

# **Technological innovation to standardise and harmonise personal injury damages: practical scenarios and their implications on the compensation paradigms.**

*Denise Amram*

## **Abstract:**

This paper analyses the barriers towards the harmonisation of heads of damages and their compensation criteria, providing a proposal of standardisation based on interdisciplinary remarks. In particular, personal injury damages compensation paradigms could take the chance to apply technical variables used in bioengineering and biorobotic studies in order to assess the performance, usability and acceptability of allied technologies and medical devices, like prosthesis. By measuring the efficacy on the user's quality of life, it could be possible to extract variables to also analyse the residual compromise of health integrity of the accident that caused the given injury.

*Key-words:* personal injury damages – compensation methodologies – allied technologies – quality of life.

Cet article analyse les limites à l'harmonisation des chefs de dommages et de leurs critères d'indemnisation et propose une méthodologie de standardisation basée sur des remarques interdisciplinaires. En particulier, les paradigmes d'indemnisation des dommages corporels pourraient profiter de l'application de variables techniques utilisées dans les études de bio-ingénierie et de biorobotique afin d'évaluer les performances, l'utilisabilité et l'acceptabilité des technologies et dispositifs médicaux connexes, comme les prothèses. En mesurant l'efficacité sur la qualité de vie de l'utilisateur, il pourrait être possible d'extraire des variables pour analyser également le compromis résiduel sur l'intégrité de la santé de l'accidenté qui a causé la blessure donnée.

*Mots-clés :* dommages corporels – méthodologies d'indemnisation – technologies connexes – qualité de vie.

Dieser Artikel analysiert die Hindernisse für die Harmonisierung von Schadenskategorien und deren Entschädigungskriterien und unterbreitet einen Vorschlag zur Standardisierung basierend auf interdisziplinären Überlegungen. Insbesondere könnten Entschädigungsparadigmen für Personenschäden die Möglichkeit nutzen, technische Variablen aus Bioingenieur- und Biorobotikstudien anzuwenden, um die Leistung, Benutzerfreundlichkeit und Akzeptanz verbündeter Technologien und medizinischer Geräte, wie Prothesen, zu bewerten. Durch die Messung der Wirksamkeit auf die Lebensqualität des Nutzers könnte es möglich sein, Variablen zu extrahieren, um auch die verbleibende Beeinträchtigung der Gesundheitsintegrität durch den Unfall, der die betreffende Verletzung verursacht hat, zu analysieren.

*Schlüsselwörter:* Personenschäden – Entschädigungsmethoden – verwandte Technologien – Lebensqualität.

## **Resumen**

Este artículo analiza las barreras que existen para la armonización de los conceptos perjudiciales y sus criterios de indemnización, y ofrece una propuesta de estandarización basada en observaciones interdisciplinarias. En particular, los paradigmas de indemnización por daños personales podrían aprovechar la oportunidad para aplicar variables técnicas utilizadas en estudios de bioingeniería y biorrobótica para evaluar el rendimiento, la usabilidad y la aceptabilidad de tecnologías afines y dispositivos médicos, como las prótesis. Al medir la eficacia en la calidad de vida del usuario, podría ser posible extraer variables para analizar también el menoscabo residual a la integridad de la salud provocado por el accidente que causó la lesión en cuestión.

**Palabras clave:** daños personales – metodologías resarcitorias – tecnologías aliadas – calidad de vida.

## 1. Introduction

1. Personal injury damages compensation is traditionally governed by a multitude of legal frameworks, forensic science guidelines, and courts interpretations<sup>1</sup>. Consequently, the same injury with similar consequences on the personal sphere of the victim might not be awarded with the same scale at international, EU, national, and even at local level. The need of harmonisation of the heads of damages and standardisation of the evaluation criteria is increasingly to ensure equal treatment among similar circumstances.
2. The multitude of attempts of compensation reforms<sup>2</sup> seem to not successfully achieve the goal of providing harmonised notions of heads of damages and standardised compensation criteria. A different methodology is required.
3. Technological advances, especially in the field of bioengineering, instead, are nowadays improving the quality of life of injured persons, thanks to the development of solutions able to restore organs' functionalities and performance. Thus, also the victim of an accident is potentially able to fully enjoy her life, despite of the seriousness of the compromise of her psycho-physical integrity, by starting personalised rehabilitation and treatment paths, including the implantation of a prosthesis or an artificial organ or a regenerative medicine technology able to partially or fully restore the health integrity of the victim. The assessment of these technologies in terms of feasibility, performance, and acceptability are standardised and globally recognised in the scientific community<sup>3</sup>.
4. This paper shows the preliminary results of a multi-disciplinary and multi-sectorial approach that combines comparative law methodologies to the evidence emerging from forensic science analyses and bioengineering studies, to detect variables able to describe the implications of technological innovation on the daily life of the victims and extract index for the development of new criteria to calculate personal injury damages compensation. For example, to certify the functionality of prostheses, there are some scales, tests, and tools that are universally accepted as validated from the scientific community (eg ISO 10128, ISO 2241-11 2018). In a complementary perspective, a series of quality analyses are shaping validated metrics to understand which activities of daily life are carried out with more or less ease and also what is

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<sup>1</sup> *Ex multis*, S. BANAKAS (2002) 'European tort law: is it possible?' *Eur Rev Private Law* 3:363–375, G. BRÜGGEMEIER, ALB COLOMBI CIACCHI, P. O'CALLAGHAN (eds), *Personality rights in European tort law*. CUP, Cambridge, 2010, C. VON BAR, *The common European law of torts*, vol II. OUP, Oxford, 2000.

<sup>2</sup> M. BUSSANI - A. SEBOK (eds), *Comparative Tort Law: Global Perspectives*, Edward Elgar Publishing, 2021.

<sup>3</sup> A. HACKSHAW, *A concise guide to clinical studies*, Wiley, 2009.

the degree of user satisfaction in using that kind of prosthesis: for example, the Activities of Daily Life (ADLs) scale<sup>4</sup> can be used to assess the overall quality of life of a patient after a treatment, considering both the basic and the instrumental dimensions. The first one includes the ability to undertake personal care and hygiene activities as well as functional mobility; the second one concerns all those activities considered as not essential, but equally important (such as the preparation of meals, housework, money management, the use of the phone, sport and leisure, etc). To combine these indicators in the variables used by forensic scientists to translate impairments into an economic value in order to describe the implications of the accident on the victim's daily life would introduce an innovative measurable layer to support the standardisation process of the compensation system.

## 2. Heads of damages and their compensation

5. Technological innovation could be nowadays able to restore organs functionalities to victims of an accident or at least to improve the quality of life of the injured person. Thanks to the advances of technological innovation, after an accident injured persons might, in fact, enjoy a new life. Organs' functionalities and performance might be restored by robotics and biorobotic solutions, that can concretely improve the quality of life of persons whose psycho-physical integrity has been compromised<sup>5</sup>.
6. This premise opens new challenges on tort law and personal injury damages compensation. In a sector affected by a multitude of legal frameworks, forensic science guidelines, and courts interpretations, the need of systematisation and harmonisation of the heads of damages as well as the requests of standardisation of the evaluation criteria are addressing two main challenges. Firstly, the urgency to ensure equal treatment among persons and similar circumstances. Secondly, the need to develop new methodologies to deal with consistent reforms of the procedure to design the criteria of evaluation of non-pecuniary losses. For example, within the Italian system a series of incertitude is raising from the evolution of non-pecuniary losses compensation paradigm that is composed of several heads of damages and a plurality of mechanisms to calculate them, according to criteria that are not connected to the concrete impact of the loss on the person's integrity, but related to the paradigm built upon the circumstances where the illicit conduct occurred.
7. For instance, there is a general paradigm, referring to articles 2043 and 2059 of the Italian Civil Code, whose judicial interpretation faced different steps along the last decades. In particular, starting from the idea that non-pecuniary losses could be awarded only in expressed cases stated by the law, non-economic damages were limited to moral harms deriving from criminal offences, as article 185 of the Italian Criminal Code expressly awarded these losses, and other few cases for a long time. During this "season" of the Italian tort law evolution<sup>6</sup>, personal injury damages were mainly assessed and awarded in terms of loss of earnings capacity under the general clause of article 2043 Italian Civil Code. Such an interpretation started to face some critical aspects, as according to the forensic science the compromission of the psycho-physical integrity of the

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<sup>4</sup> S. KATZ, T.D. DOWNS, H.R. CASH, R.C. GROTZ, 'Progress in development of the index of ADL', *Gerontologist*, vol. 10, 1970, pp. 20–30.

<sup>5</sup> S. SADEGHNEJAD, V. SHAMS ESFAND ABADI, B. JAFARI, *Rehabilitation robotics: History, applications, and recent advances*, in O. BOUBAKER, *Medical Robots and Devices: New Developments and Advances*, Medical and Healthcare Robotics, Academic Press, 2023, 63-85, <https://doi.org/10.1016/B978-0-443-18460-4.00008-1>.

<sup>6</sup> F.D. BUSNELLI, 'Il danno alla persona: un dialogo incompiuto tra giudici e legislatori', *Danno e resp.*, 2008, 609 ss.

person, *i.e.* the so-called *danno biologico*, shall be considered despite of the fact that victim is a worker and, therefore, despite of the concrete economic implications on one's earnings capacity.

This approach brought to analyse the *danno biologico* in terms of non-pecuniary loss related to the constitutionally protected right to health meeting the condition of expressed fundamental right protected by the law under the article 2059 Italian Civil Code. In particular, a new constitutional oriented interpretation developed the current paradigm, where the awards for non-pecuniary losses are justified in case of an unjust harm emerging from a serious infringement of a fundamental right. Judges shall therefore assess the compensation following the fairness principle, whose content has been covered by the *barèmes* drafted by the courts based on their own precedents.

The challenge related to the need to guarantee an equal treatment between the same injuries along the Italian jurisdiction and the effectiveness of the criteria elaborated by the Tribunals of Milan and Rome brought to spread the general application of the two mentioned *barèmes* in most of the Italian courts. This process of applied *barèmes* distribution solicited more than once the Italian High Court to decide about the adherence of one's features and criteria to the general principles on the matter, namely on the principle of full restoration *tout le dommage, rien que le dommage* and fairness in the calculation of the awards<sup>7</sup>.

8. In addition to the *ius commune* scenario, however, further sectorial paradigms are creating barriers to a standardised approach. For instance, under the Private Insurances Code issued in 2005, namely Act n. 209/20025, the *danno biologico* found a specific definition and mechanism of compensation, based on tailored national-based forensic *barèmes* and possible personalisation (*recte* individualisation) opened up to a certain percentage where the injured party provides evidence of specific implications of the harm on her life<sup>8</sup>. This initiative had the purpose to standardise heads of damages and harmonise award compensations. However, the fact that only for lower impairments (up to 9% of disability) a national *barème* has been published by the Italian Government, and all the attempts for higher impairments (10-100%) dropped off<sup>9</sup>, has produced the opposite result: incertitude, as the notions of *danno biologico* and its implications on the injured person life are evolving – as specified also by the high court – according to the values accepted within the society in a given time.
9. Different regimes might be applicable to the same injury depending on the source of the accident (*e.g.* car accidents or workplace or medical malpractice ones might adopt different criteria considering the presence of the social security system or the mandatory insurance)<sup>10</sup>. Furthermore, even within the same legal framework, forensic scientists could adopt different guidelines to identify impairments, therefore the amputation of a limb could be assessed under different parameters by medical experts. Therefore, judges – that are already used to translate

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<sup>7</sup> G. PONZANELLI, 'Il risarcimento del danno alla persona: tabelle giudiziali, controllo della Corte di Cassazione e principio di uguaglianza', in *Contratto e impresa*, 2021, p. 1027 ss.

<sup>8</sup> A. CANDIAN – G. CARRIERO (eds), *Codice delle assicurazioni private*, ESI, 2014.

<sup>9</sup> DPR 16th January 2024, *Tabella delle menomazioni all'integrità psicofisica comprese fra 10 e 100 punti*. G. PONZANELLI, *La Tabella Unica Nazionale ex art. 138 Codice delle Assicurazioni: il Consiglio di Stato bocchia la bozza di Decreto del Governo*, in *Danno e responsabilità*, 2024, 194 ss.

<sup>10</sup> This brought interpretative issues related to cross-sectorial scenarios, like in the case of medical malpractice case where insurance could be mandatory but not always private one, G. WAGNER, *Tort Law and Liability Insurance*, Springer, 2005. During the proof reading of this contribution, the Italian Government approved another version of such a national *barème*, called *Tabella Unica Nazionale*, 'Schema di decreto del Presidente della Repubblica - Regolamento recante la tabella unica del valore pecuniario da attribuire a ogni singolo punto di invalidità tra dieci e cento punti, comprensivo dei coefficienti di variazione corrispondenti all'età del soggetto leso ai sensi dell'articolo 138, comma 1, lettera b), del codice delle assicurazioni private, di cui al decreto legislativo 7 settembre 2005, n. 209', not yet into application in any case.

into monetary amounts following the available *barèmes* - might start from different premises before similar harms and circumstances. This is true at local, national, and international level<sup>11</sup>.

10. From a comparative perspective, in fact, we assist to the application of different methods of assessment that could be linked to the *calcul au point* procedure or even just identify brackets of amounts for injuries impacting on different parts of the body. Tables of evaluation built upon local precedents, taxonomies based on levels of seriousness, different charts according to the injured part of the body are all aiming to translate harms into a measurable value (namely a number, a variable, a coefficient) in order to then identify an amount for economic compensation. In addition, the presence of different paradigms depending on the source of the illicit conduct increases the disparities, due either to the different interpretations that each legal systems provides to civil liability and to the content of each head of damages, or to the criteria adopted by forensic scientists and applied in courts for compensation.
11. As a result, the same injury with similar consequences on the non-economic sphere of the victim might not be awarded with the same scale. *Viceversa*, also by applying the same forensic scale, the final award might be represented by different amounts also at local level. This constitutes a limit for the equality among citizens' fundamental rights, and strongly impacts on health and care services related to taking in charge the injured person in the rehabilitation and work/life reintegration after an accident or another illicit conduct bringing to harmful consequences to the person. This scenario is confirmed both for low impairments and high incidence disabilities, and for the evaluation of the corresponding so-called dynamic-relational implications to the victim's daily life (*e.g.* moral damage, sufferings, and loss of amenities etc).

### **3. Different criteria but same limits: the comparative overview.**

12. Despite of lots of reform proposals, not only in Italy, but in other EU and non-EU legal systems, personal injury damages compensation is far from being represented by a standardised paradigm, or at least harmonised taxonomies of heads of damages, requiring similar conditions to be awarded: thus, disparities are still detected also at local level, even among similar injuries and circumstances.
13. In France, for instance, attempts to reform the system based on the *Dintilhac nomenclature* have been firstly promoted, then abandoned with the project DataJust, aiming to develop an algorithm to promote new standardisations<sup>12</sup>. In particular, the aim of the project was to select all judgements on personal injury damages compensation issued between 2017-2019 to train an algorithm that should have been able to identify bias on the qualification of the heads of damages and the calculation of awards<sup>13</sup>.
14. The idea to apply data science methodologies to case-law analysis on the matter reflects the common need to identify variables able to better describe and classify facts, injuries, and awards, in order to extract efficient correlations among corresponding legal categories.

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<sup>11</sup> G. CALABRESI, 'Torts: the law of mixed societies' 56 Tex. L. Rev. 519 1977-1978.

<sup>12</sup> T. DOUVILLE, 'Open data des décisions de justice, cinq ans après: état des lieux et perspective', *Légipresse* N° 65, fasc. HS1 (25 gennaio 2021): 49–61, <https://doi.org/10.3917/legip.hs65.0049>. C. DUBOIS, V. MANSVELT, P. DELVENNE, 'Entre nécessité et opportunités : la digitalisation de la justice belge par l'ordre des avocats', *Droit et société*, 3, 2019, pp. 558.

<sup>13</sup> A. BENSAMOUN – T. DOUVILLE, 'Traitement des données personnelles - Datajust, une contribution à la transformation numérique de la justice', *La Semaine Juridique*, Edition Générale n° 19, 11 Mai 2020, 582 ; C. BERNFELD – F. BIBAL, 'DataJust : quand le spectre du barème surgit des brumes numériques', *Issu de Gazette du Palais - n°17 – p. 79*.

However, considering that there is not a unique taxonomy of heads of damages, algorithms shall not only process and classify case-law to define the evolution of the calculation methodologies, but also provide semantic analyses to develop a harmonised taxonomy. Text mining techniques are therefore not sufficient and current models are firstly addressing preliminary challenges, like pseudonymisation of the judgements and their automatic annotation<sup>14</sup>. In this regard, however, also the Spanish experience of the unique *Baremo* for personal injury damages in case of car accidents, including medical and pecuniary values did not solve the problem of lack of standardisation of the awards. Considering the following remarks, we may already anticipate that this new chart includes a reference to the role of prostheses in the injury assessment, but it lists the scenario as an economic cost only, without taking the chance to analyse the possible impact on the improvement of the injured person's quality of life<sup>15</sup>. In this regard, it seems that the paradigm is aiming to compensate damages *per se* and not as a consequence of the event<sup>16</sup>.

15. In Ireland, where the *calcul au point* methodology is not applicable to personal injury damages, new Guidelines have been adopted by the Judicial Council in 2021<sup>17</sup>, in the wake of those applied in England, Wales<sup>18</sup>, in Northern Ireland<sup>19</sup>, and in Germany with the so-called *Schmerzensgeld*<sup>20</sup>. In these systems, tariffs are not provided, but the judicial estimation or dismissal of the claim is based on the peculiarity of the cases according to existing court decisions with similar facts and injury patterns that can be used as an approximate guide, including brackets to suggest the amount of the compensation.
16. Looking at non-EU experiences, for example in Japan, three different standards (CALI, voluntary insurance company, and court standards) are applied to compensate the so-called "residual disability" (*i.e.* permanent impairments) considering fourteen grounds of severity applicable to all harms<sup>21</sup>. In China, judges may exercise great discretion both on *an* and *quantum debeat*, neither tariffs nor guidelines are provided<sup>22</sup>.
17. It is evident that the same (either low or high) injury might be defined with different formulas, evaluated under various parameters, even if it produces similar consequences on the victim enjoyment of fundamental rights. Law uncertainty justifies the high number of judiciary

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<sup>14</sup> G. COMANDÉ – D. LICARI, 'Italian-Legal-Bert models for improving natural language processing tasks in the Italian legal domain', *Computer Law & Security Review*, Volume 52, 2024, 105908, <https://doi.org/10.1016/j.clsr.2023.105908>.

<sup>15</sup> Ley 35/2015, de 22 de septiembre, de reforma del sistema para la valoración de los daños y perjuicios causados a las personas en accidentes de circulación. See M. MARTIN-CASALS, 'Non-pecuniary Losses of Secondary Victims when the Primary Victim Survives: Baremo v. Dintilihac', in E. Karner, U. Magnus, J. Spier, P. Widmer (eds), *Essays in Honour of Helmut Koziol*, Vienna: Jan Sramek, 2020; A. RUDA, 'Spain', in E. Karner, B.C. Steininger (eds), *European Tort Law 2017*, De Gruyter, 2018, 617 ff.

<sup>16</sup> F.D. BUSNELLI, 'Chiaroscuri d'estate. La Corte di Cassazione e il danno alla persona', *Danno e responsabilità*, 2003, p. 816.

<sup>17</sup> Irish Law Reform Commission, 126-2020.

<sup>18</sup> K. OLIPHANT, 'VII. England and Wales', *European Tort Law Yearbook*, vol. 11, no. 1, 2021, pp. 133-149. <https://doi.org/10.1515/tortlaw-2022-0007>. O. RIECKERS – S. GERDEMANN – A. SEIDEL, *Tort Law in Germany*, Wolters Kluwer, 2023. In German law, in 2002 reformed the German Civil Code (BGB), drafting a new Section 253 Paragraph 2.

<sup>19</sup> THE JUDICIAL BOARD OF NORTHERN IRELAND, 'Guidelines for the Assessment of General Damages in Personal Injury Cases in Northern Ireland', 2024.

<sup>20</sup> A. SLIKYZ, 'Schmerzensgeld 2024: Handbuch und Tabellen', Ch Beck, 2024.

<sup>21</sup> E. MATSUMOTO, 'Tort Law in Japan', in M. Bussani - A. Sebok (eds.), *Comparative Tort Law*, Elgar, 2021, p. 373 ff.

<sup>22</sup> C. DING – Z. PEI (2022), 'An Empirical Study of Pain and Suffering Awards in Chinese Personal Injury Cases', *Hong Kong Law Journal*. 52(3), p. 1194 ss.

disputes on that matter<sup>23</sup>, where unequal treatments are replicated also in case of extra-judiciary settlement.

The attempts of standardisation focused on the identification of a correlation between known variables (like age and impairments) of the injured person are falling on the premises as under the forensic science there are different approaches towards the translation of a harm into a certain grade of disability. The attempts related to look at the severity in terms of limiting functionalities might meet bias related to the absence of an objective parameter to compare each decision with.

To this end, a new methodology is required to overcome these issues and provide new opportunities of standardisation and harmonisation.

## 4. The role of bioengineering and biorobotic studies

18. Thanks to the advances in bioengineering and biorobotic studies, the injured person might start innovative treatments and rehabilitation paths aiming to restore organs and tissues' autonomy and functionalities. This will allow them to enjoy a new chapter of their life, whose differences with the previous one are measurable in terms of impact on the quality of life. As a consequence, to assess the implications of implanting / wearing / using new technologies for given injuries can provide new variables in the *barèmes* aiming to qualify and calculate the extent of the harm caused by a given personal injury.

19. Current studies on robotics, artificial organs implantation, and regenerative medicine therapies are mainly focused on the assessment of their usability to allow the highest level of restoration of organ functionalities and their performance, combining the anthropomorphic profiles to improve patients' acceptability and, therefore, their impact on one's quality of life<sup>24</sup>. The assessment aims to market placement, without exploring the regulatory implications connected to the cause of the compromise of health integrity, like the consequences on tort and civil liabilities paradigms. However, it will be increasingly frequent that injured persons would mitigate the consequences of an accident through the support (or not) of (less or more invasive) technological solutions.

The scenarios below will better describe how the mentioned approach can produce positive implications on standardising the mechanisms applied to compensation paradigms.

### 4.1. Implantable prosthesis and a new concept of permanent impairments

20. Implantable prostheses are those technologies replacing missing organs. They can be classified into passive or active ones considering their capacity to restore organs functionalities: for example, a glow that reproduces the organ without providing any (or providing very limited) support to movements healing, and an artificial hand. The latter might be classified in body-powered, where some basic functionalities are reconstituted, or myoelectric ones, where an

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<sup>23</sup> B. DRISCOLL – A. RAMINEZ, *Personal Injury Lawsuit Guide*, Forbes, 2024, <https://www.forbes.com/advisor/legal/personal-injury/personal-injury-lawsuit/>.

<sup>24</sup> C. PIAZZA, G. GRIOLI, M.G. CATALANO, A. BICCHI, 'A Century of Robotic Hands', *Annual Review of Control, Robotics, and Autonomous Systems*, vol. 2, 2019, pp. 1–32, <https://doi.org/10.1146/annurev-control-060117-105003>, C. CIPRIANI, 'Towards prosthetic limbs and assistive devices controlled via the myokinetic interface', *Nature Reviews Electrical Engineering*, vol. 1, no. 5, pp. 282–283, 2024; S.P. BAKER, B. O'NEILL, W. HADDON JR, W.B. LONG, 'The Injury Severity Score: A Method for Describing Patients with Multiple Injuries and Evaluating Emergency Care', *Journal of Trauma*, vol. 14, 1974, pp. 187–196.

electric control system connected to muscles helps to restore not only functionalities, but also sensitivity.

According to the current scientific evidence, after the rehabilitation, the injured person in case of prosthesis implant may enjoy a quality of life that is comparable with the one before the accident<sup>25</sup>.

This is due to a series of improvements in terms of motor functionality, anthropomorphism, and performance features that are characterizing the current devices placed in the market.

In particular, the so-called motor functionality ground addresses the body support during the stance phase, the balance, the ground clearance, the energy requirements for movements propulsion, as well as the absorption of possible shocks of each device. In addition, considering the same levels of motor functionality, the same prosthetic device might be designed to enhance different levels of anthropomorphism features, to which different costs are also associated. For example, size and cosmesis features might achieve a higher or lower level of acceptability also in terms of aesthetic components. Finally, also the performance constitutes a variable to be assessed considering the different role of the prostheses to recover an injury: physiological speediness and prehension forces might be essential for limbs, while not for orthodontic or breast prostheses whereas other features are required, like the stability, or the degree of conicity are instead assessed<sup>26</sup>.

21. The policy making challenge consists of developing mechanisms where if clinical and legal conditions are met<sup>27</sup>, a therapeutic path including the organ replacement and rehabilitation might be offered by the defendant or its insurance company instead of economically defining the amount of the damages compensation.
22. Within the case of an upper limb prosthesis, like an artificial hand, for example, to support costs of the implantation, rehabilitation, and maintenance might be a more efficient solution than a lump sum awarded for pain and suffering associated with the limb amputation and judicial costs to set the dispute. After the implantation and consequent rehabilitation activities - that can range from six months up to one year - the injured person is supposed to enjoy the same daily routine lived before the amputation, or at least the permanent implications of the accident could be re-assessed under these new circumstances.

This means that instead of a permanent impairment that requires a prognostic evaluation from the accident to the life expectation, we are firstly dealing with temporary impairments with different therapeutic paths that can be followed, and then to a residual gap to be covered in terms of, generally, non-pecuniary losses. The permanent loss may evolve considering the chosen option of treatment and rehabilitation: thus, the monetary compensation assessed once that impairments are consolidated might be re-assessed in case of prostheses or artificial organs successfully implanted or other biorobotic solutions applied. After tailored rehabilitation paths, the patient could have restored a higher degree of functionality and autonomy. Thus, the improvement of the quality of life of the injured person might be at least partially restored, requiring a further assessment of the residual permanent loss.

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<sup>25</sup> F. CORDELLA, A.L. CIANCIO, R. SACCHETTI, A. DAVALLI, A.G. CUTTI, E. GUGLIEMELLI, L. ZOLLO, 'Literature Review on Needs of Upper Limb Prosthesis Users', *Frontiers in Neuroscience*, 10 (2016), DOI: 10.3389/fnins.2016.00209.

<sup>26</sup> M. CONTROZZI, C. CIPRIANI, M.C. CARROZZA, '*Design of an artificial hand: a review*', *The Human Hand as an Inspiration for Robot Hand Development*, Springer International Publishing, 2014, 219-246.

<sup>27</sup> Clinical conditions refer to the patient's eligibility, while the legal ones are referred to ensure a freely given informed consent of the victim to start such an alternative rehabilitation as well as disputes resolution path, L. PALAZZANI, 'Informed consent, experimentation and emerging ethical problems', *BioLaw Journal*, 2019, I, <https://doi.org/10.15168/2284-4503-397>.



23. The heads of damages according to the Italian system could be the following ones.

- i. pecuniary losses including costs associated to the implantation, rehabilitation, and maintenance, including therefore the first device and the possible other ones considering the related life cycle of the product and the loss of earnings if demonstrated;
- ii. temporary non-pecuniary losses from the accident to the conclusion of the rehabilitation path, including the hospitalisation, related to pain and suffering and loss of enjoyment of life;
- iii. possible non-pecuniary losses resulting from the residual disability degree of the injured person.

Respect to the current paradigms, this approach will provide a more homogeneous calculation of the awards. In addition, it will ensure an overall enhancement of the quality of life of the injured person respect to the simple provision of damages compensation.

For example, an accident that brought the right-hand amputation in a 30-year-old person is actually considered with different heads of damages and *barèmes* in each legal system. The table below shows just few references on the Italian, French, and Irish systems to bring the attention on possible assessments.

	<b>Forensic <i>Barème</i></b>	<b>Heads of damages</b>	<b>Possible award</b>
<b>Italy</b>	65% Permanent Impairment applying Court of Milan <i>Barèmes</i>	<i>Danno biologico dinamico relazionale + sofferenza soggettiva interiore</i>	€ 728.824
<b>France</b>	40-50% AIPP (Atteinte à l'Intégrité Physique et Psychique) or DFC Déficit Fonctionnel Permanent	<i>AIPP</i> <i>Dommage corporel</i>	€ 2500 (unit value of AIPP) *45 (medium AIPP) = 112.500 €
		<i>Préjudice d'agrément + Pretium doloris</i>	0 < X€ < 60.000 <i>ie</i> the value is assessed between 0 and 60.000 € 0 < X€ < 80.000 <i>ie</i> the value is assessed between 0 and 80.000 €
		Total	Minimum 112.500 € Max 252.500 €
<b>Ireland</b>	The Book of Quantum specifies that “ <i>each case will need to be assessed on its individual merits. Such factors would include, above or below elbow, above or below wrist, dominant hand, appearance, use of prosthetic, age, gender and occupation impacts</i> ”. The Personal Injuries Guidelines refers to: “ <i>this bracket will apply to injuries where the capacity of the hand has been severely reduced (..) resulting in gross</i>	Severe and permanent conditions that will include more complex and multiple injuries with ongoing permanent pain and dysfunction to the arm.	€50.000 to €150.000

	<i>diminution of grip and dexterity with cosmetic disfigurement</i>		
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Table 1. Right-hand amputation compensation under the Italian, French, and Irish systems.

24. The samples show various criteria to be assessed in the concrete case, providing different range of monetary translation of the injury into a monetary amount. Conversely, costs associated with the same hand prosthesis considering equal conditions of treatment and rehabilitation will be easier to compare, considering that products and services could just be adapted to the general market costs for each legal system. The efficacy and performance of the prosthesis is also assessed with the same parameters for each injured persons despite of their nationality/domicile. Time of rehabilitation depends on each person within the general clinical prescriptions, that – again – are not nationally based. However, the calculation will be referred to a daily rate to be multiplied by days of fully/partially limited autonomy of the injured person. It will remain to calculate the “residual damage” with parameters that shall be identified through the assessment of the given device on that specific person.

## 5. Building a new *barème* for “residual damage”: methodological remarks

25. The new envisaged paradigm shall constitute a necessary adaptation of the current systems, considering the opportunities provided by the technological advancements in healthcare. To catch the standardisation enablers, new variables shall be detected from the existing monitoring activities related to the improvement of the patients’ quality of life. In fact, to analyse the benefits of a technological solution applied to persons, it means to identify objective parameters aiming to measure its efficacy and effectiveness, but also to collect information about the rehabilitation paths and the implications on the way to living together with the given allied technology. In this regard, two different methodologies can be combined to enrich the variables that can characterize a new *barème* for personal injury damages compensation adapted to the current technological advances.
26. The first one refers to the compliance with the obligations stated in the EU Medical Devices Regulation<sup>28</sup> that is entering into the final step of application during upcoming months. Its notions and procedures are extremely useful to identify variables to be applied in a standardisation process for assessing personal injury damages. For instance, the notion of Medical Device, that includes “*any instrument, apparatus, appliance, software, implant, reagent, material*” etc. also aiming to “*(...) treatment or alleviation of disease (...), compensation for an injury or disability (...), investigation, replacement or modification of the anatomy or of a physiological or pathological process or state (...)*” can support the standardization process among the legal systems. In fact, a valuable classification of existing devices – that are globally applicable - is supposed to be available together with information related either to their safety or performance benchmarks<sup>29</sup>. This information could be processed to identify the variables required to improve the quality of life after a serious permanent injury. Furthermore, considering the necessity to start a clinical investigation to get the CE certification, volunteers – thus persons with a certain degree of disability - shall necessarily

<sup>28</sup> EU Reg. 2017/745 on Medical Devices Regulation.

<sup>29</sup> A. NÜSSLER, ‘The new European Medical Device Regulation: Friend or foe for hospitals and patients?’, Injury, Volume 54, Supplement 5, 2023,110907,<https://doi.org/10.1016/j.injury.2023.110907>.

have been participating in a trial that could have provided (or provide to this specific end) useful information on the effective relational and dynamic implications of the allied technology supports in their own real-life context.

Such a material could be accessible, upon the proper organisational and technical safeguards for the purposes of general interest to build up a more standardised methodology for personal injury damages assessment.

In particular, it can be used to extract new objectively measurable variables suitable to be introduced in the current *barème*: namely, the degree of restored functionality after the injury or the coefficient of acceptability linked to the performance of the given device. This information could be assessed as a positive element in the residual disability evaluation. Therefore, the impairment originally classified under a certain degree of disability shall be balanced with the re-acquired functionality with a consistent reduction either of the grade of disability or of the corresponding amount for compensation.

27. The second branch of science that could contribute to design a new *barème* is the Health Technology Assessment one. In fact, it provides systematic evaluations of the properties and effects of a device, including both direct and indirect consequences, with the aim to enhance the decision-making process of the stakeholders in terms of market placement<sup>30</sup>. In this regard, the quantitative results of their analysis can be also useful to determine coefficients of performance/acceptability of the given device to be added in the formula aiming to define the monetary value of the personal injury. While the qualitative analyses could find application to determine harmonised ranges of individualisation, that can impact on the judges' decision on the calculation of the awards.

By introducing new variables to describe what disability means when a certain degree is assessed to verify the consequences of an accident and then re-assessed in order to evaluate the rehabilitation path, especially if the injured person could keep pursuing in its normal life thanks to the implantation or the support of specific devices or technologies that can nowadays replace human organs.

28. These new interpretations of the concept of disability introduce a reversible dimension of personal injury damages: prognostic evaluation for *pain and sufferings, danno biologico, dommage corporel et similia* requires amendments in terms of identifying standards to recognise that thanks to the scientific progress, allied technologies can entirely or partially restore a given loss. In order to shape these standards, parameters adopted for testing relative benefits could be processed as a coefficient, thanks to their attitude towards objectivization, while the results of the quantitative and qualitative improvement of patients' lives as possible variables to be applied case-by-case.

29. This methodology could shape a more efficient paradigm for non-pecuniary losses compensation, suitable to state whether -and to which extent- to restore functionalities and performance of the injured organs through innovative solutions is mitigating (or even nulling) some or all consequences of the originally assessed degree of disability.

Costs associated to prosthesis and their maintenance are measurable: in fact, the new Spanish *Barème* has already introduced them in the calculation of the costs associated to the *daño biológico* for amputees. According to our proposal, they are associated to temporary impairments more than on the calculation of permanent one. Or at least, a coefficient to correlate temporary impairments, costs of the biorobotic solution, and the effective improvement of the quality of life, might be extracted and calculated – through mathematical

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<sup>30</sup> HTA CG, 'Guidance on outcomes for joint clinical assessments', 2024, [https://health.ec.europa.eu/document/download/a70a62c7-325c-401e-ba42-66174b656ab8\\_en?filename=hta\\_outcomes\\_jca\\_guidance\\_en.pdf](https://health.ec.europa.eu/document/download/a70a62c7-325c-401e-ba42-66174b656ab8_en?filename=hta_outcomes_jca_guidance_en.pdf)

models that shall be still designed – to better calculate the residual damage, according to the levels of performance, autonomy and anthropomorphism obtained in the concrete case.

Temporary Impairments	Costs of the prosthesis and its maintenance	Residual damage Correlations between the following:
180 days * day rate	Prosthesis A = 15.000 Prosthesis B = 30.000 etc	100% - (coefficient of performance*Value1) 100% - (coefficient of acceptability*Value2)

Table 2. Heads of damages paradigm considering the impact of prosthesis.

## 6. Broader systemic implications

30. The concept of disability becomes therefore as a fluid and reversible one, not only linked to the degree of permanent impairments recognised by the medical expert after the accident but also connected to the level of usability and acceptance of an allied technology. Legal systems are usually, for certainty purposes, establishing a limit delay, called “consolidation time” of the impairment that corresponds to the medico-legal assessment during the judgement at the end of the investigation phase. This is necessary to establish the value to be awarded and allow the decision to become final. The different clinical treatment including biorobotic solutions, instead, are introducing the necessity to define further steps of evaluation, as the success on the restoration of the injured organ functionalities and autonomy might require few months of rehabilitation. Incentives shall at least be introduced in terms of law and economics to provide incentives for reducing the consequences and costs of an injury.
31. The sample of limb prosthesis is particularly effective because the amputation of the organ is easily to be recognised as a permanent impairment truly limiting the injured person in his realisation as human being. According to their level of efficacy, performance, and acceptability, each kind of prosthesis could provide a different degree of improvement of one’s quality of life, up to completely restore the opportunities of one’s personal realisation, or even shaping additional possibilities to even improve own perspectives.  
In general, it shall come up to consideration the fact that the prognostic evaluation of the permanent compromise of the health integrity might be indeed “reversible”<sup>31</sup> if the injured person is eligible to start a rehabilitation path including the implantation of artificial organs and prostheses.  
To this end, disability can be maintained as a category, describing the compromise of psycho-physical integrity as ascertained by forensic science, without necessarily determining a loss in terms of enjoyment of life. Therefore, the economic evaluation in terms of *danno biologico, damage corporel et similia* could be assessed in at least two different steps: the first one, immediately after the accident, then, the second one, if the insurance company or the defendant covers costs of the injured party to start a rehabilitation path to reduce the final consequences, another assessment shall be scheduled at the end.
32. In this scenario, a balance in terms of law and economics remarks shall be identified both on the side of the insurance companies and at institutional level. In fact, to take in charge the injured party does not only mean to provide an opportunity to reduce the impact of a given

<sup>31</sup> Please let me refer to a preliminary remark on the topic, D. AMRAM, Post fata resurgo. *Innovazione tecnologica e medicina rigenerativa: l’impatto sul danno alla persona*, in *Rivista italiana medicina legale e del diritto in campo sanitario*, 2021, pp. 1 ss.

injury on the person's life, but also to take care today that certain healthcare services are provided to avoid the institutional costs of a person that is probably getting older with a more serious injury. In terms of sustainability, thus, the proposed methodology of designing a more complex *barème* might strongly impact on several sectors, like the social security and healthcare systems, private insurance market, not limiting its implications to the one-to-one tort law mechanism between the plaintiff and the defendant.

In practice, however, costs related to the surgery or to implant a prosthesis or another allied technology shall be covered according to the applicable liability paradigm. The latter shall be ascertained or unquestionable to efficiently propose an alternative path of rehabilitation instead of a lump sum.

From this perspective, social security systems appear to be the more suitable to adopt the option to propose the injured person to cover the costs of a rehabilitation path, including the implantation of a prosthesis, as an alternative to monetary compensation. However, a proper management of the costs/benefits analysis shall also consider that the taking in charge for a rehabilitation path package should remain as an option for the injured party / victim, as only the given person could dispose about her own body: the principle of autonomy and the right to health shall be always interpreted considering the dignity of individuals.

Therefore, according to the invasiveness of the procedures on the human integrity and the current state of the art of allied technologies, the victim shall also be able to decide to receive the "traditional award" for damages compensation, maintaining the level of occurred and ascertained disability.

This approach could change in alignment with the future evolution of technologies, if what today is considered as an invasive and innovative, it will become an ordinary scenario for patients. In fact, the damage minimisation obligation for the victim of an illicit conduct, that in Italy is stated in article 1227 of the Civil Code, in France at article 1240 of the Civil Code, in Ireland under section 34(2)(b) of the Civil Liability Act 1961, etc. will remain applicable.

33. An additional remark under the general paradigm might also be explored: the one related to the evidence that the defendant could provide during the second assessment of the personal injury damages related to the possible enhancement of the quality of life of the injured person *de facto* emerging by the new life conducted because of the allied technologies support is improved.
34. In fact, while the reversibility of the degree of disability is acceptable from a systematic viewpoint, it could be reasonable to set appropriate limits to this process up to the nullification of the harmful (permanent) effects of an injury. In particular, the mechanism of the *compensation lucri cum damno* shall be framed within the limits set by the variables adopted detected to assess the impact of the technologies on one's quality of life.  
In very specific cases, it could appear that the injured person achieves a better quality of life respect to the conditions lived before the accident. For instance, a previous unemployed individual that - thanks to the reserved positions to disabled persons according to the social security system - will find a good job or a job closer to her own home; or the case of a sport passionate player that will success in a competition reserved to persons with disabilities.
35. These scenarios could enrich the debate and could also find different solutions case-by-case based. In light of the principle *tout le dommage rien que le dommage*, traditional legal categories could be interpreted in light of a renewed relationships among the functions of tort liability: deterrence, punishment and compensation component might be combined in a different balance at this stage<sup>32</sup>. However, it seems reasonably to consider that the re-

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<sup>32</sup> G. CALABRESI, 'Torts-The Law of the Mixed Society', *Texas Law Review*, vol. 56, 1977, pp. 519-521; G. COMANDÉ, 'Towards a Global Model for Adjudicating Personal Injury Damages: Bridging Europe and the United States', *Temple Int'l & Comp. L. J.*, vol. 19, no. 2, 2005, pp. 241-369.

assessment of the injury after the rehabilitation path shall be limited to the organ functionalities and performance, without concerning other private-life aspects.

In fact, also in the example of the unemployed person, it is difficult to give evidence that in that delay between the accident, the first assessment and the second one, she would not have taken a job position at all, and therefore she completely benefited from the accident.

## **7. Policy recommendations and further steps**

36. The presented approach requires a tangible validation in practical scenarios with the involvement of all the necessary stakeholders, namely clinicians and bioengineers involved in appropriate clinical trials, experts in health technology assessment, data scientists and statisticians to work on variables, injured persons experiencing the biorobotic solutions and supports, and – of course – forensic scientists, lawyers, and insurers to address the systematic implications on the resulting paradigm.
37. However, some recommendations could be addressed even at this stage to stimulate the debate towards a methodological change to boost standardisation for personal injury damages compensation in alignment with the parameters that are currently shaping the scope of technological innovation.
38. First recommendation is addressed to institutional stakeholders and market players, like insurance companies: the injured-person perspective cannot be limited only to allocate amounts for compensation, providing an economic restoration for the infringement of fundamental rights protection. This is a limiting and limited perspective, whereas the enhancement of fundamental rights requires not only to pay damages, but also to prevent them and to identify the best solution to strengthen human dignity. Technology is ready to improve the quality of life of persons with disabilities, thus it is necessary to allow their implementation in the provision of healthcare services. Public services as well as leaders of a given market are asked to take the challenges offered by technological innovation to improve the wellbeing standards for individuals and groups of persons, especially if they are vulnerable ones.
39. Second recommendation is addressed to professionals, including lawyers and forensic scientists, to think bigger in their negotiation activities as a higher level of well-being and satisfaction could be achieved for both parties if the negative implications of a tort are limited or can be limited and a level of quality of life close to the one enjoyed before the accident will be achievable in the concrete case.
40. The third one is addressed to scholars to open their research activities towards interdisciplinarity to contribute to this standardisation process.