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LIFE EXPECTANCY AND EXCESS MORTALITY OF TRAFFIC ACCIDENT VICTIMS

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The workgroup entitled "Life expectancy and excess mortality of traffic accident victims" was tasked by the French Automobile Commission with the objective of identifying scientific studies conducted on several markets and of providing an analysis of potential life expectancy and excess mortality consecutive to an accident event.

A number of studies were thus identified throughout the world notably in the United States, Finland and Australia. They concern two distinctive types of victims: those with medullary lesions (spinal cord and spinal marrow injuries by fracture, dislocation or compression) and severe traumatic brain injury (head injuries leading to cognitive and/or neurological deficit).

For persons with spinal cord injury (SCI), although their life expectancy has improved over the years, they still risk an earlier death than the rest of the population as they are exposed to a certain number of health issues. It is primarily in the first year following the injury that the risk of death is the highest. Life expectancy for victims with spinal cord injury is correlated with the severity of the injury. Resultantly, patients with tetraplegia run a higher risk of death than those with paraplegia. In high-income countries, secondary disorders are no longer the primary cause of death. This applies primarily to respiratory and urological problems, and in some cases heart conditions, neurological disorders or suicide.

Studies on people with traumatic brain injuries (TBI) are less numerous and tend to provide similar results. The severity of the disability is the most important factor to long-term victim survival. If the patient survives beyond the first twelve months following the injury, the complications thereafter include respiratory problems, the results of a stroke or behavioral disorders.

In addition to the analysis of mortality studies that were identified by the workgroup, the approach was broadened to include France and its neighboring countries. The issue of high mortality rates for traffic accident victims has never been effectively developed in France with respect to compensation for bodily damage. In March 2015, a memorandum of understanding between insurance companies and social agencies (*POAS*) extended a reduction in the annuity conversion rate to other types of victims. Within the French compensation system, it is difficult to clearly establish actual figures and even though all those involved share a number of impressions (possible high mortality rate in the early stages of the accident, shortened life expectancy), these impressions have not yet been taken into consideration.

In certain neighboring countries (Spain and the UK), authorities give consideration to excess mortality in the compensation system. Two approaches are used to integrate a mortality rate assumption into the compensation procedure. The first is to adopt specific mortality tables (Spain, Switzerland) that take excess mortality into consideration. The second is to set a duration for life expectancy according to expert opinion (UK, Israel) and on a case-by-case basis. In the new Spanish "*baremo*" (scale of indemnity), there is a specific table for severely injured victims that considers the assumption of a reduction in life expectancy. In the United Kingdom, studies are regularly conducted on Periodic Payment Orders (PPOs) by the General Insurance Research Organising (GIRO) committee. Data on the reduction of life expectancy established by medical experts are shared with other organizations. Medical experts provide an estimate of the reduction in life expectancy to two thirds of victims with TBI and almost all (97%) of those with SCI.

The workgroup wrote a memorandum presenting the different analyses it conducted on the studies identified. If you should require further information on certain points, you may find analyses of victim typology, spinal cord patients or patients with traumatic brain injuries in the annex section.

In 2014, the French Automobile Commission established a workgroup entitled "Life expectancy and excess mortality of traffic accident victims" that was tasked with the objective of identifying scientific studies conducted on several markets and of providing an analysis of potential life expectancy and excess mortality consecutive to an accident event.

The topic of "Life expectancy and excess mortality of traffic accident victims" was studied by the workgroup over an extensive period and the results are summarized in this memorandum in accordance with the following plan:

I. List of identified studies,
II. Typology of injuries / sequelae,
III. Focus on Spinal Cord Injury (SCI),
IV. Focus on severe Traumatic Brain Injury (TBI),
V. Focus on France and neighboring countries.

If you should require further information on victim typology, spinal cord patients or patients with traumatic brain injuries, you may find the following areas of interest in the annex section:

1) Detailed definitions of victim typologies,
2) Life expectancy for patients with Spinal Cord Injury (SCI),
3) Life expectancy for patients with severe Traumatic Brain Injury (TBI).

In order to achieve their objective, the members of the workgroup began by identifying the numerous studies published in the different countries concerned (USA, Australia, UK, etc.).

This memorandum therefore begins with the list of the identified studies.

I. <u>List of identified studies</u>

The document below is supported by the studies mentioned in this summary and organized by type of injury:

- **Spinal Cord Injury (SCI)**
  - Document published by the World Health Organization in 2013: "International Perspectives on Spinal Cord Injury"
  - *Finnish* study written by Ahoniemi E., Pohjolainen T. and Kautiainen H. and published in 2011: "Survival after spinal cord injury in Finland"
  - *American* study written by Strauss D.J., DeVivo M.J., Paculdo D.R. and Shavelle R.M. and published in 2006: "Trends in life expectancy after spinal cord injury"
  - *Australian* study written by O'Connor P.J. and published in 2005: "Survival after spinal cord injury in Australia"

- **Severe Traumatic Brain Injury (TBI)**
  - *American* study written by Strauss D.J., Brooks J.C. and Shavelle R.M. and published in 2012: "Long-Term Disability and Survival in Traumatic Brain Injury: Results From the National Institute on Disability and Rehabilitation Research Model Systems"
  - *Australian* Study written by Baguley I.J., Nott M.T., Howle A.A., Simpson G.K., Browne S., King A.C., Cotter R.E. and Hodgkinson A. and published in 2012: "Late mortality after severe traumatic brain injury in New South Wales: A multicentre study"
  - *American* study written by Harrison-Felix C.L., Whiteneck G.G., Jha A., DeVivo M.J., Hammond F.M. and Hart D.M. and published in 2009: "Mortality over four decades after traumatic brain injury rehabilitation: A retrospective cohort study"
  - *French* study written by Choquet M., Falaux B. and Legal G. and published in 2000: "*Les états végétatifs chroniques post-traumatiques: une charge sous-estimée pour l'Assurance-maladie*" ("Post-traumatic chronic vegetative states: an underestimated expense for the French public health system") (panel not comprised solely of victims having suffered traumatic brain injury)

- **Spinal Cord Injury (SCI) and Traumatic Brain Injury (TBI)**
  - *English* presentation written by the GIRO Periodic Payment Orders Working Party and published in 2015: "Payment Orders Working Party 2015 Update Report" This presentation utilizes data collected by *New Zealand* since 1974 and by the state of Victoria in *Australia* since 1987.
  - New Spanish "*baremo*" (scale of indemnity) (June 6, 2014) "*Bases técnicas actuariales del sistema para la valoración de los daños y perjuicios causados a las personas en accidentes de circulación*" (Technical and actuarial bases of the system for the evaluation of damages caused to persons in traffic accidents).
  - Report published on January 24, 2014: "GIRO 2013 report"

The above list of studies found throughout the world indicates the major categories of victims that may be identified. In order to fully appreciate the topic of excess mortality, the workgroup sought to detail the typology of injuries and sequelae for the most severely injured victims.

II. Typology of injuries / sequelae

In reviewing the reinsurance claims for the listed studies and based on the French "Indicative scale for the evaluation of the degrees of disability", we have retained two types of patients maintaining significantly high disability rates:

- **Victims with sensorimotor impairments resulting from spinal cord injury**
  The initial injury affects the spinal cord (rachis) and spinal marrow due to fracture, dislocation or compression. The sequelae are always complex as they combine injuries that impair mobility (prehension), urinary disorders and genito-sexual dysfunctions, respiratory disorders and spinal cord disorders.
  At present, these sequelae, except for certain cases involving compression, are considered irreversible.
  The more severe and profound the injury, the more significant the neurological sequelae:
  - Spinal cord injury affecting the cervical vertebrae -> Tetraplegia
  - Spinal cord injury affecting the dorsal vertebrae -> Paraplegia
  - Incomplete spinal cord injury -> Paresis (Quadriparesis / Paraparesis)

- **Victims with cognitive and neuro-psychological impairments resulting from brain injuries**
  Cranial trauma is a brain injury resulting from a trauma-related event. The principal injuries are caused by the acceleration, the deceleration or the violent rotation of the brain which results in the stretching or shearing of the axons (nerve connections) inside the brain. Severe Traumatic Brain Injury (TBI) can lead to cognitive impairments, neurological impairments or both.

  The severest cases are characterized by a persistent impairment of consciousness that totally (Chronic vegetative state) or partially (Pauci-relational state) limits the patient's capacity to communicate and to interact with his or her environment.
  Contrary to spinal cord injury, it is difficult to appreciate future sequelae on the basis of initial medical assessments. The diagnosis of coma and of its severity (Glasgow Coma Scale of 1 to 15 -> a low score indicates major trauma) enables physicians to provide a prognosis of the severity of the sequalae.

From the perspective of the two major categories of victims, the issues of life expectancy and excess mortality are distinctly different. In the following pages, the study presents two focus sections one on spinal cord injuries and the other on severe traumatic brain injury.

III. Focus on Spinal Cord Injury (SCI)

- **Life expectancy**

The life expectancy of persons suffering from Spinal Cord Injury (SCI) has improved over the years, yet it should be noted that great disparities remain. Although life expectancy for SCI patients is approaching that of the general population in developed countries, this is not the case for patients in less developed countries, due primarily to secondary disorders.

The fact remains that persons suffering from SCI have a higher risk of dying at an earlier age than the rest of the population. This is because they are more likely to having certain health issues. It is primarily in the first year following the injury that the risk of death is the highest.

It would seem, according to some studies for which the references are unfortunately not included in the WHO article[1], that persons suffering from SCI are 2 to 5 times more likely to die a premature death. Additionally, patients with tetraplegia run a higher risk of death than those with paraplegia. It would appear that the capacity of emergency services has a direct impact in the mortality rate.

According to an Australian study dated 2005, C1 and C4 level injured victims, 25 years of age, would have a life expectancy equal to 70% of that of an uninjured person of the same age. Life expectancy also depends on the severity of the injury. The NSCISC website provides rates of life expectancy on the basis of four criteria: age, cause of the injury, level and intensity of the wound.

- **Patients with tetraplegia die sooner than those with paraplegia**

A Finnish study found that the Standardized Mortality Ratio (SMR)[2] for a paraplegic patient is 2.3 compared to 3.0 for a tetraplegic patient. In Australia it is 1.7 compared to 2.2 for a tetraplegic patient. It would appear that the mortality rate is almost double for paraplegic patients with a complete lesion and in some cases triple for tetraplegic patients with a complete lesion.

An American study found that mortality decreased by over 40% between 1973 and 2004 in the first two years following the injury. However, it remained more or less stable beyond this period.

In high-income countries, the secondary causes of death are no longer the primary cause. In these countries, the primary causes were associated with urological and renal failure, while today, in the same way as for the rest of the population, death remains associated with respiratory problems (pneumonia or influenza). However, certain studies shed light on the fact that cardiac arrest, neurological disorders or suicide affect this category of the population more frequently.

In lower-income countries, secondary illnesses that may normally be avoided continue to cause the greatest number of deaths. These include, for example, urological complications or pressure ulcers. It should however be underscored that in these countries there are fewer studies and the reliability of their findings may sometimes be called into question. We are talking in this case of countries that are not necessarily located in Europe, but of developing countries.

This gives rise to the question of the mortality rate for victims of spinal cord injury. Another focus section is devoted to victims of the second greatest category of severe injuries that of traumatic brain injury.

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[1] International Perspectives on Spinal Cord Injury (WHO 2013)

[2] SMR: Standardized Mortality Ratio: The SMR is an estimate of the standardized mortality rate for people with SCI in comparison with the general population. An SMR of 1 corresponds to a normal mortality rate for people with SCI. Excess mortality is represented by SMR > 1.

IV. Focus on severe Traumatic Brain Injury (TBI)

While certain countries such as the United Kingdom, Switzerland or more recently Spain make explicit use of adjusted mortality tables to determine the pension amounts of persons severely injured in work or traffic accidents, there are few public studies on the relationship between traumatic brain injury and future life expectancy.

Only three such studies were analyzed, two published in the United States and one in Australia. Although the findings of all three studies differ, they provide answers to certain questions concerning reinsurers as the ultimate payers of major automobile claims.

The aim of the first study, entitled “Long-Term Disability and Survival in Traumatic Brain Injury: Results from the National Institute on Disability and Rehabilitation Research Model System" published in 2012, is to document the survival of persons having suffered traumatic brain injury as well as the effects of time over the period following the accident and the consequential impact on mortality. It is based on a cohort of 7,228 persons having experienced traumatic brain injury within the previous year and having been admitted to one of the hospitals that are a part of the TBI Model System in the United States.

The second study entitled "Late mortality after severe traumatic brain injury in New South Wales: A multicenter study" was published in 2012. The aim of this study is to determine the long-term mortality rate of adults with traumatic brain injury and to identify the risk factors associated with death. The study is based on a cohort of 2,545 adults having participated in the New South Wales (Australia) rehabilitation program between January 1990 and October 2007.

The third study, published in 2009, is entitled "Mortality over four decades after traumatic brain injury rehabilitation: a retrospective cohort study". This study seeks to underscore the impact of traumatic brain injury on life expectancy as well as on the different risk factors and causes of death for persons having suffered this type of trauma. It was conducted using a cohort of 1,678 persons having survived for at least one year and having been admitted to the Craig Hospital in Colorado.

Research shows above all that the majority of patients suffering from or having suffered traumatic brain injury were victims of traffic accidents. This proportion varies from 58% to 73% depending on the study.

All three studies also found that the proportion of deaths is higher for persons having suffered traumatic brain injury. The number of deceased persons is between 1.5 and 3 times higher than the reference population depending on the studies analyzed. As the statistical bases differ, it is difficult to compare results from one study to the next except by saying that they all pointed to the same conclusions.

Patients with traumatic brain injury who survive beyond the first year run a higher risk than the reference population of dying from respiratory disorders, from the results of a stroke or even from behavioral problems.

It should be noted that the studies do not allow us to conclude whether the age of the patient at the time of the brain injury has an impact on his or her survival. Two of the three studies do indicate that the older the patient is at the time of the injury, the less are his or her chances of survival. On the other hand, the first study concludes that life expectancy for a 40-year-old individual is the same as that for a patient who suffered an accident at the age of 25 or 35.

All the studies arrive at a similar excess mortality rate for victims of severe spinal cord or traumatic brain injuries whether on an objective basis with respect to the first year that follows the accident or on the basis of projected assumptions (statistics or expert opinion) for the following years. The workgroup therefore pursued its efforts by studying the position adopted by France and its neighboring countries on the basis of this prospective excess mortality rate.

V. Focus on France and neighboring countries

1. France

The issue of a high mortality rate for traffic accident victims was never effectively developed in France with respect to compensation for bodily damage.

We did gain knowledge of the modifications made to the memorandum of understanding between insurance companies and social agencies (*PAOS*) in France. The *PAOS* National Joint Committee comprised of representatives of insurance companies and social agencies (National Health Insurance Office - *CPAM*) decided in February 2015 to modify the rules governing the abatement of the annuity conversion rate used to establish the formal bases for recourse of severely injured victims (chronic vegetative state, pauci-relational state and tetraplegia).

PAOS memorandum of March 13, 2015: "For reasons of the changes in the life expectancy of these victims, the abatement, (…), is now
- 50% irrespective of age for victims in a chronic vegetative or pauci-relational state,
- 20% irrespective of age for victims of tetraplegia"

"These provisions, (…), are applicable to all accidents having occurred from January 1, 2013".

Given that the reasons for these modifications were the changes in the life expectancy of severely injured victims, we approached the French Insurance Federation (FFA) to access the studies on which they were based.

We received only two documents:

- Extract of the 2008 informative report relative to patients' rights and end of life (Léonetti law) "In France, there are 1,600 patients in a chronic vegetative or pauci-relational state with an estimated life expectancy ranging from six years (*testimony of Dr. Tasseau, September 2008*) to fifteen years (*testimony of Dr. Aubry, April 2008*)"
- Article published in 2000 in the *Revue Médicale de l'Assurance Maladie* (Health Insurance Medical Journal) entitled "*Les états végétatifs chroniques post-traumatiques: une charge sous-estimée pour l'Assurance-maladie*" ("Post-traumatic chronic vegetative states: an underestimated expense for the French public health system"). Data for the study is taken from a prevalence survey of chronic vegetative patients in the Nord-Pas de Calais region.
  Much information may be extracted from this journal:
    - "(…) the aggregate average mortality rate at one year is 46%. (…) the mortality rate beyond one year is approximately 25% per year. It is 63% on an overall basis for the period from one to five years."
    - "(…) the highest life expectancy for these patients, under optimal nursing conditions, is fifteen to twenty years."
    - "The principal causes of death of these fragile patients are pulmonary infection (55%), heart failure and cachexia (20%), (…). The mortality rate peaks in the first year (46%). Resultantly, life expectancy for these patients is relatively short."

After meeting with the FFA, the discussions between the representatives of insurance companies and social agencies will not be substantiated by the national studies.

The PAOS, by means of this March 2015 memo, foresees a reduction in the annuity conversion rate for a certain typology of victims. The capitalization rate and table from the memorandum of understanding enable the social agencies to calculate the basis for recourse, also established by the Committee on Application. The PAOS memo of May 20, 2015 provides, for the current year, the 2006-2008 mortality table and a capitalization rate of 1.97%.

Within the French compensation system, it is difficult to clearly establish actual figures despite the fact that all those involved share a number of impressions (possible high mortality rate in the early stages of the accident, shortened life expectancy due to an acceleration of aging).

2. Spain

In contrast to France, Spain recently updated its scale of indemnity.
The new "*baremo*" was published on and has been in application since January 1, 2016.

Spain's College of Actuaries provided significant work as well as various tables based on the Spanish population. They defined four levels of permanent disability:

- Level 1: Permanent Partial Disability
- Level 2: Permanent Disability for the Usual Profession
- Level 3: Permanent and Full Disability
- Level 4: Major Disability (requires assistance of a third person)

In the last section (Table 4 Capital-Annuity), we noted the following annuity conversion rates:

	Conversion rates Capital-Annuity life annuity article 11-14		
Age	Death Ref. level	Loss of autonomy Moderate (Level 1 & 2)	Loss of autonomy Severe and very severe (Level 3 & 4)
0	50.93	41.36	36.26
1	50.79	43.87	39.04
...	...	...	...
10	**47.93**	**40.42**	**35.05**
...	...	...	...
18	**44.98**	**37.00**	**31.23**
...	...	...	...
100	**1.00**	**1.00**	**1.00**

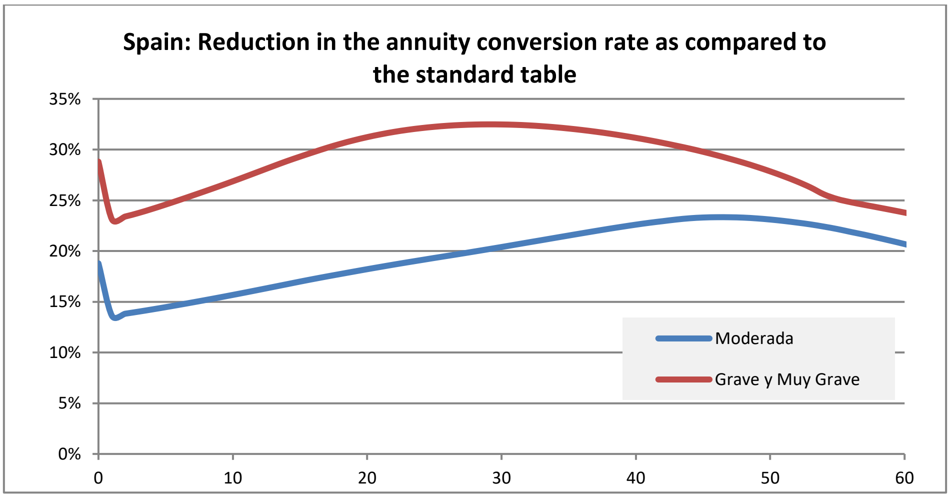
The conversion rate is lower for severe victims compared to moderate victims.
It is clear that the capital-annuity conversion tables take into account the type of disability of the victim and his or her life expectancy.

The college of actuaries applied the following mortality tables:

- Table PEB2014: Spanish population table, data: 1991-2011.
- Table TAS/4054/2005 of December 27 from the Spanish social security system for disability and death
- Swiss tables EVK/F00 used for levels 3 and 4.

The rule for obtaining the annuity conversion rate is identical to the one used in France. Each payment is adjusted using the fixed rate (1.47%) based on a probability calculation using the selected mortality table.

The calculation of the tables is one of the interesting points of the Spanish study as Spain, like all other countries, does not have tables specific to the victims of severe spinal cord or brain injuries. They have however established tables specifically for the populations in question. The method used is described in detail in the study and may be used to create a table of disabled persons. A reference table is applied for the excess mortality rates used in Spain for levels 1 and 2 and outside Spain for levels 3 and 4 (Switzerland).



The above graph demonstrates the significance of the reduction in life expectancy following application of the new scale. This reduction ranges from 23% to 32% for severe victims (levels 3 and 4) with a maximum age of approximately 30. For moderate victims (levels 1 and 2), the reduction ranges from 14% to 23% with a maximum age close to 45.

Spain is therefore one European country that has effectively integrated the mortality rate of severely injured victims into legislature for the compensation of bodily injury. Another neighboring country, the United Kingdom has also entered into discussions on this issue.

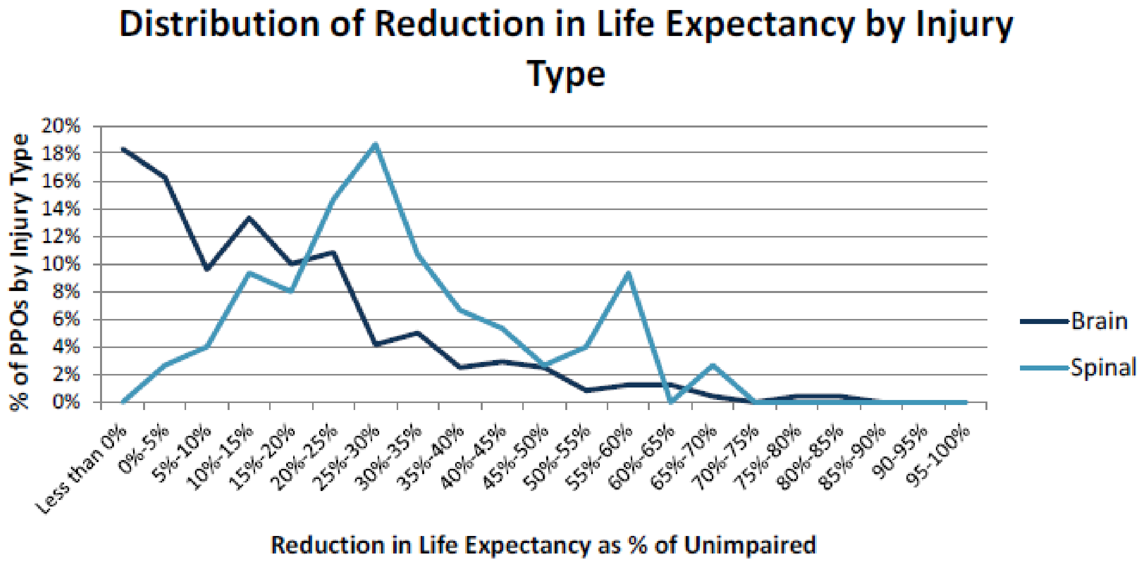
3. United Kingdom

Studies are regularly conducted in the UK on Periodic Payment Orders (PPOs: compensatory periodic payments attributed to victims of severe traffic accidents) by the PPO workgroup of the GIRO (General Insurance Research Organising) committee. Over 90% of the British market as well as the Motor Insurers' Bureau (MIB) participate in the studies by providing data on PPOs. The study gathers information on the 400 victims to whom compensation is awarded: 71% of these victims suffered traumatic brain injury, 22% spinal cord injury and 7% other types of injury.

The GIRO committee is presently focusing its efforts on the issue of excess mortality. The committee has already published a wide number of results that are available on line[3] (frequency of compensatory payments depending on the claim amount, average payment amount, types of traumatic injuries observed, etc.).

In the United Kingdom, when an insurance claim involving severe bodily injuries occurs, almost systematically, two assessments (one by a claims adjuster appointed by the defendant and another appointed by the plaintiff) are conducted in order to evaluate the life expectancy of the victim or victims and adjust compensation accordingly. Data on the reduction of life expectancy resulting from bodily injuries are shared within the GIRO committee.

([3]) http://www.actuaries.org.uk/practice-areas/general-insurance/research-working-parties/periodical-payment-orders-ppos



The above graph demonstrates the distribution of the reduction in life expectancy determined by medical experts at liquidation of compensation depending on the type of injuries (Source: January 24, 2014: "GIRO 2013 report")

Average reduction in life expectancy is estimated by medical experts to be 16% for victims with TBI and 32% for victims with SCI. Medical experts therefore reduce the life expectancy of two thirds of victims with TBI and almost all of those with SCI.

Studies conducted in New Zealand and Australia (state of Victoria) were consulted by the GIRO committee and used in order to publish initial qualitative results based on actual observations. It may be noted that mortality for persons having suffered traumatic brain injury is higher on average than for persons having suffered spinal cord injury.

A publication comprising the results of the data analyses conducted in New Zealand and in Australia has been available since 2015. The publication includes mortality statistics for four categories of severely injured victims (tetraplegia, paraplegia, severe brain injury, moderate brain injury) and for different age groups.
The results published include standardized mortality rates (SMRs) ranging from 2 to 6 depending on the severity classification and the age group. A trend was observed: the SMR decreases with age.

GIRO committee members worked on the implementation of a common severity nomenclature for insurers and reinsurers which should become a standard for the market: 6 severity classifications for traumatic brain injury, 5 types of spinal cord injury and 4 categories of amputation. This new nomenclature shall be applied to the entire panel and analyzed in the years to come.

4. Other countries

- Israel

Life expectancy is assessed on the basis of expert opinion. Future payments up to the time of death are updated using a regulatory rate to calculate the corresponding capital amount.

- Switzerland

Judges use capitalization tables in order to assess damages suffered by victims (Tables and programs by Messrs. Stauffer and Schaetzle). The tables, called activity tables, take into account the probability of death but also the probability of disability.

If a judge is unable to assess the consequences of the injuries with sufficient certainty, he or she may amend the decision within a period of two years from the date on which it is made (article 46, paragraph 2 of the Swiss Code of Obligations).

Conclusions

From the analyses conducted by the workgroup, six points may be noted in response to the objectives tasked to the group by the French Automobile Commission:

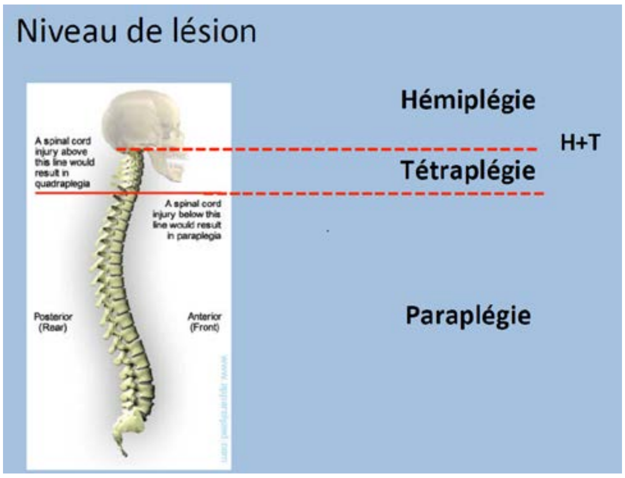
- To date, there are no specific mortality tables based on actual observation of traffic accidents.
- Studies on excess mortality consecutive to an accident event have been made in a number of countries (USA, Australia, United Kingdom, Finland, etc.).
- These studies clearly demonstrate one principle: high mortality rates for severely injured victims are a reality especially in the first years following the accident. However, the studies project excess mortality rates beyond the 2 to 5 years following the accident on the basis of statistical data.
- In France, although all the parties involved share a number of impressions, it is difficult to clearly establish actual numbers.
- In certain neighboring countries (Spain and UK), excess mortality is taken into account in the compensation system.
- Two approaches may be used to integrate a mortality rate assumption into the compensation procedure. The first is to adopt specific mortality tables (Spain, Switzerland). The second is to set a duration for life expectancy on the basis of expert opinion (the UK, Israel).

Annex 1 – Presentation of injuries

In this annex section, taken from literature, we shall address two major types of injuries: spinal cord injury (SCI) and traumatic brain injury (TBI).

Spinal Cord Injury (SCI)

These types of injury are often abbreviated to SCI for Spinal Cord Injury.



Niveau de lesion = Level of injury, *Hémiplégie* = Hemiplegia, *Tétraplégie* = Tetraplegia, *Paralégie* = Paraplegia

Types of injuries:

- Paraplegia/paralysis (spinal cord injury) : paralysis of the lower limbs
- Tetraplegia/paralysis (spinal cord injury) : paralysis of the upper and lower limbs
- Hemiplegia (brain injury or Brown-Séquard spinal cord syndrome): unilateral injury of the central nervous system

Today, complete or incomplete paralysis is defined using the ASIA (American Spinal Injury Association) classification system and ASIA impairment scale.

ASIA Impairment Scale

- **A- Complete**: No motor or sensory function preserved in the sacral segments S4-S5
- **B- Incomplete**: Sensory but not motor function preserved below the neurological level and includes the sacral segments S4-S5
- **C- Incomplete**: Motor function preserved below the neurological level and more than half of key muscles have a muscle grade less than 3
- **D- Incomplete**: Motor function preserved below the neurological level and more than half of key muscles have a muscle grade of 3 or more
- **E- Normal**

Disorders associated with tetraplegic or paraplegic patients

Circulatory System

Autonomic dysreflexia: This condition is characterized by a sudden increase in blood pressure and commonly occurs in people with SCI at or above the T6 level. Signs and symptoms include severe headache, heavy sweating, flushed or reddened skin, blurred vision, body hair "standing on end", and cardiac arrhythmias.

Autonomic dysreflexia is a medical emergency that, if left untreated, may result in serious consequences such as stroke, seizures and death.

Ischaemic heart disease: Ischaemic heart disease was cited as one of the primary causes of death among the SCI population in Australia with a mortality rate significantly higher than that of the general population.

Deep vein thrombosis (DVT): People with SCI are at a high risk of DVT, particularly during the acute and post-acute phases of injury when changes in the normal neurological control of the blood vessels and immobility can result in stasis. DVT can lead to pulmonary embolism and potentially to death, and therefore require rapid treatment with anticoagulant medication.

Hypotension: Orthostatic hypotension is a significant drop in blood pressure when a person moves from a lying to upright position. It affects people with both paraplegia and tetraplegia and is common during the acute phase of injury, although some symptoms may continue to occur later. Symptoms typically include fatigue, light-headedness, dizziness, blurred vision, muscle weakness, and even temporary loss of consciousness. Management involves close monitoring, gradual changes in posture and, where appropriate, provision of medication and salt tablets.

Genitourinary system

Urinary tract infections (UTIs): UTIs are common among people with SCI and have been cited as a major reason for re-hospitalization in high-income countries and premature mortality in developing countries.

SCI has an impact on bladder function, and the use of catheterization can lead to the risk of UTIs.

Noticeable signs and symptoms of UTIs include episodes of urinary incontinence, pain during urination, cloudy urine with increased odor, fever, malaise or lethargy, as well as an exacerbation of other SCI-related complications such as increased spasticity, neuropathic pain and autonomic dysreflexia.

Neuromusculoskeletal system

Spasticity / spasms: Spasticity is a common secondary condition for people with SCI. It can lead to involuntary movements and the development of contractures in joints, which restrict their range of motion and thereby hinder functioning. Management measures include: passive movement or stretching and antispasmodic medications.

Sublesional osteoporosis: Following SCI there is an immediate loss of bone mass, thus increasing the risk of osteoporosis below the level of injury. Inadequate calcium in a person's diet, insufficient vitamin D, aging and inactivity may also contribute to changes in bone density. If osteoporosis is present, people with SCI are at a higher risk of bone fractures, which may be sustained easily during everyday activities such as transfers. Given the immediate loss of bone mass following SCI, early management of bone health is particularly important.

Examples of interventions are: biophosphonates (medications to prevent or treat decline in bone mass), together with vitamin D and/or calcium; weight-bearing activities; and electrical stimulation. However, evidence regarding their effectiveness is limited.

Heterotopic ossification: Heterotopic ossification is a condition that results in abnormal bone formation in the soft tissues around affected joints below the level of SCI such as the hips, knees and, in cervical injuries, the shoulders and elbows. Heterotopic ossification restricts the range of movement in joints and therefore can have a significant impact on functional outcomes for people with SCI. Early detection through bone scans or X-rays is important. As the cause of heterotopic ossification is unclear, its management can be challenging. The limited evidence available suggests that early provision of anti-inflammatory medication can be effective in reducing the risk of developing heterotopic ossification. Treatment such as medication and radiotherapy may help to stop the progression of heterotopic ossification, and surgery may be useful in improving the range of motion of affected joints.

Respiratory system

Respiratory function: Lung capacity, ease of breathing and the ability to cough and clear secretions are often compromised following SCI as a result of paralysis of muscles associated with breathing. People who experience high-level tetraplegia are particularly vulnerable. People with an SCI at and above C3 may require constant mechanical ventilation or implantation of a phrenic or diaphragm pacemaker to maintain adequate breathing. Some people may have a tracheostomy inserted during the acute stage of care.

Respiratory complications: Pneumonia, atelectasis (collapsed lung), aspiration and respiratory failure remain major causes of morbidity and mortality in people with SCI. However, with good management, such complications are preventable. Measures include annual influenza vaccination, five-yearly pneumococcal vaccination, prompt treatment of upper respiratory tract infections with antibiotics, and early implementation of assisted coughing for people with high-level SCI.

Longer-term management requires: regular assessment and review of respiratory and lung function; short- or long-term mechanical ventilation aids; respiratory muscle training; aerobic exercise; psychological support to develop coping skills, particularly for those dependent on a ventilator; and education for people with SCI and their family members. In some situations a pacemaker can be surgically implanted to help stimulate some of the key respiratory nerves and muscles (e.g. diaphragm) and allow ventilator-free breathing.

Skin

Pressure ulcers: People with SCI are at high risk of developing pressure ulcers as a result of impairments in sensation and mobility. The presence of other behavioral, socio-demographic and medical factors − smoking, nutritional deficiencies, infection, moisture from sweating or incontinence, or co-morbid conditions such as diabetes and pulmonary disease − can increase the risk of pressure ulcers. Pressure ulcers may occur at any time and can have a significant impact on an individual's health and quality of life.

Digestive system

Neurogenic bladder is a disorder that occurs frequently in people with SCI and is associated with a wide number of gastrointestinal problems, including low colonic motility, an increase in intestinal transit time, chronic constipation, abdominal distension and fecal incontinence. People with SCI who suffer from neurogenic bladder often fear having fecal incontinence which can have a major impact on their capacity to take up social activities once again.

Sexual and reproductive function

SCI and its associated disorders can often affect physiological and psychological aspects as well as sexual practices. Men and women can often experience a decrease or a loss of sensation, difficulties in reaching orgasm, difficulties in moving about and of posture, as well as a decrease in self-esteem and confidence. Furthermore, men can suffer from the difficulty or inability to get or hold an erection and to ejaculate, which can have repercussions on fertility. For women, menstruation may be impaired following an accident, but usually returns to normal after some months.

Health maintenance measures for people with SCI

Genitourinary system

- Review bladder management programs regularly.
- Investigate further if there are changes in bladder function (e.g. urinary retention, episodes of incontinence, UTIs, blood in urine).
- Test renal function.
- Carry out regular imaging of the urinary tract.
- Conduct prostate cancer screening for men.

Bowel

- Review bowel management programs regularly.
- Investigate further if there are changes in bowel function (e.g. constipation, diarrhea).
- Perform a digital rectal exam routinely from middle age.
- Encourage a high-fiber diet and regular daily fluid (water) intake.
- Carry out regular monitoring of bowel function, including the frequency, color and consistency of stools.

Cardiovascular

- Check cholesterol, lipids and blood pressure regularly.
- Review risk factors (e.g. diet and smoking).
- Provide education and support for control of risk factors.
- Encourage regular aerobic exercise each week.

Mental health and well-being

- Screen and monitor psychosocial functioning (e.g. depression).
- Review capacity of caregivers to provide and sustain support.
- Provide education and support on appropriate diet and exercise.
- Encourage community participation.

Neurological / musculoskeletal

- Review neuromusculoskeletal function, particularly if there are changes in sensation, muscle strength/tone, joint range of movement, or increased pain.
- Provide education and training to prevent injuries due to overuse, particularly in the upper limbs.
- Encourage regular exercise each week.
- Review assistive technology to ensure proper fit and function.

Respiratory

- Provide education on strategies to prevent and manage infection.
- Perform regular respiratory tests (e.g. vital capacity, peak flow).
- Immunize against influenza and pneumococcal pneumonia.
- Provide support and encouragement for cessation of smoking.

Sexual and reproductive function

- Conduct Pap smear and gynecological examination for women.
- Conduct mammogram for women.

Skin

- Provide education on how to perform daily skin checks.
- Provide advice on appropriate nutrition.
- Provide education on changing posture every two hours.
- Review assistive technology regularly to ensure proper fit and function (e.g. wheelchair/seating systems).

Traumatic brain injury

Source: Translated from the French in Wikipédia

The notion of traumatic brain injury (TBI) covers traumatic injury to the neurocranium (the upper and back part of the skull containing the brain) and to the brain. Clinical signs depend on the severity of the impact and on the associated factors (age, other preexisting disorders, associated traumatic injuries). Due to the anatomy of the head region, TBI is often associated with cervical spine trauma (sprain, dislocation, fracture), injuries to the face (contusions, sores, maxillofacial fractures) and eye injuries. The immediate and long-term sequelae associated with TBI are often the consequences of injury to the central nervous system (brain and cervical spinal cord). They are a burden to the victims and their families. Their social and financial cost is high.

Three main categories of traumatic brain injury are clinically recognized: minor (without loss of consciousness or skull fracture), moderate (with initial loss of consciousness of more than a few minutes or with skull fracture) and severe (with brief coma, and with or without associated skull fracture).

Significant progress has been made in terms of the speed of medical treatment and surgical management based on accurate and timely diagnosis of injuries. Despite these advances, over 50% of severely injured patients die or are handicapped for life. Prognosis is therefore most often linked to the importance of early signs and symptoms (at the time of the accident).

Traumatic brain injuries are the principal cause of mortality and severe disability in victims under 45. The principal causes are: traffic accidents (approximately 50%), sports-related accidents, work accidents, accidents in the home, assault.

Glasgow Coma Scale

The Glasgow Coma Scale (GCS) or score provides an indication of a patient's level of consciousness. In an emergency situation, it enables physicians to select the best strategy to maintain vital functions. The scale was developed by G. Teasdale and B. Jennet at the Glasgow (Scotland) Neurological Institute in 1974 for victims of traumatic brain injury.

Scoring is closely correlated to the severity of the coma (risk stratification for complications and spontaneous development).

The scale ranges from 3 (profound coma) to 15 (normal awareness and orientation), and provides an assessment on the basis of three criteria:

- Eye opening response,
- Verbal response,
- Motor response.

Each criterion is given a score. The overall total is the sum of these scores, but the individual scores must also be taken into consideration. For example, patients who are intubated (unable to speak) will always have a verbal response score of 1 even if they are totally conscious. Their maximum total will then be 11 and not 15. This type of additional information is essential to an accurate neurological diagnosis.

Glasgow Coma Scale - Adult		
Eye opening response	**Verbal response**	**Motor response**
1 - No response 2 - To pain 3 - To verbal command 4 - Spontaneously	1 - No response 2 - Incomprehensible sounds 3 - Inappropriate words; cries 4 - Disoriented and converses 5 - Localizes pain	1 - No response 2 - Extension (decerebrate) 3 - Flexion abnormal (decorticate) 4 - Flexion withdrawal 5 - Oriented and converses 6 - Obeys command

The notion of unconsciousness during emergency care corresponds to an overall total of less than 8.

The Glasgow Coma Scale has been adapted for children:

Glasgow Coma Scale - Pediatric		
Eyes	**Verbal**	**Motor**
1 - Does not open eyes 2 - Opens eyes in response to painful stimuli 3 - Opens eyes in response to speech 4 - Opens eyes spontaneously	1 - No verbal response 2 - Inconsolable, agitated 3 - Inconsistently inconsolable, moaning 4 - Cries but consolable, inappropriate interactions 5 - Smiles, orients to sounds, follows objects, interacts	1 - No motor response 2 - Extension to pain (decerebrate response) 3 - Abnormal flexion to pain for an infant (decorticate response) 4 - Infant withdraws from pain 5 - Infant withdraws from touch 6 - Opens eyes spontaneously

Interpretation

15:	Conscious
14 to 10:	Drowsy or slightly unconscious
9 to 7:	Deeply unconscious
6 to 3:	Profoundly unconscious or dead

Prognostics after awaking from coma

Although the Glasgow Coma Scale enables physicians to assess the severity and outcome of traumatic brain injury, it should not constitute the sole means of prognosis. A GCS total score of 12 at admittance to emergency care can deteriorate rapidly depending on the circumstances of the accident and the urgency of the medical situation will oblige emergency personnel to monitor vital signs and work to avoid Secondary Cerebral Injury of Systemic Origin. In this event, it is probable that the GCS is not used to assess the patient's level of consciousness due to the urgency of the situation.

Annex 2 - Life expectancy for patients with spinal cord injury (SCI)

Introduction

This annex section is, in large part, a summary of a document published by the World Health Organization in 2013: "International Perspectives on Spinal Cord Injury". The complete document is available from the WHO website at the following address:

http://www.who.int/disabilities/policies/spinal_cord_injury/en/.

The sections also include the conclusions of a number of articles listed in the document's reference section.

Life expectancy

Improvements in life expectancy & Planning and allocation of resources

Life expectancy of people with SCI has steadily improved over time as a result of advances in medicine and improved access to medical care, rehabilitation and systems of support. While life expectancy is beginning to approach that of the general population in developed countries, it is far from equal in developing countries, where morbidity and mortality rates are likely to remain high without increased investment.

Life expectancy for people with SCI in high-income countries increased alongside a decreased risk of mortality from secondary conditions.

This increase is attributable to improvements in SCI recognition, evaluation, pre-hospital management, trauma care services, general clinical care and rehabilitation service.

People with SCI are likely to die earlier than people without SCI. They are also more likely to die of certain health disorders than people from the general population. Overall, people with SCI are most at risk of death in the first year after SCI onset. People with SCI in low-income countries continue to die from preventable secondary conditions.

Studies have indicated that people with SCI are 2 to 5 times more likely to die prematurely than people without SCI. Research is limited for each period observed by the absence of information between the accident date and the date of death. People with tetraplegia are at higher risk than people with paraplegia. Likewise, people with complete lesions are at higher risk than people with incomplete lesions. Mortality is particularly high in the first year after injury, and mortality rates are strongly affected by the capacity of the health-care system, especially emergency care. (See table below.)

Country	Locality	Years	Pediatric/adult TSCI[4]	SMR[5]
Finland	Helsinki	1976-2005	Adult	2.7
Norway	Hordaland and Sogn og Fjordane counties	1997-2001	Adult and pediatric	1.9
Estonia	Nationwide	1997-2001	Adult and pediatric	5
Australia	Nationwide	1986-1997	Adult	2.1

Another way to assess the effect of SCI is to consider its impact on life expectancy: "How long a life can someone expect to live?" Few studies compare people with SCI to the general population.

However, one Australian study showed that individuals with a spinal cord lesion between levels C1 and C4 have only 70% of the life expectancy of the general population at the age of 25. The first year after injury has the highest risk of mortality for people with SCI. Among people with SCI, mortality risk depends on the level and severity of the injury.

The table below applies to the case of a 25-year-old-male having suffered an accident and survived at least three years.

<table>
<tr><th colspan="2" rowspan="2">Life expectancy</th><th colspan="3">Intensity (ASIA level)</th><th rowspan="2">General population</th></tr>
<tr><th>A</th><th>B&C</th><th>D</th></tr>
<tr><td rowspan="5">Locality</td><td>C1-3</td><td>25.4</td><td>32.2</td><td rowspan="5">44.7</td><td rowspan="5">50.9</td></tr>
<tr><td>C4</td><td>26.4</td><td>34.9</td></tr>
<tr><td>C5</td><td>30.0</td><td>35.7</td></tr>
<tr><td>C6-C8</td><td>34.7</td><td>36.7</td></tr>
<tr><td>T1-S5</td><td colspan="2">37.6</td></tr>
</table>

(Reference 131)

[4] TSCI: Traumatic Spinal Cord Injury

[5] SMR: Standardized Mortality Ratio: The SMR is an estimate of the standardized mortality rate for people with SCI in comparison with the general population. An SMR of 1 corresponds to a normal mortality rate for people with SCI. Excess mortality is represented by SMR > 1.
The requirements for calculating the SMR for a given cohort are as follows:
- The number of people with SCI by age group and by sex;
- Observed deaths among people with SCI;
- Age and mortality rate by sex for the general population.

In the most severe of cases (complete lesion at the C1-C3 level), the study estimates excess mortality to be approximately 50% for the three years following the accident. For D-level victims (minimal neurological deficit), the estimated rate is 88%.

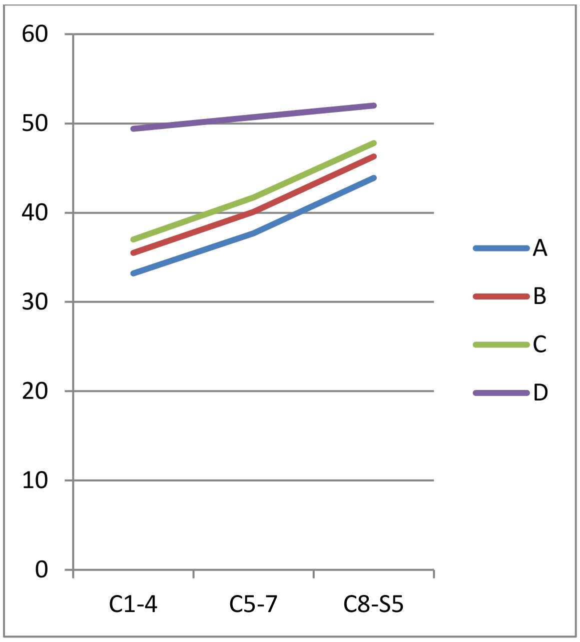
This table was updated by the National Spinal Cord Injury Statistical Center (NSCISC) using generally less significant reductions in life expectancy. The life expectancy calculator used to generate these data is available at the website of NSCISC.

Life expectancy based on the intensity and location of the spinal cord injury

		Age								
Level	Intensity	20	25	30	35	40	45	50	55	60
Normal		56.2	51.6	46.9	42.2	37.6	33.1	28.8	24.7	20.8
C1-4	A	33.2	29.4	25.7	22.5	19.3	16.4	13.9	11.7	9.5
	B	35.5	31.6	27.8	24.4	21.1	18.0	15.3	12.9	10.5
	C	37.0	33.1	29.2	25.7	22.3	19.1	16.3	13.8	11.3
	D	49.4	45.0	40.6	36.5	32.5	28.6	25.0	21.5	18.2
C5-7	A	37.7	33.8	29.8	26.3	22.9	19.7	16.8	14.2	11.7
	C	41.7	37.9	33.5	29.7	26.0	22.6	19.5	16.6	13.8
C8-S5	A	43.9	39.6	35.5	31.6	27.8	24.2	21.0	17.9	15.0
	C	47.8	43.5	39.2	35.1	31.1	27.4	23.8	20.5	17.3

Reasons; Traffic accident / fall

Life expectancy for a 20-year-old victim



Life expectancy based on sequelae and age, 24 hours or 1 year post-injury

	Age at Injury	No SCI	AIS D – Motor Functional at Any Level	Para	Low Tetra (C5-C8)	High Tetra (C1-C4)	Ventilator Dependent Any Level
For persons who survive the first 24 hours	20	59	52.0	44.6	39.6	35.3	18.6
	40	40	33.7	27.2	23.1	19.7	8.4
	60	22.7	17.5	12.7	9.9	7.8	2.0
For persons surviving at least 1 year post-injury	20	59	52.4	45.1	40.4	36.6	24.9
	40	40	34.0	27.7	23.7	20.7	12.3
	60	22.7	17.7	13.0	10.3	8.4	3.7

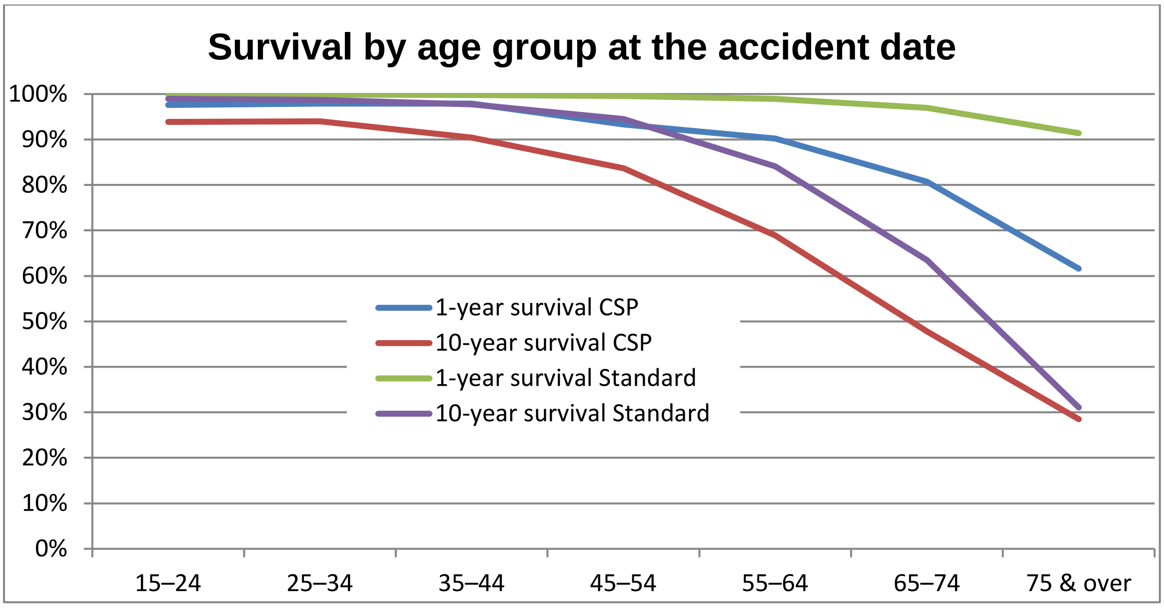
A summary by the NSCISC (Ref 1) provides the following figures. Unlike the figures provided above, the intensity of the sequela is not broken down in the results and corresponds therefore to the average of the possible levels of intensity.

The table below (Ref.129) provides the Cumulative Survival Proportion (CSP) and the Relative Survival Proportion (RSP) for one or ten years of survival

		1-year survival			10-year survival			1-year	10-year
		CSP	RSP	Compare to ave.	CSP	RSP	Compare to ave.	Standard	
All cases		94.3%	95.0%		85.7%	92.1%		99.3%	93.1%
Age at injury (y)	15-24	97.6%	97.7%	2.8%	93.9%	94.9%	3.0%	99.9%	98.9%
	25-34	97.9%	98.0%	3.2%	94.0%	95.2%	3.4%	99.9%	98.7%
	35-44	97.9%	98.1%	3.3%	90.4%	92.5%	0.4%	99.8%	97.7%
	45-54	93.3%	93.7%	-1.4%	83.7%	88.6%	-3.8%	99.6%	94.5%
	55-64	90.2%	91.2%	-4.0%	68.9%	81.9%	-11.1%	98.9%	84.1%
	65-74	80.7%	83.2%	-12.4%	47.8%	75.3%	-18.2%	97.0%	63.5%
	75 & over	61.6%	67.4%	-29.1%	28.5%	91.7%	-0.4%	91.4%	31.1%
Gender	Female	94.8%	95.5%	0.5%	86.0%	92.7%	0.7%	99.3%	92.8%
	Male	94.1%	94.8%	-0.2%	85.6%	91.9%	-0.2%	99.3%	93.1%
Neurologic level	C1-4	86.8%	87.9%	-7.5%	74.4%	84.2%	-8.6%	98.7%	88.4%
	C5-8	93.6%	94.6%	-0.4%	83.9%	91.7%	-0.4%	98.9%	91.5%
	T1-S5	97.3%	97.7%	2.8%	90.9%	94.8%	2.9%	99.6%	95.9%
Extent	Incomplete	95.5%	96.4%	1.5%	87.0%	95.1%	3.3%	99.1%	91.5%
	Complete	92.4%	92.9%	-2.2%	83.6%	87.8%	-4.7%	99.5%	95.2%

If Multiplicative effect	15-24 C1-4 Complete	88.4%	82.7%	96.1%

NB: Although the effects are multiplicative, the survival rate is 83% for a person between the ages of 15 and 24 with complete high-level tetraplegia. Reduction of life expectancy is not 57% as indicated in reference 131 (25.4/44.7).



Patients with tetraplegia die sooner than those with paraplegia

The Finnish study (Ref. 127) found that the SMR for paraplegia was 2.3 as compared to 3.0 for tetraplegia while in Australia (Ref. 34) the SMR for paraplegia is 1.7 as compared to 2.2 for tetraplegia. The Finnish study also showed that mortality is higher in people with complete lesions as compared to incomplete, with a complete injury nearly doubling the mortality rate of people with paraplegia, and nearly tripling it for those with tetraplegia. Regardless of the date of observation of the SMR, we noted that the SMR estimate for a tetraplegia is higher than that of a paraplegia.

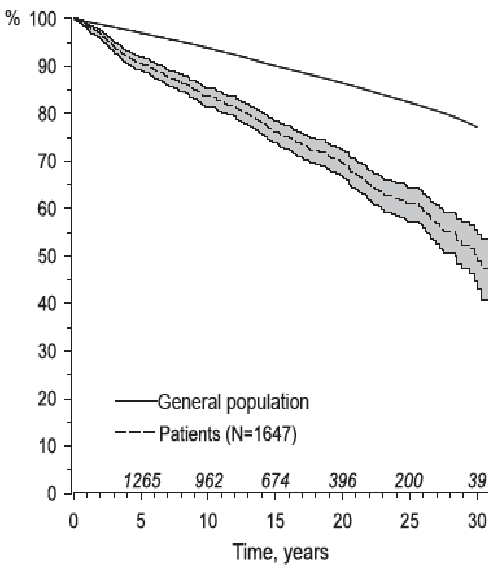
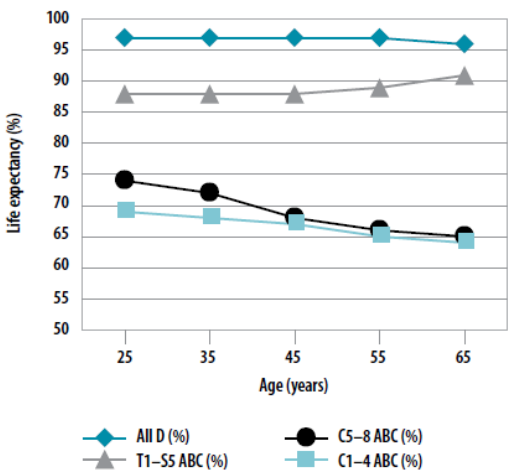


Fig. 1. Survival of persons with spinal cord injury admitted to Käpylä Rehabilitation Centre and survival of general population. Gray band gives the 95 per cent confidence interval for the patients survival.

Figure 2.10. **Life expectancy in Australia by attained age for people with SCI in comparison to general population**



Note: A: complete paralysis; B: sensory function only below the injury level; C: incomplete motor function below injury level; D: fair to good motor function below injury level. Source (*34*).

Ref 127

Ref 34

Observed regional differences (source: WHO publication)

In developed countries life expectancy has increased since the 1950s.

Longitudinal studies in high-income settings have shown a steady increase in life expectancy for people with SCI. A WHO study in the USA (Ref. 131) on TSCI observed a 40% decrease in mortality between 1973 and 2004 during the first 2 years post-injury, while mortality beyond 2 years post-injury remained fairly stable.

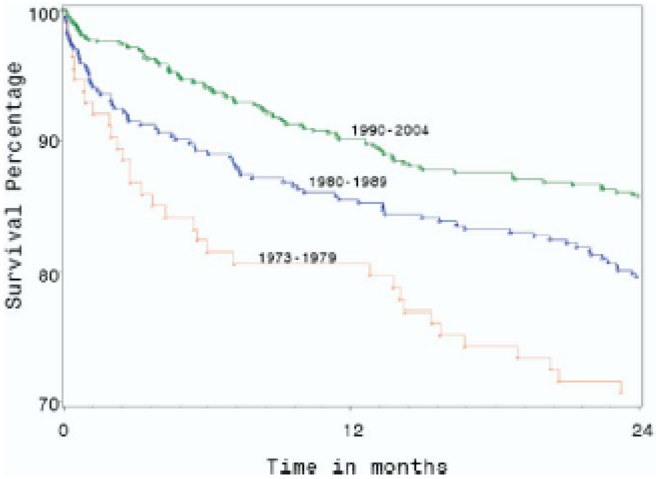


Fig 1. Two-year Kaplan-Meier survival curves for C1-4 grade A, B, and C injuries by period of injury; age greater than 30. Ref 131

Similarly, between 1981 and 1998 another study on traumatic spinal cord injury mentioned by WHO showed there was a 3% annual decrease in traumatic SCI mortality rate. In particular, mortality rates declined among males, whites and victims of motor vehicle crashes. This progression reflects the improvements in clinical care and rehabilitation medicine for people with SCI over the past 60 years.

Secondary conditions of SCI are no longer the main cause of death of people with SCI in high-income countries.

In high-income countries, there has been a shift in the principal causes of death from urologic complications, such as urosepsis or renal failure, to causes of death similar to the general population, such as respiratory problems, especially pneumonia and influenza. Some studies have found high rates of mortality caused by heart disease, suicide, and neurological problems. People with SCI die of these conditions more frequently than people in the general population.

For example, findings from a study in Norway indicate an overall increased mortality risk from respiratory diseases among SCI cases compared to the general population, with a SMR of 1.96. In Australia, a study found a cause-specific SMR of 17.11 for pneumonia and influenza, 4.37 for suicide, and 6.84 for diseases of the urinary system. One Norwegian study found respiratory disease, ischaemic heart disease, cancer and suicide as the most common causes of death.

In low-income countries, people with SCI continue to die from preventable secondary conditions, e.g. urologic complications and pressure ulcers. However, there are few data because of the extremely high rate of "lost to follow-up", anecdotal evidence indicates that urologic complications remain a common cause of death. Fatal infections from untreated pressure ulcers, because of the absence of adequate medical care, are a common cause of death in low-income countries. Mortality rates among people with SCI are strongly affected by the capacity of the health-care system, especially emergency care. Transportation and time of admission post-injury are important factors affecting survival. The first 24 hours after an SCI are the most critical for survival.

Access to health care (source: WHO publication)

A cohort study carried out in Canada showed that people with SCI were more likely to have contact with the health-care system (including having higher rates of hospitalization) than the general population during the six-year follow-up period.

A Danish register-based study, which included patients with SCI nine years after injury, found that they were being admitted to hospital 0.5 times a year, which represented three times more admissions than for a control group. The same SCI patients used general practitioners and physiotherapists six times more than the controls.

However, a study in the Netherlands showed that people with SCI living at home had significant unmet needs for care, including information and psychosocial care. Participants in the Netherlands study also considered that secondary conditions associated with SCI were largely preventable. For instance, 50% of pressure ulcers and 25% of bladder, bowel and sexuality problems were perceived to be preventable, particularly by providing access to quality care and information, and through self-management of one's own health and behavior.

References

The reference numbers correspond to the document "International Perspectives on Spinal Cord Injury" with exception to reference 1.

Ref 127: Ahoniemi E, Pohjolainen T, Kautiainen H. Survival after spinal cord injury in Finland. Journal of Rehabilitation Medicine, 2011, 43:481-485. doi: http://dx.doi.org/10.2340/16501977-0812 PMID:21533327

Survival after Spinal Cord Injury in Finland

Ref 34 Middleton JW et al. Life expectancy after spinal cord injury: a 50-year study. Spinal Cord, 2012, 50:803-811. doi: http://dx.doi.org/10.1038/sc.2012.55 PMID:22584284

Life expectancy after spinal cord injur

Ref 57. Lidal IB et al. Mortality after spinal cord injury in Norway. Journal of Rehabilitation Medicine, 2007, 39:145-151. doi: http://dx.doi.org/10.2340/16501977-0017 PMID:17351697

Mortality after spinal cord injury in Norway

Ref 129. O'Connor PJ. Survival after spinal cord injury in Australia. Archives of Physical Medicine and Rehabilitation, 2005, 86:37-47. PMID:15640987

Survival After Spinal Cord Injury in Austral

Ref 131. Strauss DJ et al. Trends in life expectancy after spinal cord injury. Archives of Physical Medicine and Rehabilitation, 2006, 87:1079-1085. doi: http://dx.doi.org/10.1016/j.apmr.2006.04.022 PMID:16876553

Trends in Life Expectancy After Spi

Ref 1 https://www.nscisc.uab.edu/reports.aspx

NSCISC - Facts and Figures at a Glance 2

Annex 3 - Life expectancy for patients with severe Traumatic Brain Injury (TBI)

Summary of life expectancy articles: Traumatic Brain Injury

Long-Term Disability and Survival in Traumatic Brain Injury: Results From the National Institute on Disability and Rehabilitation Research Model Systems

Jordan C. Brooks, PhD, MPH,a David J. Strauss, PhD,a Robert M. Shavelle, PhD,a
David R. Paculdo, MPH,a Flora M. Hammond, MD,b Cynthia L. Harrison-Felix, PhDc,d
From the a) Life Expectancy Project, San Francisco, CA; b) Department of Physical Medicine and Rehabilitation, Indiana University School of Medicine, Indianapolis, IN; c) Craig Hospital, Englewood, CO; and d) Department of Physical Medicine and Rehabilitation, University of Colorado, Denver, CO.

The article documents the long-term survival of victims still alive 1 year post-injury.
The study is based on a cohort of 7,228 survivors 1 year post-injury, monitored over a period of 20 years post-injury. Victims suffered moderate to severe traumatic brain injury. The victims were discharged from the hospital and placed in rehabilitation units. This cohort corresponds to 32,505 person-years, with 537 deaths, over the 1989 to 2011 study period.

Sampling

The definition of TBI used in the database is damage to brain tissue caused by an external mechanical force as evidenced by medically documented loss of consciousness or post-traumatic amnesia (PTA) due to brain trauma or by objective neurological findings that can be reasonably attributed to TBI on physical examination or mental status examination.
In addition, subjects included in the database must meet at least 1 of the following criteria:

1. post-traumatic amnesia for over 24 hours, trauma-related intracranial neuroimaging abnormalities, loss of consciousness exceeding 30 minutes, a Glasgow Coma Scale score in the emergency department of less than 13;
2. be over 16 years of age at the time of injury;
3. present to the TBI Model System's acute care hospital within 72 hours of injury;
4. receive both acute hospital care and comprehensive rehabilitation in a designated brain injury inpatient unit within the TBI Model System.

Results

Definition

Standardized Mortality Ratio (SMR) =

$$\frac{\textit{\# deaths observed in the cohort}}{\textit{\# expected deaths in the reference population}}$$

Descriptive statistics

There were 7,228 persons (73% men) who collectively contributed 15,516 follow-up evaluations at one year post-injury. The mean age at injury was between 38.9 and 17.9 years. Victims suffered moderate to severe traumatic brain injury. The victims were discharged from the hospital and placed in rehabilitation units. This cohort corresponds to 32,505 person-years, with 537 deaths, over the 1989 to 2011 study period.

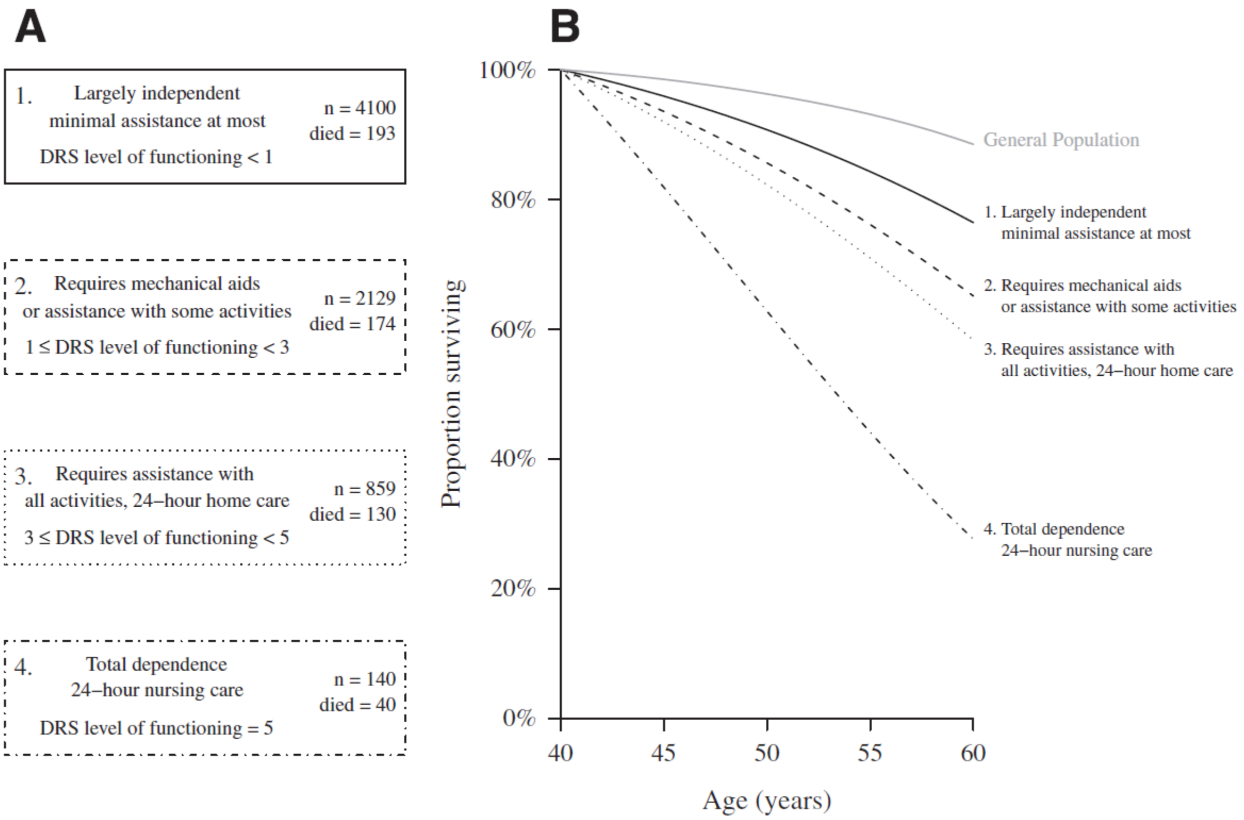


Fig 1 Comparison groups (A) and survival prognoses for a man aged 40 years (B).

The Kaplan-Meier survival estimate at 20 years post-injury in the TBI population was 70% compared with the 80% expected under age- and sex-matched US general population mortality rates. The overall SMR for the cohort was 2.1. The SMR estimate decreased from the accident date as the age of the victim increased:

Age	SMR
[20-40]	3.3
>80	1.3
Cohort	2.1

Increased mortality risk depending on age, sex and disability

In this sample, survival remains dependent upon the victim's age at the time of accident and his or her sex.

Men have a 71% higher mortality rate than women from the same sample.

A study of the survival curve for a typical 40-year-old man with minimal to moderate disability demonstrated that survival was worse than that of the general population. For those at the severe end of the spectrum, who required 24-hour nursing care, the estimated median survival time was only 13.4 additional years, that is, until age 53.4.

Time since injury and life expectancy trend

The logistic person-year analysis indicated that time since injury was not a significant risk factor for mortality. The SMR estimate remains high 20 years post-injury once the age of the victim and their disability are taken into account. The survival prognosis for a 40-year old with a TBI is the same whether they were injured at age 35 years or at age 25 years.

Limitations of the study

The study was conducted on adults who have suffered a moderate to severe TBI. Persons with mild disabilities that have no impact on physical or cognitive functions or with extremely severe disabilities, for example those in a vegetative state, are underrepresented. Persons with concussions are also absent from this study. The prognoses here are best reserved for adults who have suffered a moderate to severe TBI and who have ongoing long-term disability.

Additional limitation: Persons who have survived over 20 years may not be isolated from the sample. Additionally, the continuity of care in the US is quite different from that in Europe and from that in France in particular.

Conclusions

This study confirms that severity of disability is one of the most important factors for long-term survival in persons with TBI. Age- and disability-specific mortality rates in TBI have not declined over the last 20 years. Given the limitations of the study, i.e. the cohort is comprised of persons with moderate to severe traumatic brain injury, the results of the study do not give consideration to persons with mild or severe disabilities, for example those in a vegetative state.

Late mortality after severe traumatic brain injury in New South Wales: A multicentre study **Med J Aust. Jan 16, 2012; 196(1): 40-5. Baguley IJ, Nott MT, Howle AA, Simpson GK, Browne S, King AC, Cotter RE, Hodgkinson A (2012).**

The objective of the article is to establish a long-term trend for mortality in adults with severe traumatic brain injury, and to identify the variables for the death rate among the group studied.

The study is based on a cohort of 2,545 adults consecutively discharged from a post-acute inpatient rehabilitation service of New South Wales (Australia). The sampling is based on the following criteria: patients between 16 and 70 years of age at the accident date having suffered severe traumatic brain injury (Glasgow Coma Scale total score of less than 9 and/or post-traumatic amnesia for over 24 hours) and discharged from hospital in a living state prior to October 1, 2007.
58% of persons with traumatic brain injury received their injury as a result of a traffic accident.

2 Clinical, service and mortality variables of the 2545 patients with severe traumatic brain injury, and results of the univariate Cox regression analysis

Variable	No. of patients	Measure	Hazard ratio (95% CI)	*P*
Clinical variables				
Brain injury cause	2464			
Motor vehicle accident-related		1442 (58%)		
Fall/dive		524 (21%)		
Assault/non-accidental injury		355 (14%)		
Sport/recreation-related		63 (3%)		
Gunshot		15 (1%)		
Other traumatic brain injury		65 (3%)		
Mean functional independence measure scores (SD)*				
Admission total score	2144	69 (37)		
Independent (108–126) (reference group for Cox regression)		430 (20)	1	
Moderate assistance (55–107)		909 (42)	1.07 (0.71–1.63)	0.74
Maximal assistance (18–54)		805 (38)	1.96 (1.29–2.84)	0.001
Discharge total score	2126	104 (29)		
Independent (108–126) (reference group for Cox regression)		1447 (68)	1	
Moderate assistance (55–107)		466 (22)	1.51 (1.07–2.13)	0.02
Maximal assistance (18–54)		213 (10)	4.82 (3.49–6.66)	< 0.001
Occurrence of inhospital aspiration pneumonia*	2199	79 (4%)	3.82 (2.54–5.74)	< 0.001
Presence of percutaneous endoscopic gastrostomy during admission	1692	311 (18%)		
Dysphagia reported/documented at discharge	1752	204 (12%)		
Anticonvulsants prescribed at discharge	1467	465 (32%)		
Guardianship order in place	2545	171 (7%)		
Service variables				
Median days from injury to rehabilitation admission (IQR)	2534	25 (24)		
Median length of stay for rehabilitation (IQR)*	2545	37 (66)		
< 30 days (reference group for Cox regression)		1099 (43)	1	
31–60 days		546 (22)	1.26 (0.90–1.78)	0.18
≥ 61 days		900 (35)	1.79 (1.36–2.37)	< 0.001
Median days from injury to rehabilitation discharge (IQR)	2545	68 (89)		
Financial compensation for injury	1851	826 (45%)		
Discharge destination*	2332			
Private house (reference group for Cox regression)		1730 (74%)	1	
Ongoing rehabilitation/medical care		421 (18%)	1.45 (1.03–2.04)	0.035
Care facility (nursing home or hostel)		181 (8%)	5.91 (4.40–7.95)	< 0.001
Mortality variables				
Deceased	2545	258 (10%)		
Median years from discharge to death (IQR)	258	4.8 (6.6)		
Place of residence at time of death	253			
Private house		201 (79%)		
Hospital or care facility (nursing home/hostel)		52 (21%)		

IQR = interquartile range.
* Variables entered into the univariate Cox regression (sufficient available data).

1 Age distribution, sex and pre-injury medical history of the 2545 patients with severe traumatic brain injury, and results of the univariate Cox regression analysis

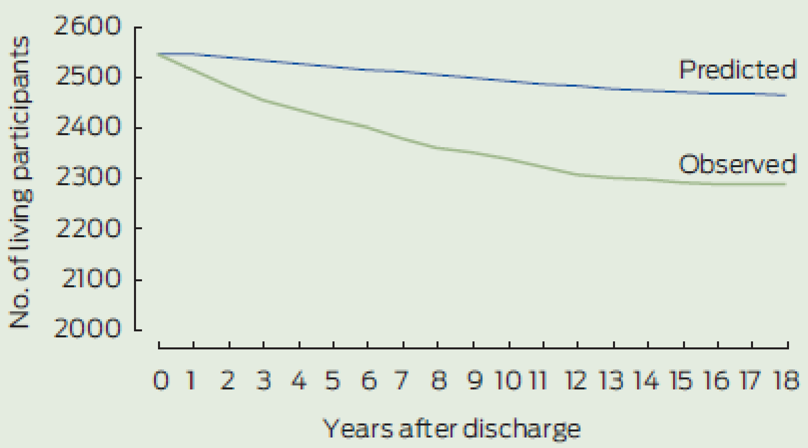
Variable	No. of patients	Measure	Hazard ratio (95% CI)	*P*
Demographic characteristics				
Mean age*† (SD)	2545	35 (14)		
16–20 years (reference group for Cox regression)		374 (15%)	1	
21–25 years		459 (18%)	0.65 (0.32–1.32)	0.24
26–35 years		591 (23%)	1.44 (0.81–2.55)	0.21
36–45 years		457 (18%)	2.82 (1.64–4.86)	< 0.001
≥ 46 years		664 (26%)	5.36 (3.23–8.88)	< 0.001
Sex*	2545			
Female (reference group for Cox regression)		485 (19%)	1	
Male		2060 (81%)	2.39 (1.57–3.64)	< 0.001
Pre-injury medical history				
Pre-injury history of traumatic brain injury*	2545	61 (2%)	1.71 (0.96–3.06)	0.07
Pre-injury history of epilepsy*	2545	77 (3%)	5.63 (3.90–8.12)	< 0.001
Pre-injury history of alcohol/drug misuse*	2169			
History not reported in medical record		1533 (71%)	1	
History verified‡ or reported in medical record		636 (29%)	3.01 (2.34–3.87)	< 0.001
Pre-injury history of psychiatric disorder*	2168			
History not reported in medical record		1848 (85%)	1	
History verified§ or reported in medical record		320 (15%)	1.36 (0.98–1.88)	0.06

* Variables entered into the univariate Cox regression (sufficient available data). † Age at injury categorised using visual binning of equal percentiles on scanned cases. ‡ Verified by drug/alcohol referral or a record of units per day. § Verified by recorded psychiatric admission, medications or referral to psychologist/psychiatrist. ◆

The study essentially seeks to measure the survival rate at October 1, 2009.
258 deaths were recorded in this sample, yielding a standardized mortality ratio of 3.19. The year-by-year SMR for the inception cohort ranged from 12.3 in the first year after discharge to 1.25 in the 15th year after discharge. Risk of death remained elevated above that of the general population for at least 8 years after discharge from rehabilitation.

3 Predicted versus observed mortality and yearly standardised mortality ratios (95% CIs) for 2545 patients with severe traumatic brain injury

A: Number of living participants over the 18 years after their discharge from rehabilitation



4 Significant risk factors for death after traumatic brain injury for 1635 patients, from the multivariate Cox regression analysis*

Predictive factors in multivariate analysis	Hazard ratio (95% CI)	*P*
Sex		
Female (reference group for Cox regression)	1	
Male	2.24 (1.38–3.62)	0.001
Age		
16–20 years (reference group for Cox regression)	1	
21–25 years	0.57 (0.24–1.33)	0.19
26–35 years	1.13 (0.58–2.20)	0.73
36–45 years	2.01 (1.07–3.80)	0.03
⩾ 46 years	3.25 (1.80–5.87)	< 0.001
Pre-injury history of epilepsy	2.11 (1.35–3.30)	0.001
Pre-injury history of alcohol/drug misuse	2.39 (1.76–3.25)	< 0.001
Occurrence of aspiration pneumonia	1.79 (1.10–2.91)	0.02
Discharge destination		
Private house (reference group for Cox regression)	1	
Ongoing rehabilitation/medical care	0.98 (0.65–1.47)	0.91
Care facility (nursing home or hostel)	1.94 (1.28–2.94)	0.002
Discharge functional independence measure scores		
Independent (108–126) (reference group for Cox regression)	1	
Moderate assistance (55–107)	1.06 (0.72–1.57)	0.76
Maximal assistance (18–54)	3.39 (2.22–5.19)	< 0.001

* Variables removed during backward multivariate Cox regression were length of stay and admission functional independence measure score. ◆

5 Causes of death based on relevant ICD-10 chapters, number of observed and predicted deaths with cause-specific SMR

ICD-10 Chapter	Title	Observed	Predicted	SMR (95% CI)*
I	Certain infectious and parasitic diseases	4	1.4	—
II	Neoplasms	29	28.8	1.0 (0.7–1.4)
III	Diseases of blood	1	0.3	—
IV	Endocrine	2	2.2	—
V	Mental and behavioural disorders	9	1.7	5.4 (2.4–9.6)
VI	Diseases of the nervous system	14	2.2	6.4 (3.4–10.3)
IX	Diseases of the circulatory system	52	19.9	2.6 (1.9–3.4)
X	Diseases of the respiratory system	49	4.8	10.2 (7.5–13.4)
XI	Diseases of the digestive system	15	2.9	5.2 (2.9–8.3)
XIV	Diseases of genitourinary system	3	0.9	—
XVIII	Symptoms, signs and abnormal clinical and laboratory findings	8	0.6	14.1 (5.9–25.8)
XX	External causes of mortality†	54	10.3	5.2 (3.9–6.7)
	Cause of death pending	18		
	Total	258		

ICD-10 = *International statistical classification of diseases and related health problems*, 10th revision. SMR = standardised mortality ratio.
* SMR (95% CI) not calculated for causes of death for which fewer than five deaths were observed, because of the inaccuracy of the prediction. † External causes of mortality include transport accidents, falls, accidental drowning and submersion, other accidental threats to breathing, exposure to smoke, fire and flames, accidental poisoning by and exposure to noxious substances, intentional self-harm, assault and inhalation of gastric contents/food. ◆

In this sampling, the factors contributing to the risk of death are:

- Functional dependence at discharge from rehabilitation (severity of trauma);
- Age at accident date: Adults aged 36 years and older were two to three times more likely to die during the study period than young adults (However, these age-related relativities are also observed in the general, non-injured population);
- Pre-injury history of substance or alcohol abuse;
- Pre-injury history of epilepsy;
- Discharge from hospital to a health-care facility for the elderly.

For persons with severe traumatic brain injury, the risk of death due to an extreme cause or respiratory and nervous system complications is 6 to 7 times higher than for the general population while the risk of death due to digestive disorders or mental and behavioral problems is 5 times higher than for the general population.

The limitations of this study include the absence of precise dates for the accidents observed and the relatively low number of observations (2,545 patients) over a long period (17 years) as well as a lack of consideration for the development of medical treatment.

Mortality over four decades after traumatic brain injury rehabilitation: A retrospective cohort study **Harrison-Felix CL, Whiteneck GG, Jha A, DeVivo MJ, Hammond FM, Hart DM (2009). Archives of Physical Medicine & Rehabilitation, 90:1506-1513.**

Objective: To investigate mortality, life expectancy, risk factors for death, and causes of death in persons with traumatic brain injury.
Design: Retrospective cohort study
Setting: Used data from an inpatient rehabilitation facility, the Social Security Death Index, death certificates, and the U.S. population age-race-sex-specific and cause-specific mortality rates
Main outcome: Vital status, standardized mortality ratio, life expectancy, cause of death.

A total of 1,678 persons were identified for this study. These consisted of persons with TBI, admitted to hospital for inpatient rehabilitation within 1 year of injury, between 1961 and 2002.

There were 130 deaths occurring after 1 year post-injury for a mortality rate of 7.7%. The length of time between injury and death ranged from 381 days to 35 years, with a median interval of 11 years. The expected number of deaths in the absence of TBI was 85.83. Because 130 deaths were observed, the SMR was 1.51, indicating that persons with TBI were one and a half times more likely to die than persons of comparable age, sex, and race from the general population.
The study presents the assumption of a constant SMR of 1.51. Assuming survival to at least the first anniversary of injury, life expectancy was shortened thereafter between 3 and 6 years. These results are dependent upon the severity of the trauma and the sex of the victim.
On average, TBI appeared to reduce life expectancy by about 4 years.
Results of the study indicate that the major factors associated with an increased risk of death after 1 year post-TBI are:
- being older in age,
- being male,
- being less educated,
- having a longer period of hospitalization,
- having an older accident year,
- being unconscious for a longer period of time,
- and being in a vegetative state in a health-care/rehabilitation unit.

Men are three times more likely to die than women. Persons who had completed high school, trade school, or some college are at 26% lower risk of death than those who did not complete high school. There is a 0.5% increased risk of death for each additional day of hospitalization. Finally, those in a vegetative state at rehabilitation discharge are 3 times more likely to die than those with less severe traumatic injury.

The largest proportion of deaths is due to circulatory conditions (25%). The next largest proportion of deaths occurred secondary to respiratory conditions (22%), with 9% of all deaths a result of aspiration pneumonia and 8% a result of other types of pneumonia. The next largest proportion of deaths was attributable to external causes of injury (18%), with half a result of unintentional injuries and half secondary to suicide.

One year post-injury, people with TBI are 49 times more likely to die of aspiration pneumonia, 22 times more likely to die of an epileptic seizure, 4 times more likely to die of pneumonia, 3 times more likely to die of suicide, and 2.5 times more likely to die of gastrointestinal disease, than a person from the general population.

This study demonstrated life expectancy after TBI rehabilitation is reduced and associated with specific risk factors.