

| **Model** | **State C** | | | | **State J** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Standard Deviation** | **Median** | **n** | **Mean** | **Standard Deviation** | **Median** | **n** |
| **1** | 0.949 | 0.166 | 0.992 | 256 | --- | --- | --- | --- |
| **2** | 0.967 | 0.083 | 0.988 | 249 | 0.923 | 0.133 | 0.970 | 249 |
| **3** | 0.953 | 0.133 | 0.995 | 250 | --- | --- | --- | --- |
| **4** | 0.959 | 0.113 | 0.992 | 254 | 0.933 | 0.161 | 0.986 | 254 |
| **5** | --- | --- | --- | --- | 0.949 | 0.143 | 0.990 | 246 |
| **6** | 0.953 | 0.161 | 0.994 | 270 | 0.932 | 0.191 | 0.982 | 270 |
| **7** | --- | --- | --- | --- | 0.844 | 0.253 | 0.976 | 250 |
| **8** | 0.938 | 0.185 | 0.994 | 251 | 0.849 | 0.358 | 0.986 | 251 |
| **Total** | **0.953** | **0.145** | **0.992** | **1530** | **0.905** | **0.224** | **0.982** | **1520** |

***Table 29. Utilities of the injuries (F, W, X, V, S, R, N, L) by group.***

| Model | State F | | | State S | | | n |
|---|---|---|---|---|---|---|---|
| | Mean | Standard Deviation | Median | Mean | Standard Deviation | Median | |
| **1** | 0.975 | 0.086 | 0.996 | 0.785 | 0.377 | 0.970 | 256 |
| **5** | 0.985 | 0.071 | 0.996 | 0.797 | 0.331 | 0.960 | 245 |
| **Total** | **0.979** | **0.079** | **0.996** | **0.791** | **0.355** | **0.970** | **501** |
| **Model** | **State W** | | | **State R** | | | **n** |
| | **Mean** | **Standard Deviation** | **Median** | **Mean** | **Standard Deviation** | **Median** | |
| **2** | 0.958 | 0.150 | 0.984 | 0.395 | 0.756 | 0.800 | 249 |
| **6** | 0.953 | 0.126 | 0.986 | 0.474 | 0.629 | 0.805 | 270 |
| **Total** | **0.955** | **0.138** | **0.984** | **0.436** | **0.693** | **0.800** | **519** |
| **Model** | **State X** | | | **State N** | | | **n** |
| | **Mean** | **Standard Deviation** | **Median** | **Mean** | **Standard Deviation** | **Median** | |
| **3** | 0.952 | 0.125 | 0.990 | 0.276 | 0.740 | 0.545 | 250 |
| **7** | 0.961 | 0.126 | 0.990 | 0.399 | 0.653 | 0.700 | 250 |
| **Total** | **0.956** | **0.125** | **0.990** | **0.337** | **0.700** | **0.640** | **500** |
| **Model** | **State V** | | | **State L** | | | **n** |
| | **Mean** | **Standard Deviation** | **Median** | **Mean** | **Standard Deviation** | **Median** | |
| **4** | 0.792 | 0.387 | 0.964 | 0.104 | 0.751 | 0.200 | 254 |
| **8** | 0.804 | 0.355 | 0.950 | 0.132 | 0.747 | 0.240 | 251 |
| **Total** | **0.798** | **0.371** | **0.960** | **0.118** | **0.748** | **0.200** | **505** |



The mean utilities of the SF-6D states are 0.953 and 0.905 for C and J respectively; the median is 0.99 to 0.982. As for the eight injuries, their mean utility ranges from a minimum of 0.118 for state L (the most serious) to a maximum 0.9794 state F (the most minor). The lowest median also corresponds to state L (0.200) and the highest to state F (0.996). Analysing the differences between utilities by state, and within each state by sample subgroup, depending on the questionnaire model, leads to the same conclusions as discussed with regard to the indifference probabilities, since they are simply a linear transformation of these.

## *4.4. Contingent valuation: willingness to pay and accept*

The results from part 4 of the questionnaire are set out below, recording the values obtained by the contingent valuation (CV) method, i.e. the instances of willingness to pay (WTP) to avoid state C and state J for the two alternative durations: 1 month and 5 months.

Table 30 shows the basic descriptive statistics for the WTP values to avoid the four scenarios resulting from combining the two states with the two durations, for the sample as a whole. The mean WTP values for state J (the most serious) are higher than those corresponding to state C (the most minor). Moreover, the mean WTP to avoid state J for 5 months is higher than the WTP to avoid the same state for 1 month. However, the mean WTP to avoid experiencing state C is higher when the duration is 1 month than when it is 5 months. This discrepancy is caused by the existence of a few outlier values in the responses of the participants in some of the groups presented with this question.

As for the medians, the values associated with the most serious state (J) are higher than those obtained with the most minor state (C) and the medians of the WTP for durations of 5 months are higher than (in the case of J) or equal to (in the case of C) those corresponding to durations of 1 month. The last row in the table indicates the percentage of zero responses to the different WTP questions. As can be seen, this percentage decreases the more serious the state of health and the greater its duration, which suggests that at least in part these are "genuine zeros" (the respondent does not feel it is worth paying (or they cannot pay) any amount to improve the health they are offered), rather than "protest zeros" (the interviewee refuses to pay money in exchange for improving their health, for various reasons such as because they already pay taxes or feel it is unethical).

***Table 30. Statistics describing the Willingness to Pay (WTP) values declared to avoid health states C and J (durations of 1 month and 5 months).***

| | C (1 month) | C (5 months) | J (1 month) | J (5 months) |
|---|---|---|---|---|
| **Mean** | 406 | 268 | 932 | 1,353 |
| **Standard Deviation** | 2,416 | 840 | 6,290 | 7,657 |
| **Median** | 50 | 50 | 70 | 150 |
| **Observations (n)** | 1,004 | 1030 | 991 | 1,019 |
| **WTP=0 (%)** | 17.63 | 14.76 | 13.93 | 7.26 |

Table 31 presents the WTP values for the two state C durations by group, according to the questionnaire model assigned. This same information for state J is shown in Table 32. As can be observed in the former of these tables, with the mean WTP to avoid state C for 1 month standing at 406 euros, there are notable differences between groups 1 and 3 on one hand, and groups 2 and 8 on the other. These latter two groups register a few outlier values which cause the mean to be significantly higher (see the standard deviation values). Meanwhile, the medians reveal no great differences between the groups. With regard to the WTP to avoid the same state C for a longer duration (5 months), the mean values are similar in groups 1, 3 and 4, and notably lower in group 6. The medians are also lower in this group and in group 1 than in groups 3 and 4.

***Table 31. Descriptive statistics of the Willingness to Pay (WTP) values declared to avoid state of health C (durations of 1 month and 5 months) by group.***



| Model | State C (1 month) | | | | State C (5 months) | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Standard Deviation | Median | n | Mean | Standard Deviation | Median | n |
| **1** | 223 | 675 | 50 | 255 | 323 | 823 | 55 | 255 |
| **2** | 819 | 4,531 | 50 | 249 | --- | --- | --- | --- |
| **3** | 173 | 438 | 50 | 250 | 355 | 1,122 | 63 | 250 |
| **4** | --- | --- | --- | | 301 | 930 | 65 | 255 |
| **6** | --- | --- | --- | | 106 | 205 | 50 | 270 |
| **8** | 415 | 1,469 | 45 | 250 | --- | --- | --- | --- |
| **Total** | **406** | **2,416** | **50** | **1,004** | **268** | **840** | **50** | **1,030** |

Note that when both durations are evaluated in a single questionnaire, in other words by the same participants (groups 1 and 3), the values are consistent in the sense that both the means and the medians are higher for the longer duration. The explanation why for all groups, the WTP to avoid C for 1 month is higher than (in mean terms) or equal to (in median terms) the WTP to avoid the same state for 5 months, is the fact that in groups where just one of the durations was evaluated, the WTP values were much higher for the shorter duration (in groups 2 and 8) and much lower for the longer duration (above all in group 6). This discrepancy in the instances of willingness to pay depending on whether the evaluation is "joint" or "separate" was also observed with the 2011 study data, in questions that were asked at the time to enquire directly of the respondents their WTP to reduce the risk of sustaining different injuries (Pinto et al., 2017). As occurs here, in groups where evaluation was separate, a lack of WTP sensitivity was noted.

In the case of state J (Table 32), this inconsistency is not registered at the aggregate level, although major differences are seen among groups. In the case of the shorter duration (1 month), group 8 registers a much lower mean than the other groups, although the median stands at an intermediate value (75), which is in fact higher than the median of the four groups which valued this scenario (70). In the case of longer duration (5 months), group 4 stands out for how low its mean is compared to the other three groups. However, although the median is lower than the sum of the four groups, it is higher than the figure recorded for groups 5 and 7, whose participants evaluated both durations. In the aforementioned groups, both the means and the medians of the WTP reveal the expected pattern (higher WTP in the case of the longer duration).

***Table 32. Descriptive statistics of the values for Willingness to Pay (WTP) declared to avoid state of health J (durations of 1 month and 5 months) by group.***

| Model | State J (1 month) | | | | State J (5 months) | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Standard Deviation | Median | n | Mean | Standard Deviation | Median | Standard Deviation |
| **2** | 1,054 | 4,737 | 90 | 248 | --- | --- | --- | --- |
| **4** | --- | --- | --- | --- | 746 | 2,359 | 115 | 254 |
| **5** | 1,156 | 9,708 | 50 | 245 | 1,703 | 11,582 | 100 | 245 |
| **6** | --- | --- | --- | --- | 1,386 | 6,693 | 200 | 270 |
| **7** | 1,105 | 6,372 | 60 | 250 | 1,590 | 7,323 | 100 | 250 |
| **8** | 416 | 1,322 | 75 | 248 | --- | --- | --- | --- |
| **Total** | **932** | **6,290** | **70** | **991** | **1,353** | **7,657** | **150** | **1,019** |

If we compare the values contained in Table 31 with those in Table 32, in aggregate terms we find that the WTP figures seem to be sensitive to the seriousness of the state of health. In both the means and the medians, the WTP to avoid experiencing state J for 1 month is higher than the WTP to avoid experiencing state C for the same time; the same occurs with the WTP figures associated with the longer duration (5 months).

Beyond this appreciation based on the individual estimates contained in the tables, it is of interest to conduct a statistical comparison of the sensitivity of the WTP values to the seriousness of the state of health and its duration. These tests can be conducted on both an aggregate scale and "intra-subject", in those groups where we have valuations for one single state and differing duration or for one single duration and the two states. First of all, taking into account all the valuations obtained for each scenario, the mean tests confirm the existence of statistically significant differences according to seriousness: the WTP values to avoid state J are higher than those revealed to avoid state C, both for the duration of 1 month (p-value=0.014) and for the duration of 5 months (p=0.000). The same cannot be said about the WTP values for different durations for a single state; with state C the differences are significant only at 90% (p=0.085) and for state J no statistically significant differences are obtained (p=0.179).

The study design also allows these differences to be compared on the "intra-subject" scale, by comparing the valuations that one single participant gives to the two states (with the same duration) or for the two durations (for one single state). The seriousness sensitivity of the WTP may be examined by comparing the WTP values of participants belonging to groups 2 and 8 (who evaluated the scenarios with State C and J for a duration of one month), and those included in groups 4 and 6 (who did so for the duration of 5 months). Both the parametric tests (t-test) and the non-parametric (Wilcoxon) tests conclude that there are significant differences in the WTP values to avoid C and to avoid J (for a single duration) in all the groups cited, except for group 8, where the mean test does not allow the equality hypothesis to be rejected (p=0.108); although the non-parametric test does suggest that the WTP is sensitive to seriousness (p=0.000), as in the other groups.

With regard to the sensitivity of the WTP values to the duration of the health problem, the intra-subject comparisons may be performed in groups 1 and 3 (for state C) and in groups 5 and 7 (for state J). In this case it is also confirmed that the valuations of the respondents are sensitive to the duration of the scenarios, for all groups with the non-parametric test (p=0.000) and for three of the four groups cited with the mean test, the exception being group 5 (p=0.140).

Lastly, a theoretical validity or construct test for the WTP values obtained involves checking that these values behave as predicted by standard economic theory (Bateman et al., 2002). The minimum generally accepted theoretical validity requirement is the existence of a positive and significant correlation between the WTP values revealed by the respondents and their capacity to pay, measured by means of their declared income. This theoretical validity exercise is conducted by means of an OLS regression analysis and is presented at the end of this report in Appendix II. The estimated coefficient for the income variable (0.575) is positive and statistically significant. As the WTP and rent variables are expressed in logarithms, this coefficient is interpreted as the income-elasticity of the WTP, with a value similar to that found in this type of study.

## 4.5. Monetary value of the QALY

### 4.5.1. MVQALY according to the enhanced chained method

As set out in section 3.5, the first approach to calculating the MVQALY, which we refer to as "enhanced chained approach", combines the results obtained in the two methods to obtain the preferences (modified standard gamble, SG, and contingent valuation, CV).

Therefore, once we have obtained the utilities of the two SF-6D healthstates, we calculate the QALY gain involved in avoiding experiencing each of these states for the two timeframes used in that part of the questionnaire containing the CV method questions (WTP questions): 1 month and 5 months. As explained in section 2.2, this QALY gain is calculated as follows:

$$\Delta AVAC_i = [1 - V_i(Q_I)] \cdot t' \qquad [19]$$

Where $V_i(Q_I)$ is the utility of the state of health (C or J) and $t'$ is the time for which this state is experienced (1 or 5 months). For example, the QALY gain associated with avoiding state C for one month, using the mean utility for the sample as a whole, would be (1-0.953) × (1/12) = 0.004 QALY. These health gains in QALY terms are calculated for each individual, and are then aggregated together with the individual WTP values, calculating the ratio of means (quotient of the mean individual WTP values and the mean QALY health gains), or alternatively the ratio of medians (replacing the mean values with the median values in the preceding quotient, for both the WTP and QALY gains).



The Table shows the results derived from applying these two aggregation methods with the different scenarios used in the contingent valuation part.

**Table 33. Estimations of the Monetary Value of the QALY (MVQALY) in euros, using the enhanced chained method.**

| | Ratio of means | Ratio of medians | Observations |
|---|---|---|---|
| State C – 1 month | 104,480 | 75,000 | 1,004 |
| State C – 5 months | 13,806 | 15,000 | 1,029 |
| State J – 1 month | 117,924 | 46,667 | 991 |
| State J – 5 months | 34,230 | 20,000 | 1,018 |
| ***Average*** | ***67,610*** | ***39,167*** | |

The first column presents the results of calculating the MVQALY as the ratio of the means of the WTP values to the individual health gains (QALY). As can be seen, following this approach, the MVQALY ranges across a very broad band, depending on the scenario used in the valuation. The minimum value obtained is thus 13,806 euros (estimation based on the "state C – 5 months" scenario) and 117,924 euros (estimation based on the "state J – 1 month" scenario). It is clear that although both the WTP and the risk values assumed in the SG (and hence the utilities of the healthstates) are sensitive to the seriousness and duration of the scenarios, the MVQALY estimations differ significantly according to the state of health and the duration considered in the calculation procedure. Accordingly, the shorter the duration and the greater the seriousness of the state of health, the higher the values.

The discrepancies observed in the estimates obtained as the ratio between the mean WTP and the mean QALY gains are also observed if we decide to calculate the ratio between the respective medians, in view of the results shown in the last column of Table 33. In this case, the values range from 15,000 euros ("state C - 5 months" scenario) to 75,000 euros ("state C - 1 month" scenario).

If we apply the same criterion followed in selecting the VSL in Abellán et al. (2023), i.e. identifying the MVQALY as the average of the smallest median value (15,000 euros, corresponding to the "state C - 5 months" scenario) and the largest mean value (117,924 euros, corresponding to the "state J - 1 month" scenario), this results in an estimate of 66,462 euros.

In addition, as indicated in section 3.5.1, the QALY gains derived from avoiding the different scenarios (C and J for 1 month and 5 months) can be calculated using the social values derived from applying the SF-6D utilities calculation algorithm estimated for Spain (Abellán et al., 2012), rather than the individual values obtained from the response given by sample participants to the SG method. These health gains, based on social preferences, would be combined with the WTP values calculated for the sample as a whole, i.e. the mean values of Table 30. As previously stated in the aforementioned section, the results of this exercise are set out in Appendix I.

### *4.5.2. MVQALY anchored in the VSL*

Below, the result of estimating the MVQALY following the methodology used in 2009 is presented: in other words anchoring this value in the VSL estimated in the first survey conducted in the context of this project, the results of which are set out in a separate report. The means of obtaining the MVQALY according to this approach involves dividing the VSL by the Quality-Adjusted Life Expectancy (QALE) of an individual representing traffic accident fatalities, discounting the QALY comprising this flow at a specific discount rate ($d$).

To identify this representative individual, the mean age upon death by traffic accident in Spain in 2021 is obtained by age group (imputed in the mean value of the band to each group), resulting in a mean age of 49 years. The QALE of this representative subject would be 27 years old, without discounting, and 20.96 years old when applying a discount rate of 1.5%, as proposed by Mason et al. (2009) as representative of the "pure" time preference[59] and the same value used in the 2009 study. The MVQALY estimated in this way would therefore be:

$$VMAVAC = \frac{VVE}{EVAC(d)} = \frac{1.921.473}{20{,}96} = 91.166\ €$$

If we combine this estimation of the implicit value of the QALY contained in the VSL with the estimation of the explicit value of the QALY, based on applying the enhanced chained method, this establishes a plausible range of valuations, bounded at the lower end by a figure of 66,462 euros, and at the upper end by an amount of 91,166 euros. In order to obtain a single-point estimate to be used by the DGT in its evaluations of road safety measures, we recommend a MVQALY of 78,814 euros, corresponding to the midpoint of the stated range.

## ***4.6. Monetary value of a statistical non-fatal injury (VoSI)***

### *4.6.1. MVoSI based on the VSL and the relative values obtained by the SG*

Firstly, the MVoSI based on the VSL and the relative individual valuations of the different health states (injuries) evaluated by means of the SG method is calculated. The procedure simply involves

[59] The positive time preference is not the only reason why the value of future years may decline as time passes. Another reason could be that the marginal utility of consumption decreases. However, as indicated by Mason et al. (2009), the theory suggests that it is possible to wait until the VSL varies at the same pace as the marginal utility of consumption, and so this effect would already be discounted. Applying a discount rate that is higher than that reflected by the pure time preference may result in double counting.

multiplying the VSL by the relative utility loss resulting from experiencing each of these states, compared with normal health, as explained in section 3.6.1.

Table 34 presents the monetary values thus calculated for each of the eight health states (F to L).

***Table 34. Monetary values associated with the health states (injuries) anchored in the VSL. Figures in euros.***

| | Monetary value (euros) |
|---|---|
| State F | 39,430 |
| State W | 79,200 |
| State X | 84,111 |
| State V | 388,390 |
| State S | 401,295 |
| State R | 1,079,018 |
| State N | 1,273,408 |
| State L | 1,695,426 |

As indicated in section 3.6.1, the minor VoSI is set at 20% of the estimated monetary value for state F, namely 7,886 euros. Meanwhile, the serious VoSI is obtained as the weighted mean for the values of the remaining seven states, with the weightings being as shown in Table 12. The result is a figure of 354,630 euros. These values (7,886 and 354,630 euros) are the figures recommended to the DGT for use in its calculations of the social costs of accidents with non-fatal injuries, which would thus replace the minor and serious VoSI estimates from the 2011 study.



### *4.6.2. Other approaches to calculating the MVoSI*

An initial, illustrative approach of how the VoSI could be estimated for Spain if a breakdown of information as to the utility losses at the maximum level of seriousness (MAIS) were available involves combining the relative US values from Table 1 with the VSL estimated by Abellán et al. (2023), as previously explained in subsection 3.6.2.

***Table 35. VoSI by MAIS anchored in the VSL. Figures in euros.***

| Maximum AIS level | Monetary Valuation |
|---|---|
| MAIS 1 | 9,417 |
| MAIS 2 | 83,404 |
| MAIS 3 | 357,060 |
| MAIS 4 | 584,979 |
| MAIS 5 | 991,619 |

Once we have access to this information, we may infer the minor and serious VoSI figures by weighting the valuations from Table 35 by the incidence rates of injuries at each MAIS level of seriousness registered in the United States, as shown in Table 13. We thus obtain a weighted value for minor accidents (MAIS1 and MAIS2) of 16,762 euros, and a value for serious accidents (MAIS 3, 4 and 5) of 410,484 euros.

If, rather than calculating the VoSI as a product of the relative values or relative disutility factors and the VSL, we instead estimate it as the product of the absolute losses of QALY and the MVQALY recommended in this study (78,840 euros), the results are different. Table 36 shows the discounted and non-discounted values. The discount applied is 4%, as in Table 2 showing the QALY losses. As can be observed, the values from Table 35 lie between the end points indicated by the discounted and non-discounted valuations from Table 36.

**Table 36. Monetary value of statistical non-fatal accidents by MAIS anchored in the MVQALY, discounted (4%) and non-discounted. Figures in euros.**

| Maximum AIS level | Non-discounted | Discounted at 4% |
|---|---|---|
| MAIS 1 | 10,088 | 6,542 |
| MAIS 2 | 110,418 | 58,480 |
| MAIS 3 | 480,293 | 250,077 |
| MAIS 4 | 651,634 | 409,754 |
| MAIS 5 | 1,573,127 | 694,667 |

If the prevalence of each of the injuries in the United States is taken into account, the VoSI (based on the recommended MVQALY) for a minor accident can be set within the range of 11,698 to 20,048 euros, while the case of serious accident victims, the range is from 287,506 to 546,855 euros.

## 4.7. Value of preventing an injury by traffic accident

To calculate the value of avoiding a non-fatal victim or the value of preventing an injury (VPI) in a traffic accident, the production losses and healthcare costs (medical and ambulance) must be added to the VoSI figures presented in subsection 4.6.1 (the VoSI anchored in the VSL and the relative values obtained from applying the modified standard gamble). Table 37 shows the estimated values of (gross) production losses for minor and serious injuries, estimated according to the methodology described in section 3.7.

**Table 37. Gross production losses associated with a non-fatal injury. Present value in 2022 euros.**

| | Production loss (euros) |
|---|---|
| Minor | 342 |
| Serious | 20,274 |

Meanwhile, the medical and ambulance costs, according to information published by UNESPA (2020), are estimated to range between 279 euros and 10,576 euros. For minor accident victims, the proposal is to consider costs coinciding with the 25th percentile, and the median for healthcare costs. Furthermore, this 279-euro figure is similar to that considered in the previous report. As for serious accident victims, the amount proposed coincides with the 90th percentile of the cost distribution provided by UNESPA, slightly higher than the 6,000 euros in the previous report.

The result of adding these costs to the minor and serious VoSI figures gives us a minor VPI and serious VPI of 8,507 euros and 385,480 euros respectively.

## 5. Conclusions

This report updates the estimates of the Monetary Value of a Quality-Adjusted Life Year (QALY), the Value of a Statistical Non-Fatal Injury (VoSI) and the Value of Preventing an Injury (VPI) in Spain, commissioned from this same research team by the DGT in 2011 in the context of road accidents. The new estimated values were achieved by mining a database of responses to a survey conducted across a broad and representative sample (n=2,027) of the general Spanish adult population.

The analysed study expands and improves on the methodologies used by Abellán et al. (2011b) to estimate the official values in force until now, and the update produced therefore does not simply reproduce the procedures previously applied, but offers estimates which provide greater validity and reliability. Therefore, beginning with the new MVQALY which is required to replace the 2011 estimate, this report infers the value in question from the results obtained by two different methods: one based on the Value of a Statistical Life (VSL) estimated by Abellán et al. (2023) which is thus an implicit value of the QALY, and the other achieved by chaining QALY gains with the willingness to pay for them, thereby giving an explicit value of the QALY, not mediated by the VSL. The first method (anchoring the MVQALY in the VSL) is equivalent to that used in 2011, while the second represents a genuine contribution by this new study. The implicit value of the QALY presented above amounts to 91,166 euros, a figure 70% higher than that estimated in Abellán et al. (2011b).

The estimation of the explicit value of the QALY, structured by what this report refers to as the enhanced chained method, gives a band or range of monetary values for the QALY, rather than a single-point value. Understandably, as previously explained, practically all estimates made within the context of healthcare interventions, which have above all used the chained method (Robinson et al., 2013), have given rise to ranges similar to that presented here, containing values which vary between a minimum of 15,000 euros and a maximum of almost 118,000 euros. Such a wide variation range is, however, not unexpected in this type of study, andcan be verified in systematic reviews such as those conducted by Ryen & Svensson (2014), Nimdet et al. (2015) or Vallejo-Torres et al. (2016).



The enhanced nature of the structured chaining is essentially based on two factors. Firstly, the use of a modified standard gamble or double gamble procedure, which offsets some of the problems of the method of the same name proposed by Carthy et al. (1999), and which was used by the research team in 2011. The double gamble utilized here was used by Abellán et al. (2012) to estimate the set of utilities of a multi-attribute health-related quality of life instrument known as SF-6D. This procedure not only prevents the bias known as the 'certainty effect' (Kahenman & Tversky, 1979), which leads many respondents to be unwilling to accept any risk of death in exchange for recovering their health, but also allows negative utilities to be obtained, representing preferences which judge certain very serious health problems as particularly intolerable. Conversely, the double gamble in the manner of Carthy et al. prevents such preferences from being expressed, by limiting utilities to 0. Furthermore, the durations of the health states used are brief (1 month and 5 months), in order to offset the insensitivity problems typically encountered in the willingness to pay.

Since both approaches used to give rise to the MVQALY (implicit and explicit) are equally valid, as they are both based on the individual preferences of the respondents, we choose to consider both estimates jointly. To this end, following the same criterion already used by Abellán et al. (2023) to select the VSL, we take the average of the endpoints of the range obtained as the explicit QALY value, corresponding to 66,462 euros. With this value as the lower bound, and the "implicitly" estimated figure using the VSL as the upper bound, a new range of 66,462-91,166 euros is established. Lastly, the MVQALY recommended to the DGT as the input for its economic evaluations of road safety measures would be the midpoint of this range: 78,814 euros.

This new official QALY value involves a 47% increase to the value proposed in 2011, a substantial rise (approximately double the increase in per capita income between the year in question and the present), which is almost perfectly aligned with the figure generated for the VSL, which rose by 46% over the same period (Abellán et al., 2023). The fact that both studies coincide points in the same direction, namely greater concern or awareness among Spanish society as to the importance of preventing road accidents.

To contextualise the value proposed in the set of estimates published, although it is higher than most of the mean MVQALY values obtained from the chained approach, it is lower than the few estimates anchoring the MVQALY in the VSL. Taking the averages from Table 6 of this report as our reference point for the explicit estimates of the QALY values, and in turn, the values reported by Mason et al. (2009) and Donaldson et al. (2010) as the reference point for the implicit estimates, assuming a constant MVQALY, a range of values between 30,301 euros (mean of the explicit value averages) and 129,402 euros (mean of the single-point estimates from the two studies cited) can be identified.[60] The MVQALY recommended to the DGT would be approximately halfway along this range, supporting the apparent consistency of the estimate made.

With regard to updating the serious and minor Value of a Statistical Non-Fatal Injury (VoSI), i.e. the valuation of the human costs borne by those injured in traffic accidents, although three different estimates have been presented in this report, only one acquires the status of an estimate recommended as the basis for the new official values to be used by the DGT to quantify the social costs of traffic accidents with non-fatal victims. This estimate is based on the combination of the VSL reported in Abellán et al. (2023) and the relative values (or relative utility losses) obtained by the new modified standard gamble referred to previously. The values estimated thus amount to 7,886 euros for minor injuries and 354,630 euros for serious injuries, representing increases of approximately 58% and 93% compared to the 2011 values. These increases (above all with regard to serious injuries) are higher than those registered for the VSL, which could indicate greater social concern with non-fatal accidents, perhaps understanding that they are more frequent consequences of road accidents than deaths.

If, in addition to the estimated production losses, we add the medical and ambulance costs to the preceding values, this results in the Value of Preventing an Injury (VPI), both minor and serious. In the former case, the figure amounts to 8,506 euros, and in the latter, 385,480 euros. The costs per serious injury collated in Table 3 for 19 of the 20 Eurozone countries serve to place this newly estimated serious VPI in context. The new figure thus boosts Spain from 9th to 5th place, nearly on a par with Austria, and only behind Croatia, Finland and Estonia. As previously argued, this update represents a major quantitative leap in Spanish society's perception of the magnitude of the costs associated with accidents causing serious injuries.



The argument of greater social sensitivity matches that put forward by Schoeters et al. (2022) to justify the very significant increase in their estimates in the VoSI for Germany, Belgium, France and the Netherlands. However, attention must be given to three circumstances that differentiate their study from ours. Firstly, as we have seen, a third of their sample revealed lexicographical preferences, which led to a very significant proportion of respondents being discarded (25.3%). Secondly, their survey was administered by means of an internet panel, rather than personal surveys with the help of interviewers, and there is evidence that data obtained in person with the help of an interviewer are of greater quality than those self-completed by online respondents (Norman et al., 2010). Lastly, the increases resulting from the estimates by Schoeters et al. (2002) with regard to the official values from the countries concerned are much greater than those recorded in our study (for example, 227% for the Netherlands).

As indicated previously, our study offers another two additional VoSI estimates, although they are purely for indicative purposes as they combine empirical data estimated for Spain (the estimates produced by the research team for the VSL and the MVQALY), with data regarding absolute and relative QALY losses registered in the United States. The fact that a data breakdown is not available in Spain for the maximum level of the Abbreviated Injury Scale (MAIS) as in the case of the USA prevents,as would be desirable, applying the procedure used by the National Highway Traffic Safety Administration (NHTSA) in the USA to estimate the VoSI with 100% national data. The approaches covered by this report instead simulate the calculations that could potentially be made in Spain if the appropriate information were available. Estimates have specifically been made firstly for the VoSI by combining the Spanish VSL with the relative MAIS disutility fractions in the USA, and furthermore by

[60] Bearing in mind that magnitudes valued at prices from different years are being mixed. Those in Table 6 are in 2010 euros, and those from Mason et al. (2009) and Donaldson et al. (2010) are in 2014 euros, since the figures were taken from the revision by Vallejo-Torres et al., 2016).

combining the MVQALY recommended to the DGT with the absolute MAIS QALY losses, also from the United States. The former estimate sets the minor VoSI at 16,762 euros and the serious VoSI at 410,484 euros. In turn, the second estimate, if no discount is applied to the QALY losses, gives values of 20,048 and 546,855 euros for minor and serious injuries respectively. Both sets of estimates are higher than the values of 7,886 and 354,630 euros recommended to the DGT.

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 should be remembered in this regard that the human costs of serious traffic accident injury victims represent between 51% and 91% of the total costs per serious injury victim in those European countries that apply the willingness to pay approach (Schoeters et al., 2017; 2020). 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 the light of the considerable variation seen in the preferences declared by citizens in this regard, both for the Monetary Value of a Quality-Adjusted Life Year and the Value of Preventing a Statistical Non-Fatal Injury between 2011 and the present, the authors of this report recommend that these estimates be revised withinthe next 10 years. Until this revision is performed, we recommend that they be updated annually in line with the nominal increase in GDP per capita.

According to the complementary analyses conducted in this report, combining US information on the number of non-fatal victims and losses of quality of life based on the maximum level of the Abbreviated Injury Scale (MAIS) with our estimates of the VSL and MVQALY, it seems clear that it would be desirable to embark on a study allowing these data to be estimated for Spain. We recommend that the DGT launch such a study, given the considerable benefits for subsequent calculations of the social and economic burden of road accidents. Similarly, as previously recommended in the case of the costs of fatalities in Abellán et al. (2023), the authors believe that when the new update of the VoSI and VPI is performed, it would also be of interest to estimate the costs related to the accidents (damage to property, administrative and other costs), with a view to obtaining an estimate of the social cost of each serious and minor injury that is as precise as possible.

## Bibliography

Abellán, J. M. (2019). Aspectos metodológicos de un análisis SROI. In Merino, M., Hidalgo, A. (eds.). El método SROI en la evaluación económica de intervenciones sanitarias. Madrid: Fundación Weber.

Abellán, J.M., Martínez, J.E., Méndez, I., Pinto, J.L., & Sánchez, F.I. (2011a). El valor monetario de una vida estadística en España. Estimación en el contexto de los accidentes de tráfico. Madrid: Dirección General de Tráfico.

Abellán, J.M., Martínez, J.E., Méndez, I., Pinto, J.L., & Sánchez, F.I. (2011b). El valor monetario de una víctima nomortal y del año de vida ajustado por la calidad en España. Madrid: Dirección General de Tráfico.

Abellán, J.M., Martínez, J.E., Méndez, I., Pinto, J.L., & Sánchez, F.I. (2023). Actualización del valor monetario de una vida estadística en España. Madrid: Dirección General de Tráfico.

Abellán, J.M., Martínez, J.E., Sánchez, F.I. & Méndez, I. (2009). The QALY model which came in from a general population survey: roughly multiplicative, broadly nonlinear and sometimes context-dependent. Working paper E2009/4. http://www.centrodeestudiosandaluces.info/PDFS/E200904.pdf

Abellán, J.M., Sánchez, F.I., Martínez, J.E. & del Llano, J. (2022). Siniestralidad vial en España. Impacto económico y sanitario. Madrid: Fundación Gaspar Casal-Fundación Mutua Madrileña.

Abellán, J.M., Sánchez, F.I., Martínez, J.E. & del Llano, J. (2022). Siniestralidad vial en España. Impacto económico y sanitario. Madrid: Fundación Gaspar Casal-Fundación Mutua Madrileña.

Abellán-Perpiñán, J.M., Pinto-Prades, J.L., Méndez-Martínez, I., Badía-Llach, X. (2006). Towards a better QALY model. Health Economics, 15(7), 665–76. https://doi.org/10.1002/hec.1095

Abellán-Perpiñán, J. M., Sánchez-Martínez, F. I., Martínez-Pérez, J. E., Méndez-Martínez, I. (2012). Lowering the 'floor' of the SF-6D scoring algorithm using a lottery equivalent method. Health Economics, 21(11), 1271-1285.

Aldy, J.E., and W.K. Viscusi, "Age Differences in the Value of Statistical Life: Revealed Preference Evidence," Review of Environmental Economics and Policy 1: 241-260, 2007.

Alfaro, J-L., Chapuis, M., Fabre, F. (Eds.). (1994). COST 313. Socioeconomic cost of road accidents. Report EUR 15464 EN. Commission of the European Communities, Brussels, Belgium.

Bahamonde-Birke, F. J., Kunert, U. & Link, H. (2015). The Value of a Statistical Life in a Road Safety Context — A Review of the Current Literature, Transport Reviews, 35 (4), pp. 488-511.

Baker, R., Chilton, S., Donaldson ,C., et al. (2011). Searchers vs surveyors in estimating the monetary value of a QALY: resolving a nasty dilemma for NICE. Health Econ Policy Law, 6:435–47.

Bateman, I., Day, B., Loomes, G., Sugden, R. (2007). Can ranking techniques elicit robust values? J Risk Uncertain., 34:49–66.

Bateman, I. J., Cameron, M. P., Tsoumas, A. (2006) Investigating the characteristics of stated preferences for reducing the impacts of air pollution: a contingent valuation experiment. Working Papers in Economics 06/08, University of Waikato

Bateman, I. J., Cole, M., Cooper, P., Georgiou, S., Hadley, D., Poe, G.L. (2004). On visible choice sets and scope sensitivity. J Environ Econ Manag 47:71–93

Bateman, I., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Özdemiroğlu, E., Pearce, D., Sugden, R., Swanson, J. (2002). Economic Valuation with Stated Presence Techniques: A Manual, Edward Elgar, for the Department of Transport.

Beattie, J., Covey, J., Dolan, P., Hopkins, L., Jones-Lee, M., Loomes, G., Pidgeon, N., Robinson, A., & Spencer, A. (1998). On the contingent valuation of safety and the safety of contingent valuation: Part 1-Caveat investigator. Journal of Risk and Uncertainty, 17(1), 5–26. https://doi.org/10. 1023/A: 10077 11416 843

Bickel, P., Friedrich, R., Burgess, A., Fagiani, P., Hunt, A., de Jong, G., Laird, J., Lieb, C., Lindberg, G., Mackie, P., Navrud, S., Odgaard, T., Ricci, A., Shires, J., Tavasszy, L. (2006). Proposal for Harmonised Guidelines. HEATCO Deliverable 5.

Bleichrodt, H., Johannesson, M. An experimental test of a theoretical foundation for rating-scale valuations. Med Decis Making. 1997; 17:208–16.

Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. (2015). The economic and societal impact of motor vehicle crashes, 2010 (Revised). Washington, DC.

Blincoe, L., Miller, T., Wang, J.-S., Swedler, D., Coughlin, T., Lawrence, B., Guo, F., Klauer, S., & Dingus, T. (2023, February). The economic and societal impact of motor vehicle crashes, 2019 (Revised) (Report No. DOT HS 813 403). National Highway Traffic Safety Administration.

Blincoe, L., Seay, A., Zaloshnja, E., Miller, T. R., Romano, E. O., Luchter, S., & Spicer, R. S. (2002). The economic impact of motor vehicle crashes 2000. Washington, D.C.: U.S. Department of Transportation, National Highway Traffic Safety Administration.

Boardman, A.E., Greenberg, D.H., Vining, A.R. & Weimer, D.L. (2017). Cost-benefit analysis. Concepts and practice. Fourth edition. Prentice Hall, Upper Saddle River, New Jersey.



Bobinac, A.,VanExel, N. J. A., Rutten, F. F. H., Brouwer, W. B. F. (2010). Willingness to pay for a quality-adjusted life-year: the individual perspective.Value in Health, 13, 1046–55.

Bobinac, A.,vanExel, N. J. A.,Rutten, F. F. H., Brouwer, W. B. F. (2012). Get more, pay more? An elaborate test of construct validity of willingness to pay per QALY estimates obtained through contingent valuation. Journal of Health Economics, 31, 158–68.

Brazier, J., Roberts, J., Deverill, M. (2002) The estimation of a preference-based measure of health from the SF-36. Journal of Health Economics, 21(2) 271-292.

Byrne, M. M., O'Malley, K., Suarez-Almazor, M. E. (2005). Willingness to pay per quality-adjusted life year in a study of knee osteoarthritis. Medical Decision Making, 25 (6), 655–666.

Camps-Herrero, C., Paz-Ares, L., Codes, M., et al. (2014). Social value of a quality-adjusted life year (QALY) in Spain: the point of view of oncologists. Clin Trans Oncol., 16:914–20.

Carthy, T., Chilton, S., Covey, J., Hopkins, L., Jones-Lee, M., Loomes, G., Pidgeon, N., & Spencer, A. (1999). On the contingent valuation of safety and the safety of contingent valuation: Part 2—The CV/SG "Chained" approach. Journal of Risk and Uncertainty, 17(3), 187–214. https://doi.org/10. 1023/A: 10077 82800 868

Chiang, C. L. (1976). Life table and mortality analysis. Geneva: WHO; 1976.

Corso, P. S., Hammitt, J. K., & Graham, J. D. (2001). Valuing mortality-risk reduction: Using visual aids to improve the validity of contingent valuation. Journal of Risk and Uncertainty, 23(2), 165–184. https://doi. org/ 10. 1023/A: 10111 84119 153

De Blaeij, A. T., Florax, R. J. G. M. , Rietveld, P., Verhoef, E. (2003). The value of statistical life in road safety: A meta-analysis. Accident Analysis and Prevention, 35(6), 973–986.

De Cock, E., Mirabitlles, M., González-Juanatey, J. R., et al. (2007). Valor umbral del coste por año de vida ganado para recomendar la adopción de tecnologías sanitarias enEspaña: evidencias procedentes de una revisión de la literatura. PharmacoEconomics Spanish Res Art., 4:97–107.

Dhondt, S., MacHaris, C., Terryn, N., Van Malderen, F., & Putman, K. (2013). Health burden of road traffic accidents, an analysis of clinical data on disability and mortality exposure rates in Flanders and Brussels. Accident Analysis & Prevention, 50, 659–666.

Dilla, T., Lizan, L., Paz, S., et al. (2016). Do new cancer drugs offer good value for money? The perspectives of oncologists, health care policy makers, patients and the general population. Pat Pref Adherence., 10:1–7.

Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on road infrastructure safety management. BOE no. 319, of 29 November 2008.

Dolan, P., Edlin, R. (2002). Is it really possible to build a bridge between cost-benefit analysis and cost-effectiveness analysis? Journal of Health Economics 21 (5), 827–843.

Donaldson, C., Baker, R., Jones-Lee, M., Loomes, G., Mason, H., Robinson, A., et al. (2008). Weighting and valuing quality adjusted life years: preliminary results from the Social Value of a QALY Project. http://www.pcpoh.bham.ac.uk/publichealth/methodology/projects/RM03 JH12 CD.shtml.

Donaldson, C., Baker, R., Mason, H., Pennington, M., Bell, S., Lancsar, E., Jones-Lee, M., Wildman, J., Robinson, A., Bacon, P., Olsen, J. A., Gyrd-Hansen, D., Bech, T. K. M., Nielsen, J. S., Persson, U., Bergman, A., Protière, C., Moatti, J. P., Luchini, S., Prades, J. L. P., Mataria, A., Khatiba, R. A. (2010). European value of a quality adjusted life year. https ://research.ncl.ac.uk/eurovaq/EuroVaQ_FinalPublishable_Report_and_Appendices.pdf

Gabbe, B. J., Lyons R. A., Simpson, P. M., Rivara, F. P., Ameratunga, S., Polinder, S., Derrett S., & Harrison, J. E. (2016). Disability weights based on patient-reported data from a multinational injury cohort. Bulletin of the World Health Organization, 94, pp. 806-816C.

Gigerenzer, G. (2002). Calculated risks: How to know when numbers deceive you. New York: Simon & Schuster.

Gyrd-Hansen, D. (2003). Willingness to pay for a QALY. Health Economics, 12 (12):1049–60.

Gyrd-Hansen, D., Kjær, T., Nielsen, J. S. (2012). Scope insensitivity in contingent valuation studies of health care services: should we ask twice? Health Economics, 21(2), 101-112.

Hammitt, J. K., & Graham, J. D. (1999). Willingness to pay for health protection: Inadequate sensitivity to probability? Journal of Risk and Uncertainty, 18(1), 33–62. https://doi.org/10. 1023/A: 10077 60327 375

Hammitt, J. K. (1986). Estimating consumer willingness to pay to reduce food-borne risk. R-3447-EPA, RAND Corporation, Santa Monica.

Hirsch, A., Eppinger, R., Shame, T., Van Nguyen, T., Levine, R., Mackenzie, J., Marks, M., Ommaya, A. (1983). Impairment scaling from the abbreviated injury scale. Washington, DC: National Highway Traffic Safety Administration.

Hojman, P., Ortúzar, J. D., Rizzi, L. I., 2005. On the joint valuation of averting fatal and severe injuries in highway accidents. Journal of Safety Research 36 (4), 377–386. https://doi.org/10.1016/j.jsr.2005.07.003.

Iragüen, P., Ortúzar, J., D., 2004. Willingness-to-pay for reducing fatal accident risk in urban areas: an Internet-based Web page stated preference survey. Accident Analysis and Prevention 36, 513–524. https://doi.org/10.1016/S0001-4575(03)00057-5.

Jones-Lee, M., Loomes, G., & Philip, P. (1995). Valuing the prevention of non-fatal road injuries: Contingent valuation vs. standard gambles. Oxford Economic Papers, 47(4), 676–695. https://doi.org/10. 1093/oxfordjournals.oep.a042193

Jones-Lee, M. W. (1976). The value of statistical life: An Economic Analysis, Chicago: University Press.

Jones-Lee, M. W., Hammerton, M., Phillips, P. (1993). The value of transport safety: results of a national sample survey. Report to the department of Transport, University of Newcastle-Upon-Tyne, Department of Economics.

Kahneman, D. and Tversky, A. (1979). Prospect theory: an analysis of decision under risk. Econometrica, 47(2): 263-291.

Klose, T. (2003), 'A Utility-Theoretic Model for QALYs and Willingness to Pay', Health Economics 12(1), 17–31.

Lapostolle, A., Gadegbeku, B., Ndiaye, A., Amoros, E., Chiron, M., Spira, A., & Laumon, B. (2009). The burden of road traffic accidents in a French Departement: the description of the injuries and recent changes. BMC Public Health, 9, 386.

Martín-Fernández, J., Polentinos-Castro, E., del Cura-González, M. I., Ariza-Cardiel, G., Abraira, V., Gil-LaCruz, A. I., García-Pérez, S. (2014). Willingness to pay for a quality adjusted life year: an evaluation of attitudes towards risk and preferences. BMC Health Serv. Res., 14, 287. https://doi.org/10.1186/1472-6963-14-287.



Mason, H., Jones-Lee, M., Donaldson, C. (2009). Modelling the monetary value of a QALY: a new approach based on UK data. Health Economics, 18(8), 933–950.

Miller, T., Pindus, N., Douglass, J., Rossman, S. (1995) Databook on Nonfatal Injury—Incidence, Costs, and Consequences, The Urban Institute Press, Washington, DC.

Miller, T. R., Levy, D. T. (2000). Cost-outcome analysis in injury prevention and control: 84 estimates for the United States. Medical Care, 38, 562-582.

Mitchell, R. C, Carson, R (1986). Valuing drinking water risk reductions using contingent valuation method: a methodological study of risks from THM and Giardia. Draft report to the U.S Environmental Protection Agency, Washington.

Murray, C. J. L., Lopez, A. D. (1996). The global burden of disease: a comprehensive assessment of mortality and disability from deceases, injuries and risk factors in 1990 and projected to 2020. Harvard University Press. Cambridge. https://doi.org/10.1186/1471-2458-13-863.

Nimdet, K., Chaiyakunapruk, N., Vichansavakul, K., Ngorsuraches, S. (2015). A systematic review of studies eliciting willingness-to pay per quality-adjusted life year: does it justify CE threshold? PLoS One 10(4), e0122760 . https://doi.org/10.1371/journal.pone.0122760

Norman, R., King, M. T., Clarke, D., Viney, R., Cronin, P., & Street, D. (2010). Does mode of administration matter? Comparison of online and face-to-face administration of a time trade-off task. Quality of Life Research, 19(4), 499–508. https://doi.org/10.1007/s11136-010-9609-5

O'Reilly, D., Hopkin, J., Loomes, G., Jones-Lee, M., Phillips, P., McMahon, K., Ives, D., Soby, B., Ball, D., Kemp, R. (1994). The value of road safety: UK research on the valuation of preventing non-fatal injuries. Journal of Transport Economics and Policy 28(1): 45-59.

Order INT/2223/2014, of 27 October, governing the communication of information to the National Register of Traffic Accident Victims. BOE no. 289, of 29 November 2014.

Paling, J. (1997). Up to your armpits in alligators? How to sort out what risks are worth worrying about, Gainesville, Florida: Risk Communication and Environmental Institute.

Paling, J. (2003). Strategies to help patients to understand risks. British Medical Journal, 327, 745-748.

Persson, U., Nilsson, K., Hjalte, K., Norinder, A. (1999). Värdet av att minska risken för vägtrafikskador- Beränking av riskvärden för dödliga, svära och lindriga skador med Contingent-valuation metoden. Department of Technology and Society. Lund Institute of Technology, Lund University, Bulletin XX, Lund.

Persson, U. (2004). Valuing reductions in the risk of traffic accidents based on empirical studies in Sweden. Lund Institute of Technology, Lund.

Persson, U., Norinder, A., Svensen, M. (1995). Valuing the benefits of reducing the risk of non-fatal road injuries: the Swedish experiment. In: Schwab Christe, N. G., Soguel, N. C. (Eds.), Contingent Valuation, Transport Safety and the Value of Life. Kluwer Academic Publishers, Boston, pp. 63–84.

Pinto, J.L., Attema, A., Sánchez-Martínez, F.I. Measuring Health Utility in Economics, in A. Jones (ed.) The Oxford Research Encyclopedia of Economics and Finance 2020. https://doi.org/10.1093/acrefore/9780190625979.013.85

Pinto, J. L, Herrero, C., Abellán, J.M. (2016). QALY-Based Cost Effectiveness Analysis. In: Adler, M.D., Fleurbaey, M., editors. The Oxford Handbook of Well-Being and Public Policy. New York: Oxford University Press; 2016. p. 160-192.

Pinto, J.L., Loomes, G., Brey, R. (2009). Trying to estimate a monetary value for the QALY, Journal of Health Economics, 28(3), 553-562.

Pinto, J.L., Martínez, J.E. (2005). Estimación del valor monetario de los años de vida ajustados por calidad: estimaciones preliminares. Ekonomiaz, 60(3), 192-209.

Pinto, J.L., Sánchez, F.I. (2003). Métodos para la evaluación económica de nuevas prestaciones. Madrid: Ministerio de Sanidad y Consumo.

Pinto, J. L., Abellán, J.M., Sánchez, F. (2004). Incorporación de las preferencias de los pacientes en la toma de decisiones clínicas. Elsevier-MASSON.

Pinto-Prades, J. L., Sánchez-Martínez, F. I., Abellán-Perpiñán, J. M. and Martínez-Pérez, J. E. (2018). Reducing preference reversals: The role of preference imprecision and nontransparent methods. Health Economics, 27(8): 1230–46.

Robinson, A., Gyrd-Hansen, D., Bacon, P., Baker, R., Pennington, M., Donaldson, C. & EuroVaQ Team. (2013). Estimating a WTP-based value of a QALY: The 'chained' approach. Social Science & Medicine, 92, 92-104.

Robinson, A., Loomes, G., Jones-Lee, M. Visual analog scales, standard gambles, and relative risk aversion. Medical Decision Making. 2001; 21, 17–27.

Sacristán, J. A., Oliva, J., Del Llano, J., et al. (2002). ¿Qué es una tecnología sanitaria eficiente en España? Gac Sanit., 16:334–43.

Sacristán, J. A., Oliva, J., Campillo-Artero, C., Puig-Junoy, J., Pinto-Prades, J. L., Dilla, T., Rubio-Terrés, C., Vicente Ortún (2020). ¿Qué es una intervención sanitaria eficiente en España en 2020?, Gaceta Sanitaria, 34(2): 189-193.

Samuelson, P. A. (1938). A note on the pure theory of consumer's behavior. Economica, 5: 61-71.

Schoeters, A., Large, M., Koning, M., Carnis, L., Daniels, S., Mignot, D., Urmeew, R., Wijnen, W., Bijleveld, F., van der Horst, M. (2022). Economic valuation of preventing fatal and serious road injuries. Results of a Willingness-To-Pay study in four European countries. Accid Anal Prev. 2022 Aug;173:106705. doi: 10.1016/j.aap.2022.106705.

Schoeters, A., Large, M., Koning, M., Carnis, L., Daniels, S., Mignot, D., Urmeew, R., Wijnen, W., Bijleveld, F., van der Horst, M. (2021). Monetary valuation of the prevention of road fatalities and serious road injuries – Results of the VALOR project

Schoeters, A., Wijnen, W., Carnis, L., Weijermars, W., Elvik, R., Johannsen, H., Vanden Berghe, W., Filtness, A. and Daniels, S. (2017). Costs related to serious injuries, D7.3 of the H2020 project SafetyCube.

Schoeters, A., Wijnen, W., Carnis, L., Weijermars, W., Elvik, R., Daniels, S., & Johannsen, H. (2020). Costs related to serious road injuries: a European perspective. European transport research review, 12, 1-12.

Shiroiwa, T., Sung, Y. K., Fukuda, T., Lang, H. C., Bae, S. C., Tsutani, K. (2010). International survey on willingness-to-pay (WTP) for one additional QALY gained: what is the threshold of cost effectiveness? Health Econ. 19(4):422-37. doi: 10.1002/hec.1481.

Spicer, R., Miller, T. (2010). Final Report to the National Highway Traffic Safety Administration: Uncertainty Analysis of Quality Adjusted Life Years Lost. Pacific Institute for Research and Evaluation (available at https://www.transportation.gov/office-policy/transportation-policy/uncertainty-analysis-quality-adjustedlife-years-lost).



Spicer, R., Miller, T., Hendrie, D., & Blincoe, L. (2011) Quality-adjusted life years lost to road crash injury: Updating the injury impairment index. Annals of Advancements in Automotive Medicine, 55: 365–377.

Tainio, M., Olkowicz, D., Teresi, G., de Nazelle, A., & Nieuwenhuijsen, M. J. (2014). Severity of injuries in different modes of transport , expressed with disability-adjusted life years (DALYs ). BMC Public Health, 14(765), 1–10.

Torrance, G. (1986). Measurement of health state utilities for economic appraisal: A review, Journal of Health Economics 5(1), 1-30.

Torrance, G.W., Thomas, W.H., Sackett, D.L. A utility maximization model for evaluation of health care programs. Health services research. 1972;7(2):118-33.

U.S. DOT. (2011, March 1). Guidance on treatment of the economic value of a statistical life in U.S. Department of Transportation analysis. www.transportation.gov/sites/dot.gov/files/docs/VSL%20Guidance.doc.
UNESPA (2020). Informe Estamos Seguros 2019. https://www.unespa.es/que-hacemos/publicaciones/informes-2020/

Vallejo-Torres, L., García-Lorenzo, B., Rivero-Arias, O., Pinto-Prades, J.L. (2020). The societal monetary value of a QALY associated with EQ-5D-3L health gains. The European Journal of Health Economics, 21:363–379.

Vallejo-Torres, L., García-Lorenzo, B., Serrano-Aguilar, P. (2018). Estimating a cost-effectiveness threshold for the Spanish NHS. Health Economics, 27(4), 746-761. https://doi.org/10.1002/hec.3633

Vallejo-Torres-Torres, L., García-Lorenzo, B., Castilla, I., Valcárcel Nazco, C., García-Pérez, L., Linertová, R., Polentinos-Castro, E., Serrano-Aguilar, P. (2016). On the Estimation of the Cost-Effectiveness Threshold: Why, What, How? Value in Health, 19, 558-566.

Veisten, K., Flügel, S., Rizzi, L. I., Ortúzar, J. D., Elvik, R., 2013. Valuing casualty risk reductions from estimated baseline risk. Research in Transportation Economics 43 (1), 50–61. https://doi.org/10.1016/j.retrec.2012.12.009.

Weijermars, W., Bos, N., Schoeters, A., Meunier, J.-C., Nuyttens, N., Thomas, P. (2018). Serious road traffic injuries in Europe, lessons from the EU research project SafetyCube. Transportation Research Record, 2672(32), 1–9.

Weijermars, W., Meunier, J.-C., Bos, N., Perez, C., Hours, M., Johannsen, H., Barnes, J., et al. (2016), Physical and psychological consequences of serious road traffic injuries, Deliverable 7.2 of the H2020 project SafetyCube.

Wesemann, P., Blaeij, A.T. de & Rietveld, P. (2005). De waardering van bespaarde verkeersdoden;Covernota bij 'The value of a statistical life in road safety'. [The valuation of casualties saved; Memorandum with the PhD thesis 'The value of a statistical life in road safety']. R-2005-4. SWOV, Leidschendam.

Wijnen, W. & Stipdonk, H. (2016). Social costs of road crashes: an international analysis. Accident Analysis and Prevention, 94, 97–106.

Wijnen, W., Schoeters, A., Daniels, S., Schönebeck, S., Kasnatscheew, A., Mignot, D., & Carnis, L. (2019b). Estimating the socio-economic costs of road crashes. Preparatory study for bridging knowledge gaps in Belgium, France and Germany. Brussels: Vias institute.

Wijnen, W., Weijermars, W., Schoeters, A., van den Berghe, W., Bauer, R., Carnis, L., Elvik, R., & Martensen, H. (2019a). An analysis of official road crash cost estimates in European countries. Safety Science, 113, 318–327. https://doi.org/10. 1016/j.ssci. 2018. 12. 004

Wijnen, W., Weijermars, W., Vanden Berghe, W., Schoeters, A., Bauer, R., Carnis, L., Elvik, R., Theofilatos, A., Filtness, A., Reed, S., Perez, C., and Martensen, H. (2017), Crash cost estimates for European countries, Deliverable 3.2 of the H2020 project SafetyCube.

Yamagishi, K. (1997). When a 12.86% mortality is more dangerous than 24.14%: implications for risk communication, Applied Cognitive Psychology, 11: 495-506.

# Appendix I. Estimations of the MVQALY using the utilities of the Spanish SF-6D tariff

The Spanish SF-6D tariff associates states C (311112) and J (412422) with utilities of 0.908 and 0.551, respectively, translating into a QALY loss for each scenario of between 0.0077 (state C, 1 month) and 0.1871 (stage J, 5 months). The result of dividing the WTP figures between the QALY gains that represent avoiding each of the four scenarios is shown in Table 38.

***Table 38. Estimates of the Monetary Value of the QALY (MVQALY) in euros, by an enhanced chained method (using the Spanish SF-6D tariff utilities)***

| | Based on mean WTP | Observations |
|---|---|---|
| State C – 1 month | 52,966 | 1,004 |
| State C – 5 months | 6,999 | 1,029 |
| State J – 1 month | 24,911 | 991 |
| State J – 5 months | 7,231 | 1,018 |
| ***Average*** | ***23,027*** | |

Clearly, the values of Table 38 are substantially lower than those presented in Table 33. The mean values obtained with state C, when using the utility of the social tariff to calculate the QALY gained, are approximately 50% of those obtained using the utilities measured directly in the sample with the SG. In the case of state J, the means of Table 38 are 25% of those shown in Table 33.

# Appendix II. Theoretical validity of willingness to pay (WTP)

The theoretical validity of the results is analysed by confirming that the WTP values behave as predicted by standard economic theory. One commonly accepted minimum theoretical validity requirement is the existence of positive (and significant) correlation between the WTP declared by interviewees and their capacity to pay, typically measured by means of their income. Specifically, we consider the WTP expressed for the set of instances of willingness to pay, expressed by each subject.

In this study, we corroborate the theoretical value of the results by means of an ordinary least square (OLS) regression analysis. This analysis serves to establish whether the declared WTP values show a statistically significant relationship with the expected sign, not only with the individuals' income, but also with a series of selected explanatory variables. The model is expressed as follows:

$$LnDAP = \alpha + \beta_i \cdot X_i + \varepsilon_i \quad \mathrm{i} = 1\,,2, \ldots \mathrm{n} \qquad [20]$$

Where $\alpha$ is a constant, $\beta_i$ the coefficients estimated, $X_i$ the explanatory variables, and $\varepsilon_i$ a disturbance distributed according to a normal mean 0 and variance $\sigma^2$. Both the dependent variable (WTP) and the explanatory variable "Household income" are subject to logarithmic transformation before being entered in the model, thereby immediately obtaining the income-elasticity based on the coefficient estimated for the variable representing the respondent's income. 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; size of household.
- 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 (objective risk of dying in an accident: above, equal to or below the mean; kilometres travelled; educational level; employment status, etc.). The age variable is incorporated as a continuous variable, as is age squared, in order to test a possible relationship between the WTP and the quadratic age.

***Table 39. Results of the OLS regression analysis. Efficient model***

| | WTP explained Variable | |
|---|---|---|
| | Coeffic. | Est. error |
| *Ln* Income | 0.575*** | (0.068) |
| Kilometres travelled | 5.84e-06* | (3.24e-06) |
| Aggressive driver | -0.0363** | (0.016) |
| Subjective risk = mean | -0.362*** | (0.083) |
| Consider themselves happy | 0.018** | (0,007) |
| Slight accident to self | -0,227** | (0,950) |
| Serious accident of friend | -0,278** | (0,109) |
| Serious accident of partner | 0.526* | (0,280) |
| Fatal accident of partner | 0.786* | (0,427) |
| Fatal accident of acquaintance | -0,311** | (0,127) |
| Bus | -0.149* | (0,085) |
| Van | -0.508* | (0,235) |
| Exercises occasionally | 0,413*** | (0,106) |
| Smoker | -0,195** | (0,087) |
| Survive to age of 85 | -0,007*** | (0,001) |
| Duration of survey | 0,062 | (0,015) |
| **Observations** | 1,832 | |

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

Table 39 shows the regression coefficients which explain individuals' WTP values based on the stated variables. The efficient model identifies a few regressors with statistically significant coefficients. For the purposes pursued with this regression analysis, it is worth emphasising the fact that the results from estimating the model show the existence of a positive and statistically significant relationship between income declared by the participants and their WTP values to avoid state of health X, which supports the theoretical validity of the contingent valuation study developed. Furthermore, the value obtained for income elasticity is similar to that found in this type of study. Apart from this, the number of kilometres travelled per year by road vehicle, stating a higher level of happiness, taking occasional exercise and having experienced an accident in the family (a serious or fatal accident in the case of their partner) are associated with a higher WTP to avoid state X. On the contrary, declaring a subjective risk of death by traffic accident equal to the mean, own experience of minor accident, serious or fatal accidents within their social circle (friend or acquaintance), smoking, using a van or bus as a regular means of transport, and a higher probability of surviving at the age of 85, are associated with a lower WTP.

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