Medico-legal prognosis in traffic accidents. Current status and new demands (Solvency II, Act 35/2015)

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1. Introduction

If we delve into the history of humanity we can identify very remote traces of what could be called the assessment of bodily harm, however, medico-legal activity as we know it today is relatively recent and very closely tied to the world of civil liability insurance. The publication of the first systems for the assessment of bodily harm (Ministerial Order, March 1991) and particularly Act 30/1995 on the Regulation and Supervision of Private Insurance have without a doubt been the driving force behind the need to have recourse to medical experts in the assessment of bodily harm. Post-graduate university training in personal injury assessment was initiated during the 90s of the last century, and medical experts began to be included in the process for the assessment of the damages caused by road accidents. Not only were they called upon for assessing the consequences of an accident once treatment had finalised, but with increasingly greater frequency there was a need to have initial prognostic assessment for the handling of the technical provisions (reserves in actuarial language) of insurance undertakings.

This area of specialisation gradually became consolidated in pace with the successive legislative revisions of the legal systems for the assessment of the bodily harm caused by road accidents, culminating in the current Act 35/2015 which significantly expands the need for these medical reports compared to the requirements of previous legislation.

While the legal personal injury assessment models guide experts in the framework of a defined post-treatment procedure model, the prognostic expert activity has been less developed, both in training as well as in doctrinal terms, and we can affirm that it is expert-dependent. No defined model or uniform pattern of action exists, and therefore the experience of the experts themselves serves as the orientation for issuing a medico-legal prognosis based on the initial information obtained immediately after the accident. Personal injury assessment has focussed its attention primarily on the use of scales and to a lesser degree on the methodology for the study of causality, while interest in the construction of predictive models is irrelevant, saving a few scarcely significant exceptions.

We must make a distinction between medical prognosis and medico-legal prognosis. Medical prognosis in traffic accidents is related to short-term survival, while the medico-legal prognosis is associated with the long-term consequences.

When medical experts perform an initial assessment of an accident victim, they make a medico-legal prognosis (expected days of healing time, foreseeable sequelae, etc.), in most cases on the basis of their experience, adjusting their estimates to the specific circumstances observed (age, medical history, etc.), and on the basis of the information provided. We can say that the majority of the assessments made are expert-dependent, or subjective.

In the context of the insurance world, medical experts in personal injury assessment are called upon for providing an initial –and as stable as possible- prognostic assessment, seeking to avoid significant variations in the course of the life of a bodily harm claim. However, and in general, the increasing complexity of the obligations imposed upon insurance undertakings in terms of technical provisions is little known by the medical profession. At the present time, the technical provisions of insurance undertakings are based on complex statistical models developed by actuarial science, particularly with respect to the claims Incurred But Not Reported (IBNR) and, although to a lesser degree, also in the non-life claims pending (Reported But Not Settled – RBNS). Although the individualised assessment of a case is essential in this process, particularly in serious cases, recourse to these statistical models appears to improve accuracy in the estimate of reserves in all stages, in comparison to the traditional subjective assessment performed by medical experts. The implementation of these actuarial statistical methods for the calculation of reserves in the RBNS claims is addressed in Solvency II (European Insurance and Occupational Pensions Authority - EIOPA Guidelines on the valuation of technical provisions and on the use of internal models). To sum up, the technical provisions in motor vehicle accidents of the known and reported cases, in progress (RBNS), can be made on an individualised basis (case-by-case) or by means of statistical methods. At the present time, in the case-by-case provisions, the philosophy of the insurer will be able to choose between a pessimistic, realistic or optimistic policy.

This collaboration has been evolving in a more or less quiet manner, facilitating the current scenario, where accident victims are paid compensation in the majority of cases without having recourse to legal action. In addition, at the present time, we have a revised system for the assessment of personal injuries (Act 35/2015) and a system for the control and supervision of the technical provisions of insurance undertakings (Solvency II), which render the aforementioned limitations more visible. Act 35/2015 is a major qualitative and quantitative step forward, far removed from the previous damage assessment systems, and calls for a higher level of technical preparation on the part of all players. A consequence of this is the possibility of obtaining very different assessments of a single case, particularly when victims with moderate and/or serious injuries are involved. In a recent research report, published in 2015 in the *Journal of Forensic and Legal Medicine [33]*, differences were found in terms of days of healing time and sequelae points for a single case evaluated by different medical experts in accordance with the previous assessment system (Royal Decree 8/2004). The results were measured by means of a statistical indicator that quantifies inter-rater consistency (Fleiss' kappa), obtaining a very poor outcome (0.37). This means, among other things, that the assessment model was excessively interpretable by the experts themselves. Although in relative terms (days, points) the outcome could be similar by applying Act 35/2015, if we were to make a study in absolute terms of the final economic repercussions, the degree of inter-rater inconsistency would probably increase. The architecture of the new scale allows much wider variations by relating medical and/or legal damages to the outcome of the scores. We should recall that in the new system there are damages (Tables 2.B and 2.C, for example) which are applied practically automatically by means of score thresholds.

This relative uncertainty in assessments not only has an impact on the technical provisions of insurance undertakings, but is also relevant when the obligations derived from Act 35/2015 in terms of Reasoned Offer arise or, above all, when payments on account are made during the healing process prior to the stabilising of the injuries, based on the prediction made by the medical experts.

Another unresolved issue is the definition of severe injury. From the insurance undertaking perspective, the definition is based on cost, while from the medical perspective there is as yet no uniform criterion for defining a seriously injured victim. This is another of the issues which we will address, keeping in mind the Community directives in the field of transport, which must be harmonised. The unification of criteria is indispensable for undertaking epidemiological studies of traffic accidents, studies of costs and similar aspects.

2. Medical prognosis

We must make a distinction between medical prognosis and medico-legal prognosis. *Medical prognosis* in traffic accidents is related to short-term survival, while the *medico-legal prognosis* is associated with the long-term consequences. When medical experts perform an initial assessment of an accident victim, they make a medico-legal prognosis (expected days of healing time, foreseeable sequelae, etc.), in most cases on the basis of their experience, adjusting their estimates to the specific circumstances observed (age, medical history, etc.), and on the basis of the information provided. We can say that the majority of the assessments made are expert-dependent, or subjective.

Starting from the need for this expert method, it would be advisable to supplement this subjective assessment with an objective predictive model designed on the basis of initial clinical metric indicators and developed biostatistically. To do so, the first step is to identify the system or clinical scale for quantifying severity and, secondly, to identify the variables with statistical significance in the final result. It is evident that, in addition to the foregoing, this model requires a large number of cases in order to be representative and, for this reason, the collaboration of the insurance sector would be desirable.

The greatest difficulty for attaining the objective proposed is that very few comparative models exist for associating the initial clinical metric indicators (severity scales) with the medico-legal consequences of a motor vehicle accident, or at least these have not been published in scientific literature, possibly existing as in-house research of an insurance undertaking. An exception would be the publications by the Swedish insurer Folksam and the recent publication by our University of Santiago de Compostela (USC) working group, to which we will refer later [32]. Similar studies have been published in our country within the field of actuarial science, particularly the contributions by the University of Barcelona working group (Mercedes Ayuso, Miguel Santolino, Ramón Alemany, among others). Although of significant interest in the actuarial science associated with motor vehicle claims, these studies are not focussed on the purpose of this article, which is the use of a prognostic medical scale based on the measurement of initial severity for the development of a predictive model.

Other studies associate the initial severity of accident injuries with the final cost of the claim, but are set in the context of the countries where the studies were made and are not comparable in the context of our personal injury assessment system. Another added difficulty is the lack of official data published by local insurance undertakings on the economic consequences of traffic accidents in our geographical area, associating the injuries sustained with the final cost of the process, contrary to what occurs in other countries such as the U.S., England, Germany, Sweden, Japan, among others.

In this article our intention is to initiate our readers in a language which will become increasingly more visible and necessary in the insurance world, particularly in the scope of motor vehicle claims. This language refers to the medical scales measuring injury severity, that is, the same scales which we are going to use in the scientific research for the development of predictive models and, particularly, to the Abbreviated Injury Scale (AIS) which, as we will see, has already been present in the world of traffic accidents and will be mandatory as a reference for reporting serious accidents in the European Union.

It would be a very extensive and complex exercise to discuss all of the medical scales here, both those used for estimating the probability of short-term survival (the Glasgow Coma Scale, the American Spinal Injury Association - ASIA impairment scale, the Abbreviated Injury Scale - AIS, among others); as well as those used for measuring the long-term outcome of trauma patients. Of these, the most widely accepted and disseminated scales evaluate, above all, the perception of loss of quality of life and the long-term incapacity for work. There are also specific scales for children and the elderly. The best known scales, such as the World Health Organization Quality of Life Survey (WHO-QoL), the Glasgow Outcome Scale - Extended (GOS-E), the European Quality of Life 5D (EQ-5D), the Rehabilitation Complexity Scale (RCS), the Functional Independence Measure (FIM), the Spinal Cord Independence Measure (SCIM), the Paediatric Quality of Life Measure (Peds-QL), have in common the weight of subjective aspects in their results.

For approximately half a century, an effort has been made to search for a reliable, and at the same time not very complex, method for associating the initial data of a trauma patient with the vital prognosis and in turn with outcomes of an economic nature (days of hospitalisation, medical care costs, need for future resources, among others). The Abbreviated Injury Scale (AIS) responds to this approach. Developed since the mid 70's, this scale is, without a doubt, the world reference for measuring the severity of trauma patients. In its most recent revisions (post 1998), the AIS has also incorporated a scale for measuring the functional outcome to be expected after 1 year for each injury coded, called the Functional Capacity Index (FCI).

3. The Abbreviated Injury Scale and its derivatives

The Abbreviated Injury Scale or AIS was described by the American Medical Association (AMA) Committee on Medical Aspects of Automotive Safety as a method for classifying the severity of the injuries sustained in traffic accidents. Since its introduction in 1971, this scale has undergone successive updates, the most recent in 2015. The first version of this scale included only 75 blunt traumas, to each of which a code was assigned. The latest version of the scale contains more than 1300 codes, including blunt traumas and penetrating wounds.

The AIS is a standardised system for classifying the type and the severity of injuries according to the anatomical region involved. It contains nine chapters which include: head (skull and brain); face (includes eyes and ears); neck; thorax; abdomen; spine (cervical, thoracic and lumbar); upper extremity; lower extremity, pelvis and buttocks; external wounds (skin) and burns and other traumatic injuries. The scale locates each injury in the relevant body region and assigns each a numerical seven-digit code, six digits to the left of a decimal point to enable computerised handling of the scales and one digit immediately after the decimal point, indicating the AIS severity score, in accordance with the following scale:

AIS Code	Description
1	minor
2	moderate
3	serious
4	severe
5	critical
6	maximum (currently untreatable)

This severity scoring is valid as a mortality measurement reference, although mortality is not the only determining factor of severity on the AIS, since the severity of an injury is arrived at by consensus on the basis of several dimensions (including mortality), such as whether the injury is life-threatening, the existence of tissue damage, the cost and complexity of the treatment, hospitalisation time, temporary or permanent incapacity for work, permanent disability, quality of life, etc.

This scale also makes it possible to identify the anatomic location of certain injuries or even the mechanism of injury, by incorporating into the severity code several locators or numerical codes. Both the locators as well as the descriptors of the cause of the injuries are shown on tables within the AIS. In this way, the AIS code for an injury can be made up by fifteen numbers, although normally only the figure representing severity is used.

To assign an AIS code, we use a catalogue (AIS CODE BOOK) where we first identify the anatomical region and, secondly, the injury to be assessed. Qualified knowledge is necessary (injury taxonomy, anatomy, orthopaedic surgery, neurotrauma, etc.) and appropriate training for accurate coding. The apparent simplicity of the AIS, with only 6 severity levels for all possible injuries, should not be confused with the intrinsic complexity of its construction, which justifies the need for being handled by healthcare professionals.

Another of the contributions by the AIS is the “Predictive Functional Capacity Index” (pFCI). This descriptor is based on the Functional Capacity Index (FCI), defined as a health measurement developed for characterising functional limitation in the aftermath of non-fatal injuries on the individual and general population level (Mackenzie 1996), in the following 10 dimensions: eating, excretion, sexual function, walking, grip strength, bending and standing up, vision, hearing, speech and cognition. The pFCI, based on the AIS, indicates the most likely functional condition one year after the event of an individual between 18 and 65 years of age who sustained a single, non-fatal injury and received proper medical care and rehabilitation. The result of the pFCI varies from 1 (the poorest condition possible) to 5 (perfect condition) inversely scaled with respect to the AIS scoring, that is, a pFCI = 1 is assigned to all of the AIS = 6 codes.

As we have seen, the coding of an injury on the AIS is going to give us a measurement of the severity of such injury; but, what happens when a single patient has several injuries? The AIS indicates the severity of each injury separately, but does not reflect the combined effect of multiple injuries. When we have multiple injuries in a single patient, we must use other derivatives of AIS. The MAIS, the Injury Severity Score (ISS) and, derived from this, the New Injury Severity Score (NISS) were created for this purpose.

3.1. Maximum AI*S* (MAIS)

A first scale derived from the AIS is the Maximum AIS or MAIS, a scale which enables the assessment of a multiple injury patient. The MAIS represents the most severe injury of the patient evaluated, that is, the highest score on the AIS given to each of the injuries. By consensus, it is accepted that an injured person with a MAIS ≥ 3 is a severely injured patient.

3.2. Injury Severity Score (ISS)

This scale is used for the assessment of the combined effect of multiple injuries in a single patient, that is, it is used for polytraumatised patients. To make the calculation, the body is divided into six regions (head and neck, face, chest, abdomen, pelvis and extremities and external region). First, the AIS code is assigned to each of the injuries sustained in each of the 6 anatomical regions. The second step is to select the 3 highest AIS scores; however, they must refer to different regions. In the third step, we square these three AIS scores and, finally, the outcome of the sum of these three squared scores is the ISS score.

The minimum possible ISS score is 1 and the maximum 75. By consensus, a patient with ISS ≥15 is considered as severely injured. If a patient has been assigned an AIS of 6 for any of the injuries sustained, an ISS = 75 is assigned automatically, regardless of the rest of the injuries.

3.3. New Injury Severity Score (NISS)

The NISS is a modification of the ISS and has come to remedy some of the limitations observed in the latter. This new severity indicator, the same as the ISS, is based on the AIS. The difference with respect to the ISS is that the squares of the three highest AIS scores, independently of the anatomical region, are added together. It has been observed that the capacity for the prediction of mortality is more accurate.

The following table sets out an example of the AIS, MAIS, ISS and NISS:

Region	Injury	AIS	MAIS	ISS	NISS
Head	TBI moderate subdural haematoma	4	4	29	34
Head	TBI closed, undisplaced cranial vault fracture	2			
Thorax	Fracture 2 ribs	2			
Lower Extremity	Closed diaphyseal femur fracture	3			
Lower Extremity	Extra-articular open distal tibia fracture	3			

Note: ISS = $4^2 + 3^2 + 2^2 = 29$ / NISS = $4^2 + 3^2 + 3^2 = 34$

4. Applications of the AIS

Now that we have been introduced to the AIS and its different uses (AIS, MAIS, ISS, NISS), we are going to explore its current applications in the automotive world and in road accidents which, without a doubt, will surprise a good number of our readers.

4.1. Grading of injuries. European Union recommendations

The term seriously injured traffic accident victim has different meanings (medical, administrative, insurance-related, etc.). Since 2014, Spain's General Directorate for Traffic (DGT) has considered the term as referring to an injured person hospitalised for more than twenty-four hours, excluding patients deceased within a period of 30 days following the accident. For an insurance undertaking, the term refers to cases involving a specific cost, pre-established by the claims department, while for a physician, it will depend on the anatomic location of the injuries and the reference scales used.

Given the disparity of definitions of a seriously injured person in the countries of the European Union, one of the priority objectives since 2011 in the field of transport was to unify these definitions, based in almost all cases on one or more of the following criteria:

1. On the basis of days of hospitalisation.
2. According to the type of injury, severity and the body region affected.
3. Whether temporary incapacity for work is generated.
4. On the basis of the recovery time.
5. In cases of the persistence of sequelae.

Finally, in January 2013, the High Level Group on Road Safety unified the definition of a seriously injured accident victim as a person with MAIS ≥ 3 injuries, recommending the Member countries to use this definition in the statistics of the CARE (Community Road Accident Database) starting from 2015.

Recently (March 2017), the *Valletta Declaration on Road Safety* was approved during the transport ministers meeting in Malta and includes, among other points, the recommendation to continue the effort of notifying seriously injured road accident victims on the basis of the AIS (MAIS ≥ 3) from 2018 to 2020.

It is evident that these recommendations will end up becoming the rule, the requirement, for classifying the victims injured in road accidents in the European environment, the same as has been the practice in other regions of the world for a number of years (the U.S., Australia, among others). This will contribute to the design of prevention programmes and the unification of criteria for epidemiological studies. Therefore, we should make an effort to implement this scale (AIS) in the measurement of injury severity in traffic accident victims, using it on a routine basis in conjunction with medical diagnostics, both from the Medical Care as well as the Legal Medicine perspectives and from the viewpoint of the insurance world.

Although the European Union solely recommends the AIS score for the classification of severe injuries, it would be advisable to extend the classification to include patients with minor and moderate injuries, in accordance with the following classification recommended by a number of publications and medical experts:

Type of Injury	AIS (MAIS)	ISS
Minor	1	≤ 3
Moderate	2	4 - 15
Severe	≥ 3	> 15

4.2. The *eCall*

In our country, it has been mandatory since 31 March 2018 for all newly type-approved passenger vehicles and vans to be equipped with the *eCall* automatic emergency dialling system. Basically, this is a device installed in vehicles which, in certain circumstances, will automatically dial the 112 emergency number when an accident occurs, although the emergency call can also be made from the vehicle itself by pressing the SOS button. The device informs the emergency switchboard of the position of the vehicle (geolocation by GPS) and activates alerts to the various emergency services (ambulances, fire station, Traffic Department, etc.).

Figure 1. Outline of how the eCall devices work.
(Source: http://revista.dgt.es/es/reportajes/2018/04ABRIL/0404ecall-obligatorio-a-partir-del-31-de-marzo.shtml#.WsdOa0xuJYo)

This technology is not new and, although it has now been introduced into our country on a mandatory basis, it has been operational for a number of years in other countries (the U.S., Japan, Australia, Sweden, among others). Thanks to this, we already have a large number of scientific studies which have evaluated the performance of the system and its applicability in the triage of injured occupants even before the emergency services arrive at the scene of the accident. Again we will see how the AIS is relevant in the operation of this system.

The Advanced Automatic Crash Notification (AACN) has been operational in the United States for a number of years. The device installed in a vehicle can detect, in addition to the geolocation of the vehicle, the direction of the main force of the collision, the instantaneous change in velocity (delta V), the number of occupants, the use of safety devices and the existence of multiple impacts. An analysis of the vehicle's telemetry compared to the information available in its databases (National Automotive Sampling System / Crashworthiness Data System – NASS/CDS) generates an algorithm which enables the activation of different triage protocols and the deployment of resources consistent with the potential severity of the injury. At the present time, a high risk of a potentially severe injury is considered to exist, when there is more than a 20% probability that the ISS score will be higher than 15, according to a determination by the U.S. CDC (Centre for Disease Control and Prevention, Division of Injury Response).

Recently, in Japan, an adjustment of the American threshold to a 10% probability was recommended as a result of a study using EDR (Event Data Recorder) devices and the Toyota-Niho University AACN algorithm protocol applied to a sample of close to 3 million accidents analysed. Figure 2 shows an example of the Toyota-Niho University AACN algorithm. Although most of the text is in Japanese, on the left we can identify the vehicle data and the geolocation of the accident and, on the right, the position of the occupant, the main direction of the force (frontal collision), the delta V (59 km/h) and the probability of severe injuries (88%) to the front seat occupants:

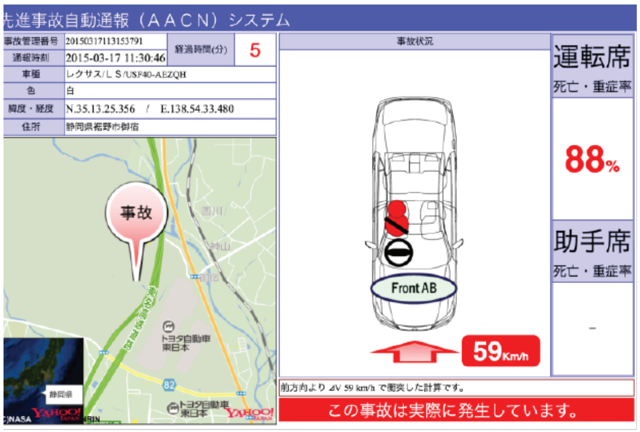

Figure 2. Example of the use of the Toyota-Niho University algorithm. (Source: https://pdfs.semanticscholar.org/687-f/626e33b604e950f2bf2b6b9bf84999026578.pdf)

Once again we can see the importance of the AIS in the implementation of the automatic collision reporting devices, *eCall* in our region, in such a way that the result of the vehicle's telemetry will enable us to predict the severity of injuries, a system which has been shown to be relevant in improving the survival and morbidity of accident victims, particularly in cases of severe injuries.

4.3. Active and passive vehicle safety

In recent decades (around 20 years), new vehicle crash tests in parameterised scenarios have become generalised. These crash tests are useful for evaluating the risk of injury and/or death in typical road collisions. The dissemination of these tests has been such that, today, almost all potential vehicle purchasers will ask about passive safety as a priority option. For example, terms such as the EuroNCAP "stars" of a particular vehicle have become generalised.

In Europe, these tests are performed basically by EuroNCAP (Euro New Car Assessment Programme), and although it ranks as a world reference, there are other similar programmes: the NHTSA (National Highway Traffic Safety Administration) and the IIHS (Insurance Institute for Highway Safety) in the United States, LatinNCAP in Latin America and the Caribbean, ANCAP (Australasian New Car Assessment Program) in Australia and New Zealand or the C-NCAP (China New Car Assessment Program) in China.

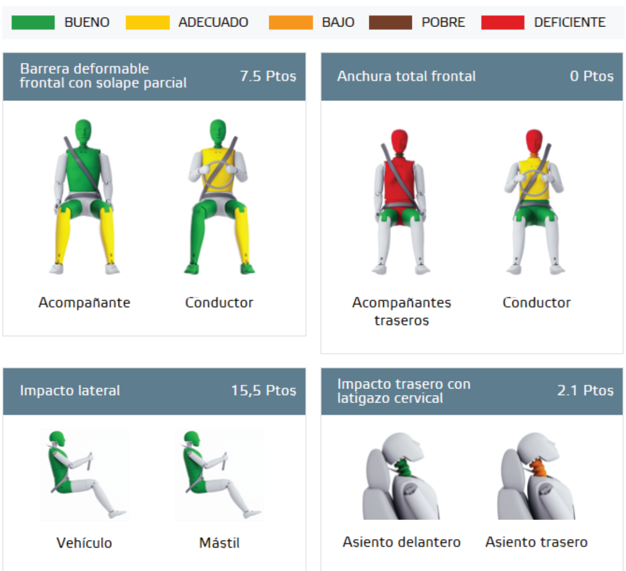

Figure 3. Example of the assessment of an automobile. (Source: https://www.euroncap.com/es)

When observing the result of a crash test (Figure 3), we find that the results are represented by graphics of the dummies (driver, occupant – front/rear -, pedestrian, adult, child, etc.), where the different parts of the body can have a range of colours (green, yellow, orange, brown, red). The colours are associated with a higher or lower likelihood of an injury to the respective anatomical region in the collision studied (frontal, side, collision with pedestrian, etc.).

The information provided by the dummies makes it possible to establish the probability of an injury and its severity, measured by applying the AIS. In this way, the protocols of the EuroNCAP programme set the risk of injury, which they will express in different colours (green, yellow, orange, brown or red) depending on the likelihood of sustaining an injury with an AIS code determined for each anatomical region and for each type of collision. Many research studies have been carried out for the purpose of correlating the predictions of the EuroNCAP protocols with real-life collisions, in all cases by using the AIS as the reference scale for assessing the severity of the real-life injuries.

These crash tests are performed with new vehicles; however, previously, during the design, component type-approval and other stages, the AIS also plays a role in the laboratory tests for measuring the potential severity of injuries.

4.4. Accident reconstruction

This can be seen as travelling the same road as in the previous section but in the opposite direction and, at the present time, is known as Forensic Biomechanics, a concept similar to impact or injury biomechanics. Explained very briefly, the objectives of impact biomechanics are the study of injury, the mechanism of injury and human impact tolerance. As a result of the research on the development of active and passive safety measures in vehicles, we have been able to identify physical parameters which are related to the risk of injury. The delta V (instantaneous change in velocity), acceleration, force, energy, etc., are physical variables generated in an accident.

Following decades of research, we can adequately relate a physical parameter to a specific injury, both in the population threshold of risk of injury as well as in the mechanism of injury. For example, at the present time we know quite well what direction and magnitude of forces are necessary for causing a bone fracture, and this would enable us to reconstruct the sequence of an accident, through a multidisciplinary effort (engineers, physicians, etc.), starting on the basis of the bone injuries.

The important consideration here is that for a number of decades, any research for the purpose of determining the risk of injury in an accident has referred and is going to refer to the potential severity of the injury in terms of the AIS. As an example, we have reproduced Figure 4, because it sums up, simply but at the same time very completely, the relationships that can be established between different types of collision, the change in velocity of the vehicle and the likelihood of sustaining a severe injury depending on the occupants' position in the vehicle.

An exponential increase in the risk of severe injuries (MAIS ≥ 3) can be observed as the delta V increases, with the lateral collisions in the occupant's area (*Near Side*) being more serious, the lateral collisions on the opposite side (*Far Side*) and the frontal collisions (*Frontal*) being similar and the rear collisions (*Rear*) less serious.

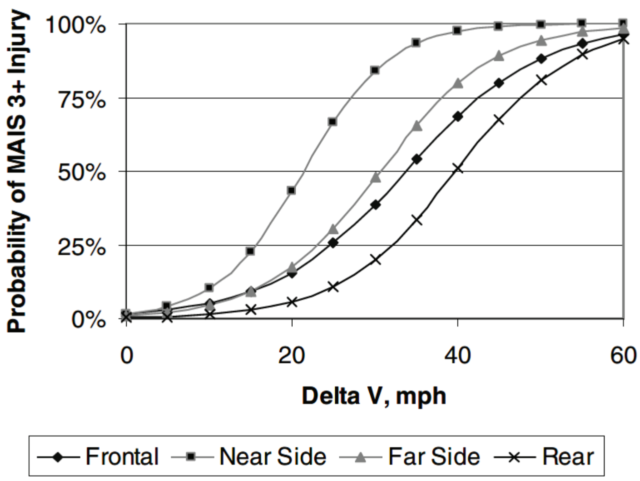

Figure 4. Relationships between location inside the vehicle, abrupt change in velocity and probability of sustaining a severe injury. (Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3217552/pdf/aam47_p561.pdf)

4.5. Other applications associated with road accidents

We could discuss here many research studies that associate road accidents with their direct and indirect economic consequences, taking the AIS as our reference for quantifying the severity of the injuries. Although these studies are relevant from a research point of view, due to their possible reproducibility in our local environment, most of the scientific production comes from other countries. Therefore, the relationships established between the AIS codes and the economic consequences (hospitalisation expenses, social costs, compensation payments, etc.) depend on the circumstances of each of the countries where the research has been carried out (medical care environment, social protection systems, compensation models, among others) and are not reproducible here. The majority of these studies associate the AIS with the following consequences of traffic accidents:

- Hospitalisation expenses
- Other direct costs: needs for care, pharmaceutical expenses, loss of labour productivity
- Loss of days/years of quality of life, residual disability.
- Economic compensation

Figure 5 shows the average cost following a road accident, in accordance with the maximum AIS (MAIS). We are including this here because it is a recent study made in Portugal, a neighbouring country and similar to ours in terms of the costs of medical care resources in road accidents. (Note HCC: Health Care Costs)

A research study carried out in the field of Forensic Medicine by the USC (University of Santiago de Compostela) has been published recently (https://www.tandfonline.com/doi/full/10.1080/20961790.2017.1379122), proposing a predictive statistical model for the sequelae points in accordance with Royal Decree 8/2004, using the AIS as the reference scale. Unquestionably, this is good starting point for continuing the development of a predictive model consistent with our geographical area, for which purpose, it would be recommendable to adopt the AIS as a universal severity measurement of the injuries caused in road accidents in Spain.

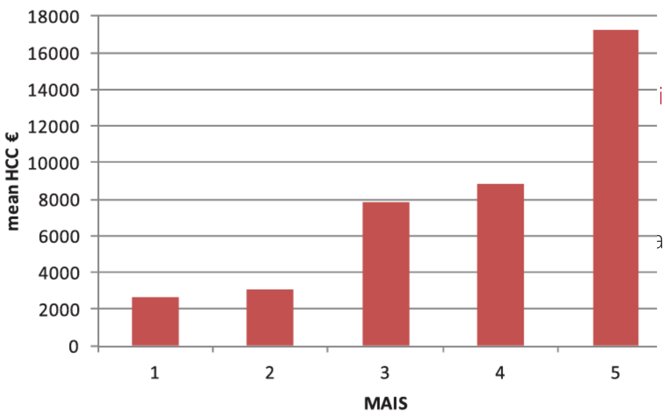

Figure 5. Average cost following a road accident according to the MAIS. (Source: https://www.tandfonline.com/doi/full/10.1080/17457300.2017.1341936)

5. Recommendations

Without prejudice to the fact that the work of medical experts in the assessment of the bodily harm caused by a road accident (*ex post*), as we understand it today, has been reinforced by the most recent legal provisions and standardised, it is no less certain that from the *ex ante*, predictive or prognostic perspective, this activity needs to be updated through the use of predictive models based on objective reference scales. In this study we have used the Abbreviated Injury Scale (AIS) as our reference, not as an arbitrary choice, but rather on account of its close association with the research on many aspects of road accidents, due to its taxonomic relationship with the Community directives on injury notification and because it has been shown to be valid in the early medico-legal studies on predictive models. We can affirm that the AIS is a medical tool closely linked to the automotive world and which will progressively extend its influence beyond the research laboratory.

Although we have spoken indistinctly of prognostic models and predictive models, they do not have the same meaning. The prognostic models refer to the need to harmonise the taxonomy of injured patients by means of adopting a validated and objective universal scale. The predictive models are complex statistical constructions starting from a core element: the scale used for the prediction. These are consecutive stages of a different nature; from the prognostic model chosen, the predictive model will then be developed. While the first model mentioned is medical, the second also enters the terrain of statistics, for which reason it will be multidisciplinary.

The updating of the prognostic / predictive models should have the following priority objectives, which are to:

1. Identify and classify the severity of injuries on the basis of objective criteria.
2. Comply with Community nomenclature regulations for determining the classification of the severity of the injuries sustained in traffic accidents.
3. Adjust the technical provisions to medical severity indexes assigned to the injuries.
4. Provide justification to the administrative authorities (General Directorate for Insurance and Pension Funds - Solvency II) and others (Reinsurance) in support of the decisions reached in the calculation and movements of the individualised technical provisions in RBNS claims.

Other objectives of a secondary nature could be to:

1. Use it as a guide for establishing the costs of the medical care processes within the framework of the Traffic Accident Medical Care Agreements.
2. Identify factors outside of the intrinsic severity of an injury, both medical and non-medical, which influence the final outcome to be expected in an *a priori* deterministic model. For example: the behaviour of a closed diaphyseal tibia fracture, without risk factors, is predictable in terms of its progress, with a known statistical risk of complications. This deterministic behaviour would be predictable through the initial AIS code assigned to this injury.
3. Have a reference guide as orientation with respect to the foreseeable severity/disability in the injured party/insurer relations under Act 35/2015 (Articles 7 and 37).

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