

MASTER THESIS

Title: The impact of traffic bodily injury damages on quality-adjusted life expectancy: the case of Spain

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Contribution to the SDGs

This study contributes to several Sustainable Development Goals (SDGs), particularly those related to public health, gender equality, and the socioeconomic impact of traffic accidents. The analysis of the loss of quality of life resulting from injuries, as well as the comparison between the actual assessment of damages and the current compensation scale, allows for the identification of inequalities and areas for improvement in public policies on road safety and compensation for damages.

SDG 3: Good Health and Well-being

This study makes a key contribution to SDG 3 by analyzing the health impact of traffic accidents in Spain. The estimation of the loss of quality-adjusted life years across different profiles provides useful evidence for advancing Target 3.6, which aims to reduce the number of deaths and injuries caused by traffic accidents.

SDG 5: Gender Equality

This study incorporates a sex-disaggregated analysis that allows for the identification of potential differences in the severity of injuries and in the loss of quality-adjusted life years between men and women. This perspective contributes to SDG 5 by promoting gender equality in the assessment of the impact of accidents and in the evaluation of bodily injury. The comparison with the standard scale allows for reflection on whether the current system adequately captures these differences.

Abstract

Motor-vehicle crashes generate substantial losses in quality-adjusted life years (QALYs). Using 2022 hospital data from the Spanish Ministry of Health, this study estimates expected QALY loss across injury profiles. Hospitalized victims show significantly higher losses than those treated only in emergency departments, and QALY loss is greater among males, younger individuals, summer and weekend crashes, ICU admissions, and fatalities. A comparison with the *baremo* shows that QALY-based valuations tend to exceed statutory amounts in severe cases while remaining below them in minor injuries, highlighting both the proportionality of the QALY approach and its potential complementarity with the current system.

Key words: QALY; MAIS; severity; hospitalization; discount rate.

Resum

Els accidents de trànsit generen pèrdues substancials en anys de vida ajustats per qualitat de vida (QALY). Utilitzant dades hospitalàries del 2022 del Ministeri de Sanitat, aquest estudi estima la pèrdua de QALY esperada segons el perfil de les lesions. Les víctimes hospitalitzades presenten pèrdues significativament més altes que les tractades només als serveis d'urgències, i la pèrdua de QALY és més gran entre els homes, les persones més joves, els accidents d'estiu i de cap de setmana, les admissions a la UCI i les víctimes mortals. Una comparació amb el barem mostra que les valoracions basades en QALY tendeixen a superar les quantitats legals en els casos greus, mentre que es mantenen per sota en les lesions lleus, la qual cosa destaca tant la proporcionalitat de l'enfocament com la seva possible complementarietat amb el sistema actual.

Paraules claus: QALY; MAIS; gravetat; hospitalització; taxa de descompte.

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1. Introduction

Traffic accidents are one of the main public health problems worldwide, with a significant impact on the physical integrity and health of persons. Every year, more than one million of people is killed or injured in traffic accidents (WHO, 2023). Traffic accidents have a significant economic impact, as they generated administrative costs, material costs and costs associated with victims, including productivity losses, medical costs, and human costs (FITSA, 2008). According to the World Health Organization, trauma caused by traffic accidents represented an economic cost to societies between 1% and 3% of GDP, and in some cases 6% (WHO, 2023). For the healthcare system, attending to motor-vehicle crash victims represents a significant use of hospital resources. In Spain, 1.3% of patients treated in emergency departments and 0.5% of those hospitalized in 2022 were admitted due to traffic accidents (Ministry of Public Health, 2025a).

At the individual level, the impact on the health of a person involved in a traffic accident can range from minor injuries with temporary effects to very severe injuries with permanent health consequences, or even loss of life. Ordinal categorical scales are normally used to classify the severity of motor injuries. A widely used measure of injury severity in road safety research is the severity categorization based on police records, which typically distinguishes between injuries not requiring hospitalization, injuries requiring hospitalization, and fatalities (Cespedes et al., 2024; Fountas et al., 2018; Hou et al., 2022). In clinical settings, however, injury severity is commonly assessed using specialized injury scoring systems, such as the Maximum Abbreviated Injury Score (MAIS) (Asscheman et al., 2023) or the Injury Impairment Index (Spicer et al., 2011). More broadly, hospital managers often rely on general inpatient classification systems widely used for cost-adjustment analyses, such as the All Patient Refined Diagnosis Related Group (APR-DRG) system, which assigns each inpatient episode—whether injury-related or not—to a diagnosis-related group as well as to a Risk of Mortality (ROM) subclass and a Severity of Illness (SOI) subclass (Santos et al., 2022).

In health economics, quantitative metrics are frequently used to assess health outcomes. Policy decisions regarding the allocation of healthcare resources across competing interventions require evaluating their impact on both costs and health outcomes. The quality-adjusted life year (QALY) is widely used as a summary measure of health outcomes, as it incorporates both the effect of an intervention on a patient's length of life and its impact on health-related quality of life (Whitehead and Ali, 2010; Pettitt et al., 2016). In a novel approach, we propose using the loss of QALYs as a measure of the impact of injuries on health resulting from motor-vehicle crashes. In cases of fatal traffic accidents, victims are deprived of all their remaining years of life. When the injuries sustained in traffic crashes are non-fatal, the impact on individuals may lead to permanent disabilities that reduce their health-related quality of life. Measuring the impact in terms of quality-adjusted life years is appropriate because it accounts for both the quantity and the quality of life lost by the victims. In this way, not only the impact of fatalities but also

the impact of injuries resulting from accidents that affect the daily lives of those injured are considered.

The database used in this study was provided by the Spanish Ministry of Health and contains information on medical diagnoses and procedures recorded up to hospital discharge for victims of road-traffic crashes in the year 2022. The expected loss of QALYs is calculated by distinguishing between individuals who died as a result of the traffic accident and those who sustained non-fatal injuries. In the case of fatal injuries, the loss of QALYs is computed as the average number of quality-adjusted life years expected to remain for individuals of the same age and gender as the victim. For non-fatal injuries, the QALY loss is calculated as a proportion of the expected quality-adjusted life years, determined by the severity of the injury. The proportions of QALY loss applied to non-fatal injuries correspond to those adopted by the National Highway Traffic Safety Administration (NHTSA) in the United States (Blincoe et al., 2023). The injury severity of the casualty is assessed using the Maximum Abbreviated Injury Scale (MAIS), distinguishing in the calculation of QALY loss between individuals who required hospitalization and those who were treated in the emergency department but not admitted. Following the motor-injury classification established by the Spanish traffic authority, individuals who require hospitalization are considered serious injury casualties, whereas those who do not require hospitalization are considered mild injury casualties (DGT, 2024).

We argue that the loss-of-QALY metric, capable of capturing the health impact of motor-vehicle crashes by integrating different levels of injury severity and fatalities into a single indicator, can play a valuable role in several areas of road-safety research and practice, including the design of motor-insurance compensation systems and the evaluation of public road-safety policies. In Spain's insurance sector, monetary compensation for injuries and fatalities resulting from motor-vehicle collisions is determined by a statutory injury-compensation scale (Law 35/2015, 2015). According to the rationale of this legal framework, compensation amounts are inversely related to the age of the injured party and are calculated by considering the loss of quality of life arising from the consequences of the injury that prevent or restrict the victim's autonomy in performing essential everyday activities or pursuing personal development through specific activities (Law 35/2015, 2015, arts. 107–109). In this context, comparing QALY-based valuations with the *baremo* allows us to assess the extent to which this approach provides a more proportional representation of the damage suffered, particularly in cases of higher injury severity, and to explore its potential complementarity with the current compensation system. Moreover, because ICD-10-CM diagnoses are available immediately after the crash, this approach could also support insurers in establishing more accurate and timely initial claim reserves that better reflect the actual severity of the injuries.

In the evaluation of road-safety measures, assessing all the consequences of traffic accidents is fundamental for policymaking (Blincoe et al., 2023, p. 87; Elvik, 2019).

National traffic authorities seek to determine the relationship between the cost of a road-safety measure or intervention and its effectiveness, measured in terms of the benefits derived from preventing road-traffic casualties (DGT, 2024). In cost-benefit analysis, several studies have sought to assign monetary values to the injuries sustained by victims of traffic accidents (Abellán et al., 2024a; 2024b). These monetary valuations are then aggregated across all casualties involved in a crash to compute its total economic impact (Céspedes et al., 2025). However, valuation approaches based on human-capital costing fail to capture the intangible value associated with the loss of quality of life resulting from injuries (Blincoe et al., 2023). Although these more intangible effects could, in principle, be assessed through individuals' willingness to pay to avoid the risk of death or injury, economic valuation studies have not yet produced credible monetary estimates for life and physical integrity (Elvik, 2019). In this context, analyses that focus on providing objective information about the actual impacts of accidents on longevity and health status—rather than imposing value judgements by analysts or policymakers—may be preferable in road-safety policy evaluation. In addition, quantifying the impact of traffic accidents in terms of life years lost as a consequence of the crash, rather than in monetary values, allows for more meaningful comparisons across societies or population groups with different socioeconomic characteristics. Moreover, the use of QALYs enables comparisons between the consequences of traffic accidents and those of other health problems, thereby supporting more effective prioritisation of healthcare and preventive resources (Elvik, 2019; Furberg et al., 2018).

The study is structured in five sections. Section 2 defines different concepts related to life expectancy and details the calculation of loss of quality-adjusted life years in cases of fatal injuries resulting from traffic accidents. Section 3 explains the methodology used to estimate the expectancy loss of quality-adjusted life years in case of non-fatal injuries. In the fourth section, the database used in the research is described, and the preliminary calculation required to estimate the loss of quality-adjusted life years is performed. Section 5 presents the results obtained from the analysis. Finally, a discussion of main results derived from the study is presented in Section 6, along with recommendations for future research and possible practical applications. Conclusions are summarized in Section 7.

2. Loss of quality-adjusted life years in fatal injuries

In case of a person who has died as a result of a traffic accident, the loss of QALY will be calculated based on the expectancy life of the individual. Assuming that death occurs at the beginning of the year, the life expectancy of an individual of age x , e_x , is defined as (Ayuso et al., 2001; Céspedes et al., 2025),

$$e_x = \sum_{t=1}^{\omega-x} {}_t p_x$$

where ${}_t p_x$ is the probability that this individual of age x survives to age $x+t$ and ω is the actuarial infinity (normally, 110 or 115 years). Likewise, the quality-adjusted life expectancy of an individual of age x is defined as:

$$e_x^{QA} = \sum_{t=1}^{\omega-x} {}_t p_x \cdot u_{x+t-1}$$

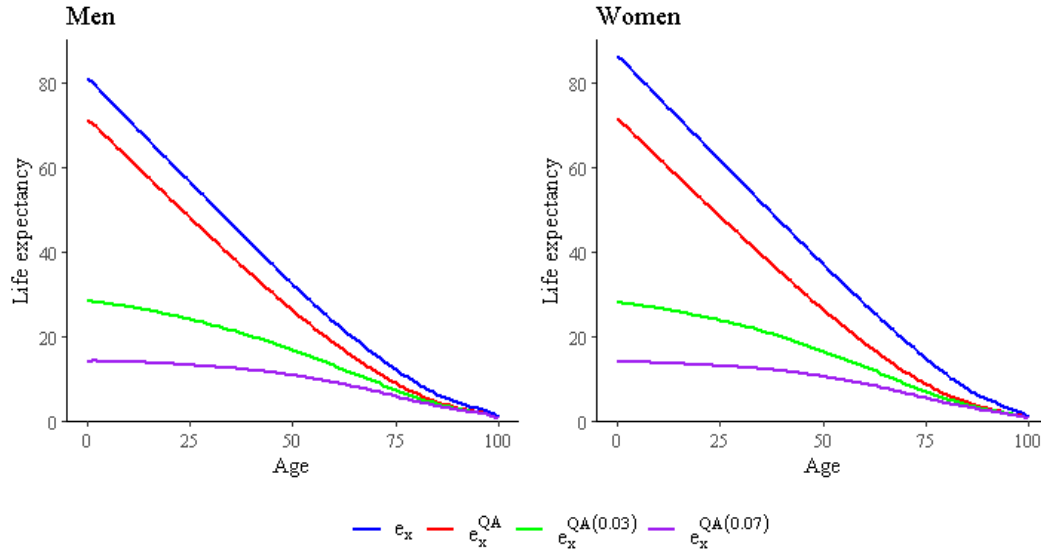
where u_{x+t-1} is the average utility at age $x+t-1$ defined as the quality of life related to health enjoyed by surviving individuals (Martínez-Pérez et al., 2016).

The above definitions do not consider the existence of time preference, that is, the value given to years further away in time may be less than that given to years closer in time (Mason et al., 2009). A discount rate can be included to capture the temporal preference. The discounted quality-adjusted life expectancy of an individual of age x is defined as,

$$e_x^{QA(d)} = \sum_{t=1}^{\omega-x} {}_t p_x \cdot u_{x+t-1} \cdot (1+d)^{-t}$$

where d is the discount rate. Note that $e_x^{QA(d)} = e_x^{QA}$ if $d = 0$, and $e_x^{QA(d)} = e_x$ if $u_{x+t-1} = 1$ and $d = 0$ for any x and t . In this study, the discount rates selected are 3% and 7%, as recommended by the Office of Management and Budget (OMB, 2003) and used in Blincoe et al. (2023). Figure 1 shows the (quality-adjusted) life expectancy of the Spanish population in 2022 by gender. As observed for both genders, the impact of time preference on the estimated life expectancy is greater than the impact of the utility adjustments, particularly at younger ages.

Figure 1. (Discounted) quality-adjusted life expectancy by gender in Spain. Year 2022.



Source: Own elaboration based on data from the Spanish National Statistics Institute (INE, 2024). Note that e_x , e_x^{QA} y $e_x^{QA(d)}$ refer to life expectancy, quality-adjusted life expectancy and discounted quality-adjusted life expectancy, respectively. Discount rates of 3 and 7% are used, following Blincoe et al. (2023) and OMB (2003).

Throughout this study, the expected loss of years without adjusting for quality of life will be denoted by le_x , while the expected loss of (discounted) quality-adjusted life years (QALYs) will be denoted by $le_x^{QA(d)}$. The discount rates applied are 0% (no time preference), 3%, and 7%. For fatal injuries, the expected loss of years without adjustment at age x , le_x , and the expected loss of (discounted) QALYs, $le_x^{QA(d)}$, correspond to e_x and $e_x^{QA(d)}$, respectively. For non-fatal injuries, le_x and $le_x^{QA(d)}$ are computed as described in Section 3.

3. Loss of quality-adjusted life years in non-fatal injuries

3.1. Key concepts

The severity of a non-fatal injury can be estimated based on the percentage of quality-adjusted life years lost that it represents when compared to a fatal injury. That is, in the case of non-fatal injuries, the expected loss of QALYs, $le_x^{QA(d)}$, will be expressed as a proportion of the expected loss of QALYs that would have occurred if the individual had died, $e_x^{QA(d)}$. This indicator assesses the expected loss of functional capacity in a replicable manner and is useful for evaluating the health-related quality of life lost because of an injury (Miller, 2000). In this regard, the use of QALYs allows us to measure the impact that an injury has on the health of a person in terms of both the quality and quantity of life (Spicer et al., 2011). One QALY on an annual basis is valued at 1.0 for

perfect health and at 0.0 for death, with negative values allowed in some cases (i.e., health states considered worse than death). Thus, the loss of one year of QALY is equivalent to losing one year of life in perfect health due to premature mortality (Spicer et al., 2011, p.365). The proportion of QALYs lost annually due to a non-fatal injury can therefore be represented as a percentage between 0% (no loss) and 100% (total loss, in the case of death).

There are various methods for estimating the percentage loss of QALYs. Over time, preference-based instruments have been developed that assign utility weights to multiple dimensions of health, with the objective of reflecting the social preferences. One of the main advantages of these instruments is that they enable the obtaining of a utility measure related to health through a standardized scoring system (Spicer and Miller, 2010). This study adopts the QALY loss percentages used by the National Highway Traffic Safety Administration (NHTSA) in its cost–benefit analyses of road safety interventions. These percentages are derived from the Injury Impairment Index (III), an instrument based on preference which allows estimation the impact of non-fatal injuries in terms of loss of quality of life. As Spicer and Miller (2010) note, other health scales can also be used to estimate the percentage of QALYs, including the Functional Capacity Index (FCI), the three generations of Health Utilities Index (HUI), the Quality of Well-Being Scale (QWB), the EuroQol and the Disability Adjusted Life Years (DALYs).

Finally, for explanatory purposes, we present below a set of concepts required to estimate the percentage loss of QALYs for non-fatal injuries in our database of traffic accidents in Spain, in accordance with the country’s public health system.

ICD-10-CM

The Spanish Public Health System uses the International Classification of Diseases – Clinical Modification (ICD-10-CM) coding system for the classification of medical diagnoses and procedures (MSSSI, 2016). Developed by the WHO, this classification system is widely used around the world. Its main purpose is to facilitate the registration, analysis, interpretation, and comparison of mortality and morbidity data over time, which is essential for healthcare management.

Abbreviated Injury Scale (AIS) y Maximum Abbreviated Injury Scale (MAIS)

The Abbreviated Injury Scale (AIS) is an anatomically based severity scoring system that classifies each injury by body region and rates its severity on a six-point ordinal scale: level 1 denotes a minor injury, level 2 a moderate injury, level 3 a serious injury, level 4 a severe injury, level 5 a critical injury, and level 6 a fatal (unsurvivable) injury (Greenspan et al., 1985). Originally developed by the American Medical Association’s Committee on Medical Aspects of Automotive Safety (1971), the system is now maintained and updated by the Association for the Advancement of Automotive Medicine (AAAM). The AIS severity ratings form the basis for calculating the Injury Severity Score (ISS), developed by Baker et al. (1974), which remains one of the most widely used methods for describing overall injury severity (Paladugu et al., 2002). Victims of traffic

collisions may sustain multiple injuries, each of which is assigned an AIS score. The Maximum Abbreviated Injury Scale (MAIS) is defined as the highest AIS score among all injuries sustained by an individual, and it provides a concise summary measure of the overall severity of a victim's injuries.

Injury Impairment Index (III)

The Injury Impairment Index (III) can be used to estimate the loss of QALYs associated with injuries resulting from accidents. Despite certain limitations—such as the lack of formal validation—its use is widespread (Spicer et al., 2011). The index was originally developed by physicians to assess the functional consequences of injuries (Hirsch et al., 1983). To this end, they designed a scale comprising six dimensions that enable the evaluation of functional capacity loss over time. These dimensions include mobility, cognitive function, activities of daily living, pain, sensory function, and aesthetic aspects. For each dimension, evaluators assessed both the level of disability at the time of hospital discharge and its duration thereafter. Subsequently, a seventh dimension was added, capturing the probability of permanent work disability (Miller et al., 1995). Miller et al. (1995) also established the weights for QALY loss on a scale from 1 to 100, expressed as percentages, based on the magnitude of loss in each dimension and the relative contribution of each dimension to an individual's overall quality of life. Later, Spicer et al. (2011) updated the original utility weights through a literature review of studies employing various health-related quality-of-life scales. Annex 1 provides a detailed explanation of how to calculate QALY loss for non-fatal injuries using the III.

Validating and Improving Injury Burden Estimates Study (VIBES)

The results of the Validating and Improving Injury Burden Estimates Study (VIBES) were published in 2016 providing updated disability weights (Gable et al., 2014, 2016). A major contribution of VIBES project is that, unlike the III—which is based on expert medical opinion—it derives its estimates from information reported directly by patients treated in emergency departments or hospitalized after injury, using data from a multinational cohort. The study incorporates six longitudinal datasets from five different countries, all of which measure loss of self-perceived quality of life among injured individuals. In general, patient responses to the three-level EQ-5D questionnaire were used to estimate disability weights. The questionnaire is designed to capture self-reported health status across five domains: (i) anxiety/depression, (ii) mobility, (iii) pain/discomfort, (iv) self-care, and (v) usual activities. For each domain, respondents indicate whether they experience no problems, some problems, or extreme problems (Dolan, 1997).

3.2. Percentages of quality-adjusted life years lost according to injury severity

The percentages of QALY loss by MAIS severity level and discount rate for mild and serious motor-injury casualties considered in the study are presented in Table 2. We apply the percentages of QALY loss adopted by the NHTSA for victims of traffic accidents in

road-safety cost-utility analyses (Blincoe et al., 2023). In 2022, NHTSA commissioned the Pacific Institute for Research and Evaluation (PIRE) to update these percentages by conducting a meta-analysis of the available literature. PIRE concluded that the sample of non-hospitalized patients in the VIBES study was too small and therefore recommended continuing to use the weights based on the III, which are reported in Table 2 (Spicer et al., 2011). For hospitalized patients, PIRE determined that the VIBES study weights were also insufficiently disaggregated by severity level and affected body region. To address this limitation, PIRE proposed hybrid estimates -also included in Table 2- that were obtained by combining information from the III with the VIBES weights.

Table 1. Percentage of QALY loss by MAIS level and discount rate for mild and serious motor casualties

	Mild casualties (Non-hospitalized)			Serious casualties (Hospitalized)		
Discount Rate	0%	3%	7%	0%	3%	7%
MAIS						
MAIS 1	0.18%	0.20%	0.24%	0.35%	0.43%	0.54%
MAIS 2	1.74%	2.57%	3.77%	3.86%	4.17%	4.51%
MAIS 3	6.38%	6.79%	7.43%	16.79%	18.28%	18.72%
MAIS 4	-	-	-	22.78%	30.44%	30.71%
MAIS 5	-	-	-	54.99%	52.52%	50.10%

Source: Blincoe et al. (2023).

4. Calculation of QALY loss for traffic victims on Spanish roads

The expected loss of QALYs among traffic accident victims who were treated in emergency departments or required hospitalization during 2022 is estimated. In the case of fatal injuries, QALY loss is calculated as the quality-adjusted life expectancy, as described in Section 2. For non-fatal injuries, the calculation of QALY loss is performed in two steps.

Step 1. Calculation of MAIS Using ICD-10-CM Codes

In the first stage, each victim's injury diagnosis, classified using ICD-10-CM codes, is translated into a corresponding severity category based on the Maximum Abbreviated Injury Scale (MAIS). Ideally, AIS/MAIS scoring requires trained personnel with direct access to the injured individuals or to their detailed medical records. When such assessment is not feasible, several automated methods allow for the conversion of ICD codes into AIS/MAIS severity levels. In the present study, we apply the classification

procedure developed by Clark et al. (2018) and by Black and Clark (2022), which was constructed using data from the National Inpatient Sample (NIS).¹ Based on the ICD-10-CM codes corresponding to the primary and secondary diagnoses of traffic-accident patients, the MAIS severity level is derived using this classification algorithm. Although this method does not attain the level of precision provided by AIS scoring derived from complete clinical evaluations, it has demonstrated a high degree of agreement in injury-severity classification (Airaksinen et al., 2019) and is therefore considered a valid alternative (Clark et al., 2018; Zonfrillo et al., 2015).

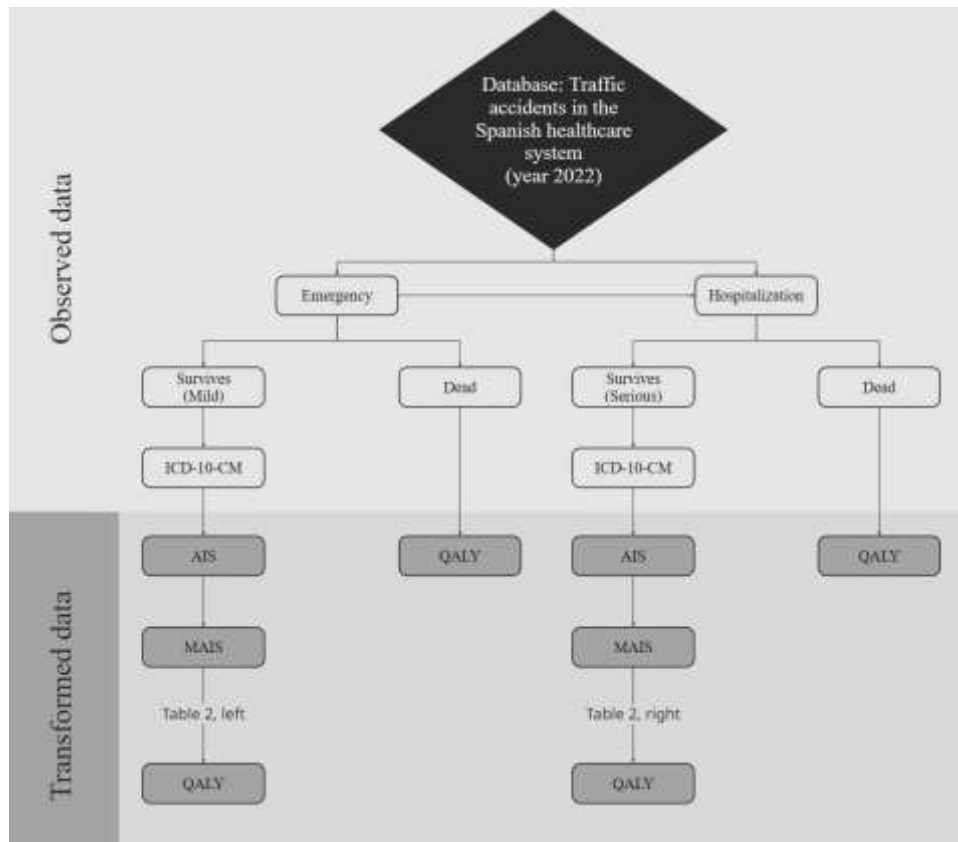
Step 2. Calculation of QALY loss using MAIS

Once MAIS values are obtained for all traffic accident victims in Spain, the next step consists of estimating the QALY loss as outlined in Section 3. In this process, we distinguish between victims who received only emergency care (mild injuries) and those who required hospitalization (severe injuries). The QALY loss is calculated by applying the percentages shown in Tables 2, depending on the injury classification and the MAIS severity level. The estimates are computed for the three discount rates: 0%, 3%, and 7%.

An outline summarizing the complete procedure for calculating QALY loss among fatal and non-fatal traffic victims in Spain is presented in Figure 2.

¹ The NIS is the largest and most accessible publicly available database of hospital care in the United States (AHRQ, 2025).

Figure 2. Flowchart of the process followed in classifying fatal and non-fatal injuries. Victims of traffic accidents in Spain 2022



Source: Own elaboration. In parenthesis, severity of victims.

5. Data

We use information provided by the Spanish Ministry of Health on victims of traffic accidents who were treated in hospitals during 2022. The costs incurred by the Spanish public health system for treating motor-vehicle casualties must be reimbursed by insurance companies. For this reason, motor-vehicle accident victims treated within the health system can be distinguished from other types of patients. The database contains anonymized records of motor victims who either attended an emergency department or required hospital admission. Victims may initially be treated in an emergency department and subsequently admitted to the hospital. In addition, the database includes cases involving readmissions and patients who died either in the emergency department or during hospitalization. We preprocess the data so that, when multiple records share the same identifier, we retain the most recent record or, if recorded on the same date, the most severe one. The final database includes a total of 195,763 unique patient records, each containing a wide range of clinical, demographic, and administrative information. Of the patients in our dataset, 181,998 were treated exclusively in the emergency department, while 13,329 patients required hospitalization. Among them, 432 patients died as a consequence of the crash. These figures represent approximately 65% of all individuals treated in emergency departments, about 65% of those hospitalized, and 73% of all

fatalities resulting from motor-vehicle crashes in 2022 (Ministry of Public Health, 2025b).

Table 3 provides a description of the variables included in the statistical analysis. The categorical variables classify cases according to the following criteria: injury severity (mild, serious, or deceased), gender, categorized age, the four-month term in which the accident occurred, type of day (workday or weekend), and type of hospital discharge. Additionally, two numerical variables capture the duration of hospitalization and ICU stay, when applicable.

Table 2. Definition of the variables

Name	Categories	Description
<i>Categorical variable</i>		
Severity	Mild	Hospitalization was not required.
	Serious	Hospitalization was required.
	Death	Patient dies.
Gender	Women	Gender.
	Men	
Age	0-17	Under 18 years old.
	18-30	Between 18 and 30 years old.
	31-65	Between 31 and 65 years old.
	>65	Over 65 years old.
Four-month term	Gen-Apr	Accident occurred in the first four-month term.
	May-Aug	Accident occurred in the second four-month term.
	Sept-Dec	Accident occurred in the third four-month term.
Type of day*	Workday	00:00 h Monday - 14:59 h Friday.
	Weekend	15:00 h Friday – 23:59 h Sunday.
Type of hospital discharge	Home	Discharged to home.

	Another hospital	Discharged with transfer to another hospital.
	Voluntary	Discharged by patient decision.
	Death	Discharged due to death.
	Transfer to center	Discharged with transfer to a social and healthcare center.
	Others	Discharge for unspecified reasons.
	Yes	Whether or not the patient has been admitted to the hospital
Hospital admission	No	
Admission to ICU	Yes	Whether or not the patient has been admitted to ICU
	No	
<i>Numerical variable</i>		
Hospitalization		Duration in days of the hospitalization (only cases admitted to hospital)
ICU		Duration in days in ICU (only cases admitted to ICU)

* Note: We follow the Spanish traffic authority's definition, which classifies working days as 00:00 Monday to 14:59 Friday, and weekends as 15:00 Friday to 23:59 Sunday (DGT, 2025).

Source: Own elaboration

5.1. Statistical analysis

Table 4 presents descriptive statistics of the variables segmented by patient severity: mild injuries, serious injuries, and deaths. The distribution of severity shows that 181,998 sustained mild injuries (92.97%), 13,329 were seriously injured (6.81%), and 436 individuals died (0.22%). Women exhibit a statistically significant higher proportion of mild cases (95.18%) than men (91.25%), whereas men show higher proportions of serious injuries (8.47%) and deaths (0.27%). Statistically significant differences also emerge across age groups. Patients under 18 present a very high proportion of mild cases (95.42%) and an extremely low incidence of deaths (0.05%). As age increases, the share of mild cases declines while the proportion of serious injuries and deaths rises. Among individuals aged 65 and over, only 79.35% of cases are mild, and the mortality rate reaches 1.41%, the highest among all age categories.

With respect to the four-month term, accidents occurring between May and August show a statistically significant higher proportion of serious injuries (7.84%) and deaths (0.28%) than accidents in other periods. This pattern may be associated with seasonal factors, such as increased mobility during holidays. Analysis by type of day indicates that weekends show slightly higher proportions of severe injuries (7.39%) and deaths (0.26%) compared

to workdays (6.51% and 0.20%, respectively). Regarding the type of hospital discharge, a strong association is observed with injury severity, with cases transferred to social and healthcare centers originating predominantly from serious injuries (90.12%).

The analysis also shows a significant association between fatalities and hospitalization or the need for ICU admission. Of the 436 recorded deaths, 372 had been hospitalized prior to death, while 64 were treated only in the emergency department. Among the hospitalized fatalities, 296 had been admitted to the ICU. Finally, ANOVA results indicate no statistically significant differences between serious and deceased patients in either hospital length of stay or ICU duration. Serious patients remained hospitalized for an average of 8.96 days, while deceased individuals stayed an average of 9.04 days. Regarding ICU care, serious patients spent an average of 6.46 days in the unit, compared with 7.39 days among those who died.

Table 3. Descriptive statistics

		Mild		Serious		Deaths		Contrast
<i>Categorical variables</i>		N	%	N	%	N	%	Chi-square p-value
Gender	Women	81,264	95.18	3,984	4.66	134	0.16	<0.001
	Men	100,659	91.25	9,345	8.47	302	0.27	
Age	0-17	21,625	95.42	1,026	4.53	12	0.05	<0.001
	18-30	52,286	95.62	2,388	4.27	60	0.11	
	31-65	97,175	92.85	7,319	6.99	170	0.16	
	>65	10,912	79.35	2,646	19.24	194	1.41	
Four-month term	Gen-Apr	59,740	93.60	3,973	6.22	114	0.18	<0.001
	May-Aug	60,897	91.88	5,195	7.84	183	0.28	
	Sept-Dec	61,361	93.45	4,161	6.34	139	0.21	
Type of day	Workday	120,397	93.29	8,400	6.51	262	0.20	<0.001
	Weekend	61,601	92.35	4,929	7.39	176	0.26	
Type of hospital discharge	Home	166,884	93.63	11,355	6.37	-	-	< 0.001*
	Another hospital	1,832	60.80	1,181	39.20	-	-	
	Voluntary	3,035	96.93	96	3.07	-	-	
	Death	-	-	-	-	436	100	

	Transfer to center	25	9.88	228	90.12	-	-	
	Others	10,222	95.61	469	4.39	-	-	
Hospital admission	Yes	-	-	13,329	97.28	372	2.72	<0.001
	No	181,998	99.96	-	-	64	0.04	
Admission to ICU	Yes	-	-	2,963	90.92	296	9.08	<0.001
	No	181,998	94.54	10,336	5.39	140	0.07	

<i>Numerical variable (mean)</i>		ANOVA		
Hospitalization	-	8.96	9.04	0.92
ICU	-	6.46	7.39	0.17

* Note: In the Chi-square contrast the death category was excluded because it did not present values in two of the injuries categories.

Source: Own elaboration

6. MAIS severity level and QALY loss

6.1. MAIS severity level for non-deceased

Based on the ICD-10-CM primary and secondary diagnosis codes associated with each patient, the MAIS severity level was derived using the classification algorithm developed by Black and Clark (2022). This system converts diagnosis-specific trauma into corresponding MAIS severity scores. When a patient's principal and secondary diagnoses are not related to trauma, the algorithm does not assign a MAIS level.² Additionally, mild injury casualties who were classified by the classification algorithm with MAIS scores of 4 or 5 were recoded as MAIS 3, considering that there may be non-hospitalized victims with severe injuries, although experts who use only the MAIS typically define serious injuries as MAIS 3+ (Ferreira et al., 2017).

Table 5 reports the relative frequencies of MAIS scores across the different categorical variables. Mild-injury victims are predominantly classified as MAIS 1 (49.80%), whereas serious-injury victims are most frequently classified as MAIS 3 (32.79%). Female casualties exhibit a higher proportion of MAIS 1 (50.53%) compared to males (44.52%), while males have a higher frequency of MAIS 4 (2.09%) and MAIS 5 (1.31%). With respect to age, it can be observed that the proportion of cases with higher MAIS scores increases as age rises. For instance, 29.51% of victims under the age of 18 have a MAIS score of 3 or higher, whereas this percentage rises to 46.41% among victims aged 65 and

² The classification system identifies only those ICD-10-CM codes that begin with S or T, which correspond to diagnoses related to trauma. These codes encompass a broad range of injuries, including wounds, fractures, burns, and poisoning. In cases where a patient's diagnoses include codes outside the trauma-related categories, the algorithm assigns a MAIS value of 0.

over. Interestingly, slight variations in the distribution of MAIS severity scores are observed across the four-month periods in which the accidents occurred, with a tendency toward a higher proportion of MAIS 4 and MAIS 5 cases during the months of May to August. Similarly, weekends are associated with a higher proportion of patients presenting MAIS 4 and MAIS 5 scores, whereas workdays concentrate the majority of cases in the MAIS 1 category.

The type of hospital discharge, hospital admission, and ICU admission also reveal notable differences in the distribution of MAIS scores. Patients who were transferred to other hospitals or to social and healthcare centers show a much higher proportion of MAIS 4 and MAIS 5 scores, in contrast with those discharged to their homes, whose injuries are predominantly classified as MAIS 1. Similarly, patients admitted to hospital or requiring ICU care present higher proportions of severe MAIS categories, with the highest concentrations observed among those admitted to the ICU. Finally, ANOVA results confirm statistically significant differences in the mean lengths of hospitalization and ICU stay across the various MAIS severity levels. As the MAIS category increases, both the expected number of days spent in hospital and the expected number of days in the ICU rise markedly.

Table 4. Frequency distribution of MAIS score by category (expected value for numerical variables)

		MAIS1		MAIS2		MAIS3		MAIS4		MAIS5		Contrast
<i>Categorical variables</i>		N	%	N	%	N	%	N	%	N	%	Chi-square p-value
Severity	Mild	44,148	49.80	15,442	17.41	29,067	32.79	-	-	-	-	< 0.001
	Serious	2,980	25.22	1,833	15.51	4,138	35.02	1,792	15.17	1,073	9.08	
Gender	Women	20,168	50.53	6,378	15.98	12,562	31.47	527	1.32	279	0.70	< 0.001
	Men	26,942	44.52	10,888	17.99	20,628	34.09	1,265	2.09	794	1.31	
Age	0-17	6,190	50.54	2,444	19.95	3,457	28.22	92	0.75	66	0.54	< 0.001
	18-30	13,365	49.39	4,506	16.65	8,729	32.25	268	0.99	195	0.72	
	31-65	26,634	46.59	8,822	16.69	17,821	33.70	1,012	1.91	585	1.11	

Four-month term	>65	2,937	35.45	1,503	18.14	3,198	38.60	420	5.07	227	2.74	< 0.001
	Gen-Apr	15,733	49.06	5,256	16.39	10,243	31.95	517	1.61	316	0.99	
	May-Aug	15,713	45.30	6,199	17.87	11,623	33.51	722	2.08	431	1.24	
	Sept-Dec	15,682	46.51	5,820	17.26	11,339	33.63	533	1.64	326	0.97	
Type of day	Workday	31,473	47.90	11,174	17.01	21,357	32.51	1,079	1.64	617	0.94	< 0.001
	Weekend	15,655	45.02	6,101	17.55	11,848	34.07	713	2.05	456	1.31	
Type of hospital discharge	Home	43,048	47.61	15,633	17.29	29,455	32.57	1,437	1.59	851	0.94	< 0.001 *
	Another hospital	487	20.72	367	15.62	1,091	46.42	245	10.43	160	6.81	
	Voluntary	222	29.25	153	20.16	356	46.90	230	3.03	55	0.66	
	Death	-	-	-	-	-	-	-	-	-	-	
	Transfer to centers	28	16.57	23	13.61	57	33.73	34	20.12	27	15.97	
	Others	3,343	49.37	1,099	16.23	2,246	33.17	53	0.79	30	0.44	
Hospital admission	Yes	2,980	25.22	1,833	15.51	4,138	35.02	1,792	15.17	1,073	9.08	< 0.001
	No	44,148	49.80	15,442	17.41	29,067	32.79	-	-	-	-	
Admission to the ICU	Yes	164	5.73	190	6.64	1,059	36.95	850	29.69	601	20.99	< 0.001
	No	2,816	48.11	1,643	17.50	3,080	32.93	942	0.97	472	0.49	
Numerical variable (mean)												
Hospitalization		5.41		6.90		8.35		13.57		17.36		<0.001
ICU		1.82		3.45		4.55		7.61		10.62		< 0.001

*Note: The Chi-square contrast has been done excluding the “Death” category, since it does not present data associated with the MAIS categories.

Source: Own elaboration

6.2. Loss of quality-adjusted life years

The expected loss of QALYs for traffic accident victims, based on their quality-adjusted life expectancy and MAIS severity level, is presented in Table 6. The table reports the expected life years lost without quality adjustment (le_x), as well as the expected loss of discounted quality-adjusted years using discount rates of 0%, 3% and 7% (le_x^{QA} , $le_x^{QA(d=0.03)}$, $le_x^{QA(d=0.07)}$), respectively. Spanish motor-vehicle casualties treated in hospitals in 2022 lost, on average, 1.77 years of life expectancy. When the impact of the accident is measured in terms of the expected number of years lived with quality of life, reflecting the health state of survivors, the estimated loss amounts to 1.42 quality-adjusted years of life. This figure is further reduced to 0.87 and 0.57 when applying discount rates of 3% and 7%, respectively, which assigns a lower weight to years further into the future. Males lose approximately 1.89 expected years of life as a result of being involved in traffic accidents, whereas this figure decreases to 1.58 years for females. In terms of quality-adjusted years of life lost, the estimated losses are 1.57 years for men and 1.19 years for women. As expected, the age of the victim is a determining factor. Minors under the age of 18 lose, on average, 2.20 years of life expectancy as a result of traffic accidents, and this value decreases progressively as the age of the victims increases. However, when the discount rate is taken into account, the age group with the highest loss of discounted QALYs is individuals aged 18 to 30. That occurs because, when a discount rate is applied, future years are weighted less, so the present value of losses for younger individuals decreases more sharply, making losses for individuals aged 18 to 30 appear greater in this case.

The time of year in which the accident occurs has a significant influence on the expected loss of years of life, both unadjusted and adjusted for quality of life. Victims of accidents registered between May and August experience an average loss of 1.86 years of life expectancy, a figure that decreases to 1.49 years when adjusted for quality of life. The second-largest losses in life expectancy are observed for accidents occurring between September and December, followed by those occurring between January and April. In addition to the time of year, the day of the week on which the accident occurs also shows a significant association with the loss of expected years of life. Accidents occurring on weekends result in a reduction of 1.60 years in quality adjusted expected life years for victims, whereas those occurring on weekdays lead to an average loss of 1.33 years.

Statistically significant differences in the expected loss of life years are observed according to the type of hospital discharge, with the highest QALY losses associated with death (21.50 years), followed by patients transferred to other hospitals (3.83 years). In contrast, patients discharged home experience the lowest QALY losses (1.30 years). Finally, hospital admission—and, among hospitalized patients, ICU admission—is associated with higher average losses of expected years of life compared with those of

non-hospitalized victims. The expected loss of QALYs is 4.95 years for hospitalized patients and 9.17 years for ICU admissions, while the loss decreases to 0.94 years for non-hospitalized casualties. Although being hospitalized or admitted to the intensive care unit is strongly associated with the expected loss of QALYs, there is no strong correlation between the length of stay in hospital or in the ICU and the expected loss of quality-adjusted life years. A possible explanation is that longer hospital and ICU stays are more common among older patients, who experience a relatively smaller expected loss of QALYs—despite requiring prolonged care—because they have a shorter remaining life expectancy.

Table 5. Expected life years lost without adjustment and adjusted for quality of life, for different discount rates

		le_x	le_x^{QA}	$le_x^{QA(d=0.03)}$	$le_x^{QA(d=0.07)}$	Contrast*
Total		1.77	1.42	0.87	0.57	
<i>Categorical variables</i>						ANOVA
Severity	Mild	1.14	0.92	0.55	0.37	< 0.001
	Serious	5.52	4.43	2.78	1.72	
Gender	Women	1.58	1.19	0.72	0.47	< 0.001
	Men	1.89	1.57	0.96	0.63	
Age	0-17	2.20	1.86	0.91	0.53	< 0.001
	18-30	2.11	1.76	0.95	0.57	
	31-65	1.60	1.26	0.84	0.57	
	>65	1.11	0.76	0.66	0.54	
Four-month term	Gen-Apr	1.71	1.38	0.83	0.54	< 0.001
	May-Aug	1.86	1.49	0.92	0.60	
	Sept-Dec	1.73	1.39	0.85	0.56	
Type of day	Workday	1.65	1.33	0.81	0.54	< 0.001
	Weekend	1.98	1.60	0.96	0.62	
Type of hospital discharge	Home	1.61	1.30	0.79	0.52	< 0.001
	Another hospital	4.11	3.30	2.07	1.30	
	Voluntary	2.18	1.78	1.09	0.71	

	Death	27.3 3	21.5 0	12.97	8.41	
	Transfer to centers	4.99	3.83	2.60	1.70	
	Others	1.28	1.03	0.64	0.43	
Hospital admission	Yes	6.18	4.95	3.09	1.93	< 0.001
	No	1.17	0.94	0.56	0.38	
Admission to the ICU	Yes	11.4 2	9.17	5.63	3.46	< 0.001
	No	1.46	1.17	0.71	0.47	
						Correlation
<i>Numerical variable</i>						n
Hospitalization		-				0.161 [±]
ICU		-				0.114 [±]

* The ANOVA contrast has been calculated based on the average loss $le_x^{QA(d=0.03)}$.

[±] Significant at 1%.

Source: Own elaboration

To conclude, the application of a temporal discount rate has a significant impact on the estimation of the expected average loss of years of life, both unadjusted and adjusted for quality of life. The expected loss of QALYs decreases as the preference for years closer to the accident becomes stronger; that is, the loss diminishes as the discount rate increases. For example, the expected loss in quality-adjusted life years in patients who ultimately die as a result of the injuries, it is reduced from 21.50 to 12.97 years with a 3% discount rate, and to 8.41 years with 7%. The impact of the discount rate is especially pronounced in younger patients, showing that the present value of quality-adjusted years of life lost decreases more when these losses are projected over a long-time horizon. In the under 18 age group, the estimated loss of QALYs is 1.86 years; however, when applying a discount rate of 7%, this loss is reduced to 0.53 years. In contrast, among patients over 65 years old, the expected loss is 0.76, and applying a 7% discount, it is reduced to 0.54.

7. Comparison between the *baremo* and the QALYS approach

The system for assessing personal injury resulting from traffic accidents in Spain (Law 35/2015, 2015), which is based on the compensation scale named *baremo*, follows the principle of full compensation for bodily injury, with the aim of returning the victim to a situation as close as possible to that which existed before the accident. This system is characterized using uniform, objective, and predictable criteria, based on actuarial tables and predefined categories that help reduce discretion in the quantification of damages.

In contrast to this approach, the model developed in this study introduces an alternative methodology based on Quality-Adjusted Life Years (QALYs), which allows for an integrated measurement of the loss of quality-adjusted life years. This approach combines the duration and severity of the damage into a single metric, incorporating the consequences of both fatal and non-fatal injuries, and allowing for a continuous assessment of the impact on quality of life. To make this comparison, we will consider that, according to Vallejo et al. (2018), the value of a QALY ranges from 22,000 to 25,000 euros.

Both models share certain structural elements, such as the use of life expectancy as a reference time horizon and the recognition of the impact of after-effects on quality of life. However, they differ significantly in their analytical approach: while the *baremo* distinguishes between non-economic and economic damages and employs largely categorical approaches, the QALY-based model offers a unified, quantitative assessment of the damage.

To illustrate the differences between the two approaches, two simulated cases have been developed with similar characteristics regarding the victim's profile, but with variations in the severity of the temporary injuries. In both scenarios, the victim is a 40-year-old male, a Group A1 civil servant at level 26 with an annual salary of 30,586.30 euros (Ministry of Finance, 2025). Furthermore, in both cases, the permanent after-effects remain constant (10 functional points and 2 aesthetic points), with only the severity of the temporary injuries changing.

In Case 1, the victim has more severe injuries (hospitalization) with 10 days of severe personal injury, 20 days of moderate personal injury, and 50 days of basic personal injury. Based on these factors, under the current compensation scale, the total compensation would be 34,416.55 euros, broken down as follows:

Table 6. Compensation according to the compensation scale for Case 1

1. Permanent Injuries (After-effects)	25,117.15 €
1.1. Basic Personal Damage	14,335.13 €
Functional after-effects – 10 points	12,219.89 €
Aesthetic after-effects – 2 points	2,115.24 €
1.2. Particular Personal Damage	10,782.02 €
Moral damage due to loss of quality of life caused by after-effects (mild)	10,782.02 €
1.3. Pecuniary Damage	-
2. Temporary Injuries	9,299.40 €

2.1. Basic Personal Damage	1,960.00 €
50 basic days	50 x 39,20 € = 1,960.00 €
2.2. Particular Personal Damage	2,339.40 €
10 serious days	10 x 98,02 € = 980.20 €
20 moderate days	20 x 67,96 € = 1,359.20 €
2.3. Pecuniary Damage	5,000.00 €
Actual Expenses	5,000.00 €
Loss of earnings	-
Total Compensation	34,416.55 €

Source: Own elaboration

The application of the QALY model shows increasing results based on the severity level measured using the MAIS (Maximum Abbreviated Injury Scale). Specifically, the values of $le_x^{QA(d=0.03)}$ are 0.086 QALYs for MAIS 1, 0.838 for MAIS 2, 3.674 for MAIS 3, 6.118 for MAIS 4, and 10.555 for MAIS 5. These results reflect a nonlinear increase in harm, demonstrating the model's high sensitivity to increases in injury severity. Therefore, considering the QALY value mentioned above, the results are as follows:

Table 7. Compensation according to QALY-loss study for Case 1, for different MAIS levels

	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5
1. Permanent Injuries (After-effects)	2,160.52 €	20,952.00 €	91,847.14 €	152,944.58 €	263,884.65 €
1.1. Compensation according to QALY loss	0.08642072 x 25,000 € = 2,160.52 €	0.83808 x 25,000 € = 20,952.00 €	3.67388549 x 25,000 € = 91,847.14 €	6.117783 x 25,000 € = 152,944.58 €	10.555386 x 25,000 € = 263,884.65 €
1.2. Pecuniary Damage	-	-	-	-	-
2. Temporary Injuries			9,299.40 €		
2.1. Basic Personal Damage			1,960.00 €		
50 basic days			50 x 39,20 € = 1,960.00 €		

2.2. Particular Personal Damage	2,339.40 €
10 serious days	10 x 98,02 € = 980.20 €
20 moderate days	20 x 67,96 € = 1,359.20 €
2.3. Pecuniary Damage	5,000.00 €
Actual Expenses	5,000.00 €
Loss of earnings	-
Total Compensation	11,459.92 € 30,251.40 € 101,146.54 € 162,243.98 € 273,184.05 €

Source: Own elaboration

In Case 2, a relatively less severe situation is considered (no hospitalization), eliminating the days of severe impairment and reducing the duration of moderate impairment to 15 days, while maintaining the 50 base days. Based on these data, under the current schedule, the total compensation would be 27,756.75 euros, broken down as follows:

Table 8. Compensation according to the compensation scale for Case 2

1. Permanent Injuries (After-effects)	25,117.15 €
1.1. Basic Personal Damage	14,335.13 €
Functional after-effects – 10 points	12,219.89 €
Aesthetic after-effects – 2 points	2,115.24 €
1.2. Particular Personal Damage	10,782.02 €
Moral damage due to loss of quality of life caused by after-effects (mild)	10,782.02 €
1.3. Pecuniary Damage	-
2. Temporary Injuries	2,639.60 €
2.1. Basic Personal Damage	1,960.00 €
50 basic days	50 x 39,20 € = 1,960.00 €
2.2. Particular Personal Damage	679.60 €
10 moderate days	10 x 67,96 € = 679.60 €
2.3. Pecuniary Damage	5,000.00 €

Actual Expenses	5,000.00 €
Loss of earnings	-
Total Compensation	27,756.75 €

Source: Own elaboration

In this scenario, the values obtained in terms of QALYs are significantly lower: 0.040 for MAIS 1, 0.517 for MAIS 2, and 1.365 for MAIS 3. This difference highlights the model's ability to accurately distinguish between different levels of clinical impairment and their impact on quality of life. Therefore, considering the QALY value mentioned above, the results are as follows:

Table 9. Compensation according to our QALY-loss study for Case 2, for different MAIS levels

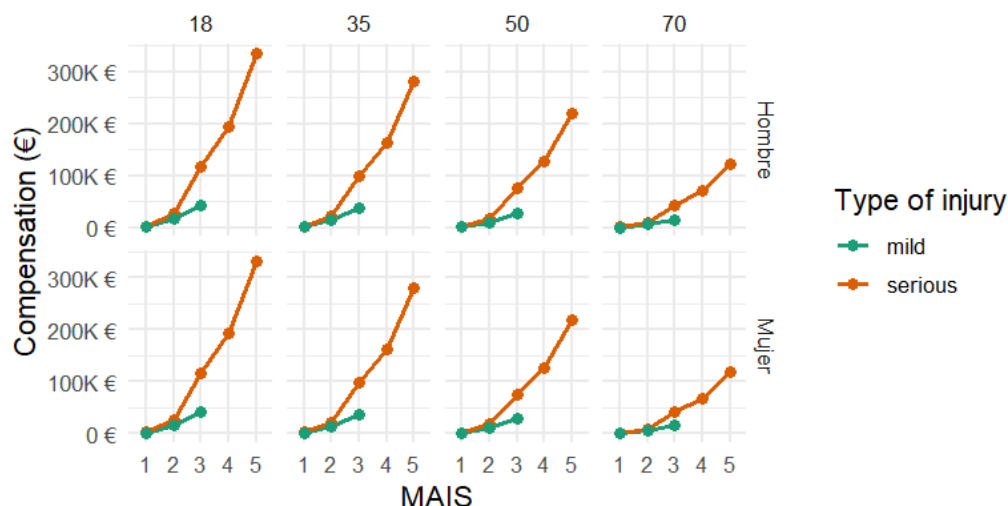
	MAIS 1	MAIS 2	MAIS 3
1. Permanent Injuries (After-effects)	1,004.89 €	12,912.86 €	34,116.09 €
1.1. Compensation according to QALY loss	0.04019568 x 25,000 € = 1,004.89 €	0.51651453 x 25,000 € = 12,912.86 €	1.36464345 x 25,000 € = 34,116.09 €
1.2. Pecuniary Damage	-	-	-
2. Temporary Injuries		2,639.60 €	
2.1. Basic Personal Damage		1,960.00 €	
50 basic days		50 x 39,20 € = 1,960.00 €	
2.2. Particular Personal Damage		679.60 €	
10 moderate days		10 x 67,96 € = 679.60 €	
2.3. Pecuniary Damage		5,000.00 €	
Actual Expenses		5,000.00 €	
Loss of earnings		-	
Total Compensation	3,644.49 €	15,552.46 €	36,755.69 €

Source: Own elaboration

Comparing the two cases allows us to extract several relevant conclusions. First, the QALY-based model shows a high sensitivity to hospitalization and the severity of

injuries, resulting in significant differences in the assessment of damage even with relatively moderate variations in clinical conditions, as shown in the figure.

Figure 3. Compensation by MAIS, type of injury, age and sex according to our QALY-loss study



Source: Own elaboration

Second, it is observed that, for low severity values (low MAIS scores), the *baremo* tends to offer higher compensation amounts, which could be interpreted as a protective mechanism in mild cases. However, as severity increases, the QALY model increases compensation amounts more sharply, eventually far exceeding the amounts set by the *baremo*.

This approach raises important implications from the perspective of equity and proportionality. On the one hand, the QALY model appears to more accurately capture the actual impact of harm in severe cases, thereby avoiding potential underestimation. On the other hand, it introduces a strong dependence on the monetary value assigned to the QALY, which can lead to variability in results and highlights the need to establish robust reference criteria.

Finally, the analysis of the cases suggests the advisability of exploring possible ways to integrate both approaches. In particular, the QALY model could complement or partially replace the assessment of sequelae, providing a continuous and anticipatory measure of damage, without the need to wait for the patient's clinical stabilization. Alternatively, its application in the context of lost earnings would allow for a more precise incorporation of the impact of quality of life on the individual's productive capacity.

In summary, the cases analyzed show that the QALY-based approach is a flexible tool capable of reflecting different levels of injury severity. Its structure allows for the economic value assigned to an QALY to be adjusted, and by distinguishing between hospitalized and non-hospitalized victims, it enables a quick and flexible assessment of the severity of bodily injuries without having to wait for the aftereffects to stabilize.

Furthermore, since ICD-10-CM diagnoses are available immediately after the accident, this approach can help insurers establish early claims reserves that better align with the expected severity of injuries.

8. Discussion

This study proposes an innovative metric for assessing the expected loss of quality-adjusted life years (QALYs) among victims of traffic accidents, using Spain as a case study for accidents occurring in 2022. The analysis introduces a single unified indicator to estimate the loss of life years associated with both fatal and non-fatal injuries. This represents a significant departure from traditional approaches, which typically separate mortality and morbidity indicators and therefore limit comparability and hinder decision-making. By integrating both causes of the reduction in quality-adjusted life years, the proposed metric enables a more accurate and comprehensive assessment of the true magnitude of the harm suffered by victims, supporting more consistent and comparable evaluations in the field of public health. The study builds on the work of authors such as Blincoe et al. (2023), Elvik (2019), and Furberg et al. (2018), who emphasize the need to move beyond purely economic valuations when measuring the impact of traffic accidents, and to adopt metrics that facilitate meaningful comparisons, particularly in relation to the effect on population longevity and health status.

When traffic accidents do not result in fatalities, the injuries sustained may nonetheless have enduring consequences for those affected, often leading to permanent disabilities and a substantial deterioration in their quality of life (Alemany et al., 2013; Bull et al., 1985; Ferrando et al., 1998; Palmera, 2017). In this context, the use of QALYs as a measure to assess the impact of the crash is particularly appropriate, as it captures both the loss of life expectancy and the reduction in health-related quality of life. This approach accounts not only for the effects associated with mortality (Albayati and Lateif, 2018; Boo and Choi, 2022; Gowthami and Kavitha, 2025; Spoerri et al., 2011), but also for the repercussions of traffic-related injuries on the daily lives of survivors (Holtslag et al., 2007; Hung et al., 2021; Pozzato et al., 2020; Rissanen et al., 2016).

To estimate the loss of life years, it is necessary to use biometrics measures such as life expectancy, which summarize the number of years individuals are expected to live at a specific age. Moreover, given the well-documented differences in longevity between men and women (Ayuso et al., 2021), it is standard practice to present results for life expectancy disaggregated by gender. However, when the objective is to jointly assess survival and quality of life, temporal survival probabilities must be adjusted using utility measures that capture quality of life, typically associated with the health status of surviving individuals (Martínez-Pérez et al., 2016).

Furthermore, it is possible to incorporate temporal preferences into the calculations by applying discount rates, which assign greater weight to years that are closer in time to the crash than to those further in the future. This approach may be justified either by the more

acute consequences of the injuries in the immediate aftermath of the crash or because the after-effects are still undergoing a stabilization process (Mason et al., 2009; York Health Economics Consortium, 2025). The quality-adjusted life expectancy in the context of traffic accidents has been previously used in health economics literature to assess the monetary value of a quality-adjusted life year (Mason et al., 2009, Abellán et al., 2024a; 2024b; Cespedes et al., 2025). Mason et al. (2009) propose a model for estimating the willingness-to-pay-based value of a QALY for individuals in the UK. More recently, Abellán et al. (2024a; 2024b) follow a similar willingness-to-pay approach to that of Mason et al. (2009) to provide updated estimates of the monetary value of a statistical life (VSL) for fatalities and non-fatal injuries. In contrast, Céspedes et al. (2025) use QALYs solely as the basis for adjusting the VSL and subsequently quantifying injury-severity risk in monetary terms.

The severity of a non-fatal injury can be estimated as a percentage of the total QALY loss associated with a fatal injury. The percentage should vary according to the degree of injury severity, making the selection of appropriate injury severity scales particularly critical. Indeed, the resulting severity classification may differ substantially depending on the scale used (Spice and Miller, 2010). In this study, we use the QALY-loss percentages estimated by the National Highway Traffic Safety Administration (NHTSA) for cost-utility analyses (Blincoe et al., 2023). These percentages are derived by combining estimates produced through the VIBES project and the Injury Impairment Index (III), and they distinguish between hospitalized and non-hospitalized victims. The resulting QALY-loss percentages are assigned according to the Maximum Abbreviated Injury Scale (MAIS) severity level. The MAIS scale was selected because it is an internationally standardized measure of anatomical injury severity that is widely used in trauma care and injury management. Moreover, severity levels can be derived from ICD-10-CM diagnostic codes through the application of established classification algorithms (Clark et al., 2018; Loftis et al., 2016; Zonfrillo et al., 2015). It is also important to note that the distinction between hospitalization and non-hospitalization aligns with the classification used by the Spanish traffic authority, which categorizes victims as serious (requiring hospitalization) or mild (treated only in the emergency department), in addition to the fatality category.

Numerous studies have examined the impact of various sociodemographic variables on the occurrence of traffic accidents and on injury severity. Factors such as the age and gender of drivers and passengers, the location of the crash, the month and day of the week, and the time of day have been widely discussed in the literature (Clèries et al., 2015; Delen et al., 2017; Eboli et al., 2020; Kononen et al., 2011; Potoglou et al., 2018 and so on). In this study, however, we propose an innovative approach by assessing the association between several of these risk factors and the expected loss of QALYs. Moreover, we incorporate admission to hospital after emergency care as an additional risk factor. This analysis is conducted after first examining the relationship between these risk factors and the different severity levels of the MAIS scale. Together, this analytical

framework enables a more precise assessment of injury severity and its impact on victims' quality of life.

A rich dataset provided by the Spanish public health system, containing ICD-10-CM diagnoses of patients involved in motor-vehicle accidents who were either treated in the emergency department or admitted to hospital in 2022, is used to compute the MAIS severity level and to estimate the loss of QALYs for each crash victim. The percentage of serious victims (those hospitalized) is significantly lower than that of mild victims treated in the emergency department, representing approximately 7% of all injury casualties in the dataset. In absolute terms, this amounts to 13,329 individuals with serious condition, in addition to 436 fatalities. Aligned with the existing research literature (Chen et al., 2016; Delen et al., 2017; Kononen et al., 2011), we identify male sex and older age as significant risk factors for sustaining serious injuries and for mortality. The proportion of serious victims and fatalities among men was approximately twice that observed among women. Individuals aged 65 years or older faced a substantially higher risk, with a proportion of serious victims four times greater than that of groups under 30 years of age, and a mortality proportion twenty-eight times higher than those under 18, twelve times higher than those aged 18–30, and nine times higher than those aged 31–65. The period of the year and the day of the week in which the crash occurs also play a decisive role in injury severity, as noted in previous research (Delen et al., 2017; Eboli et al., 2020; Potoglou et al., 2018). Accidents occurring between May and August and during weekends show a higher percentage of serious cases and fatalities compared with other periods and weekdays. Finally, admission to the ICU is strongly associated with injury severity: among victims admitted to the ICU, 91% were serious cases and 9% died, whereas among hospitalized patients, 97.3% were serious cases and 2.7% died.

The previous findings are confirmed when analyzing the MAIS severity levels. With respect to gender, men show nearly twice the proportion of cases with a MAIS score greater than 3 compared with women. Moreover, the proportion of higher MAIS scores increases progressively with age: for example, the proportion of MAIS 5 among victims aged over 65 is approximately five times higher than that observed among victims under 18. Accidents occurring between May and August also show a higher proportion of cases with a MAIS score greater than 3, a pattern that similarly appears in crashes taking place on weekends. Finally, 50% of victims admitted to the ICU have a MAIS score greater than 3, compared with 24.25% among those admitted to hospital wards.

Traffic accident victims who are transferred to a hospital lose, on average, 1.77 years of life expectancy and 1.42 quality-adjusted life years. The expected QALY loss is higher among men than among women. It is important to note that QALY loss reflects a combination of factors: injury severity, remaining life expectancy, and the health-utility values assigned to quality of life. On average, women sustain less severe injuries and exhibit lower health-utility values. Although women have a higher remaining life expectancy, this factor alone does not offset the combined effects of lower injury severity and utility differences, resulting in a smaller overall loss of QALYs. A different pattern

emerges with respect to age. Older victims tend to sustain more severe injuries than younger individuals; however, their substantially lower remaining quality-adjusted life expectancy exerts a stronger influence. As a consequence, older victims experience a lower expected loss of QALYs than younger individuals. For the remaining risk factors, the direction of their effects on QALY loss aligns with their effects on the MAIS severity levels. Victims of accidents occurring between May and August and during weekends are expected to experience a higher loss of QALYs. Hospitalization and ICU admission are also associated with higher QALY losses. Patients who require hospitalization lose, on average, approximately five times more QALYs than those who are not hospitalized, while patients requiring ICU admission lose eight times more QALYs than those who are not admitted. Finally, the temporal preference for nearer years plays a significant role. As the discount rate increases, the magnitude of the QALY loss decreases. This effect is particularly pronounced among younger individuals, who have a longer remaining quality-adjusted life expectancy; therefore, higher discount rates lead to a sharper reduction in their estimated loss.

In 2022, the Spanish health system attended more than 279 thousand individuals in emergency departments, nearly 21 thousand of whom were hospitalized, and 597 ultimately died as a result of motor-vehicle crashes (Ministry of Public Health, 2025a). Considering the estimated loss of QALYs due to motor crashes, these figures correspond to an aggregate loss of more than 402 thousand years of quality of life attributable to motor-vehicle accidents in 2022 in Spain. These aggregate QALY losses would be distributed as follows: 71.4% from victims treated exclusively in emergency departments, 25.4% from hospitalized victims, and 3.2% from those who died as a consequence of the motor crash.

Motor-vehicle crash victims also generate substantial hospital healthcare costs, with significant implications for the broader healthcare system and, in particular, for the insurance sector. In 2022, the average hospital healthcare cost in Spain for a person injured in a motor-vehicle crash and treated in the emergency department without hospitalization was 300 euros (Ministry of the Presidency, Relations with the Parliament and Democratic Memory, 2022). This cost increased to 7,442.84 euros when hospitalization was required. By contrast, the average cost of a hospitalized patient for any cause was 5,199.44 euros (Ministry of Public Health, 2025a). Thus, inpatients admitted as a result of motor-vehicle crashes are 43% more expensive than those hospitalized for other reasons. Regarding the direct economic impact on the healthcare system, patients treated in emergency departments generated an estimated cost of 83.7 million euros, while those requiring hospitalization resulted in an additional cost of nearly 153.6 million euros. Overall, hospital healthcare costs associated with motor-vehicle accidents in 2022 amounted to 237.4 million euros, representing 0.43% of total public healthcare spending on hospital and specialized services, which totaled 55,892 million

euros³ (Ministry of Public Health, 2025c). In addition, these hospital healthcare costs impose a substantial financial burden on motor insurance companies. Expenditure related to the treatment of motor-vehicle crash victims in hospitals represents approximately 45.2% of the healthcare costs covered by motor insurers, estimated at 525 million euros in 2022 (UNESPA, 2023).

From a public health perspective, our findings demonstrate that traffic accidents not only generate substantial healthcare costs but also have profound consequences for individuals' well-being and quality of life, directly affecting life expectancy in good health. This study is pioneering in that it quantifies the expected number of quality-adjusted life years lost as a result of traffic accidents, offering a metric with significant potential to raise public awareness regarding the true burden of these events. The findings also open new avenues for research that could lead to a more nuanced understanding of the impact of traffic accidents. One promising line of inquiry involves examining the loss of quality-adjusted life years by differentiating according to the type of injury sustained. Another potential direction is to distinguish between different categories of victims—such as pedestrians, drivers, and passengers—given that previous evidence indicates that injury severity varies substantially according to the victim's profile (Chen and Lin, 2015; Sango et al., 2016).

The comparison with the *baremo* shows that the QALY-based approach is highly sensitive to injury severity, producing a much sharper increase in compensation as MAIS levels rise. While the *baremo* tends to offer higher amounts in minor injuries, QALY-based valuations grow substantially in severe cases, reflecting a more continuous and proportional response to clinical deterioration. A key advantage of this framework is that QALY loss can be estimated directly from ICD-10-CM diagnoses, available immediately after the crash, allowing insurers to perform an early and consistent assessment of injury severity and to set initial claim reserves without waiting for the stabilization of sequelae. Overall, the results suggest that the QALY approach can complement the *baremo* by providing greater detail and flexibility in the evaluation of bodily injury.

³ Note that this analysis is based exclusively on road traffic accidents victims who were treated by the public healthcare system in Spain during 2022, which excludes cases attended in the private sector or not officially recorded.

9. Conclusions

Analyses that focus on providing objective information about the actual impacts of accidents on longevity and health status—rather than imposing value judgements by analysts or policymakers—may be preferable in road-safety policy evaluation. The quality-adjusted life year (QALY) is widely used as a summary measure of health outcomes, as it incorporates both the effect of an intervention on a patient's length of life and its impact on health-related quality of life and, as we demonstrate in our research, it can be used as a measure of the impact of injuries on health resulting from motor-vehicle crashes. The loss-of-QALY metric, capable of capturing the health impact of motor-vehicle crashes by integrating different levels of injury severity and fatalities into a single indicator, can play a valuable role in several areas of road-safety research and practice. The use of QALYs enables comparisons between the consequences of traffic accidents and those of other health problems, thereby supporting more effective prioritisation of healthcare and preventive resources.

The analysis also indicates that the QALY-based approach offers a flexible and continuous framework for distinguishing different levels of injury severity, complementing the more categorical structure of the *baremo*. While the *baremo* provides higher compensation in minor injuries, QALY-based valuations increase more significantly in severe cases, offering a more proportional reflection of damage. Since QALY loss can be estimated immediately from ICD-10-CM diagnoses, this approach also enables quick preliminary assessments and supports insurers in establishing more accurate early claim reserves. These findings highlight the potential value of integrating QALY-based metrics into specific components of the current compensation system.

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References

- Abellán, J.M., Martínez-Pérez, J.E., Méndez, I., Pinto, J.L., Sánchez-Martínez, F.I. (2024a). Actualización del valor monetario de una vida estadística en España. Dirección General de Tráfico.
- Abellán, J.M., Martínez-Pérez, J.E., Méndez, I., Pinto, J.L., Sánchez-Martínez, F.I. (2024b). Actualización del valor monetario del año de vida ajustado por la calidad (avac) y del valor de una víctima no mortal en España. Dirección General de Tráfico.
- Agency for Healthcare Research and Quality. (2025). HCUP National Inpatient Sample (NIS) Database Documentation. <https://www.hcup-us.ahrq.gov/db/nation/nis/nisdbdocumentation.jsp>.
- Airaksinen, N. K., Heinänen, M. T., Handolin, L. E. (2019). The reliability of the ICD-AIS map in identifying serious road traffic injuries from the Helsinki Trauma Registry. *Injury* 50 (9), 1545–1551. <https://doi.org/10.1016/j.injury.2019.07.030>.
- Albayati, A.H., Lateif, R.H. (2018). Statistical Analysis of Mortality and Morbidity Due to Traffic Accidents in Iraq. *Journal of Engineering* 24 (1), 20–40. <https://doi.org/10.31026/j.eng.2018.01.02>.
- Aleman, R., Ayuso, M., Guillén, M. (2013). Impact of road traffic injuries on disability rates and long-term care costs in Spain. *Accident Analysis and Prevention* 60, 95–102. <https://doi.org/10.1016/j.aap.2013.08.016>.
- Asscheman, S., Versteeg, M., Panneman, M., Kemler, E. (2023). Reconsidering injury severity: Looking beyond the maximum abbreviated injury score. *Accident Analysis and Prevention* 186, 107045. <https://doi.org/10.1016/j.aap.2023>.
- Association for the Advancement of Automotive Medicine. (n.d.). *Abbreviated Injury Scale (AIS)*. <https://www.aaam.org/abbreviated-injury-scale-ais/>.
- Ayuso, M., Corrales, H., Guillen, M., Pérez-Marín, A. M., Rojo, J. L. (2001). *Estadística Actuarial Vida*. Ediciones UB (2nd edition: 2006). Barcelona.
- Ayuso, M., Bravo, J. M., Holzmann, R. (2021). Getting life expectancy estimates right for pension policy: period versus cohort approach. *Journal of Pension Economics and Finance* 20 (2), 212–231. <https://doi.org/10.1017/S1474747220000050>.

- Baker, S. P., O'Neill, B., Haddon, W., Jr, Long, W. B. (1974). The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *The Journal of trauma* 14 (3), 187–196.
- Black, A., Clark, D. (2022). 'ICD' Programs for Injury Categorization in R. Package 'icdpicr', R version 1.0.1. <https://cran.r-project.org/web/packages/icdpicr/icdpicr.pdf>.
- Blincoe, L. J., Miller, T. R., Wang, J.-S., Swedler, D., Coughlin, T., Lawrence, B., Guo, F., Klauer, S. G., Dingus, T. (2023). The economic and societal impact of motor vehicle crashes, 2019 (Revised) (Report No. DOT HS 813 403). U.S. Department of Transportation, National Highway Traffic Safety Administration.
- Boo, Y., Choi, Y. (2022). Comparison of mortality prediction models for road traffic accidents: an ensemble technique for imbalanced data. *BMC Public Health* 22 (1), 1476. <https://doi.org/10.1186/s12889-022-13719-3>.
- Bull J. P. (1985). Disabilities caused by road traffic accidents and their relation to severity scores. *Accident; analysis and prevention* 17 (5), 387–397. [https://doi.org/10.1016/0001-4575\(85\)90093-4](https://doi.org/10.1016/0001-4575(85)90093-4).
- Cespedes, L., Ayuso, M., Santolino, M. (2024). How to use public-private databases in insurance risk management: Geography, climate and people in motor insurance. *Anales del Instituto de Actuarios Españoles* 30, 147–167. <https://doi.org/10.26360/2024-08>.
- Cespedes, L., Santolino, M., Ayuso, M. (2025). The monetary injury risk value of a crashed vehicle: a gender driving analysis. *Research in Transportation Economics* 113, 101631. <https://doi.org/10.1016/j.retrec.2025.101631>.
- Chen, P.-L., Lin, H.-Y. (2015). P06 Varied Severity of Motor Vehicle Crash Injuries Using National Dataset in Taiwan. *Journal of Transport and Health* 2 (2), S66–S67. <https://doi.org/10.1016/j.jth.2015.04.465>.
- Chen, C., Zhang, G., Qian, Z., Tarefder, R. A., Tian, Z. (2016). Investigating driver injury severity patterns in rollover crashes using support vector machine models. *Accident; analysis and prevention* 90, 128–139. <https://doi.org/10.1016/j.aap.2016.02.011>.
- Clark, D. E., Black, A. W., Skavdahl, D. H., Hallagan, L. D. (2018). Open-access programs for injury categorization using ICD-9 or ICD-10. *Injury epidemiology* 5 (1), 11. <https://doi.org/10.1186/s40621-018-0149-8>.
- Clèries, M., Bosch, A., Vela, E., Bustins, M. (2015). Lesiones por accidente de tráfico: aproximación desde el conjunto mínimo básico de datos de urgencias y hospitalización de agudos de Cataluña. *Gaceta Sanitaria* 29 (S1), 36–42. <https://doi.org/10.1016/j.gaceta.2015.03.011>.

- Committee on Medical Aspects of Automotive Safety. (1971). Rating the severity of tissue damage. I. The abbreviated scale. *Journal of the American Medical Association* 215 (2), 277–280. <https://doi.org/10.1001/jama.1971.03180150059012>.
- Delen, D., Tomak, L., Topuz, K., Eryarsoy, E. (2017). Investigating injury severity risk factors in automobile crashes with predictive analytics and sensitivity analysis methods. *Journal of Transport and Health* 4, 118–131. <https://doi.org/10.1016/j.jth.2017.01.009>.
- Dirección General de Tráfico. (2024). Valor estadístico de una vida y una lesión no mortal. <https://seguridadvial2030.dgt.es/practicas-de-interes/respuesta-al-siniestro-efectiva-y-justa/valor-estadistico-de-una-vida-y-una-lesion-no-mortal/index.html>.
- Dirección General de Tráfico. (2025). Informe de siniestralidad mortal en vías interurbanas. Año 2024: Cómputo de las personas fallecidas a 24 horas. Datos provisionales. Observatorio Nacional de Seguridad Vial.
- Dolan P. (1997). Modeling valuations for EuroQol health states. *Medical care* 35 (11), 1095–1108. <https://doi.org/10.1097/00005650-199711000-00002>.
- Drummond, M. F., Stoddart, G. L., Torrance, G. W. (1987). *Methods for the Economic Evaluation of health Care Programs*. Oxford University Press. New York.
- Eboli, L., Forciniti, C., Mazzulla, G. (2020). Factors influencing accident severity: An analysis by road accident type. *Transportation Research Procedia* 47, 449–456. <https://doi.org/10.1016/j.trpro.2020.03.120>.
- Elvik, R. (2019). How to trade safety against cost, time and other impacts of road safety measures. *Accident; Analysis and Prevention* 127, 150–155. <https://doi.org/10.1016/j.aap.2019.02.028>.
- Ferrando, J., Plasència, A., MacKenzie, E., Orós, M., Arribas, P., Borrell, C. (1998). Disabilities resulting from traffic injuries in Barcelona, Spain: 1-year incidence by age, gender and type of user. *Accident; analysis and prevention* 30 (6), 723–730. [https://doi.org/10.1016/s0001-4575\(98\)00024-4](https://doi.org/10.1016/s0001-4575(98)00024-4).
- Ferreira, S., Amorim, M., Couto, A. (2017). Risk factors affecting injury severity determined by the MAIS score. *Traffic injury prevention* 18 (5), 515–520. <https://doi.org/10.1080/15389588.2016.1246724>.
- Fountas, G., Anastasopoulos, P. C., Abdel-Aty, M. (2018). Analysis of accident injury-severities using a correlated random parameters ordered probit approach with time variant covariates. *Analytic Methods in Accident Research*, 18, 57–68. <https://doi.org/10.1016/j.amar.2018.04.003>.

- Fundación Instituto Tecnológico para la Seguridad del Automóvil. (2008). El valor de la seguridad vial. Conocer los costes de los accidentes de tráfico para invertir más en su prevención.
- Furberg, A., Arvidsson, R., Molander, S. (2018). Live and Let Die? Life Cycle Human Health Impacts from the Use of Tire Studs. *International journal of environmental research and public health* 15 (8), 1774. <https://doi.org/10.3390/ijerph15081774>.
- Gabbe, B. J., Lyons, R. A., Harrison, J. E., Rivara, F. P., Ameratunga, S., Jolley, D., Polinder, S., Derrett, S. (2014). Validating and Improving Injury Burden Estimates Study: the Injury-VIBES study protocol. *Injury prevention: journal of the International Society for Child and Adolescent Injury Prevention* 20 (3), e4. <https://doi.org/10.1136/injuryprev-2013-040936>.
- 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 (11), 806–816C. <https://doi.org/10.2471/BLT.16.172155>.
- Gowthami, C., Kavitha, S. (2025). Comprehensive approach to predictive analysis and anomaly detection for road crash fatalities. *AIP Advances*, 15, 015022. <https://doi.org/10.1063/5.0251493>.
- Greenspan, L., McLellan, B. A., Greig, H. (1985). Abbreviated Injury Scale and Injury Severity Score: a scoring chart. *The Journal of trauma* 25 (1), 60–64. <https://doi.org/10.1097/00005373-198501000-00010>.
- Hirsch, A. E., Eppinger, R. H., Shams, T., Nguyen, T., Levine, R., MacKenzie, J., Marks, M., Ommaya, A. K. (1983). Impairment scaling from the Abbreviated Injury Scale. Final report.
- Holtslag, H. R., van Beeck, E. F., Lindeman, E., Leenen, L. P. (2007). Determinants of long-term functional consequences after major trauma. *The Journal of trauma* 62 (4), 919–927. <https://doi.org/10.1097/01.ta.0000224124.47646.62>.
- Hou, Q., Huo, X., Leng, J., Mannering, F. (2022). A note on out-of-sample prediction, marginal effects computations, and temporal testing with random parameters crash-injury severity models. *Analytic Methods in Accident Research* 33, 100191. <https://doi.org/10.1016/j.amar.2021.100191>.
- Hung, K. K. C., Kifley, A., Brown, K., Jagnoor, J., Craig, A., Gabbe, B., Derrett, S., Dinh, M., Gopinath, B., Cameron, I. D. (2021). Impacts of injury severity on long-term outcomes following motor vehicle crashes. *BMC Public Health* 21, 602. <https://doi.org/10.1186/s12889-021-10638-7>.
- Instituto Nacional de Estadística. (2024). Tablas de mortalidad por año, sexo, edad y funciones. <https://www.ine.es/jaxiT3/Tabla.htm?t=27153>.

- Kononen, D. W., Flannagan, C. A. C., Wang, S. C. (2011). Identification and validation of a logistic regression model for predicting serious injuries associated with motor vehicle crashes. *Accident; Analysis and Prevention* 43, 112–122. <https://doi.org/10.1016/j.aap.2010.07.018>.
- Law 35/2015, of September 22 (2015) on the reform of the system for the assessment of damages caused to persons in traffic accidents. *Boletín Oficial del Estado*, No. 228, 84473–84979. [in Spanish]. <https://www.boe.es/buscar/doc.php?id=BOE-A-2015-10197>.
- Lawrence, B. A., Miller, T. R., Waehrer, G. M., Spicer, R. S., Cohen, M. A., Zamula, W. W. (2018). The Consumer Product Safety Commission's Revised Injury Cost Model. Consumer Product Safety Commission.
- Loftis, K. L., Price, J. P., Gillich, P. J., Cookman, K. J., Brammer, A. L., St Germain, T., Barnes, J., Graymire, V., Nayduch, D. A., Read-Allsopp, C., Baus, K., Stanley, P. A., Brennan, M. (2016). Development of an expert based ICD-9-CM and ICD-10-CM map to AIS 2005 update 2008. *Traffic injury prevention* 17 (Suppl 1), 1–5. <https://doi.org/10.1080/15389588.2016.1191069>.
- Martínez-Pérez, J. E., Sánchez-Martínez, F. I., Abellán, J. M. (2016). Quality-Adjusted Life Expectancy in Spain: an estimate. *Journal of Public programs and policy evaluation* 6, 28-48. <https://doi.org/10.5944/reppp.6.2016.15348>.
- 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. <https://doi.org/10.1002/hec.1416>.
- Miller, T. R., Galbraith, M., Lestina, D., Schlax, T., Mabery, P., Deering, R., Massie, D., Campbell, K. (1995). Understanding the harm from U.S. motor vehicle crashes. 39th Annual Proceedings, Association for the Advancement of Automotive Medicine, Chicago, IL.
- Miller, T. R. (2000). Valuing Nonfatal Quality of Life Losses Quality-Adjusted Life Years: The Health Economist's Meow. *Journal of Forensic Economics* 13, 145-167.
- Ministry of Finance. (2025). Civil service remuneration 2026. Real Decreto-ley 14/2025, de 2 de diciembre. Government of Spain.
- Ministry of Health, Social Services and Equality. (2016). Manual de Codificación CIE-10-ES Diagnósticos.
- Ministry of Public Health. (2025a). Registro de Actividad de Atención Especializada. RAE-CMBD. <https://www.sanidad.gob.es/estadEstudios/estadisticas/cmbdhome.htm>. In combination with Ministry of Public Health. (2025b).

- Ministry of Public Health. (2025b). Summary by Autonomous Community: Type of contact, type of hospital, services, and patient characteristics. National Health System Statistical Portal. <https://pestadistico.inteligenciadegestion.sanidad.gob.es/publicoSNS/C/rae-cmbd/rae-cmbd/informacion-general/resumen-por-comunidad-autonoma-tipo-de-contacto-tipo-de-hospital-servicios>.
- Ministry of Public Health. (2025c). Estadística de Gasto Sanitario Público 2023: Principales Resultados. Subdirección General de Cartera de Servicios del SNS y Fondos de Compensación.
- Ministry of the Presidency, Relations with the Parliament and Democratic Memory. (2022). Resolution of April 11, 2022, publishing the Agreement between the Consorcio de Compensación de Seguros, UNESPA, and INGESA on public healthcare assistance derived from traffic accidents for the years 2022–2025 (BOE-A-2022-6300). Boletín Oficial del Estado, 91, 52730–52737.
- Office of Management and Budget. (2003). To the heads of executive agencies and establishments (Circular A-4). https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/.
- Paladugu, R., Schein, M., Gardezi, S., Wise, L. (2002). One hundred citation classics in general surgical journals. World journal of surgery 26 (9), 1099–1105. <https://doi.org/10.1007/s00268-002-6376-7>.
- Palmera, R. (2017). Discapacidad causada por los accidentes de tráfico en la población adulta española, 2008–2010 (Tesis doctoral). Universidad Autónoma de Madrid. <http://hdl.handle.net/10486/681253>.
- Pettitt, D., Raza, S., Smith, J. (2016). The Limitations of QALY: A Literature Review. Journal of Stem Cell Research and Therapy 06 (04). <https://doi.org/10.4172/2157-7633.1000334>.
- Potoglou, D., Carlucci, F., Cirà, A., Restaino, M. (2018). Factors associated with urban non-fatal road-accident severity. International Journal of Injury Control and Safety Promotion 25 (3), 303–310. <https://doi.org/10.1080/17457300.2018.1431945>.
- Pozzato, I., Craig, A., Gopinath, B., Kifley, A., Tran, Y., Jagnoor, J., Cameron, I. D. (2020). Outcomes after traffic injury: mental health comorbidity and relationship with pain interference. BMC Psychiatry 20, 189. <https://doi.org/10.1186/s12888-020-02601-4>.
- Rissanen, R., Berg, H.-Y., Hasselberg, M. (2016). Quality of life following a road traffic injury: A systematic literature review. Injury Prevention 22 (Suppl 2), A213. <https://doi.org/10.1136/injuryprev-2016-042156.593>.

- Sango, H. A., Testa, J., Meda, N., Contrand, B., Traoré, M. S., Staccini, P., Lagarde, E. (2016). Mortality and Morbidity of Urban Road Traffic Crashes in Africa: Capture-Recapture Estimates in Bamako, Mali, 2012. *PloS One* 11 (2), e0149070. <https://doi.org/10.1371/journal.pone.0149070>.
- Santos, J. V., Viana, J., Pinto, C., Souza, J., Lopes, F., Freitas, A., Lopes, S. (2022). All Patient Refined-Diagnosis Related Groups' (APR-DRGs) Severity of Illness and Risk of Mortality as predictors of in-hospital mortality. *Journal of medical systems* 46 (6), 37. <https://doi.org/10.1007/s10916-022-01805-3>.
- Spicer, R., Miller, T. R. (2010). Uncertainty Analysis of Quality Adjusted Life Years Lost. National Highway Traffic Safety Administration.
- Spicer, R. S., Miller, T. R., Hendrie, D., Blincoe, L. J. (2011). Quality-Adjusted Life Years Lost to Road Crash Injury: Updating the Injury Impairment Index. *Annals of advances in automotive medicine. Association for the Advancement of Automotive Medicine. Annual Scientific Conference* 55, 365–377.
- Spoerri, A., Egger, M., von Elm, E., Swiss National Cohort Study. (2011). Mortality from road traffic accidents in Switzerland: Longitudinal and spatial analyses. *Accident; Analysis and Prevention* 43, 40–48. <https://doi.org/10.1016/j.aap.2010.06.009>.
- UNESPA. (2023). El seguro y sus proveedores. Datos 2022. Asociación Empresarial del Seguro.
- 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>.
- Whitehead, S. J., Ali, S. (2010). Health outcomes in economic evaluation: the QALY and utilities. *British medical bulletin* 96, 5–21. <https://doi.org/10.1093/bmb/ldq033>.
- World Health Organization. (2023). Informe sobre la situación mundial de la seguridad vial 2023.
- York Health Economics Consortium. (2025). Discount rate. YHEC. <https://www.yhec.co.uk/glossary-term/discount-rate/>.
- Zonfrillo, M. R., Weaver, A. A., Gillich, P. J., Price, J. P., Stitzel, J. D. (2015). New Methodology for an Expert-Designed Map From International Classification of Diseases (ICD) to Abbreviated Injury Scale (AIS) 3+ Severity Injury. *Traffic injury prevention* 16 (Suppl 2), S197–S200. <https://doi.org/10.1080/15389588.2015.1054987>.

Annexes

Annex 1: Calculation of QALY loss for non-fatal injuries using the III

Following Lawrence et al. (2018), the loss of QALY in non-fatal injuries based on *Injury Impairment Index*, is calculated in two stages.

Stage 1. The losses from the six dimensions of the scale are combined with the losses from permanent disability related to the person's usual work as follows:

$$QALY_t = 1 - (1 - IIIimp_t) \times [1 - 0,021 \times (PTotPerm + PPtPerm \times \%imp)],$$

where $QALY_t$ is the loss of QALY in period t , differentiating between the first year ($QALY_1$), between the second and fifth year ($QALY_{2-5}$), and from the sixth year onwards ($QALY_{6+}$). $IIIimp_t$ is the weight of the QALY loss based on the *III* scale in six dimensions during period t . The value 0.021 is the QALY weighting factor for loss of ability to work, excluding loss of income (Drummond et al., 1987). $PTotPerm$ is the probability of total permanent disability. $PPtPerm$ is the probability of partial permanent disability. Finally, $\%imp$ is the average percentage of loss of earning capacity as a result of partial permanent disability.

Stage 2. The $QALY_{tot}$ is calculated based on a discount rate d :

$$QALY_{tot} = a_1 \times QALY_1 + a_{2-5} \times QALY_{2-5} + a_{6+} \times QALY_{6+}$$

where $a_1 = \left(\frac{1}{1+d}\right)^{1/2}$, $a_2 = \left(\frac{1}{1+d}\right)^{3/2} + \left(\frac{1}{1+d}\right)^{5/2} + \left(\frac{1}{1+d}\right)^{7/2}$ y $a_{6+} = e_x^{QA(d)} - (a_1 + a_2)$. The discount rate affects the productivity loss weights and also the discounted life expectancy, limiting the impact of the discount rate on the total $QALY$ loss value. Blincoe et al. (2023, p.92) recommend a discount rate of 3 or 4 percent.

Abbreviations:

e_x Life expectancy at age x .

e_x^{QA} = Quality-adjusted life expectancy at age x .

$e_x^{QA(d)}$ = Discounted and quality-adjusted life expectancy at age x , with a discount rate d .

le_x = Loss of years of life at age x .

le_x^{QA} = Loss of quality-adjusted life years at age x .

$le_x^{QA(d)}$ = Loss of years of life discounted and quality-adjusted at age x , with a discount rate d .

Annex 2: R code

```
#-----  
# R code for the TFM:  
#-----  
#-----  
# Installed packages:  
#-----  
  
library("readr")  
library("dplyr")  
library("ggplot2")  
library("icdpicr")  
library("summarytools")  
library("gridExtra")  
library("lubridate")  
library("readxl")  
library("reshape2")  
library("extrafont")  
library("patchwork")  
library("scales")  
  
#-----  
# PART I: DDBB:  
#-----  
  
datos <-  
read_delim("C:/Users/forne/Desktop/tfm/sanidad_biel/RAECMBD_454_20241226-  
171708.txt", delim = ";")  
View(datos)  
  
options(max.print=length(datos$Año))  
  
datos2<-as.data.frame(datos)#convertimos en data frame para poder operar  
datos2$id<-1:nrow(datos2)#identificar observaciones repetidas  
names(datos2)<-  
  c("año", #Año  
    "ccaa", #Comunidad Autónoma  
    "historial", #Historia Recodificada  
    "cip", #CIP SNS Recodificado  
    "birth", #Fecha de nacimiento  
    "edad", #Edad  
    "contacto", #Circunstancia de Contacto  
    "servicio", #Servicio  
    "uci_dias", #Días UCI  
    "uci_ingres", #Ingreso en UCI  
    "cont_asist", #Continuidad Asistencial  
    "procedenc", #Procedencia  
    "financia", #Régimen Financiación  
    "sexo", #Sexo  
    "pais", #País Nacimiento  
    "fecha_inic", #Fecha de Inicio contacto  
    "fecha_fin", #Fecha de Fin Contacto  
    "fecha_inter", #Fecha de Intervención
```

```

"tipo_contact",#Tipo contacto
"alta",#Tipo Alta
"duracion",#Estancia Días
"d1",#Diagnóstico Principal
"d2",#"Diagnóstico 2
"d3", "d4", "d5", "d6","d7","d8", "d9",
"d10","d11","d12","d13","d14","d15","d16","d17","d18","d19","d20",
"pr1",#Procedimiento 1

"pr2","pr3","pr4","pr5","pr6","pr7","pr8","pr9","pr10","pr11","pr12","pr13","
pr14", "pr15","pr16","pr17", "pr18","pr19",
"poa_dp",#POA Diagnóstico Principal
"poa_d2",#"POA Diagnóstico 2"
"poa_d3","poa_d4","poa_d5","poa_d6", "poa_d7","poa_d8","poa_d9",
"poa_d10","poa_d11","poa_d12",
"poa_d13","poa_d14","poa_d15",
"poa_d16","poa_d17","poa_d18",
"poa_d19","poa_d20",
"pr20",#Procedimie 20
"morf1",#Morfología 1
"morf2","morf3","morf4","morf5","morf6",
"gravedadAPR",#Nivel Severidad APR
"riesgoAPR",#Riesgo Mortalidad APR
"costeAPR",#Coste APR
"id"
)

#Tipo contacto:

datos2$tipo_contact<-factor(datos2$tipo_contact, levels = c(1,6), labels =
c("hospitalizacion", "urgencias"))

#Tipo Alta
datos2$alta[datos2$alta==9]<-NA
datos2$alta<-factor(datos2$alta, levels = c(1,2,3,4,5,8),labels =
c("Domicilio", "Traslado a otro hospital", "Alta voluntaria", "Exitus",
"Traslado a centros sociosanitarios", "Otros"))

#gravedad numérica
datos2$lesion<-NA

datos2$lesion[(datos2$tipo_contact=="hospitalizacion")]<-2 #grave
datos2$lesion[(datos2$tipo_contact=="urgencias")]<-3#leve
datos2$lesion[datos2$alta=="Exitus"]<-1#muerte
table(datos2$lesion)

#ordenamos datos según historial, gravedad y fecha. Así nos quedaremos con el
más grave de las duplicidades y la primera evaluación realizada
datos2$fecha_inic2<-as.POSIXct(strptime(datos2$fecha_inic, format="%d%m%Y
%H%M")) #la utilizaremos depues para entre semana/fin de semana
datos2$fecha_inic<-as.Date(datos2[,16], "%d%m%Y")
data3<-datos2[order(datos2$historial, datos2$lesion, datos2$fecha_inic),]

tail(data3,100)

data4a<-data3[1:218568,]#no missings historial
data4b<-data3[218569:nrow(data3),]#missings historial

```

```

data4<-distinct(data4a,historial, .keep_all = TRUE)#eliminamos casos
repetidos con mismo historial. Nos quedamos con el más grave y más reciente.
data5<-rbind(data4,data4b) #datos sin repeticiones

data5$lesion<-as.factor(data5$lesion)
levels(data5$lesion)<-c("muerte","grave","leve")
table(data5$lesion) #categórica

data5$alta[is.na(data5$alta)]<-"Otros"
data5 <- data5[year(data5$fecha_inic) == 2022, ] #escogemos solo datos del
2022

#-----
# Analysis of the study variables:
#-----

table(data5$lesion)
prop.table(table(data5$lesion))

#Sexo:

data5$sexo[data5$sexo==9]<-NA
data5$sexo<-factor(data5$sexo, levels = c(1,2), labels = c("Hombre",
"Mujer"))

table(data5$sexo, useNA = "always") #tiene 75 missing values
prop.table(table(data5$sexo, useNA = "always"))
pie(table(data5$sexo))

table(data5$sexo,data5$lesion)

prop.table(table(data5$lesion[data5$sexo=="Hombre"]))
prop.table(table(data5$lesion[data5$sexo=="Mujer"]))

chisq.test(table(data5$sexo, data5$lesion))

#Fecha de nacimiento y edad:

sum(is.na(data5$edad)) #no na
table(data5$edad)
summary(data5$edad) #la media son 37,51 años
media<-mean(data5$edad);media

data5$intervalos <- ifelse(data5$edad < 18, "0-17",
                           ifelse(data5$edad <= 30, "18-30",
                                   ifelse(data5$edad <= 65, "31-65", "65+")))

table(data5$lesion[data5$edad<18])
prop.table(table(data5$lesion[data5$edad<18]))
table(data5$lesion[data5$edad > 17 & data5$edad <= 30])
prop.table(table(data5$lesion[data5$edad > 17 & data5$edad <= 30]))
table(data5$lesion[data5$edad > 30 & data5$edad <= 65])
prop.table(table(data5$lesion[data5$edad > 30 & data5$edad <= 65]))
table(data5$lesion[data5$edad>65])
prop.table(table(data5$lesion[data5$edad>65]))

chisq.test(table(data5$intervalos, data5$lesion))

```

```

#Dias UCI:

sum(is.na(data5$uci_dias)) #tiene 192.504 missing values
table(data5[!(is.na(data5$uci_dias)), "lesion"])

sum(is.na(data5[data5$tipo_contact=="hospitalizacion", 9 ])) #10.442 NA

mean(data5$uci_dias[data5$lesion=="leve"], na.rm = T)
mean(data5$uci_dias[data5$lesion=="grave"], na.rm = T)
mean(data5$uci_dias[data5$lesion=="muerte"], na.rm = T)

anova_uci <- aov(uci_dias ~ lesion, data = data5)
summary(anova_uci)

#Ingreso UCI:

data5$uci_ingres <- ifelse(is.na(data5$uci_ingres), 2, data5$uci_ingres)
data5$uci_ingres[data5$uci_ingres==9]<-2
data5$uci_ingres<-factor(data5$uci_ingres, levels = c(1,2), labels =
c("SI", "NO"))

table(data5$uci_ingres, data5$lesion)

prop.table(table(data5$lesion[data5$uci_ingres=="SI"]))
prop.table(table(data5$lesion[data5$uci_ingres=="NO"]))

chisq.test(table(data5$uci_ingres, data5$lesion))

#Tipo contacto:

sum(is.na(data5$tipo_contact)) #no tiene missing values
prop.table(table(data5$tipo_contact))

table(data5$tipo_contact, data5$lesion)

prop.table(table(data5$lesion[data5$tipo_contact=="hospitalizacion"]))
prop.table(table(data5$lesion[data5$tipo_contact=="urgencias"]))

chisq.test(table(data5$tipo_contact, data5$lesion))

#Estancia en días:

sum(is.na(data5$duracion)) #no tiene missing values

summary(data5$duracion)
summary(data5$duracion[data5$duracion!=0])

hospitalizacion<- data5[data5$tipo_contact=="hospitalizacion",]
mean(hospitalizacion$duracion[hospitalizacion$lesion=="grave"], na.rm=T)
mean(hospitalizacion$duracion[hospitalizacion$lesion=="muerte"], na.rm = T)

anova_hospital <- aov(duracion ~ lesion, data = hospitalizacion)
summary(anova_hospital)

#Tipo alta:

table(data5$alta, useNA = "always")
prop.table(table(data5$alta, useNA = "always"))

```

```

table(data5$alta,data5$lesion)
table(data5$lesion[data5$alta=="Domicilio"])
prop.table(table(data5$lesion[data5$alta=="Domicilio"]))
table(data5$lesion[data5$alta=="Traslado a otro hospital"])
prop.table(table(data5$lesion[data5$alta=="Traslado a otro hospital"]))
table(data5$lesion[data5$alta=="Alta voluntaria"])
prop.table(table(data5$lesion[data5$alta=="Alta voluntaria"]))
table(data5$lesion[data5$alta=="Exitus"])
prop.table(table(data5$lesion[data5$alta=="Exitus"]))
table(data5$lesion[data5$alta=="Traslado a centros sociosanitarios"])
prop.table(table(data5$lesion[data5$alta=="Traslado a centros
sociosanitarios"]))
table(data5$lesion[data5$alta=="Otros"])
prop.table(table(data5$lesion[data5$alta=="Otros"]))

nomuertos<-data5[!data5$alta=="Exitus",]
nomuertos$alta<-droplevels(nomuertos$alta)
nomuertos$lesion<-droplevels(nomuertos$lesion)
table(nomuertos$alta, nomuertos$lesion)
chisq.test(table(nomuertos$alta, nomuertos$lesion))

#Análisis por cuatrimestres:

data5$cuatrimestre <- ifelse(month(data5$fecha_inic) <= 4, "1 cuatrimestre",
                             ifelse(month(data5$fecha_inic) <= 8, "2
cuatrimestre", "3 cuatrimestre"))

table(data5$lesion[data5$cuatrimestre=="1 cuatrimestre"])
prop.table(table(data5$lesion[data5$cuatrimestre=="1 cuatrimestre"]))
table(data5$lesion[data5$cuatrimestre=="2 cuatrimestre"])
prop.table(table(data5$lesion[data5$cuatrimestre=="2 cuatrimestre"]))
table(data5$lesion[data5$cuatrimestre=="3 cuatrimestre"])
prop.table(table(data5$lesion[data5$cuatrimestre=="3 cuatrimestre"]))

chisq.test(table(data5$cuatrimestre, data5$lesion))

#Días entre semana y fin de semana:

data5$tipo_dia <- sapply(data5$fecha_inic2, function(fecha) {
  dia <- weekdays(fecha)
  hora <- as.numeric(format(fecha, "%H"))
  minuto <- as.numeric(format(fecha, "%M"))
  hora_total <- hora + minuto / 60

  if (dia == "viernes" && hora_total >= 15) {
    return("fin de semana")
  } else if (dia %in% c("sábado", "domingo")) {
    return("fin de semana")
  } else {
    return("entre semana")
  }
})

table(data5$tipo_dia, data5$lesion)
prop.table(table(data5$lesion[data5$tipo_dia=="entre semana"]))
prop.table(table(data5$lesion[data5$tipo_dia=="fin de semana"]))

```

```

chisq.test(table(data5$tipo_dia, data5$lesion))

#festivos:

festivos<-c("2022-01-01","2022-01-06","2022-04-15","2022-05-01","2022-08-
15","2022-10-12",
            "2022-11-01","2022-12-06","2022-12-08","2022-12-25")

festivos_df <- subset(data5, fecha_inic %in% festivos)

table(festivos_df$lesion)
prop.table(table(festivos_df$lesion))

#-----
# PART II: QALY calculation:
#-----

#separamos las distintas bases de datos:
muerte<-data5[data5$lesion=="muerte",]
grave<-data5[data5$lesion=="grave",]
leve<-data5[data5$lesion=="leve",]

#-----
# MAIS calculation
#-----

###Graves:
#Preparamos la tabla para aplicarle la función
id_grave<-1:(length(grave$d1))
dx_grave<-grave[,22:41]
names(dx_grave)<-paste0("dx",1:ncol(dx_grave))
datos_grave<-cbind(id_grave,dx_grave)

MAIS_grave<-cat_trauma(datos_grave,dx_pre = "dx", icd10 = "cm",
i10_iss_method = "roc_max_NIS")
table(MAIS_grave$maxais)

###leves:
id_leve<-1:(length(leve$d1))
dx_leve<-leve[,22:41]
names(dx_leve)<-paste0("dx",1:ncol(dx_leve))
datos_leve<-cbind(id_leve,dx_leve)

MAIS_leve<-cat_trauma(datos_leve,dx_pre = "dx",icd10 = "cm", i10_iss_method =
"roc_max_NIS")

table(MAIS_leve$maxais)

grave2<-grave
grave2$MAIS<-NA
grave2$MAIS<-MAIS_grave$maxais

leve2<-leve
leve2$MAIS<-NA
leve2$MAIS<-MAIS_leve$maxais
leve2$MAIS<-ifelse(leve2$MAIS==4 | leve2$MAIS==5,3, leve2$MAIS) #de los leves
convertimos MAIS 4 y 5 en 3

```

```

calculos_MAIS<-rbind(grave2, leve2)
sum(is.na(calculos_MAIS$sexo))

calculos_MAIS<-calculos_MAIS[!calculos_MAIS$MAIS==0,] #quitamos los que son
MAIS 0

calculos_MAIS$MAIS <- factor(calculos_MAIS$MAIS,
                             levels = 1:5,
                             labels = paste("MAIS", 1:5))

calculos_MAIS <- calculos_MAIS[year(calculos_MAIS$fecha_inic) == 2022, ]

#-----
# Analysis of the MAIS:
#-----

prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$lesion=="leve"]))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$lesion=="grave"]))
calculos_MAIS$lesion<-droplevels(calculos_MAIS$lesion)

chisq.test(table(calculos_MAIS$lesion, calculos_MAIS$MAIS))

prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$sexo=="Hombre"]))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$sexo=="Mujer"]))

chisq.test(table(calculos_MAIS$sexo, calculos_MAIS$MAIS))

prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$intervalos=="0-17"]))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$intervalos=="18-30"]))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$intervalos=="31-65"]))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$intervalos=="65+"]))

chisq.test(table(calculos_MAIS$intervalos, calculos_MAIS$MAIS))

prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$cuatrimestre=="1
cuatrimestre"])))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$cuatrimestre=="2
cuatrimestre"])))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$cuatrimestre=="3
cuatrimestre"])))

chisq.test(table(calculos_MAIS$cuatrimestre, calculos_MAIS$MAIS))

prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$tipo_dia=="entre semana"]))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$tipo_dia=="fin de
semana"])))

chisq.test(table(calculos_MAIS$tipo_dia, calculos_MAIS$MAIS))

prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$alta=="Domicilio"]))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$alta=="Traslado a otro
hospital"])))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$alta=="Alta voluntaria"]))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$alta=="Exitus"]))) #no hay,
porque si fallecen no tienen MAIS
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$alta=="Traslado a centros
socio-sanitarios"])))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$alta=="Otros"])))

```

```

sin exitus<-calculos MAIS[calculos MAIS$alta != "Exitus", ]
sin exitus$alta<-droplevels(sin exitus$alta)
table(sin exitus$alta,sin exitus$MAIS)
chisq.test(table(sin exitus$alta, sin exitus$MAIS))

prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$tipo_contact=="hospitalizac
ion"])))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$tipo_contact=="urgencias"]
))

chisq.test(table(calculos_MAIS$tipo_contact, calculos_MAIS$MAIS))

calculos_MAIS$uci_ingres <- as.character(calculos_MAIS$uci_ingres)
calculos_MAIS$uci_ingres[is.na(calculos_MAIS$uci_ingres)] <- "NO"
calculos_MAIS$uci_ingres <- factor(calculos_MAIS$uci_ingres, levels = c("SI",
"NO"))

table(calculos_MAIS$uci_ingres, calculos_MAIS$MAIS)
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$uci_ingres=="SI"])))
prop.table(table(calculos_MAIS$MAIS[calculos_MAIS$uci_ingres=="NO"])))

chisq.test(table(calculos_MAIS$uci_ingres, calculos_MAIS$MAIS))

mean(calculos_MAIS$duracion[calculos_MAIS$MAIS=="MAIS 1"&
calculos_MAIS$lesion=="grave"])
mean(calculos_MAIS$duracion[calculos_MAIS$MAIS=="MAIS 2"&
calculos_MAIS$lesion=="grave"])
mean(calculos_MAIS$duracion[calculos_MAIS$MAIS=="MAIS 3"&
calculos_MAIS$lesion=="grave"])
mean(calculos_MAIS$duracion[calculos_MAIS$MAIS=="MAIS 4"&
calculos_MAIS$lesion=="grave"])
mean(calculos_MAIS$duracion[calculos_MAIS$MAIS=="MAIS 5"&
calculos_MAIS$lesion=="grave"])

anova_estancia_MAIS<-calculos_MAIS[calculos_MAIS$lesion=="grave",]
anova_hospital_MAIS <- aov(duracion ~ MAIS, data = anova_estancia_MAIS)
summary(anova_hospital_MAIS)

mean(calculos_MAIS$uci_dias[calculos_MAIS$MAIS=="MAIS 1"&
calculos_MAIS$lesion=="grave"], na.rm = T)
mean(calculos_MAIS$uci_dias[calculos_MAIS$MAIS=="MAIS 2"&
calculos_MAIS$lesion=="grave"], na.rm = T)
mean(calculos_MAIS$uci_dias[calculos_MAIS$MAIS=="MAIS 3"&
calculos_MAIS$lesion=="grave"], na.rm = T)
mean(calculos_MAIS$uci_dias[calculos_MAIS$MAIS=="MAIS 4"&
calculos_MAIS$lesion=="grave"], na.rm = T)
mean(calculos_MAIS$uci_dias[calculos_MAIS$MAIS=="MAIS 5"&
calculos_MAIS$lesion=="grave"], na.rm = T)

table(calculos_MAIS$lesion)
anova_uci_MAIS<-calculos_MAIS[calculos_MAIS$uci_ingres=="SI",]
anova_uci_MAIS2<-aov(uci_dias ~ MAIS, data=anova_uci_MAIS)
summary(anova_uci_MAIS2)

#-----
# Life expectancy calculation:
#-----

```

```

# Estructura datos
# primer columna: lx general
# segunda columna: lx hombre
# tercera columna: lx mujer
# cuarta columna: utilidad hombre
# quinta columna: utilidad mujer

#datos año 2022
my_data <- read_excel("C:/Users/forne/Desktop/tfm/sanidad_biel/explicación
datos sanidad/esperanzas vida/valor (2022).xlsx")

View(my_data)

esperanza<-function(data, edad=0, d=0, mujer=TRUE, ajuste=TRUE){

  mort<-as.matrix(data)
  i<-(edad+1):nrow(mort)
  r<-i-edad-1
  if(mujer=="TRUE"){
    px<-(mort[i,3]/mort[(edad+1),3])#probabilidad temporal supervivencia
    aj<- mort[i,5]#utilidad
  }else{
    px<-(mort[i,2]/mort[(edad+1),2])
    aj<- mort[i,4]
  }

  if(ajuste=="TRUE"){
    pxa<-px*aj} else{
    pxa<-px
  }
  exd<-pxa*((1+d)^(-r))
  sum(exd)
}

##hombre

hombre<-matrix(0,nrow=101, ncol=4)
for (i in 0:100){
  hombre[(i+1),1]<-esperanza(my_data,i,0, mujer="FALSE", ajuste="FALSE")
  hombre[(i+1),2]<-esperanza(my_data,i,0, mujer="FALSE", ajuste="TRUE")
  hombre[(i+1),3]<-esperanza(my_data,i,0.03, mujer="FALSE", ajuste="TRUE")
  hombre[(i+1),4]<-esperanza(my_data,i,0.07, mujer="FALSE", ajuste="TRUE")
}

##mujer

mujer<-matrix(0,nrow=101, ncol=4)
for (i in 0:100){
  mujer[(i+1),1]<-esperanza(my_data,i,0, mujer="TRUE", ajuste="FALSE")
  mujer[(i+1),2]<-esperanza(my_data,i,0, mujer="TRUE", ajuste="TRUE")
  mujer[(i+1),3]<-esperanza(my_data,i,0.03, mujer="TRUE", ajuste="TRUE")
  mujer[(i+1),4]<-esperanza(my_data,i,0.07, mujer="TRUE", ajuste="TRUE")
}

#-----
# QALY loss calculation:
#-----

```

```

#Crear nueva columna con el MAIS:

grave$MAIS<-NA
leve$MAIS<-NA
muerte$MAIS<-NA #recordamos que la perdida es toda la esperanza de vida

grave$MAIS<-MAIS_grave$maxais
leve$MAIS<-MAIS_leve$maxais
leve$MAIS<-ifelse(leve$MAIS==4 | leve$MAIS==5,3, leve$MAIS) #en los leves los
MAIS 4 y 5 los convertimos a 3
table(leve$MAIS)

#Tablas porcentajes QALY perdido para MAIS y tasa de descuento
QALY_leve<-
matrix(c(0.0018,0.002,0.0024,0.0174,0.0257,0.0377,0.0638,0.0679,0.0743), nrow
= 3, byrow = TRUE)
rownames(QALY_leve)<- c("MAIS 1","MAIS 2","MAIS 3")
colnames(QALY_leve)<-c("0%","3%","7%")

QALY_grave<-
matrix(c(0.0035,0.0043,0.0054,0.0386,0.0417,0.0451,0.1679,0.1828,0.1872,0.227
8,0.3044,0.3071,0.5499,0.5252,0.5010), nrow = 5, byrow = TRUE)
rownames(QALY_grave)<- c("MAIS 1","MAIS 2","MAIS 3","MAIS 4","MAIS 5")
colnames(QALY_grave)<-c("0%","3%","7%")

#Conseguir QALY perdido con esperanza de vida y con estos porcentajes de QALY
perdido:

#grave:

grave$esp_vida<-NA
grave$esp_vidaQA0<-NA
grave$esp_vidaQA3<-NA
grave$esp_vidaQA7<-NA

indices_hombres_grave <- which(grave$sexo == "Hombre")
for (i in indices_hombres_grave) {
  if(grave$edad[i]<=100){
    grave$esp_vida[i] <- hombre[grave$edad[i] + 1, 1]
    grave$esp_vidaQA0[i] <- hombre[grave$edad[i] + 1, 2]
    grave$esp_vidaQA3[i] <- hombre[grave$edad[i] + 1, 3]
    grave$esp_vidaQA7[i] <- hombre[grave$edad[i] + 1, 4]
  }
  else{
    grave$esp_vida[i] <- hombre[100 + 1, 1] #tenemos solo la esperanza
antes de 100 años
    grave$esp_vidaQA0[i] <- hombre[100 + 1, 2]
    grave$esp_vidaQA3[i] <- hombre[100 + 1, 3]
    grave$esp_vidaQA7[i] <- hombre[100 + 1, 4]
  }
}

indices_mujeres_grave <- which(grave$sexo == "Mujer")
for (i in indices_mujeres_grave) {
  if(grave$edad[i]<=100){
    grave$esp_vida[i] <- mujer[grave$edad[i] + 1, 1]
    grave$esp_vidaQA0[i] <- mujer[grave$edad[i] + 1, 2]
    grave$esp_vidaQA3[i] <- mujer[grave$edad[i] + 1, 3]
  }
}

```

```

    grave$esp_vidaQA7[i] <- mujer[grave$edad[i] + 1, 4]
  }
  else{
    grave$esp_vida[i] <- mujer[100 + 1, 1]    #tenemos solo la esperanza
antes de 100 años
    grave$esp_vidaQA0[i] <- mujer[100 + 1, 2]
    grave$esp_vidaQA3[i] <- mujer[100 + 1, 3]
    grave$esp_vidaQA7[i] <- mujer[100 + 1, 4]
  }
}

#leve:

leve$esp_vida<-NA
leve$esp_vidaQA0<-NA
leve$esp_vidaQA3<-NA
leve$esp_vidaQA7<-NA
sum(is.na(leve$sexo)) #hay NA de sexos ¿QUITARLOS?
sum(is.na(leve$edad))
leve<-leve[!is.na(leve$sexo),] #quitamos a los sexos NA porque no podemos
calcular esperanza de vida

indices_hombres_leve <- which(leve$sexo == "Hombre")
for (i in indices_hombres_leve) {
  if(leve$edad[i]<=100){
    leve$esp_vida[i] <- hombre[leve$edad[i] + 1, 1]
    leve$esp_vidaQA0[i] <- hombre[leve$edad[i] + 1, 2]
    leve$esp_vidaQA3[i] <- hombre[leve$edad[i] + 1, 3]
    leve$esp_vidaQA7[i] <- hombre[leve$edad[i] + 1, 4]
  }
  else{
    leve$esp_vida[i] <- hombre[100 + 1, 1]
    leve$esp_vidaQA0[i] <- hombre[100 + 1, 2]
    leve$esp_vidaQA3[i] <- hombre[100 + 1, 3]
    leve$esp_vidaQA7[i] <- hombre[100 + 1, 4]
  }
}

indices_mujeres_leve <- which(leve$sexo == "Mujer")
for (i in indices_mujeres_leve) {
  if(leve$edad[i]<=100){
    leve$esp_vida[i] <- mujer[leve$edad[i] + 1, 1]
    leve$esp_vidaQA0[i] <- mujer[leve$edad[i] + 1, 2]
    leve$esp_vidaQA3[i] <- mujer[leve$edad[i] + 1, 3]
    leve$esp_vidaQA7[i] <- mujer[leve$edad[i] + 1, 4]
  }
  else{
    leve$esp_vida[i] <- mujer[100 + 1, 1]    #tenemos solo la esperanza antes
de 100 años
    leve$esp_vidaQA0[i] <- mujer[100 + 1, 2]
    leve$esp_vidaQA3[i] <- mujer[100 + 1, 3]
    leve$esp_vidaQA7[i] <- mujer[100 + 1, 4]
  }
}

#grave:
grave$QALY<-NA
grave$QALY0<-NA

```

```

grave$QALY3<-NA
grave$QALY7<-NA

for (i in 1:length(grave$MAIS)) {
  mais_val <- grave$MAIS[i]

  if (mais_val >= 1) {
    grave$QALY[i] <- grave$esp_vida[i] * QALY_grave[mais_val, 1]
    grave$QALY0[i] <- grave$esp_vidaQA0[i] * QALY_grave[mais_val, 1]
    grave$QALY3[i] <- grave$esp_vidaQA3[i] * QALY_grave[mais_val, 2]
    grave$QALY7[i] <- grave$esp_vidaQA7[i] * QALY_grave[mais_val, 3]
  } else {
    grave$QALY[i] <- NA
    grave$QALY0[i] <- NA
    grave$QALY3[i] <- NA
    grave$QALY7[i] <- NA
  }
}
table(grave$MAIS)
sum(is.na(grave$QALY)) #son los MAIS 0

#leve:
leve$QALY<-NA
leve$QALY0<-NA
leve$QALY3<-NA
leve$QALY7<-NA

for (i in 1:length(leve$MAIS)) {
  mais_val <- leve$MAIS[i]

  if (mais_val >= 1) {
    leve$QALY[i] <- leve$esp_vida[i] * QALY_leve[mais_val, 1]
    leve$QALY0[i] <- leve$esp_vidaQA0[i] * QALY_leve[mais_val, 1]
    leve$QALY3[i] <- leve$esp_vidaQA3[i] * QALY_leve[mais_val, 2]
    leve$QALY7[i] <- leve$esp_vidaQA7[i] * QALY_leve[mais_val, 3]
  } else {
    leve$QALY[i]<-NA
    leve$QALY0[i]<-NA
    leve$QALY3[i]<-NA
    leve$QALY7[i]<-NA
  }
}

table(leve$MAIS)
sum(is.na(leve$QALY)) #son los de MAIS 0

#muertos:

muerte$esp_vida<-NA
muerte$esp_vidaQA0<-NA
muerte$esp_vidaQA3<-NA
muerte$esp_vidaQA7<-NA

indices_hombres_muerte <- which(muerte$sexo == "Hombre")
for (i in indices_hombres_muerte) {
  if(muerte$edad[i]<=100){
    muerte$esp_vida[i] <- hombre[muerte$edad[i] + 1, 1]
    muerte$esp_vidaQA0[i] <- hombre[muerte$edad[i] + 1, 2]
  }
}

```

```

    muerte$esp_vidaQA3[i] <- hombre[muerte$edad[i] + 1, 3]
    muerte$esp_vidaQA7[i] <- hombre[muerte$edad[i] + 1, 4]
  }
  else{
    muerte$esp_vida[i] <- hombre[100 + 1, 1]    #tenemos solo la esperanza
antes de 100 años
    muerte$esp_vidaQA0[i] <- hombre[100 + 1, 2]
    muerte$esp_vidaQA3[i] <- hombre[100 + 1, 3]
    muerte$esp_vidaQA7[i] <- hombre[100 + 1, 4]
  }
}

indices_mujeres_muerte <- which(muerte$sexo == "Mujer")
for (i in indices_mujeres_muerte) {
  if(grave$edad[i]<=100){
    muerte$esp_vida[i] <- mujer[muerte$edad[i] + 1, 1]
    muerte$esp_vidaQA0[i] <- mujer[muerte$edad[i] + 1, 2]
    muerte$esp_vidaQA3[i] <- mujer[muerte$edad[i] + 1, 3]
    muerte$esp_vidaQA7[i] <- mujer[muerte$edad[i] + 1, 4]
  }
  else{
    muerte$esp_vida[i] <- mujer[100 + 1, 1]    #tenemos solo la esperanza
antes de 100 años
    muerte$esp_vidaQA0[i] <- mujer[100 + 1, 2]
    muerte$esp_vidaQA3[i] <- mujer[100 + 1, 3]
    muerte$esp_vidaQA7[i] <- mujer[100 + 1, 4]
  }
}

muerte$QALY<-muerte$esp_vida    #ya que para fallecidos la perdida de QALY
es toda la esperanza de vida
muerte$QALY0<-muerte$esp_vidaQA0
muerte$QALY3<-muerte$esp_vidaQA3
muerte$QALY7<-muerte$esp_vidaQA7

#juntamos las bases de datos con los MAIS:

data6<-rbind(muerte,grave,leve)
data7<-data6[!is.na(data6$QALY),]

data7 <- data7[year(data7$fecha_inic) == 2022, ] #escogemos solo datos del
2022

#-----
# QALY analysis:
#-----

summary(data7[,c("QALY","QALY0","QALY3","QALY7")]) ##perdida QALY en caso
general

summary(data7[data7$lesion=="muerte",c("QALY","QALY0","QALY3","QALY7")])
#perdida QALY en caso de muerte
summary(data7[data7$lesion=="grave",c("QALY","QALY0","QALY3","QALY7")])
#perdida QALY en caso de paciente grave
summary(data7[data7$lesion=="leve",c("QALY","QALY0","QALY3","QALY7")])
#perdida QALY en caso de paciente leve

leveygrave<-data7[data7$lesion=="grave" |data7$lesion=="leve", ]

```

```

leveygrave$lesion <- droplevels(leveygrave$lesion)
table(leveygrave$lesion)
anova_casos <- aov(QALY3 ~ lesion, data = leveygrave)
summary(anova_casos)

summary(data7[data7$sexo=="Hombre",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$sexo=="Mujer",c("QALY","QALY0","QALY3","QALY7")])

anova_sexo <- aov(QALY3 ~ sexo, data = data7)
summary(anova_sexo)

summary(data7[data7$intervalos=="0-17",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$intervalos=="18-30",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$intervalos=="31-65",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$intervalos=="65+",c("QALY","QALY0","QALY3","QALY7")])

anova_edad <- aov(QALY3 ~ intervalos, data = data7)
summary(anova_edad)

summary(data7[data7$cuatrimestre=="1
cuatrimestre",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$cuatrimestre=="2
cuatrimestre",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$cuatrimestre=="3
cuatrimestre",c("QALY","QALY0","QALY3","QALY7")])

anova_cuatri <- aov(QALY3 ~ cuatrimestre, data = data7)
summary(anova_cuatri)

summary(data7[data7$tipo_dia=="entre
semana",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$tipo_dia=="fin de
semana",c("QALY","QALY0","QALY3","QALY7")])

anova_tipodia <- aov(QALY3 ~ tipo_dia, data = data7)
summary(anova_tipodia)

summary(data7[data7$alta=="Domicilio",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$alta=="Traslado a otro
hospital",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$alta=="Alta
voluntaria",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$alta=="Exitus",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$alta=="Traslado a centros
socio-sanitarios",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$alta=="Otros",c("QALY","QALY0","QALY3","QALY7")])

anova_alta <- aov(QALY3 ~ alta, data = data7)
summary(anova_alta)

data7$uci_ingres <- as.character(data7$uci_ingres)
data7$uci_ingres[is.na(data7$uci_ingres)] <- "NO"
data7$uci_ingres <- factor(data7$uci_ingres, levels = c("SI", "NO"))

summary(data7[data7$uci_ingres=="SI",c("QALY","QALY0","QALY3","QALY7")])
summary(data7[data7$uci_ingres=="NO",c("QALY","QALY0","QALY3","QALY7")])

anova_ingres <- aov(QALY3 ~ uci_ingres, data = data7)

```

```

summary(anova_ingres)

summary(data7[data7$tipo_contact=="hospitalizacion",c("QALY","QALY0","QALY3",
"QALY7")])
summary(data7[data7$tipo_contact=="urgencias",c("QALY","QALY0","QALY3","QALY7
")])

anova_hospi <- aov(QALY3 ~ tipo_contact, data = data7)
summary(anova_hospi)

hospitalizados<-data7[data7$tipo_contact=="hospitalizacion",]
cor.test(hospitalizados$duracion, hospitalizados$QALY3, method = "pearson")

cor.test(data7$suci_dias, data7$QALY3, use = "complete.obs", method =
"pearson")

mean(data7$duracion[data7$tipo_contact=="hospitalizacion" &
data7$intervalos=="0-17"])
mean(data7$duracion[data7$tipo_contact=="hospitalizacion" &
data7$intervalos=="18-30"])
mean(data7$duracion[data7$tipo_contact=="hospitalizacion" &
data7$intervalos=="31-65"])
mean(data7$duracion[data7$tipo_contact=="hospitalizacion" &
data7$intervalos=="65+"])

data8 <- data7 %>%
  filter(tipo_contact=="hospitalizacion") %>%
  arrange(desc(duracion)) %>%
  select(intervalos, duracion, QALY3)

top5_por_intervalo <- data8 %>%
  group_by(intervalos) %>%
  slice_max(order_by = duracion, n = 5, with_ties = FALSE) %>%
  ungroup() %>%
  arrange(intervalos, desc(duracion))

#Tasa de descuento:

df_filtrado<-data7[data7$intervalos=="0-17" | data7$intervalos=="65+",
c("intervalos", "QALY", "QALY0", "QALY3", "QALY7")]

df_long <- df_filtrado %>%
  pivot_longer(cols = starts_with("QALY"),
               names_to = "Tipo_QALY",
               values_to = "Valor")

ggplot(df_long, aes(x = Tipo_QALY, y = Valor, fill = intervalos)) +
  geom_violin(trim = FALSE) +
  labs(title = "Distribución de QALY por Grupo de Edad",
       x = "Tipo de QALY", y = "Valor QALY") +
  theme_classic()

#Festivos:
festivos_df3 <- subset(data7, fecha_inic %in% festivos)
summary(festivos_df3[,c("QALY","QALY0","QALY3","QALY7")])

```

```

#-----
# Comparison of compensations:
#-----
data7 <- data7 %>%
  mutate(lesion = recode(lesion,
                        "leve" = "mild",
                        "grave" = "serious"))

data7$indemnizacion <- data7$QALY3*25000

df_plot <- data7 %>%
  filter(edad %in% c(18, 35, 50, 70),
         lesion != "muerte"
        ) %>%
  mutate(
    lesion = factor(lesion, levels = c("mild", "serious")),
    MAIS = factor(MAIS, levels = sort(unique(MAIS))),
    edad = factor(edad)
  )

ggplot(df_plot, aes(x = MAIS, y = indemnizacion, color = lesion, group =
lesion)) +
  geom_line(size = 1) +
  geom_point(size = 2) +
  scale_color_manual(values = c("mild" = "#1b9e77", "serious" = "#d95f02")) +
  scale_y_continuous(
    labels = label_number(
      scale_cut = cut_short_scale(),
      suffix = " €"
    )
  ) +
  facet_grid(sexo ~ edad) + # ← FILAS = SEXO, COLUMNAS = EDAD
  labs(
    title = "Compensation by MAIS, injury, age and sex",
    x = "MAIS",
    y = "Compensation (€)",
    color = "Type of injury"
  ) +
  theme_minimal(base_size = 13)

```