

The monetary value of a statistical life in Spain

1. Introduction

Until now the Spanish State lacked its own estimate of an official value of statistical life, which would permit such assessments to be done, as provided for in Royal Decree No 345/2011 of 11 March 2011 on the management of the road infrastructure safety on the Spanish Government Road Network. This report presents the first estimate of the monetary value of statistical life made in Spain, which will enable correct assessment of the costs and benefits of road safety. Its achievement has been the result of a research project undertaken by José M^a Abellán, Jorge Eduardo Martínez, Ildelfonso Méndez and Fernando Ignacio Sánchez (University of Murcia), and José Luis Pinto (Pablo de Olavide University), for the National Road Safety Observatory of the Directorate-General for Traffic.

Passenger and freight traffic, in all its forms, results in a wide range of costs and benefits. For example, drivers use of road infrastructure brings undeniable benefits in terms of mobility. At the same time, however, road traffic involves a number of costs in the form of higher levels of air and noise pollution, a great loss of time due to traffic congestion and, one of the most important costs, the quality of life losses caused by accidents. These losses, usually referred to as *human costs* in scientific literature, represent the intrinsic value attributed to all the pain and sorrow caused by the tragic consequences of traffic accidents, that is, premature death and disability. Since human costs (unlike material losses) are not directly observable, economics research has developed methodologies for approximating their monetary value, so that they can be included within the set of social costs of traffic accidents. In the specific case of fatal accidents, this approximation is called *value of statistical life*, the value used by the most advanced motorized countries in the world with the aim to assess the impact that road infrastructures have on the number of accidents. It is estimated that human costs can amount to 50-90% - depending on the country - of the total cost of fatal traffic accidents, so omission of such costs certainly leads to the underestimation of any road safety measures that reduce the number of fatalities.

2. Concept and measurement of the value of statistical life

The concept of value of statistical life (VoSL) was coined in the late 1960s with the objective of valuing the effects of road safety in monetary terms. This concept is in no way intended to reflect the value (or price) that a person would accept as compensation for the certainty of his/her own death, since there would be no sum that is large enough for this purpose, nor the VoSL corresponds to the value assigned to an identified victim, but to an anonymous victim (hence the term "statistical" life). The VoSL is simply the value that people place on small decrease in the fatal accident rate, which corresponds to the well-being that road safety really can offer to every person. This idea can be explained intuitively by means of an example. Consider a population of 100,000 individuals whose annual death rate from traffic accidents is 3 deaths per 100,000 inhabitants. If the members of this population were willing to pay, on average, 50 euros for the reduction of the annual fatal accident rate to 2 per 100,000 (that is, a reduction in death risk of 1/100,000),

it could be concluded that the value assigned by such population to the fact of saving any life (a "statistical" life) would be 5,000,000 euros (50 euros x 100,000 inhabitants).

When a fatal traffic accident occurs, there are certain costs that are directly linked to the casualties, while others are indivisible (for instance, the costs resulting from fire-fighting services). The value of all those costs which are closely linked to road fatalities is called *value of saving or preventing a road fatality* (VPF), including more components in addition to the VoSL⁽¹⁾. In particular, the VPF is obtained by adding together three elements: VoSL, medical costs and (net) loss of productive capacity caused by the premature death of the victim⁽²⁾. Of these, the VoSL is by far the most important component.

There are two main methodological approaches to estimate the VoSL: the *revealed preference* methods and the *stated preference* methods. The former set of methods assumes that the VoSL can be inferred from the observation of the decisions made by the individuals on related markets, when they trade off risk of death and money (for example, in the automotive market, when a higher price is paid for a car equipped with better safety devices). The main advantage offered by this approach is that it is based on actual market behaviour by the individuals. However, it faces various problems (for example there are some devices which are compulsory, such as the seat belt) that make their applicability questionable for the VoSL estimate in the field of traffic accidents.

The term *stated preferences* refers to a set of methods to derive valuations of goods for which there is no market (such as health or pollution) through the use of hypothetical questions in surveys. There are at least three types of methods within the stated preference approach. The two methodologies which one could describe as "classic" are *contingent valuation* and *discrete choice experiments*. Over the last couple of decades, however, a third group of methodological proposals not falling into any of the above two categories has taken shape.

Contingent valuation (or CV) studies use a questionnaire to recreate a virtual market where the interviewer plays the role of the supply, the interviewee of the demand, and the willingness to pay (WTP) of the market price. Basically, the method consists in presenting a hypothetical scenario and asking the respondent how much money he/she would be willing to pay for receiving a "good" (e.g. a health benefit) or avoiding a "damage" (e.g. the risk of living near a polluting facility). The WTP is therefore contingent on the market recreated in the questionnaire. Sometimes they are also asked about their willingness to accept (WTA), that is, the minimum sum of money that the respondent would accept as a compensation for

(1) While the term VoSL may sometimes be used to refer to the same thing as the VPF, the convention used by, for example, Wijnen et al. (2009) is followed in this report, identifying the VoSL as a VPF component.

(2) Net lost production is derived by subtracting the value of the consumption that the fatality will not be able to consume because of his/her decease from the value of everything the fatality could have produced if he or she had not died. The loss of consumption in the life years lost is included in the VoSL as well as the human losses.

the loss of a good or for dealing with damage. The main advantage of CV is that it allows the researcher to present the subjects included in the sample exactly with the information that needs to be valued. In the case of deriving the VoSL in the context of road safety, this method would involve deriving a sample of the population's WTP for a certain reduction in the risk of dying from a road traffic accident and then extrapolating the aggregate value that the population assigns to the fact of saving a life, as indicated in the example found at the beginning of the section. Contingent valuation has undeniable advantages, but it also faces numerous problems, one of the most significant being the insensitivity of the WTP to the magnitude of the risk reduction (e.g. to be willing to pay the same amount for a reduction of 5/100,000 as for another reduction of 10/100,000).

This problem of insensitivity to the reduction of small risks of death was clearly observed by Jones-Lee et al. (1995) in the United Kingdom. This prompted the UK Department of the Environment, Transport and the Regions to fund a project to study the scope of this problem in depth as well as possible measures to address it. The result of such research was the development of a new method (Carthy et al., 1999) that was named "*contingent valuation (CV)/standard gamble (SG) chained approach*" (*CV/SG chained approach*), which is the method chosen in the study described in this report to estimate the VoSL in Spain.

The logical sequence of the CV/SG chained method is as follows: as it is difficult to elicit reliable WTP and WTA responses for small risks changes, since respondents do not display enough discrimination between variations of such small magnitude, the solution involves breaking the elicitation of the WTP (and the WTA) for a variation of the risk of death down into two stages. Firstly, CV questions are used to elicit the respondent's WTP for the certainty of a complete cure for a given non-fatal road injury and the WTA compensation for the certainty of suffering from the same injury, in such a way that the implicit marginal rate of substitution (MRS)

of wealth for risk of the non-fatal injury can be inferred (denoted as M_i). Next, the respondent is presented with a modified variant of a conventional standard gamble question aimed at estimating the ratio between the MRS of wealth for risk of death (M_d) and M_i . Finally, the product of the estimate M_i from the first stage and the ratio M_d/M_i from the second stage is equal to the VoSL. The VPF is the result of adding net production loss and medical costs to the VoSL.

The recommended VPF in the United Kingdom in the context of road transport, estimated at £ 1 million in 1997, is based on the approach described. In addition, several European reports intended to set official values within the EU take this value as a point of reference. The UNITE project (Nellthorp et al., 2000) –whose assumptions and conventions were subsequently also adopted by the HEATCO project (Bickel et al., 2006), which recommended official values of VoSL for the 25 EU countries plus Norway and Switzerland –proposed the European Standard value of €1.5 million PPP⁽³⁾ per fatality (in 1998 market prices), which would be transferred to each of the countries considered in their study adjusting the value linear with the index of GDP per capita. It is important to stress that the study carried out by Carthy et al. (1999) is the main source on which the European Standard value recommended by Nellthorp et al. (2000) in the UNITE project is based. The value estimated for Spain presented in this report has been based on this methodology.

The overview of the international evidence concerning the VoSL used in different developed countries, presented in Table 1, suggests that in most cases this value falls within the range 2 to 4 million PPP dollars.

(3) Purchasing Power Parity: rate for conversion of currencies that takes into account not only the exchange rate but also the differences in price levels between countries.

Table 1. Comparison of international values of VoSL (2009).

Country	VoSL (PPP million \$)*	GDPpc (PPP \$)	VoSL/GDPpc
Germany	1.56	36,340	43
Austria	3.32	38,823	85
Belgium **	6.82	36,308	188
Canada	3.91	37,808	103
Denmark	1.54	37,688	41
United States	5.85	45,674	128
France	1.38	33,698	41
Norway	3.51	55,750	63
The Netherlands	3.01	40,813	74
United Kingdom	2.67	35,159	76
Sweden	2.54	37,163	68

* Dollars adjusted in accordance with the Purchasing Power Parity (PPP) indices published by the OECD to take into account the differences in price levels between countries.

** Not an official value.

Source: Own elaboration based on *New Zealand Ministry of Transport* (2009)

3. The field study

The sampling design and the fieldwork were conducted by GFK Emer Ltd during the period November 2010 to January 2011. A multi-phase sampling stratified by autonomous community (Spanish regions) and population size was carried out, with the aim of obtaining a sample that was representative of the Spanish adult population. The stratification was done by population size and autonomous community (see Table 2), as well as by age groups and gender (see Table 3). The total sample was 2,020 observations. Surveys were conducted through personal interviews, in the respondent's home, and computer- assisted.

The questionnaire was structured in five distinct parts in which there were a total of forty-two questions. Although the structure of the questionnaire was the same for all respondents, eight different models of survey were designed, which differed from one another in certain details of the core parts of the questionnaire. The interviewees were randomly assigned one model or the other.

The central part of the questionnaire contained the questions aimed at obtaining the two basic inputs for the computation of the VoSL using the CV/SG chained method, that is, the rate of exchange between wealth and a non-fatal health state (see the description in Figure 1) and the rate of exchange

Table 2. Quotas (%) by population size (thousands of inhabitants) and autonomous community.

	Up to 10	10–50	50–200	200–500	Over 500	The city of Madrid	The city of Barcelona	Total
Andalusia	3.8	4.9	4.8	1.3	2.8	--	--	17.7
Aragon	0.9	0.6	--	--	1.5	--	--	3.0
Asturias	0.5	0.8	0.2	1.1	--	--	--	2.7
Balearic Islands	0.5	0.9	--	0.8	--	--	--	2.2
Canary Islands	0.5	1.6	0.9	1.3	--	--	--	4.3
Cantabria	0.4	0.4	0.5	--	--	--	--	1.2
Castile and León	2.6	0.7	1.9	1.0	--	--	--	6.2
Castile-La Mancha	2.0	1.0	1.1	--	--	--	--	4.1
Catalonia	2.9	4.0	3.7	1.6	--	--	3.7	16.0
Extremadura	1.3	0.6	0.6	--	--	--	--	2.5
Galicia	2.1	2.1	1.0	1.2	--	--	--	6.3
Madrid	0.7	1.1	3.2	0.7	--	7.1	--	12.8
Murcia	0.4	1.0	0.5	1.3	--	--	--	3.2
Navarre	0.6	0.5	0.7	--	--	--	--	1.8
La Rioja	0.3	0.2	0.3	--	--	--	--	0.8
Valencian Community	1.8	4.0	1.7	1.3	1.8	--	--	10.6
Basque Country	1.1	1.4	0.9	1.3	--	--	--	4.6
Total	22.2	25.8	22.0	12.9	6.2	7.1	3.7	100

Table 3. Quotas (%) by age group and sex.

Age Group	Males	Females	Total
Under 25	5.3	5.1	10.5
25-34	10.9	10.2	21.0
35-44	10.0	9.6	19.7
45-54	7.9	7.9	15.7
55-64	6.2	6.5	12.7
64+	8.6	11.7	20.3
Total	49.0	51.0	100.0

between such health state and death. The former of these two components requires the WTP to avoid such health state under certainty, as well as the WTA for suffering such health state. To this end, respondents were asked to suppose they were in the hypothetical situation of having had a traffic accident, as a result of which, and if no medical care is received, they would be in a particular health state. Next, they were offered a state-

of-the-art medical treatment, which would return them to their pre-accident health state almost immediately. In this scenario, interviewees were asked what would be their maximum WTP for the alternative treatment which would make it possible for them to avoid the health state subject to valuation. A second monetary valuation of the same health state was obtained by asking the subjects about the minimum sum of money that would be

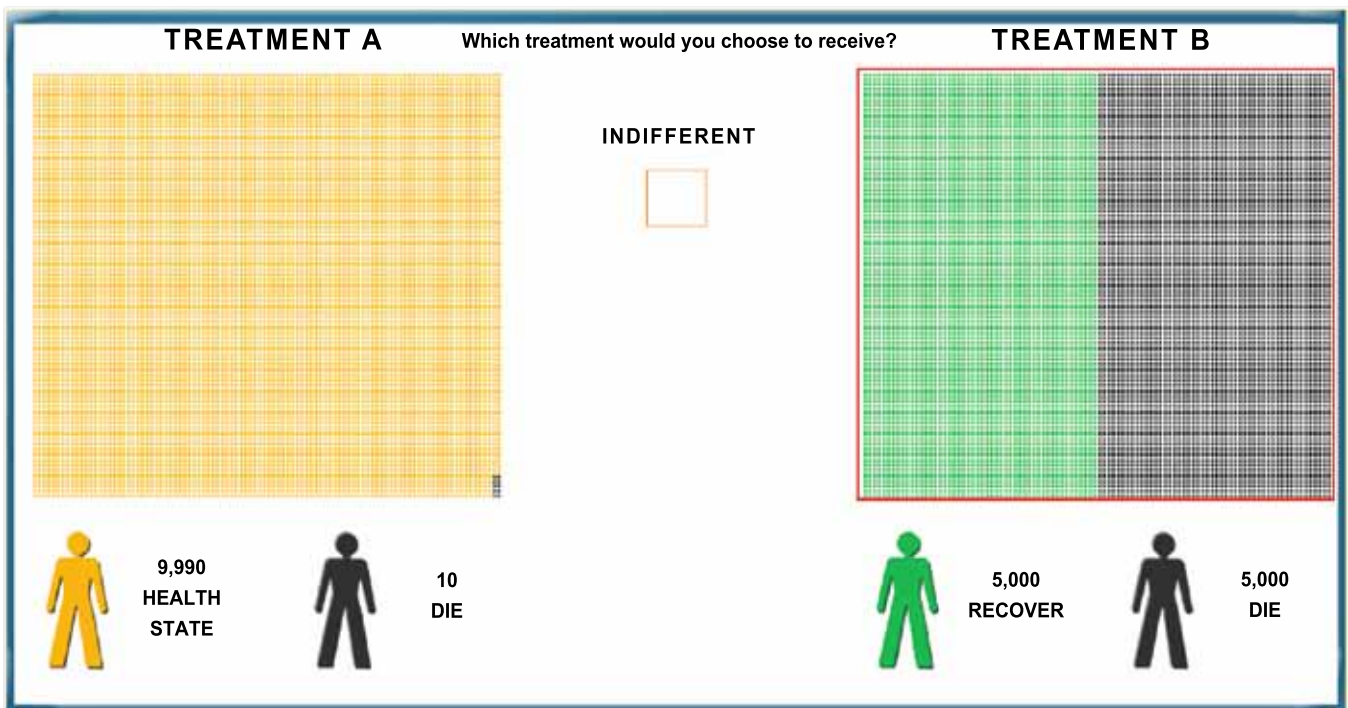
Figure 1. Description of the Health States R, V, X and W.

HEALTH STATE R	HEALTH STATE V	HEALTH STATE X	HEALTH STATE W
<p>In hospital:</p> <p>For over 4 weeks, possibly several months.</p> <p>Moderate to severe pain.</p> <p>After hospital:</p> <p>Chronic pain for life.</p> <p>There are substantial and permanent difficulties in working and performing leisure activities for life.</p> <p>Possibly some prominent scars for life.</p>	<p>In hospital:</p> <p>For 2 weeks.</p> <p>Moderate pain.</p> <p>After hospital:</p> <p>Moderate to severe pain for 1-4 weeks.</p> <p>Thereafter, the pain will be gradually reducing, but it returns when the individual performs some activities.</p> <p>There are some difficulties in working and performing leisure activities for life.</p>	<p>In hospital:</p> <p>For 2 weeks.</p> <p>Moderate pain.</p> <p>After hospital:</p> <p>Pain gradually disappearing.</p> <p>There are some difficulties in working and performing leisure activities, steadily improving.</p> <p>After 18 months, return to normal health with no permanent disability.</p>	<p>In hospital:</p> <p>For 1 week.</p> <p>Slight pain.</p> <p>After hospital:</p> <p>Some pain or discomfort for some weeks.</p> <p>There are some difficulties in working and performing leisure activities, steadily improving.</p> <p>After 3 or 4 months, return to normal health with no permanent disability.</p>

enough to compensate them for suffering such estate, that is, their WTA. In this case, assuming the same hypothetical situation of being in a particular health state resulting from an accident, they were asked to imagine that they had won a prize in the lottery on that same day. Their task was to fix the amount of the lottery prize that succeeded in compensating for the consequences of the accident (i.e., what monetary prize would make “the day, after all, neither good nor bad”). Following Carthy et al. (1999), we assume that the marginal rate of substitution between wealth and non-fatal health state is bounded between the WTP and the WTA thus estimated, its exact precision depending on the specific functional form assumed for the utility function (well-being index). In our study, as the British authors did, four different functional forms are considered: Negative Exponential, Homogeneous, Logarithmic and Nth root.

The second component of those required in order to calculate the VoSL using the chained method is the relative value of the health state in relation to death. In practice this requires knowledge of the risk of death that the subjects are willing to take to avoid suffering the non-fatal health state previously valued using the contingent valuation approach. To this end interviewees were asked to suppose that they had had a traffic accident, and were informed that if they did not receive urgent medical attention, they might die. The subsequent task was to choose between several medical treatments with various possible outcomes and different probability of success (as it is done in real life). Before the valuation questions were posed, interviewees were presented with a series of trial choices to familiarise themselves with this type of situations. In order to communicate the risks visual aids were used for ease of understanding, as the one shown in Figure 2.

Figure 2. Visual aid to choose between two medical treatments.



The task involved a sequence of successive choices, the ultimate goal of which was to elicit the value of the probability of death in treatment B that made the interviewee indifferent between both treatments. The specific procedure that was followed to determine the

value of indifference is known as *ping-pong*, by which upper and lower probabilities for treatment B are being offered, gradually narrowing the interval, until the respondent is indifferent between the two treatments.

4. Results

In Table 4 the values of statistical life calculated using the CV/SG chained method are given for each of the four forms assumed for the utility function.

It should be noted that only the responses from the interviewees attached to 6 of the 8 groups were used, since the subjects assigned to the remaining two groups serve control functions. Also, certain observations have been excluded from the calculation of VoSL for two reasons. On the one hand, those observations for which it is not possible to calculate the values using some of the functional forms have been avoided, although it may be possible with others⁽⁴⁾. Moreover, the most extreme values (*outliers*) have

(4) Typically if the WTP or the WTA are null, for example, the logarithmic function is not defined; however, it would be possible to calculate the value

been removed, that is, those whose amount exceeded the mean plus three standard deviations. In practical terms, the criterion has resulted in setting a maximum threshold slightly higher than 49.7 million euros. The *outlier* elimination involves not taking into account 13 of 1,455 observations, that is, it would mean excluding slightly less than 1% of the sample

using the homogeneous functional form. Nevertheless, for the sake of the minimum homogeneity required, the observations are only taken into account if they can be calculated using every means. In any case, this does not entail any relevant quantitative nor qualitative change as regards the mean and median values obtained through the different functional forms.

Table 4. Values of statistical life (€) obtained using the chained method.

	Negative Exponential	Homogeneous	Logarithmic	Nth root
Mean	955,262	1,142,331	1,730,253	2,294,897
Median	72,128	90,212	149,683	188,062
Standard Deviation	2.79E+06	3.25E+06	4.65E+06	6.23E+06
Minimum	7.51	10.42	13.97	13.97
Maximum	3.66E+07	3.66E+07	3.66E+07	4.95E+07
Standard Error	73,458	85,514	122,576	164,086
Observations	1,442	1,442	1,442	1,442

As the table shows, the VoSL means range between 1 and 2.3 million euros, depending on the functional form which is chosen for its calculation (the medians reach, as was to be expected, substantially lower values: between 72,000 and 188,000 euros). In the absence of a normative criterion for choosing a functional specification over the others, we opted to use the average of the four estimates as the summary value of the study. If we focus on the mean values, which are the most common measure of central tendency, this gives an average VoSL of €1.5 million.⁽⁵⁾

The theoretical validity of the valuation exercise was checked through a number of regression analyses, which were aimed at seeing whether the WTP and WTA expressed by the respondents, as well as the VoSL obtained using the chained method, were in line with what the economic theory had predicted. These analyses found a significant positive relationship between the income level and the value of life, which serves as a minimum validity requirement in a CV study.

An assumption inherent in the determination of the VoSL using the chained method is that the utility of income is independent of the individual's health state, that is, the satisfaction that an individual derives from his/her income level is the same regardless of his/her health state. There is, however, some evidence against this assumption. For example, Viscusi and Evans (1990), in the context of accidents at work, found that the marginal utility of income in bad health was between 77 and 92% of that in healthy state. Thus, it makes sense to take this fact into account by incorporating this difference in marginal utility of income in the analysis. Carthy et al. (1999) estimated (for the specific case of the function that shows the most extreme behaviour, the nth root), that incorporating a 20% reduction of the marginal utility of income results in a decrease in

the VoSL obtained of about 15%. Accordingly, we have opted for a conservative interpretation and applied a reduction coefficient of 0.85 to the average of the means of the values obtained in our study (1.5 million euros). As a result of this adjustment, the reference VoSL is set at 1.3 million euros.

As stated above, the total *value of saving or preventing a road fatality* (VPF) can be considered as the sum of three components: VoSL, net production loss and medical and ambulance costs. As regards lost production, it was estimated making a series of simplifying assumptions - details of which can be found in the final report of the study⁽⁶⁾. The results of the estimates led to a range of values in terms of net output of between 70,000 and 180,000 euros, with an average value of 113,000 euros and a median of 99,300 euros.

There is little information available about medical and ambulance costs for Spain. Nevertheless, based on the estimates by Lladó y Roig (2007) and the FITSA (2008) study data, we believe it is reasonable to assume a total increase in connection with these issues of approximately 1,000 euros. Account taken of all the above, a round-figure value of 100,000 euros is assumed, which includes both the value of net production loss and medical and ambulance costs incurred per fatal casualty. If this figure is added to the VoSL, a final VPF of **€1.4 million** is obtained.

5. Conclusions

In the research undertaken VoSL was estimated by means of a procedure similar to that employed by Carthy et al. (1999) for the UK. Since 1997 the UK official value (Spackman et al., 2011) is based on this technique, which is known as the *contingent valuation/standard gamble chained approach*. In the view of the authors of

(5) The application of an alternative procedure to select the point estimation of the VOSL, giving more weight to the median VOSL, as Carthy et al. did, leads to a very similar result (100,000 euros lower).

(6) http://www.dgt.es/was6/portal/contenidos/documentos/seguridad_vial/estudios_informes/InformeValor_MonetarioVidaEstadistica.pdf

this report, this method is the most robust procedure known (the best available “technology”) to estimate VoSL. In fact, this view is shared by the authors of the European projects UNITE and HEATCO, whose recommendations flow directly from the million pounds estimated by Carthy et al. (1999) for the UK (Nellthorp et al., 2000: p. 22).

Our study provides average estimates of the VoSL, ranging from 1 to 2.3 million euros. In order to be able to calculate the cost associated with a road fatality - what we have agreed to call the *value of saving or preventing a fatality* (VPF) - it is necessary to choose a point estimate within this range. This value has been set at the average of the means derived, that is, a value of €1.5 million, which has been reduced by 15% to take into account the evidence (Viscusi and Evans, 1990) suggesting the possibility that the marginal utility of income conditional on suffering a certain deterioration in the health state may differ to that on normal health. This gives a final VoSL of €1.3 million. When this sum is increased by the estimated scale of medical costs and (net) loss of productive capacity, we obtain that the total value of preventing a road fatality in Spain amounts to €1.4 million. This value is equivalent to around \$2 million in Purchasing Power Parity; a value 61 times the Spanish GDP per capita. If we compare this relationship with the one currently in force in some countries in our environment (those presented in Table 1), Spain would be ahead of Denmark, France and Germany (countries listed in the bottom third), far below Belgium, the United States, Austria and Canada, slightly below United Kingdom, the Netherlands and Sweden, and very close to Norway.

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