Quality of Life Lost Due to Road Crashes*

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Abstract

The objective of this paper is to evaluate the effect of a road crash on the health-related quality of life of injured people. A new approach based on the cardinalization of different categorical measures of ill-health, such as TTO and VAS indexes, is suggested and used for assessing the robustness of the results. The methodology is based on the existing literature about treatment effects. Our main contribution focuses on evaluating the chronic loss oh health, that would allow to properly estimate the health losses in quality-of-life terms.

JEL Classification: C25; I10

Keywords: Health-related quality of life; Health measurement; Road crashes

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1 Introduction

The objective of this work is to estimate the chronic loss of health following a road crash. The methodology is based on the definition of comparison groups, by using the existing literature regarding treatment effects. The main contribution of this paper is the evaluation of health losses due to diseases in terms of quality of life. Moreover, this paper developes a different method for scaling categorical health measures, a powerful tool in health-related analysis.

The selection of the topic "road crashes" is not pointless. In 2001, injuries represented 12% of the global burden of disease [1]. The category of injuries worldwide is dominated by those incurred in road crashes. In 2004, over 50% of deaths caused by road crashes were associated to young adults in the age range of 15–44 years, and traffic injuries were the second-leading cause of death worldwide among both children aged 5–14 years, and young people aged 15–29 years [2]. In addition, road crashes are expected to be the main origin of the projected 40% increase in global deaths resulting from injury between 2002 and 2030 [3].

In Spain traffic accidents are also a major health problem. The tendency is decreasing, but still in 2006 the number of deaths by road traffic injuries (RTIs, hereafter) reached 4,144 individuals [4]. Similarly to other countries, RTIs affect young people more significantly, causing more than half of the deaths for those aged 15-24 (see **Figure 1**).

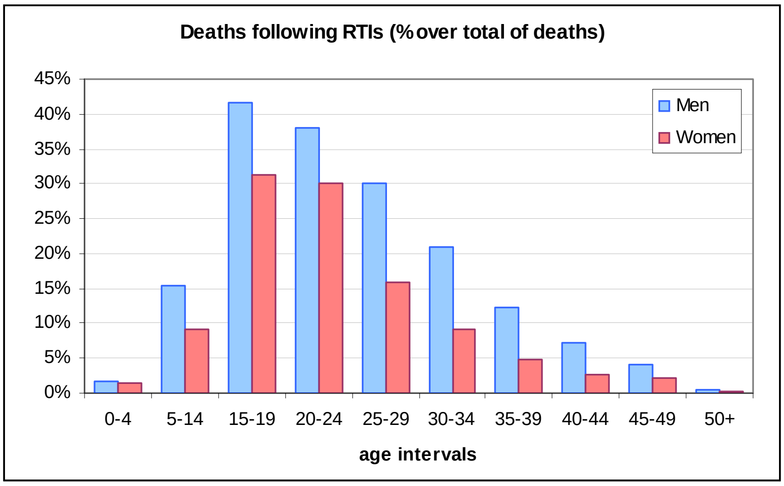

Figure 1: Deaths by RTIs over all causes of death. Spain, 2006 (Source: INE)

Counts of the (absolute or relative) number of deaths have been one of the primary instruments for quantifying the burden of illnesses. However, as the World Health Organization defined in 1946, the idea of health "is not only the absence of infirmity and disease, but also a state of physical, mental and social well-being" [5]. This broad definition captures essential elements of quality of life, which underlies most human health metrics. Based on this definition, it is also clear that life expectancy or mortality-based measures are no longer being considered adequate as measures of a population's health.

Currently, measures of disability and health-related quality of life are becoming important, even essential parameters in the evaluation of treatment and prevention strategies for reducing the burden of injury [6]. Studies in such a context are performed throughout the evaluation of cost-effectiveness ratios, that are obtained by taking the cost of the treatment and dividing it by the health gains [7]. The cost of the treatment is calculated in monetary terms, and there exists a general agreement about the computational methodology. However, evaluating changes in health (gains or losses) requires a thoughtful analysis of the key features.

Let us illustrate this idea in the context of evaluating health losses due to a road crash[1]. Following the path that Gold et al. establish [7], we consider the life path of an individual as a continuous function that represents frequent changes in health-related quality of life (QoL). Let us call $Y(i,t)$ the function that describes the health status of individual i at time t. Now image that the individual i suffers from a traffic accident at time T. Let us represent the health state of this individual under two possible scenarios: in case the accident did not happen, and in case it did (let us call these health paths as $Y_0(i,t)$ and $Y_1(i,t)$, respectively). The loss of health (evaluated at time $T+1$) would coincide to the difference $Y_0(i,T+1)-$ $Y_1(i,T+1)$. However, the *potential* health status $Y_0(i,T+1)$ is always unidentified, since it is impossible to know what the state of health of the individual would have been had the accident not occurred. The problem is how to approximate this unknown *potential* health status.

Many authors consider the health state prior to the accident (pre-injury status), evaluated at time $T-1$, as a proxy of the *potential* health state, that is, $Y_0(i,T+1) \simeq Y_0(i,T-1)$. And yet, a problem related to the lack of data could arise at this point. If the studies deal with institutionalized individuals, that is, if the treatment is defined

[1] The design of the methodology we develope later implies that it only makes sense in an aggregate context, that is, it must be framed in a context of evaluating average losses for targeted groups of population. However, for simplicity purposes, the following explanation will refer to the evaluation of health losses for a single individual.

over targeted subpopulation with well-known health state (e.g. cancer treatments, effectiveness of dialysis programs, etc.), it is plausible to obtain proper information about the pre-injury status of the patients. Specially difficult is the analysis of injuries in prevention control (burning, road crashes, falls, poisoning, etc.), since the pre-injury status of the individual is completely unknown. Given the lack of pre-injury measures, most studies in this area consider the pre-injury health state as "perfect health".

A different strategy for approximating the *potential* health state of the injured people remains on obtaining information from other people, rather than the injured individual per se. Following our illustration, let's imagine that we can find information about the health state of an individual (say, j) who has not suffered a road traffic crash, and that j is highly comparable to the injured individual, since they coincide in several factors (maybe age, gender, studies...). Call the health state of individual j $Y(j,t)$. We can approximate $Y_0(i,T+1)$ by means of $Y(j,T+1)$, but the results could still present some bias (see **Figure 2**).

The approaches suggested previously (*pre-injury status* and *comparison groups*) are highly connected, and can be easily combined. In fact, the use of comparison groups to approximate the pre-injury status is the most common choice nowadays. In fact, the use of population norms that provide some benchmark against which to compare pre-injury status is often particularly important to the study of trauma outcomes [8].

In this work I estimate the chronic loss of health (in quality of life terms) that is due to a road crash, for those who suffer the road crash. The methodology is based on the definition of comparison groups, by using the existing literature concerning treatment effects. In Section 2 the methodology is described, starting with the cardinalization of categorical variables, and following with the estimation of the direct loss of health; Section 3 describes the data used for the analysis; Section 4 provides the main results, and gives evidence to their robustness; Section 5 summarizes the main conclusions.

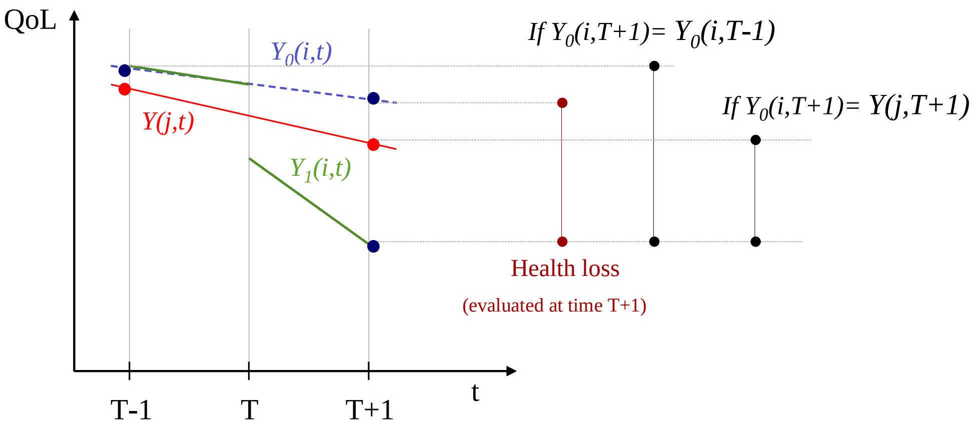

Figure 2: possible bias at estimating potential health effect in terms of pre-injury status and comparison group

2 Methodology

2.1 Measurement of health

A wide variety of metrics are used to quantify the burden of illnesses and injuries to population (an exhaustive description of these measures can be found in [6],[8] or [9], among others). In general terms, we can talk about two different sort of measures, depending on how we approach the problem.

Measures in the first group focus on the impact of the injury over the general health state of the individual, developing a variety of indices or metrics that define "health". Measures as *Visual Analogue Scale* (*VAS*), *Self-Assessed Health* (*SAH*), *Euroquol five-dimensional index* (*EQindex* or *VAS preferences tariff*), *Time-Tradeoff tariff* (*TTO preferences tariff*), *Short-Form Healh Survey* (*SF-36*) or *Health Utility Index* (*HUI*) can be placed within such an approach. These metrics are commonly used in cost-effectiveness analysis of medical treatments, since they reflect the quality of health states both form a physical and psychological aspect. Those measures are, generally, being preference-based. Consequently, they can combine the effect of death and nonfatal consequences into a summary measure which typically ranges from 0 (representing death) to 1 (representing optimal health) and where any number reflects the relative preference for particular health states. However, it must be taken into account that most of them reflect self-reported health states. Previous characteristic can, on the one hand, complicate interpersonal comparisons among subjects (and therefore the consistency of aggregation procedures), and, on the other hand, securing data from some targeted groups of population as can be children, elderly or unconscious.

Metrics in the second group try to estimate the seriousness of the injuries, either reflecting the degree of functional limitation of the injured individuals (*Functional Capacity Index* (*FCI*), *Disability weights*, etc.), or attending to the mortality risk or life threat (*Abbreviated Injury Scale* (*AIS*), *Injury Severity Score* (*ISS*), *ICD-9 Injury Severity Score* (*ICISS*), *Anatomic Profile Score* (*APS*), etc.). These sorts of metrics are considered as objective, since they can be observed from the medical point of view; are easy to obtain, and examine in detail the characteristics of the concrete injury. Nonetheless, not all metrics in this group have been clearly validated [10], and moreover they present some other disadvantages, as can be not allowing for heterogeneity, problems with co-morbidities, and not taking into account the psychological dimension.

Of the scales that have been reviewed, those that belong to the second group are the ones most commonly used to asses health losses due to injuries. However, several studies suggest that an individual's injury and acute psychological responses are strongly linked and so both play important roles in determining quality of life and disability outcomes (e.g. [11]). Although measures of severity in the second group provide some understanding of the relative seriousness of injuries in terms of threat to life and resource utilization, they still fall short in measuring the long-term impact of nonfatal injuries on the person, his or her family, and the society at large. These considerations have challenged the field to move beyond counting injuries by severity alone to measuring their direct impact on health-related quality of life.

In the present work I approach the problem from a quality-of-life perspective, that is: I analyze the impact of fatal and nonfatal injuries on the quality of life of the injured individuals, not only attending to the physical damage that the injury caused, but also contemplating the possible psychological consequences, as well as the potential impact on the well-being of those affected. In order to check the robustness of the results, the analysis is performed by using different quality-related health state scores (*VAS tariff* and *TTO tariff),* that are obtained by applying the Spanish EQ-5D index tariffs. [12] [13]. Both scores allow negative values, that is, health states worse than death, what may create some confusion in the measurement of health effects. One criterion for overcoming these controversies remains on changing the negative values to zero (e.g. [14], [15]). A different method centers on re-scaling the scores to the interval (0,1), based on the minimal and maximal values obtained in the tariff (related to health states 33333 and 11111, respectively) [16]. None of both is, in principle, preferable to the other, but they can lead to different results. Our analysis is performed by using both criteria for each measure. I denote the outcomes as $VASz, VASr, TTOz$ and $TTOr$, depending on the tariff (VAS *tariff* or TTO *tariff*) and the adopted criterion (to change negative values to zero or to re-scale them).

2.2 Cardinalization of SAH

The loss of health is derived from the respondent's assessment of her own health status. That piece of information about self-assessed health will be obtained from the categorical variable SAH : "In your opinion, how is your health in general?", where respondents must choose one of the following categories: "very good", "good", "fair", "bad" or "very bad". Since categorical measures of health are one of the most commonly used indicators in socioeconomic surveys, a wide variety of methods were developed with the aim of dealing with the cardinalization of ordinal health measures (e.g. [18], [19], [20]). In this study I adopt the interval regression model, stated by Van Doorslaer and Jones ([21]). This model is shown to outperform other econometric approaches, in terms of validity and ability to mimic the distribution of scaling health measures.

This methodology remains on combining the distribution of observed SAH with external information on the distribution of a generic measure of health y, in order to construct a continuous standardized latent health variable. The crucial idea that lies beneath the selected methodology (interval regression) remains on considering the true health state of an individual i as a latent, continuous but unobservable variable (y_i^*), that can take on any real value. The relationship between the true health state of individual i (y_i^*) and the self-reported health variables (SAH_i and y_i) is assumed to be as follows: the higher the value of y_i^*, the more likely the individual is to report a higher category in SAH_i, and a higher value in y_i. For such a connection to be correct, it is necessary to assume that there is a stable mapping from y_i^* to y_i that determines SAH_i, and that this applies for all individuals in both samples. This statement implies that the reported variables have rank properties; that is, the *qth*-quantile of the distribution of y will correspond to the *qth*-quantile of the distribution of SAH.

Let divide the range of y and y^* into five intervals, each one corresponding to a different value of SAH :

$$SAH_i = j \quad if \quad \mu_{j-1} < y_i^* < \mu_j, \quad j = 1, 2, 3, 4, 5 \tag{1}$$

$$SAH_i = j \quad if \quad \eta_{j-1} < y_i < \eta_j, \quad j = 1, 2, 3, 4, 5 \tag{2}$$

where it is set that $\mu_0 = -\infty, \mu_5 = +\infty, \eta_0 = 0, \eta_5 = 1, \mu_j \leq \mu_{j+1}, \eta_j \leq \eta_{j+1}$ and y_i^* is assumed to be a linear function of a vector of socioeconomic factors X_i

$$y_i^* = X_i\beta + u_i, \text{ with } u_i \sim N(0, \sigma^2) \tag{3}$$

Expressions (1) and (3) represent the well-known ordered probit model, and (2) will allow us to use a nonparametric approach to estimate the (re-scaled) thresholds of the model, by using the cumulative frequency of observations for each category of SAH to find the quartiles of the empirical distribution function for y. Since we have set the thresholds, this allows us to identify the variance of the error term $\widehat{\sigma}^2$ and hence, the scale of y^* without having any scaling or identification problems [21].

A variation of the methodology explained above will be used in this study. It is well-known that the health of a general population sample has a very skewed distribution, with the great majority of respondents reporting their health in higher levels. To ensure that the latent health variable is skewed in the appropriate direction, we redefine the true health of the individual in a range $(-\infty, 0]$, and assume that $h_i^* = -y_i^*$ has a standard lognormal distribution. The new variable h_i^* is decreasing in health, so that represents the latent "ill-health" of the individual. Since the connection between y and SAH is due to represent the latent variable, an adaptation is needed.

Let us denote $h = 1 - y$, and define SAH^{ih} as a new variable where the ordering of the self-assessed health categories has been reversed, now interpreted in terms of ill-health. If the values of the generic measure y yields in the range $[0, 1]$, the connection between the variables holds as **Table 1** shows:

health			ill-health		
SAH	y	y^*	SAH^{ih}	h	h^*
1	$[0,\lambda_1]$	$(-\infty,\alpha_1]$	5	$[1-\lambda_1,1]$	$[-\alpha_1,+\infty]$
2	$]\lambda_1,\lambda_2]$	$[\alpha_1,\alpha_2]$	4	$[1-\lambda_2,1-\lambda_1]$	$[-\alpha_2,-\alpha_1]$
3	$]\lambda_2,\lambda_3]$	$[\alpha_2,\alpha_3]$	3	$[1-\lambda_3,1-\lambda_2]$	$[-\alpha_3,-\alpha_2]$
4	$]\lambda_3,\lambda_4]$	$[\alpha_3,\alpha_4]$	2	$[1-\lambda_4,1-\lambda_3]$	$[-\alpha_4,-\alpha_3]$
5	$]\lambda_4,1]$	$[\alpha_4,0]$	1	$[0,1-\lambda_4]$	$[0,-\alpha_4]$

Table 1: Relationship among health and ill-health variables

Let $\eta_0 = 0, \eta_1 = 1-\lambda_4, \eta_2 = 1-\lambda_3, \eta_3 = 1-\lambda_2, \eta_4 = 1-\lambda_1$ and $\eta_5 = 1$. The methodology assumes that the latent true ill-health h^*can be represented by h in a $0-1$ scale, and the thresholds of the intervals determining SAH^{ih} $(\eta_j, j = 1..4)$ are obtained from external information and thus, are observable.

Therefore, the model becomes:

$$SAH_i^{ih} = j \text{ iff } \eta_{j-1} < h_i < \eta_j,\ j = 1,2,3,4,5$$

$$\log(h_i) = X_i\beta + u_i, \text{with } u_i \sim N(0,\sigma^2) \tag{4}$$

Our aim is to estimate the health valuation of each individual in a continuous 0 -1 scale, knowing X_i. Noticing that $\exp(u_i) \sim lognormal(0,\sigma^2)$, I obtain the expression:

$$H(i) = E[h_i|x_i] \approx \exp\left(X_i\widehat{\beta}\right) \cdot \exp\left(\widehat{\sigma}^2/2\right),$$

where $H(i)$ captures the estimated value of ill-health, ranging from 0 to 1, associated to individual i.

In order to evaluate the robustness of the methodology, the thresholds are determined in terms of different generic health measures obtained from external data: $y \in \{TTOz, TTOr, VASz, VASr\}$.

2.3 Evaluation of health losses

The analysis of health losses due to RTIs can be analyzed using the *treatment effects* literature. In this context, the "treatment" is interpreted as the occurrence of a road crash that causes severe injuries to the individuals affected. Some notation is useful at this point. Let D_i indicate whether individual i had a road crash ($D_i = 1$) or not ($D_i = 0$). Let $H(i)$ represent the health status[2] for individual i. This health state is measured after the road creash takes place.

Following Rubin (1974) [22] and Heckman (1990) [23] causality is defined in terms of potential outcomes. Variable $H_0(i)$ is the outcome that individual i would attain if he had not been affected by the treatment. Equivalently, variable $H_1(i)$ is the outcome that individual i would realize if he had received the treatment. Individual causal effects cannot be calculated since only one of these potential outcomes is observed for a given individual at a given time period. Thus, the evaluation literature analyzes average measures of the effect of the treatment. In this paper I focus on the average loss of health as a result of a road crash, for those who had an accident. This quantity is known as the average treatment effect on the treated ($ATET$) and is written as follows:

$$ATET = E\left[H_1(i) - H_0(i) / D_i = 1\right] = E\left[H_1(i) / D_i = 1\right] - E\left[H_0(i) / D_i = 1\right] \quad (5)$$

The $ATET$ cannot be identified using observational data since $H_0(i)$ is only observed for those targeted by $D_i = 0$. A suitable solution is to approximate the average health state that injured people would have had in the absence of the road crash (potential health status) by the average health state observed in a comparable group of people that have not had an accident. As I mentioned in the Introduction, real data show that traffic crashes are not random, but they are more likely to happen to people with particular traits (for instance men aged 15-29). Therefore the average health of injured (*affected group*, hereafter) and non-injured (*comparison group*, hereafter) individuals cannot be unconditionally compared. Thus, the validity of this approximation is likely to be higher once differences in the distribution of observed individual characteristics are controlled for.

Let $Z(i)$ be a vector including information relative to individual i that is a priori thought to influence his probability of suffering a road crash. Under this approximation the $ATET$ can be expressed as follows:[3]

$$ATET = E\left[H/Z, D = 1\right] - E\left[H/Z, D = 0\right], \quad (6)$$

where $H = D \cdot H_1 + (1 - D) \cdot H_0$ is the observed health status of the individuals.

[2]The concept "health status" could be interpreted broadly. In this case, we consider $H(i)$ as a continuous measure of ill-health, ranging from 0 (absence of ill-health or perfect health) to 1 (full ill-health)

[3]Hereafter the individual argument will dropped out to simplify notation.

The power of this estimator to identify the $ATET$ relies on the so-called "selection on observables" restriction, that can be formally written as:

ASSUMPTION 1: $E\left[H_0/Z, D=1\right] = E\left[H_0/\ Z,\ D=0\right]$

This condition states that the health status that a person who has been injured by a road crash would have attained, had the road crash not occurred, is that for a person who did not have an accident and has the same values of the variables in Z. In other words: the effect of events other than the road crash do not contaminate the causal analysis. Furthermore, Assumption 1 implicates that unobserved individual characteristics do not affect the causal analysis, or its overall average impact is equal for both affected and comparison group.

Figure 3 illustrates the assumption.

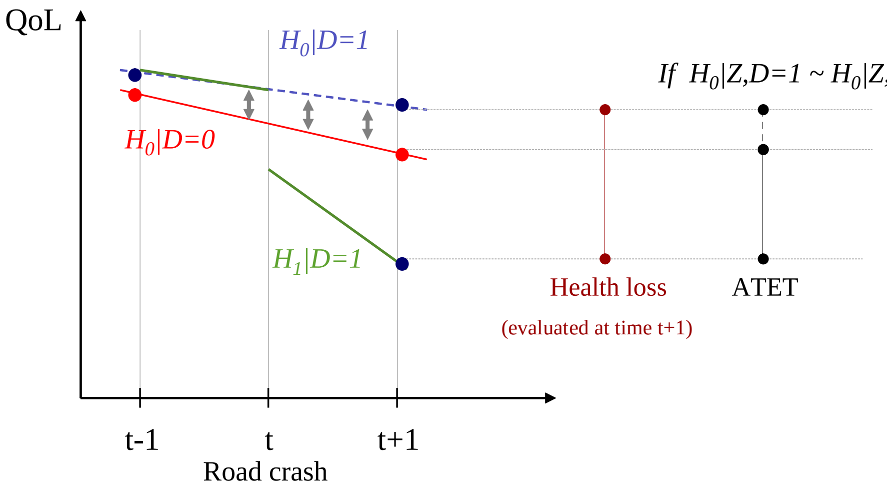

Figure 3: estimating health effect under selection on unobservables

The context of RTIs is a particular framework, which cannot be considered

Abadie (2005) [24] develops a simple two-step procedure to identify the $ATET$ using the difference-in-differences estimator. In Abadie (2005), the basic element needed to estimate the $ATET$ is the conditional probability of receiving the treatment, also called *propensity score*. This procedure is now adapted to the situation where we only have data for the post-treatment period, that is, to the selection on observables case. Since identification is attained after conditioning on covariates, it is required that for a given value of the covariates there is some fraction of the population in the pre-treatment period to be used as controls[4].

[4] Assumption 2 is a well-known condition for identification of the average impact on the treated

ASSUMPTION 2: $P(D=1)>0$ *and with probability one* $P(D=1/Z)<1$.

In a similar vein to Abadie, I establish the following lemma:

Lemma 2.1 *If Assumption 1 holds, and for values of Z such that* $0<P(D=1/Z)<1$, *we have* $E[H_1-H_0/Z,D=1]=E[\rho\cdot H/Z]$, *where*

$$\rho=\frac{D-P(D=1/Z)}{P(D=1|Z)\cdot(1-P(D=1/Z))}$$

Proof. For simplicity, let us call $w=P(D=1/Z)$. Then:

$$\begin{aligned}
E[\rho\cdot H|Z] &= E[\rho\cdot H \mid Z,D=1]\cdot P(D=1|Z)+E[\rho\cdot H|Z,D=0]\cdot P(D=0|Z)\\
&=E\left[\frac{D-w}{w\cdot(1-w)}\cdot H \mid Z,D=1\right]\cdot w+E\left[\frac{D-w}{w\cdot(1-w)}\cdot H \mid Z,D=0\right]\cdot(1-w)\\
&=E[H \mid Z,D=1]-E[H \mid Z,D=0]\\
&=E[D\cdot H_1+(1-D)\cdot H_0 \mid Z,D=1]-E[D\cdot H_1+(1-D)\cdot H_0 \mid Z,D=0]\\
&=E[H_1 \mid Z,D=1]-E[H_0 \mid Z,D=0]
\end{aligned}$$

Under Assumption 1, previous expression can be written as:

$$E[H_1-H_0 \mid Z,D=1],$$

that estimates the $ATET$ for those values of Z such that $0<P(t=1/Z)<1$.

■

Previous Lemma lets us to express the $ATET$ as follows:

$$\begin{aligned}
E[H_1-H_0/D=1] &= \int E[H_1-H_0|Z,D=1]\;dP(Z/D=1)\\
&= \int E[\rho\cdot H\;/\;Z]\;dP(Z/D=1)\\
&= E\left[\rho\cdot H\cdot\frac{P(D=1/Z)}{P(D=1)}\right]\\
&= E\left[\frac{H}{P(D=1)}\cdot\frac{D-P(D=1/Z)}{1-P(D=1/Z)}\right] \qquad (5)
\end{aligned}$$

Equation (5) suggests a simple two-step method to estimate the $ATET$ under Assumptions 1 and 2. First, conditional probabilities are estimated by means of a

under selection on covariates (see, e.g. Heckman et al., 1997 [23]).

probit model and fitted values of $P(D = 1/Z)$ are calculated for each individual in the sample. Second, fitted values are plugged into the sample analog of equation (5). Then, a simple weighted average of the outcome variable recovers the *ATET*. Finally, the asymptotic variance of the estimator is also calculated, following the procedure developed in Abadie (2005) [24] for the conventional DD estimator, now adapted for the selection on observables case.

3 Data and variable definitions

The analysis is performed with data collected from diverse sources of information:

For estimating the impact of RTIs on population health, I base on the survey about diseases, disabilities and health states (*Encuesta de Discapacidades, Deficiencias y Estados de Salud*) [25], arranged by the Spanish National Institute of Statistics (*INE*) in 1999. The survey includes 70,402 households (about 217,760 individuals), selected with a probability proportional to the size of each region. The weighting factor of the survey is 175, that is, each observation in the sample represents, on average, about 175 individuals of the general population. It implies that subsamples that include less than 25 observations must be taken with caution, since they can contain sampling errors. The survey is divided into two sections: Diseases and Disabilities Unit (*Módulo de Discapacidades y Deficiencias*), and Health Unit (*Módulo de Salud, MS* hereafter). The data for our investigation come from the *MS*. In that unit an individual in each household is randomly chosen - in total: 69,555 individuals; however, 840 observations from Ceuta and Melilla were dropped. The interviewed is confronted with a battery of questions related to health habits, as well as demographic and socioeconomic information.

I consider a wide range of factors that can affect the self-valuation of the health state of an individual (some observations are dropped because of missing values in some of the regressors): age, gender, location of residence, existence of a chronic illness (epilepsy, cholesterol,...), existence of some deficiency (mental, visual,...), if the individual is taking some medicines, if she had some accident (not traffic accident), sleeps more than 6 hours, practices sports, BMI, smoking, marital status, studies, income, household size, population size, and nationality. For practical reasons, the analysis is performed over the population aged 15 or higher. The final sample size is $53,303$ individuals.

Two questions in *MS* have been selected to target those seriously injured due to traffic accidents. These questions state as follows: "During the last 12 months, have you suffered from a traffic accident that has prevented you from performing any usual activity?" (Yes/No), and "How has this traffic accident influenced in your daily life" (Seriously/ Quite a lot /Slightly). From a total of 900 individuals who give an affirmative answer to the first question, I select those who answered "Seriously" (149) or "Quite a lot" (178) in the latter.

Summary statistics for key variables are given in **Table 2.** People that have a traffic crash ($D = 1$) differs considerably from people that belong to the comparison group ($D = 0$). In order to emphasize these differences, I calculate the difference ratio between both groups (e.g. the injured group includes a percentage of $(52 - 46)/46) \cdot 100 = +13\%$ more male than the comparison group. Thus, we find that the group of injured people includes higher proportion of male ($+13\%$), aged 16-35 ($+58\%$), and present unhealthy habits: smokers ($+55\%$), consumption of alcoholic drinks in labour days ($+25\%$) and weekends ($+16\%$), and less people who sleep more than 6 hours (-2%). Furthermore, on average the income is slightly lower for those in the injured group (-2%), and the highest level of education completed differs mainly by the higher proportion in secondary studies ($+37\%$) in contrast to a lower proportion of superior studies (-28%) and no studies (-17%). These differences in the distribution of observed individual characteristics give evidence of the necessity of controlling for them, with the aim of obtaining a valid estimate of the $ATET$.

	Injured (D=1)	Non-injured (D=0)
N	327	52,802
male	52	46
age	44 (20.7)	50 (20.1)
16 - 25	22.0	12.2
26 - 35	21.7	15.4
36 - 45	13.5	14.3
46 - 55	9.2	12.9
56 - 65	8.9	14.0
66 - 75	15.6	17.9
75 +	9.2	13.3
income	101,184 (63,759)	102,881 (64,087)
smoker	44.0	28.4
alcohol lab. days	5.8	4.7
alcohol wkds	25.1	21.6
studies		
no studies	19.3	23.3
primary	30.9	33.6
secondary	39.8	29.1
superior	10.1	14.1

(Standard deviation in brackets)

Table 2: descriptive statistics for affected and comparison groups

The required external information is obtained from the Catalan health surveys *Enquesta de Salut de Catalunya* 2002 (*ESCA02* hereafter) and *Enquesta de Salut de Catalunya* 2006 (*ESCA06* hereafter), arranged by the catalan government (*Generalitat de Catalunya*) [26], [27]. A total of 8,400 individuals (in the former) and 18,126 individuals (in the latter) were selected for the surveys, which include different health measures as VAS, *EQ-5D* and SAH. From these variables, three cardinal health measures could be obtained: VAS (directly from the survey), *VAS tariff* and *TTO tariff* (estimated from *EQ-5D*). These measures are used to estimate the health effect. In *ESCA02* I dropped from the sample 1,401 proxy-respondent interviews (related to children aged under 15 or impairments), and 19 observations because either VAS or SAH were not reported. A total of 2,200 and 47 observations (corresponding to children aged under 15 and missing values of SAH or VAS, respectively) were dropped from *ESCA06.*

Several observations have been discarded from both samples, since they presented clear contradictions. Those have been detected based on the values provided by the variables VAS and SAH. Thus, several individuals reported "excellent" health or VAS close to 1, but negative values for the tariffs. Similarly, some individuals reported " bad" health or VAS close to 0, but tariff values close to 1. The final sample sizes are 7,081 in *ESCA02* and 15,875 in *ESCA06*

It is important to notice that the SAH variable included in both surveys is not identical to the SAH variable incorporated into *MS*. The dissimilarity lies in the five possible answers given to the respondents: the category "very bad" is not available in neither *ESCA02* nor *ESCA06*, but "excellent" is incorporated. In order to define a single health index, the construction of SAH containing 4 categories is performed (the new variable will be called $SAH4$), following the approach adopted by several authors (e.g. [28], [29], [30]). The collapsed categorizations are summarized in **Table 3**. As I did with the SAH, let me define $SAH4^{ih}$ as a new variable where the ordering of the self-assessed health categories has been reversed, now interpreted in terms of ill-health. Similarly, I denote $y^{ih} = 1 - y$, for $y \in \{TTOz, TTOr, VASz, VASr\}$.

	SAH	
$SAH4$	ESCA02/06	MS
1	Bad	Very bad Bad
2	Fair	Fair
3	Good	Good
4	Very good Excellent	Very good

Table 3: definition of SAH4

4 Results

Table 4 shows the characteristics of the thresholds obtained in *ESCA02* and *ESCA06*:

		thresholds (ill-health)				
		η_0	η_1	η_2	η_3	η_4
ESCA02	$VASz^{ih}$	0	0.09	0.23	0.62	1
	$VASr^{ih}$	0	0.08	0.22	0.58	1
	$TTOz^{ih}$	0	0.04	0.13	0.72	1
	$TTOr^{ih}$	0	0.02	0.08	0.43	1
ESCA06	$VASz^{ih}$	0	0.11	0.25	0.63	1
	$VASr^{ih}$	0	0.10	0.23	0.59	1
	$TTOz^{ih}$	0	0.05	0.16	0.75	1
	$TTOr^{ih}$	0	0.03	0.10	0.46	1

Table 4: thresholds in ESCA02 and ESCA06

Observe that η_1 is considerably small both for the VAS and TTO *tariffs*, what is a direct consequence of the "ceiling effect" of these scores (a value of health = 1 is assigned to the majority of the people, what results in a value of ill-health =0. Indeed, the interpolation that have been used for estimating the thresholds, avoids that $\eta_1 = 0$ for these metrics).

In both samples we observe that the thresholds are significantly independent from gender and age. The values should be interpreted as follows: for instance, referring to $VASz$ in *ESCA02*, an individual who reports the worst category of health ($SAH4^{ih} = 4$) is assumed to have a $VASz^{ih}$ level that belongs to the interval (0.62, 1]. Similarly, the values for the remaining $SAH4^{ih}$ categories are (0.23, 0.62] for the "fair" category, (0.09, 0.23] for the "good" category and [0, 0.09] for the "very good" and "excellent" categories (low amount of ill-health or $SAH4^{ih} = 1$).

The specification for intervals is implemented into similar regression models. The characteristics of the regressors as well as the parameter estimates of the interval regression model are found in the Appendix. The health status of each individual is controlled for a wide range of socioeconomic variables, and most of the coefficients are significant (CI 5%). The McKelvey and Zavoina pseudo-R^2 is computed for each model, and rounds 0.48, indicating that these predictors account for approximately 48% of the variability in the latent outcome variable. On average, 63% of the estimated health tariffs lay into the correct interval (settled by the reported answer to the SAH question). A RESET test has been applied to each interval and probit regression model, and any of them shows evidence of mis-specification.

It is important to remark that the value of health is highly linked to the self-perception of health status, rather than the actual health status per se. A positive coefficient means that an individual has a higher value of latent ill-health and is more likely to report a lower category of self-assessed health. The regressors have been built so that the reference individual is a woman aged 25-35, who lives in Galicia, married, employed, with superior studies ended, who did not suffer an injury during the last 12 months, no chronic illness, non-smoker, sleeps less than 6 hours per day, does not make any physical exercise and has a proper BMI.[5]

As it was expected, the ill-health decreases with income, level of education, absence of chronic illness, and absence of injuries or limitations. Besides, those that sleep more than 6 hours per day or exercise have partial effects lower than 1, which means that ill-health decreases with them. Students are healthier than any other employment condition, married and widowers are more likely to report a lower category of SAH^{ih} (and thus higher value of true health) than single people. Related to regions, Galicia shows the poorest levels of health. The results also provide evidence about the decline of quality of life as age increases.

For evaluating the *propensity score* I perform a logit model that include as covariates every variable that could affect the probability of having a road crash, most of them already included in the interval regression (gender, age, region, if smoker, etc.) and some additional variables as: if drinks alcohol, if pregnant, etc. We must take special care for not including causal-effect reversals into the regression. The characteristics of the injured people are recorded up to one year after the accident, so that they could be reflecting the consequences of a road crash rather than the probability of suffering it. These sort of variables could introduce an additional problem, that is the endogeneity in the regression, what could reduce the estimated effect of the treatment. Taking this fact into consideration, the individual characteristics that are likely to be a consequence rather that a factor related to the propensity to have an accident, are dropped from the regression. For instance, the current labour status, number of hours of sleep, BMI, among others.

It interesting to stress the main objective of the probit regression. From equation (5) we can write:

[5]In order to allow for some variability in the effect of a road crash in health, several interactions (e.g. with gender, age, studies, labor status,...) were introduced in the preliminar models; since any interaction was significant, and they did not modify the results, the interactions were finally dropped.

$$ATET = E\left[\frac{H}{P\left(D=1\right)}\cdot\frac{D-P(D=1/Z)}{1-P(D=1/Z)}\right] \quad (6)$$
$$= E_T\left[H\right]-E_C\left[w\cdot H\right]$$

where $E_T\left[\cdot\right] = E\left[\cdot|D=1\right], E_C\left[\cdot\right] = E\left[\cdot|D=0\right]$ and $w = \frac{P(D=1/Z)}{1-P(D=1/Z)}\cdot\frac{P(D=0)}{P(D=1)}$. Thus, the probit model provides the construction of a proper comparison group by introducing a weight for each individual in the comparison group. **Table 5** illustrates this idea (some statistics have been already shown in **Table 2**).

X	$E_T\left[X\right]$	$E_C\left[X\right]$	$E_C\left[w\cdot X\right]$
male	52	46	52
age	44 (20.7)	50 (20.1)	44 (27.9)
16 - 25	22.0	12.2	23.3
26 - 35	21.7	15.4	18.7
36 - 45	13.5	14.3	13.3
46 - 55	9.2	12.9	10.7
56 - 65	8.9	14.0	10.9
66 - 75	15.6	17.9	13.7
75 +	9.2	13.3	9.3
income	101,184 (63,759)	102,881 (64,087)	101,011 (101,977)
smoker	44.0	28.4	43.8
alcohol lab. days	5.8	4.7	5.7
alcohol wkds	25.1	21.6	24.9
studies			
no studies	19.3	23.3	19.1
primary	30.9	33.6	30.6
secondary	39.8	29.1	40
superior	10.1	14.1	10.3

(Standard deviation in brackets)

Table 5: descriptive statistics for affected groups, comparison groups and comparison groups with adjustment

The average health effect under "selection of observables" together with the confidence intervals are computed by bootstrapping, in terms of decrease in health. The number of iterations is 1,500, and the bias-corrected estimate has been considered , assuming that standard errors are normally distributed. It can be observed that the effects differ depending on the metric in which the ratio is expressed. The results of the estimate and the confidence interval are illustrated in **Figure 4**. For a better comprehension, the results are expressed in terms of decrease in health, instead of increase in bad health. On average terms, we can talk about a decrease in health from 0.039 ($TTO\ tariff$, after re-scaling, with the thresholds given by *ESCA02*) to 0.061 ($TTO\ tariff$, changing negative values to zero, with the thresholds obtained from *ESCA06*). Once a particular metric is fixed, the health effects that are based in the surveys do not differ significantly, maybe slightly lower those corresponding to *ESCA06*. For every health measure, the confidence interval embraces values strictly negative, what gives evidence to the existence of a permanent reduction in quality of life for those injured by a road traffic crash.

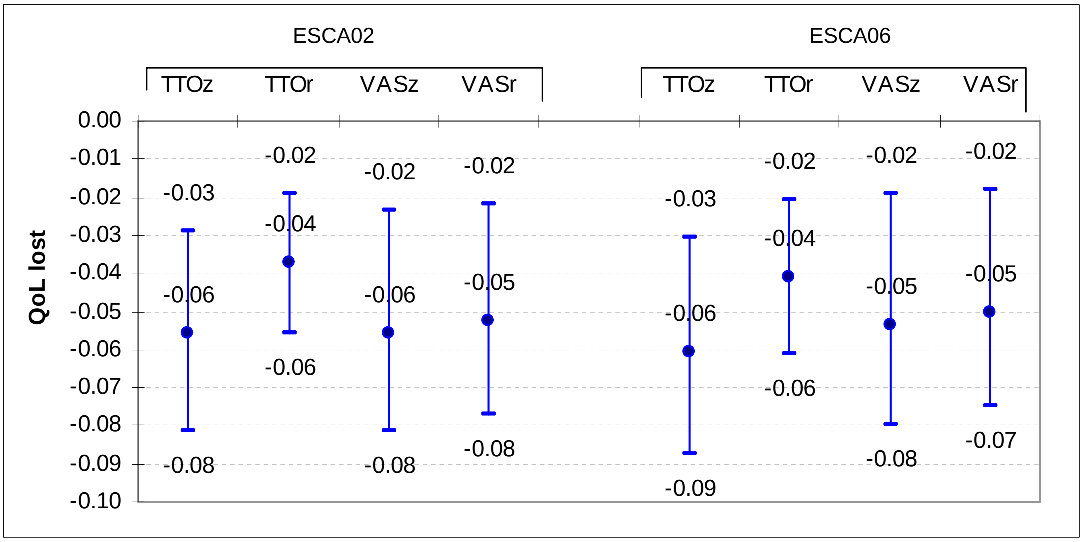

Figure 4: ATET by different thresholds and health measures.

The average effect can be analyzed for different population groups. **Figure 5** shows the ATET evaluated for different age groups (only for those metrics were the intervals were significant). Notice that the ATET increases with age, and so the confidence interval does.

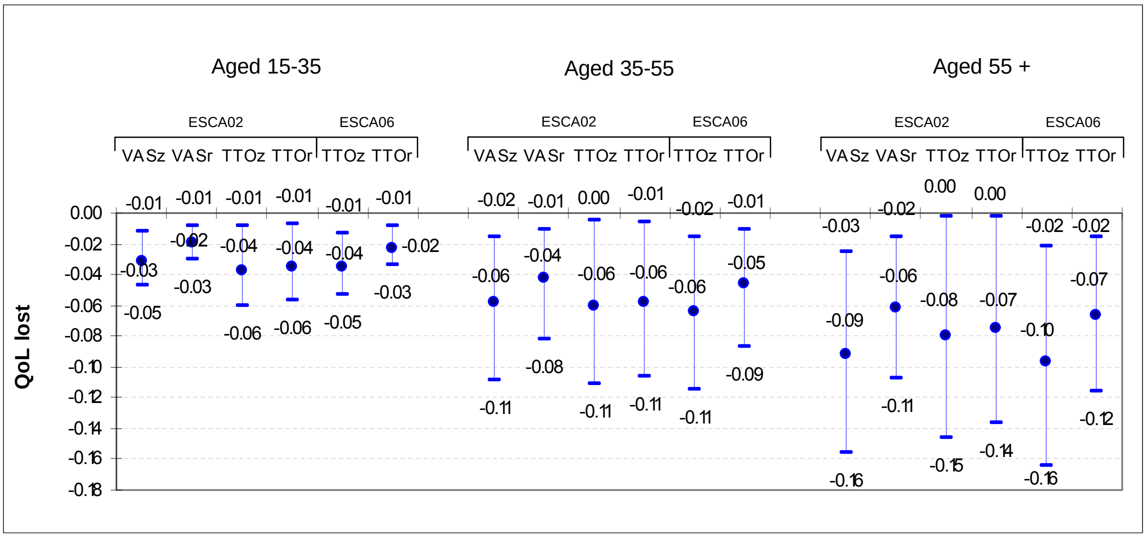

Figure 5: ATET by different thresholds, health measures and age-intervals.

Finally I compute the loss of health separately for men and women (see Figure 6). We can observe that the loss of health is, on average, more significative for men. This fact could be explained by factors related to driving behavior, as higher speed, more use of highways, less use of security measures.

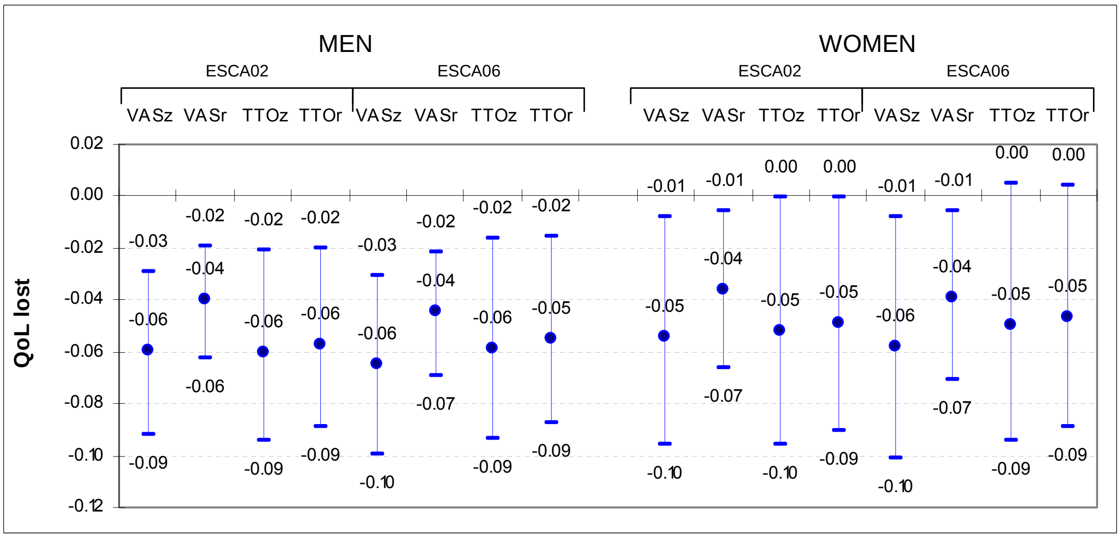

Figure 6: ATET by different thresholds, health measures and gender.

The differences between simple averages of health for affected and comparison group have been computed (Table 6). The results differ from the estimated ATET, what supports the validity of the hypothesis about the existence of selection on observables. In order to highlight the real impact of the total loss of health on individuals' health state, I compute the following rate:

$$\Delta H = \frac{E_T\left[H\right] - E_C\left[w \cdot H\right]}{E_C\left[w \cdot H\right]} = \frac{ATET}{E_T\left[H\right] - ATET}$$

ΔH indicates the proportion of health that the individual has loss due to a road crash, with respect to the health state that the individual would have if the accidente had not happened, estimated by using adjusted comparison groups. The confidence interval of ΔH is also re-scaled. The results are shown in **Table 6.**

		$ATET$	$E_T[H]{-}E_C\,[H]$	ΔH	$CI(\Delta H)$
ESCA02	$VASz$	-0.056	-0.037	-7.10%	[-10.09% , -3.12%]
	$VASr$	-0.052	-0.035	-6.55%	[-9.35% , -2.87%]
	$TTOz$	-0.056	-0.038	-6.61%	[-9.35% , -3.53%]
	$TTOr$	-0.037	-0.026	-4.15%	[-6.09% , -2.16%]
ESCA06	$VASz$	-0.053	-0.035	-6.97%	[-7.89% , -2.84%]
	$VASr$	-0.050	-0.033	-6.41%	[-9.82% , -2.55%]
	$TTOz$	-0.061	-0.041	-7.37%	[-10.42% , -1.21%]
	$TTOr$	-0.041	-0.028	-4.63%	[-9.36% , -3.48%]

Table 6: different estimates for health effects

5 Conclusions

The fact that road crashes represent an alarming threat to health has been reported by most of studies that deal with injuries, causes of death or the evaluation of the burden of diseases. The application of different policies aimed at reducing the magnitude of the problem is essential. The effectiveness of these policies should be estimated carefully, allowing for making a distinction among the different outcomes they could yield: a reduction of the number of crashes, fatalities and severity of the nonfatal injuries. In this context, Bishai et al. (2006) [31] demonstrated that observed patterns in rich countries show only a decline in fatalities, but no decline of crashes or injuries. Improvements in emergency transport, trauma care and passenger protection devices may be the mediating factor for that better survival.

Several countries as Germany, Great Britain and Denmark started up in 2002 what was called "intelligent emergency system", which combines information technology and communications for reducing the time for emergency vehicles to reach the crash scene (a minimum time of assistance was fixed: 12 min. in Germany, 8 in Great Britain and 5 in Denmark). Such measures have leaded to considerably reducing the probability of death subsequent to the traffic accident. The possibility of introducing these measures has already been considered in Spain, where quick emergency response is decisive, since 35% of deaths occur beyond four hours after the crash. On February 2004 the RACC published a study which reflects the fact that emergency resources in Spain (SAMUR, provision of helicopters for emergencies..), are adequate enough for introducing such intelligent system; what the country evidences is the lack of a more advanced coordination, as well as a large investment for supporting this infrastructure.

Improvements in occupant protection devices also yield to decreasing death rates. For instance, establishing the use of mandatory seat belts on car passengers in Spain (June 1992) led to a permanent reduction in fatalities (ranging from -15% to -18%, depending on alternative models' estimates) and seriousness on injuries, but it did not involve a reduction in the number of crashes (García-Ferrer et al., 2007) [32].

Besides the investment in trauma care systems and traffic safety measures, it is determinant the success of the government to enforce the traffic laws. The attitude of drivers and passengers might get into the habit of new regulations (e.g. mandatory seat belts, maximum blood alcohol level, etc.), but enforcement efforts are essential to achieve this goal (e.g. speed cameras, police controls, drivers education, etc.)in particular at a starting point.

A large investment is needed for supporting both the implementation of new measures and the enforcement resources. Hence the evaluation of the costs and benefits of such novel instruments is essential. In order to pursue this task, and for allowing a comparison among analysis of different measures, we should express the total toll of deaths, injuries and sequelae derived from traffic accidents in a simple metric, that could estimate the total loss of health that could be avoided.

Databases are becoming more complete. CARE *(European Road Accident Database)*, IRTAD *(International Road Traffic and Accident Database)* or CCIS *(Cooperative Crash Injury Study)* are examples of the improvement in the data collection, and they include a wide set of variables related to road crashes that some decades ago were ignored. However, there is still much to do before there is a complete set of data that comprises all valuable information (details of the accident, joint with description of the health state of the injured individuals, etc.). Meanwhile, the short-term objective consists of obtaining the best estimation of health losses under the limitation of the lack of data available.

Several measures have been developed in this direction. For a start, monitoring health-related quality of life can be enhanced by establishing equivalences between cardinal and categorical health variables, since the former are the preferred measures for cost-effectiveness analysis, but the latter is more frequently enclosed in surveys. Furthermore, overcoming typical assumptions, as could be considering health states as chronic or pre-injury health status as perfect health, can be considered as a great step forward. For instance, given the lack of pre-injury measures, the use of appropriately defined comparison groups should be crucial for the study of trauma outcomes.

The permanent effect that RTIs causes in health must be pointed out. In the present study I have analyzed the health status of individuals up to one year after the road crash. Significant decreases in *QoL* have been observed, that are robust to changes in data or changes measure definitions. Results have shown that the QoL of people seriously injured by a traffic crash decreases on a rate of 6.23%[6]. Therefore it is plausible to talk about *chronic health effects*, or, better said, *chronic effects in QoL* produced by a traffic crash, what should be taking into account at evaluating the impact on the injured individuals.

Our research has limitations, mainly derived from the source of data. Due to the lack of information available, continuos measures of health have been partially obtained from external data. Despite the validity of the model, it may have introduced some bias, derived from different self-perceptions. Furthermore, both surveys are administered to non-institutionalized population, so that the analysis cannot be performed for those individuals, maybe the most seriously injured, that still remain in trauma centers. Following Seguí-Gómez, for those individuals that are hospitalized due to a motor vehicle crash, about 90% of these patients are discharged from hospital to home in less than one year after the crash. Therefore the mis-estimation that could be derived form this matter may not be significant. There is also missed information regarding possible RTIs occurred in the past (more than one year previous to the survey), that may be affecting the actual health state of the individual but is not observed. Thus, our results could be interpreted as a lower bound of the real effect, and hence they bring to light the relevance of the impact of road crashes

[6] The average of the rates obtained from the different metrics has been taken as the representative figure.

in health-related quality of life.

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7 Appendix

	ESCA02				ESCA06			
	TTO tariff		VAS tariff		TTO tariff		VAS tariff	
	zero	rescaled	zero	rescaled	zero	rescaled	zero	rescaled
male1525	-0.095	-0.095	-0.078	-0.078	-0.096	-0.096	-0.067	-0.067
	(4.97)***	(4.90)***	(5.35)***	(5.34)***	(5.12)***	(5.05)***	(5.22)***	(5.21)***
male2535	0.013	0.014	0.006	0.007	0.011	0.012	0.007	0.007
	(-0.81)	(-0.84)	(-0.52)	(-0.53)	(-0.71)	(-0.74)	(-0.62)	(-0.62)
male3545	0.079	0.078	0.062	0.062	0.079	0.078	0.054	0.054
	(4.80)***	(4.68)***	(4.97)***	(4.94)***	(4.90)***	(4.77)***	(4.89)***	(4.86)***
male4555	0.142	0.14	0.115	0.114	0.144	0.142	0.099	0.098
	(7.88)***	(7.62)***	(8.51)***	(8.45)***	(8.18)***	(7.90)***	(8.26)***	(8.20)***
male5565	0.161	0.157	0.131	0.131	0.164	0.16	0.112	0.112
	(8.19)***	(7.84)***	(9.17)***	(9.09)***	(8.65)***	(8.26)***	(8.79)***	(8.71)***
male6575	0.05	0.043	0.056	0.055	0.06	0.052	0.043	0.042
	(2.17)**	(1.79)*	(3.39)***	(3.30)***	(2.71)***	(2.28)**	(2.92)***	(2.83)***
male7585	0.065	0.057	0.066	0.065	0.074	0.066	0.053	0.051
	(2.39)**	(2.01)**	(3.44)***	(3.35)***	(2.87)***	(2.44)**	(3.02)***	(2.92)***
male85m	0.099	0.097	0.089	0.088	0.105	0.102	0.074	0.074
	(1.95)*	(1.81)*	(2.57)**	(2.53)**	(2.20)**	(2.04)**	(2.34)**	(2.30)**
female1525	-0.082	-0.082	-0.065	-0.065	-0.082	-0.082	-0.057	-0.057
	(4.22)***	(4.18)***	(4.40)***	(4.39)***	(4.30)***	(4.25)***	(4.34)***	(4.33)***
female3545	0.076	0.075	0.064	0.063	0.078	0.077	0.054	0.054
	(4.79)***	(4.65)***	(5.27)***	(5.24)***	(5.00)***	(4.85)***	(5.09)***	(5.07)***
female4555	0.181	0.181	0.141	0.141	0.179	0.18	0.123	0.123
	(9.98)***	(9.82)***	(10.54)***	(10.50)***	(10.23)***	(10.05)***	(10.34)***	(10.30)***
female5565	0.214	0.216	0.163	0.163	0.211	0.213	0.143	0.143
	(10.93)***	(10.74)***	(11.46)***	(11.42)***	(11.18)***	(10.97)***	(11.26)***	(11.22)***
female6575	0.156	0.155	0.124	0.123	0.156	0.156	0.107	0.107
	(7.46)***	(7.20)***	(8.22)***	(8.16)***	(7.81)***	(7.52)***	(7.93)***	(7.87)***
female7585	0.163	0.162	0.127	0.126	0.162	0.161	0.11	0.11
	(6.68)***	(6.40)***	(7.40)***	(7.33)***	(7.01)***	(6.71)***	(7.11)***	(7.04)***
female85m	0.194	0.195	0.151	0.151	0.192	0.193	0.132	0.131
	(5.16)***	(4.91)***	(5.89)***	(5.83)***	(5.48)***	(5.20)***	(5.60)***	(5.53)***

	ESCA02				ESCA06			
	TTO tariff		VAS tariff		TTO tariff		VAS tariff	
	zero	rescaled	zero	rescaled	zero	rescaled	zero	rescaled
Andalucia	-0.248	-0.256	-0.179	-0.18	-0.238	-0.246	-0.161	-0.162
	(17.63)***	(17.57)***	(17.99)***	(17.99)***	(17.78)***	(17.72)***	(17.89)***	(17.88)***
Aragon	-0.177	-0.184	-0.126	-0.127	-0.169	-0.176	-0.114	-0.115
	(8.97)***	(9.04)***	(8.97)***	(8.99)***	(8.96)***	(9.03)***	(9.00)***	(9.02)***
Asturias	-0.066	-0.069	-0.047	-0.048	-0.063	-0.066	-0.043	-0.043
	(2.97)***	(2.97)***	(2.98)***	(2.98)***	(2.98)***	(2.97)***	(2.98)***	(2.98)***
Canarias	-0.082	-0.085	-0.06	-0.061	-0.079	-0.082	-0.054	-0.055
	(3.96)***	(4.00)***	(4.11)***	(4.12)***	(4.00)***	(4.04)***	(4.08)***	(4.09)***
Cantabria	-0.16	-0.166	-0.114	-0.115	-0.152	-0.158	-0.103	-0.104
	(6.43)***	(6.48)***	(6.36)***	(6.37)***	(6.40)***	(6.45)***	(6.40)***	(6.41)***
CLM	-0.188	-0.196	-0.134	-0.135	-0.179	-0.187	-0.121	-0.122
	(11.18)***	(11.28)***	(11.20)***	(11.23)***	(11.16)***	(11.27)***	(11.24)***	(11.26)***
CYL	-0.164	-0.171	-0.116	-0.117	-0.156	-0.162	-0.105	-0.106
	(11.24)***	(11.31)***	(11.12)***	(11.14)***	(11.18)***	(11.26)***	(11.19)***	(11.21)***
Catalunya	-0.167	-0.173	-0.12	-0.121	-0.16	-0.166	-0.108	-0.109
	(10.82)***	(10.82)***	(10.92)***	(10.92)***	(10.87)***	(10.86)***	(10.90)***	(10.90)***
CV	-0.243	-0.25	-0.175	-0.176	-0.233	-0.241	-0.157	-0.158
	(14.60)***	(14.57)***	(14.68)***	(14.68)***	(14.65)***	(14.63)***	(14.67)***	(14.67)***
Extremadura	-0.168	-0.171	-0.123	-0.124	-0.163	-0.166	-0.11	-0.11
	(7.66)***	(7.51)***	(7.94)***	(7.92)***	(7.82)***	(7.65)***	(7.82)***	(7.80)***
Baleares	-0.195	-0.2	-0.14	-0.14	-0.187	-0.192	-0.126	-0.126
	(7.87)***	(7.86)***	(7.79)***	(7.79)***	(7.85)***	(7.85)***	(7.82)***	(7.82)***
LaRioja	-0.165	-0.17	-0.118	-0.119	-0.158	-0.163	-0.106	-0.107
	(4.64)***	(4.67)***	(4.65)***	(4.66)***	(4.64)***	(4.67)***	(4.66)***	(4.67)***
Madrid	-0.16	-0.165	-0.115	-0.116	-0.153	-0.159	-0.104	-0.104
	(9.01)***	(9.06)***	(9.03)***	(9.05)***	(9.01)***	(9.07)***	(9.05)***	(9.07)***
Murcia	-0.192	-0.197	-0.14	-0.141	-0.185	-0.191	-0.125	-0.126
	(8.06)***	(7.99)***	(8.22)***	(8.21)***	(8.15)***	(8.07)***	(8.16)***	(8.15)***
Navarra	-0.155	-0.16	-0.111	-0.112	-0.148	-0.154	-0.1	-0.101
	(6.34)***	(6.42)***	(6.27)***	(6.29)***	(6.29)***	(6.38)***	(6.32)***	(6.34)***
P. Vasco	-0.1	-0.105	-0.071	-0.071	-0.095	-0.1	-0.064	-0.065
	(4.78)***	(4.85)***	(4.69)***	(4.71)***	(4.73)***	(4.81)***	(4.74)***	(4.77)***

	ESCA02				ESCA06			
	TTO tariff		VAS tariff		TTO tariff		VAS tariff	
	zero	rescaled	zero	rescaled	zero	rescaled	zero	rescaled
bronchitis	0.345	0.366	0.232	0.235	0.321	0.341	0.215	0.217
	(23.22)***	(23.19)***	(23.30)***	(23.30)***	(23.27)***	(23.25)***	(23.30)***	(23.30)***
allergy	0.058	0.06	0.043	0.043	0.056	0.058	0.038	0.039
	(5.44)***	(5.40)***	(5.61)***	(5.60)***	(5.51)***	(5.47)***	(5.55)***	(5.55)***
epilepsy	0.343	0.361	0.231	0.234	0.319	0.338	0.213	0.216
	(6.75)***	(6.68)***	(6.79)***	(6.78)***	(6.79)***	(6.72)***	(6.76)***	(6.75)***
diabetes	0.244	0.258	0.162	0.164	0.226	0.24	0.151	0.152
	(15.18)***	(15.15)***	(15.34)***	(15.34)***	(15.26)***	(15.23)***	(15.31)***	(15.31)***
hypert.	0.047	0.05	0.031	0.031	0.044	0.046	0.029	0.029
	(4.19)***	(4.22)***	(4.08)***	(4.09)***	(4.15)***	(4.18)***	(4.12)***	(4.14)***
heart inj	0.325	0.344	0.211	0.214	0.298	0.318	0.197	0.2
	(20.91)***	(20.78)***	(20.77)***	(20.75)***	(20.93)***	(20.79)***	(20.79)***	(20.77)***
cholesterol	0.099	0.104	0.067	0.068	0.093	0.098	0.062	0.062
	(8.07)***	(8.08)***	(8.10)***	(8.11)***	(8.08)***	(8.09)***	(8.10)***	(8.11)***
arthritis	0.395	0.405	0.273	0.274	0.374	0.385	0.248	0.249
	(38.12)***	(37.71)***	(38.81)***	(38.74)***	(38.54)***	(38.09)***	(38.54)***	(38.46)***
ulcer	0.205	0.215	0.141	0.143	0.193	0.203	0.129	0.13
	(13.47)***	(13.37)***	(13.69)***	(13.68)***	(13.59)***	(13.49)***	(13.61)***	(13.59)***
hernia	0.168	0.176	0.114	0.116	0.157	0.166	0.105	0.106
	(10.74)***	(10.71)***	(10.90)***	(10.89)***	(10.81)***	(10.78)***	(10.85)***	(10.85)***
cardiovasc	0.18	0.189	0.119	0.12	0.167	0.176	0.11	0.111
	(15.63)***	(15.63)***	(15.42)***	(15.42)***	(15.57)***	(15.58)***	(15.50)***	(15.50)***
anaemias	0.212	0.23	0.145	0.148	0.196	0.215	0.135	0.137
	(7.89)***	(8.04)***	(8.00)***	(8.04)***	(7.87)***	(8.05)***	(8.02)***	(8.06)***
other	0.338	0.354	0.235	0.237	0.319	0.335	0.214	0.216
	(22.64)***	(22.49)***	(23.22)***	(23.20)***	(22.89)***	(22.74)***	(23.03)***	(23.00)***

	ESCA02				ESCA06			
	TTO tariff		VAS tariff		TTO tariff		VAS tariff	
	zero	rescaled	zero	rescaled	zero	rescaled	zero	rescaled
def1	0.414	0.449	0.276	0.281	0.38	0.416	0.258	0.263
	(12.42)***	(12.43)***	(12.47)***	(12.48)***	(12.42)***	(12.46)***	(12.47)***	(12.47)***
def2	0.084	0.089	0.052	0.053	0.076	0.081	0.05	0.05
	(4.04)***	(4.00)***	(3.80)***	(3.80)***	(3.97)***	(3.94)***	(3.86)***	(3.86)***
def3	0.019	0.021	0.014	0.014	0.018	0.02	0.013	0.013
	(-0.96)	(-0.97)	(-1.03)	(-1.03)	(-0.99)	(-0.99)	(-1.01)	(-1.02)
def4	0.132	0.145	0.097	0.099	0.125	0.138	0.089	0.09
	(1.67)*	(1.67)*	(1.83)*	(1.83)*	(1.72)*	(1.72)*	(1.78)*	(1.78)*
def5	0.373	0.404	0.234	0.238	0.335	0.367	0.222	0.226
	(21.17)***	(21.28)***	(20.43)***	(20.46)***	(20.87)***	(21.05)***	(20.71)***	(20.74)***
def6	0.551	0.609	0.357	0.365	0.497	0.557	0.339	0.347
	(15.40)***	(15.51)***	(15.04)***	(15.07)***	(15.22)***	(15.38)***	(15.19)***	(15.21)***
def7	0.406	0.452	0.257	0.264	0.363	0.409	0.246	0.252
	(12.38)***	(12.39)***	(11.79)***	(11.80)***	(12.15)***	(12.21)***	(11.98)***	(11.98)***
def8	0.288	0.314	0.183	0.186	0.26	0.286	0.173	0.177
	(10.57)***	(10.62)***	(10.26)***	(10.28)***	(10.44)***	(10.52)***	(10.38)***	(10.39)***
road crash	0.2	0.205	0.147	0.147	0.194	0.199	0.131	0.132
	(4.09)***	(4.05)***	(4.24)***	(4.23)***	(4.15)***	(4.11)***	(4.19)***	(4.18)***
other inj	0.164	0.175	0.109	0.111	0.151	0.163	0.102	0.103
	(7.14)***	(7.26)***	(6.94)***	(6.97)***	(7.04)***	(7.17)***	(7.04)***	(7.07)***
limitations	0.085	0.087	0.059	0.06	0.08	0.083	0.054	0.054
	(3.45)***	(3.40)***	(3.56)***	(3.55)***	(3.50)***	(3.45)***	(3.51)***	(3.50)***
sleep +6h	-0.185	-0.195	-0.122	-0.124	-0.17	-0.181	-0.113	-0.115
	(13.68)***	(13.74)***	(13.40)***	(13.42)***	(13.57)***	(13.66)***	(13.52)***	(13.54)***
exercise ft	-0.137	-0.138	-0.103	-0.103	-0.134	-0.136	-0.091	-0.091
	(15.07)***	(15.01)***	(15.27)***	(15.26)***	(15.16)***	(15.11)***	(15.21)***	(15.20)***
exercise wrk	-0.05	-0.051	-0.035	-0.035	-0.047	-0.049	-0.031	-0.032
	(5.11)***	(5.19)***	(4.84)***	(4.86)***	(4.99)***	(5.09)***	(4.95)***	(4.97)***

	ESCA02ESCA02				ESCA06			
	TTO tariff		VAS tariff		TTO tariff		VAS tariff	
	zero	rescaled	zero	rescaled	zero	rescaled	zero	rescaled
BMI infra	0.095	0.099	0.071	0.071	0.092	0.096	0.063	0.064
	(3.58)***	(3.62)***	(3.63)***	(3.64)***	(3.58)***	(3.63)***	(3.63)***	(3.64)***
BMI supra	0.014	0.014	0.012	0.012	0.015	0.014	0.01	0.01
	(1.86)*	(1.77)*	(2.25)**	(2.24)**	(2.02)**	(1.93)*	(2.12)**	(2.10)**
medicines	0.313	0.314	0.237	0.236	0.308	0.309	0.208	0.208
	(38.86)***	(38.17)***	(39.94)***	(39.81)***	(39.48)***	(38.78)***	(39.50)***	(39.34)***
smoker	0.021	0.021	0.017	0.017	0.021	0.021	0.014	0.014
	(2.66)***	(2.63)***	(2.83)***	(2.83)***	(2.73)***	(2.69)***	(2.77)***	(2.77)***
married	0.001	0.003	0	0	0	0.002	0	0.001
	(-0.14)	(-0.29)	(-0.04)	(-0.01)	(-0.03)	(-0.19)	(-0.05)	(-0.09)
widow	-0.144	-0.152	-0.097	-0.098	-0.134	-0.142	-0.089	-0.09
	(9.18)***	(9.32)***	(8.84)***	(8.87)***	(9.01)***	(9.18)***	(8.99)***	(9.02)***
sep or div	0.085	0.089	0.059	0.06	0.08	0.085	0.054	0.055
	(3.82)***	(3.92)***	(3.72)***	(3.74)***	(3.75)***	(3.86)***	(3.78)***	(3.81)***
nostuds	0.332	0.339	0.242	0.243	0.321	0.328	0.216	0.217
	(21.99)***	(21.84)***	(22.28)***	(22.25)***	(22.15)***	(22.00)***	(22.18)***	(22.15)***
primstuds	0.196	0.197	0.152	0.152	0.195	0.195	0.133	0.133
	(16.28)***	(16.03)***	(16.93)***	(16.89)***	(16.59)***	(16.33)***	(16.69)***	(16.64)***
secndstuds	0.088	0.089	0.071	0.071	0.089	0.089	0.061	0.061
	(8.20)***	(8.08)***	(8.67)***	(8.64)***	(8.40)***	(8.27)***	(8.50)***	(8.47)***

	ESCA02				ESCA06			
	TTO tariff		VAS tariff		TTO tariff		VAS tariff	
	zero	rescaled	zero	rescaled	zero	rescaled	zero	rescaled
unemployed	0.044	0.043	0.034	0.034	0.044	0.043	0.03	0.03
	(3.18)***	(3.08)***	(3.34)***	(3.31)***	(3.27)***	(3.16)***	(3.26)***	(3.24)***
unable	0.342	0.356	0.232	0.234	0.32	0.335	0.213	0.214
	(8.09)***	(7.80)***	(8.28)***	(8.20)***	(8.25)***	(7.93)***	(8.14)***	(8.06)***
retired	0.118	0.119	0.085	0.085	0.114	0.115	0.076	0.076
	(7.42)***	(7.24)***	(7.66)***	(7.62)***	(7.55)***	(7.37)***	(7.54)***	(7.49)***
housekeeper	0.074	0.073	0.057	0.057	0.074	0.073	0.05	0.049
	(5.71)***	(5.46)***	(6.03)***	(5.98)***	(5.90)***	(5.64)***	(5.87)***	(5.81)***
student	-0.068	-0.068	-0.055	-0.055	-0.068	-0.068	-0.047	-0.047
	(4.03)***	(4.01)***	(4.29)***	(4.28)***	(4.12)***	(4.10)***	(4.21)***	(4.20)***
other	0.107	0.108	0.078	0.078	0.103	0.105	0.069	0.069
	(4.61)***	(4.47)***	(4.85)***	(4.81)***	(4.73)***	(4.58)***	(4.74)***	(4.70)***
logincome	-0.105	-0.106	-0.077	-0.077	-0.102	-0.103	-0.069	-0.069
	(14.79)***	(14.59)***	(15.09)***	(15.06)***	(14.97)***	(14.76)***	(14.96)***	(14.92)***
househ size	0.01	0.01	0.007	0.007	0.009	0.01	0.006	0.007
	(3.35)***	(3.45)***	(3.35)***	(3.37)***	(3.31)***	(3.43)***	(3.39)***	(3.41)***
municip size	-0.028	-0.027	-0.02	-0.02	-0.027	-0.026	-0.018	-0.017
	(3.86)***	(3.71)***	(3.81)***	(3.78)***	(3.90)***	(3.74)***	(3.79)***	(3.76)***
nation	0.079	0.079	0.061	0.061	0.078	0.078	0.053	0.053
	(2.29)**	(2.26)**	(2.35)**	(2.35)**	(2.32)**	(2.29)**	(2.33)**	(2.32)**
Constant	-1.584	-2.061	-1.212	-1.281	-1.426	-1.902	-1.148	-1.218
	(17.04)***	(21.59)***	(17.99)***	(18.94)***	(15.95)***	(20.69)***	(19.04)***	(20.11)***
Obs	53129	53129	53129	53129	53129	53129	53129	53129
% fit	62%	62%	64%	64%	63%	64%	64%	64%
pseudo-R2	0.49	0.49	0.48	0.48	0.49	0.48	0.48	0.47

Robust z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

McKelvey-Zavoina pseudo-R2 =[Var(predicted-h*)/Var(h*)]