

1 Title: *Excess burden of a chronic disabling condition: life lost due to traumatic spinal cord*
2 *injury in a Swiss population-based cohort study*

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35 **Abstract**

36

37 *Objective*

38 To estimate excess mortality and life-years lost in a Swiss cohort of individuals with traumatic spinal
39 cord injury (TSCI).

40 *Methods*

41 This study uses population-based data collected in the Swiss Spinal Cord Injury Cohort (SwiSCI)
42 study, which covers all specialized rehabilitation centers. Flexible parametric survival models were
43 used to model life years remaining (LYR), potential years life lost (PYLL), relative survival and excess
44 hazard ratios.

45 *Results*

46 Men and women with TSCI and an attained age of 30, were estimated to have 42 LYR (95% CI=37.9-
47 45.5) and 43 LYR (95% CI=40.1-45.5), respectively; this equates to a life expectancy (LE) of 80.6%
48 and 76.9% of that of the Swiss general population. With respect to lesion level and completeness,
49 persons with incomplete paraplegia had 45.1 LYR at an attained age of 30, whereas individuals with
50 complete tetraplegia only had 28.7 LYR. This pattern was similar for PYLL.

51 *Conclusion*

52 The extended LE following TSCI, even for the most severe lesions, underscores the need for
53 sustained follow-up to support functioning and health for individuals aging with SCI.

54 **Introduction**

55 The 2017 Global Burden of Disease (GBD) report identified non-communicable diseases (NCDs) as
56 the leading contributor to mortality as well as to disability-adjusted life years (DALYs), a
57 comprehensive measurement of disease burden that has globally seen a 40% increase between 1990
58 and 2017 (Cao et al. 2018; GBD 2017 DALYs and HALE Collaborators 2018). While previous GBD
59 reports have reported positive trends of improved health and life expectancy virtually universally, the
60 recent 2017 report presents a sobering picture with reductions in progress towards improved health,
61 and projected escalations in the burden of disease due to NCDs (Cao et al. 2018; GBD 2017 DALYs
62 and HALE Collaborators 2018). To curb this trend, it is necessary to quantify the burden of disease in
63 order to set priorities for resource management and targeting improvement. To this aim, estimates of
64 life expectancy or potential years of life lost are important parameters of individual and societal
65 burden. These indicators evaluate the integral impact of health conditions or health states on human
66 functioning inasmuch as they serve as a censor, aid in planning of resources and service needs, and
67 contribute to the evaluation of DALYs (2018). Additionally, relative measures – including relative
68 survival or excess mortality – can be used to account for background mortality in the general
69 population in order to quantify the true impact of spinal cord injuries (SCIs) on risk of premature
70 mortality.

71 Traumatic spinal cord injuries (TSCIs) are a non-communicable, neurological condition with
72 lifelong implications including reduced well-being, increased morbidity and mortality, and a generally
73 high individual and societal economic burden (WHO 2013). Albeit rare, the individual impact of TSCIs
74 on mortality risk is similar to other chronic conditions (e.g., multiple sclerosis). For instance, persons
75 with a TSCI experience mortality rates more than double that of the general population (Standardized
76 mortality ratio [SMR]=2.32; 95% CI=2.10-2.56), similar to that of multiple sclerosis (SMR=2.7; 95%
77 CI=2.4-3) or traumatic brain injury (SMR=2.25; 95% CI=2.1-2.4) (Lunde et al. 2017; Chamberlain et al.
78 2019; Harrison-Felix et al. 2012). Further contributing to the burden associated with TSCIs, in addition
79 to the burden attributed to premature mortality, TSCIs are associated with a high disability weight in
80 DALY calculations, thereby directly implicating a higher burden given the impact on years lived with
81 disability (Salomon et al. 2015). However, the available evidence of burden is limited; particularly
82 within the Swiss context. Therefore, the purpose of this study is to provide Swiss-specific estimates of
83 life expectancy, life years lost, excess mortality and relative survival.

85 **Methods**

86 *Study population*

87 This study uses data collected from the Swiss Spinal Cord Injury Cohort (SwiSCI) study (Post et al.
88 2011; Chamberlain et al. 2017). Data on vital status have been further enhanced through probabilistic
89 record linkage with the Swiss National Cohort (SNC) to obtain cause of death and additional
90 sociodemographic variables (e.g., marital status). This has been previously described in detail
91 (Chamberlain et al. 2019). The SwiSCI study includes all persons admitted to one of the five
92 specialized rehabilitation centers (currently four active) within Switzerland for first rehabilitation
93 following SCI. Importantly, individuals who died before admission to first rehabilitation are therefore not
94 included within the SwiSCI study. Individuals with cauda equina lesions, which are peripheral lesions
95 with a differential impact on prognosis and evolution of SCI-specific secondary health conditions, as
96 compared to non-peripheral lesions of the spinal cord, were excluded from all analyses (N=150). To
97 ascertain vital status, a comprehensive follow-up was recently undertaken for individuals injured
98 between 1990 and 2011; the present study is thus restricted to those individuals who sustained a
99 traumatic SCI, and were included within the vital status update. Individuals were considered lost to
100 follow-up (LTFU) if information on vital status at study end (administrative censoring date: September
101 30, 2011) was unavailable even after active follow-up through participating clinics and municipalities.
102 This has been described in further detail previously (Buzzell et al. 2018; Chamberlain et al. 2018).
103 Information on mortality in the Swiss general population (GP) was acquired through the Swiss Federal
104 Statistical Office (Neuchâtel), including information on the mortality rate, number of deaths and time-
105 at-risk according to age, sex, and calendar year.

106

107 *Statistical analysis*

108 For this study, level and completeness of the spinal cord lesion were grouped together into a four-level
109 variable, including: paraplegia incomplete; paraplegia complete; tetraplegia incomplete; tetraplegia
110 complete. Age was included as a categorical variable according to ISCoS guidelines to ensure
111 comparability with previous research (DeVivo et al. 2011). For the estimation of excess mortality rate
112 ratios (eHRs) and relative survival we used splitting techniques to partition follow-up time of individuals
113 with SCI with respect to age class and year, thus facilitating proper benchmarking to the mortality data
114 of the GP by age, sex, and calendar year. Given the high mortality rate during the months immediately
115 following injury, estimates were restricted to individuals that survived at least six months post-injury.

116 GP mortality rates – stratified by age, sex, and year of death – were merged with attained age, sex,
117 and attained year of death of the SCI cohort. This was similarly performed for estimation of potential
118 years life lost (PYLL), with the exception that age and year at injury were used in place of attained age
119 and year.

120

121 Time-at-risk started with date of SCI, with study start on date of admission to first rehabilitation.
122 Individuals exited the study on date of death or end of study (September 30, 2011), whichever came
123 first. Individuals LTFU were censored on last date of known vital status. To prevent over-
124 parameterization of models, confounders were identified using directed acyclic graphs (DAGs)
125 informed by theory, previous evidence, and data availability; included confounders were: age, sex,
126 level and completeness of lesion (Greenland et al. 1999). Excess mortality and relative survival were
127 modelled using a flexible parametric survival model (FPM) (Dickman and Coviello 2015). The
128 Bayesian Information Criterion (BIC) value was used to identify best-fitting models given the degrees
129 of freedom (df); 3 df were determined for best fit. The proportional hazards assumption was assessed
130 using a likelihood ratio test comparing models with and without inclusion of time-dependent effects. A
131 FPM was used to predict life years remaining (LYR) using restricted mean survival time at attained
132 ages: 30; 40; 50; and 60 years of age. A maximum attained age of 90 years, which is close to the
133 oldest ages observed in the study population was used in modelling. A FPM was similarly used to
134 model the PYLL; level and completeness of injury, age at injury as a continuous variable using splines,
135 and sex were controlled for in the model. Pre-2000, information on the American Spinal Injury
136 Association (ASIA) Impairment Scale (AIS) score (Roberts et al. 2017) was not regularly collected,
137 estimates stratified by injury severity (a combination of AIS score and level of lesion) thereby exclude
138 individuals who incurred a TSCI pre-2000. Hazard ratios (HRs) and excess hazard ratios (eHRs) were
139 modelled using a FPM, and are presented with 95% confidence intervals. Excess hazard ratios and
140 standard HRs can be interpreted similarly, with the addition that eHRs account for variation in the
141 background mortality rates of the GP. For example, an eHR of 1.2 for males relative to females would
142 indicate that males have a 20% higher risk of mortality after controlling for the background variation in
143 GP mortality.

144

145 All analyses were carried out using Stata version 14.2 (StataCorp 2015), and all figures were created
146 using SigmaPlot (Systat Software, San Jose, CA).

147

148 **Results**

149 This study includes 2'492 individuals, of which 379 (15.2%) had a known date of death. Of those
150 individuals that died, 149 (39.3%) died within the first two years post-injury, 87 (23.0%) between two
151 and five years, 81 (21.4%) between five and ten years, and 62 (16.4%) between 10 and 21 years.
152 Additionally, more than half were male (68.6%), nearly two thirds of the population were over the age
153 of 60 years at time of death (60.1%), and roughly 40% had an incomplete tetraplegia (Table 1).

154

155 *Life years remaining and potential life years lost*

156 Estimated life years remaining (LYR) according to study characteristics are presented in Table 2. No
157 notable differences in residual life expectancy (LE) were identified between men and women. For
158 example, men with an attained age of 30 had an estimated 42 LYR (95% CI=37.9-45.5), while women
159 had an estimated 43 LYR (95% CI=40.1-45.5) (Table 2). However, in comparison to the GP, men and
160 women with an attained age of 30 years experienced a LE of roughly 80.6% and 76.9% compared to
161 that of the Swiss GP (data not shown) (2017). The number of LYR was influenced by completeness
162 and level of lesion. For example, with an attained age of 30 years, persons with incomplete paraplegia
163 had 45.1 LYR, whereas individuals with complete tetraplegia only had 28.7 LYR, equating to 53.9% of
164 the LE of the GP (Table 2).

165 For individuals injured between 1990 and 2011, there is an estimated total of 8'486.5 PYLL
166 due to TSCI; of which 75% is attributable to TSCIs incurred between 16 and 45 years of age. Figure 1
167 provides a visualization of PYLL according to lesion characteristics across different ages at injury.
168 Individuals with incomplete and complete paraplegia as well as with incomplete tetraplegia exhibited
169 similar PYLLs, with an average estimated PYLL at 20 years of 4.4, 5.9, and 4.8, respectively (Figure
170 1). In comparison, a complete tetraplegia incurred at 20 years of age, reduced LE by nearly 14 years
171 (Figure 1). This gap in PYLL according to lesion level and completeness persisted across differing
172 ages at injury.

173

174 *Relative survival and excess mortality*

175 Estimated excess mortality per 1'000 persons-years is provided in Table 3. Across sociodemographic
176 characteristics, excess mortality is impacted by lesion level and completeness. For example, the

177 excess mortality rate for individuals aged between 16 and 30 years old with an incomplete paraplegia
178 was 0.6 (95% CI=0.15-2.04) per 1'000 person-years, while for individuals with complete tetraplegia the
179 excess mortality was roughly four additional deaths per 1'000 person-years (95% CI=1.07-11.98)
180 (Table 3). This divergence increased with age. A comparison of HRs and eHRs is presented in Figure
181 2. When accounting for background mortality in the GP, effect sizes for the 31-45 year old age group
182 increased slightly, while eHRs for the oldest age group were attenuated, accounting for the higher risk
183 of mortality with older ages experienced by the general population (Figure 2). Differences in risk of
184 mortality according to lesion level and completeness were similarly exaggerated when accounting for
185 background GP mortality rates, with an excess mortality rate nearly seven-fold higher for individuals
186 with complete tetraplegia in comparison to persons with incomplete paraplegia (eHR=6.78; 95%
187 CI=3.29-13.93) (Figure 2). Comparisons of standard survival estimates and relative survival estimates
188 demonstrate the mortality attributable to TSCI by accounting for the expected mortality among persons
189 with SCI, estimated from age- and sex- stratified mortality rates in the GP (Figure 3). For example,
190 individuals with a complete tetraplegia who survived at least half a year post-injury had an estimated
191 10-year survival probability of roughly 75% (Figure 3). When accounting for background mortality rates
192 in the GP, relative survival estimates showed that excluding the possibility of mortality due to any other
193 disease or external factor, 20% of persons with complete tetraplegia will have died due to their
194 diagnosis 10 years post-injury (Figure 3).

195

196 **Discussion**

197 *Summary*

198 In Switzerland, persons with a traumatic SCI and an attained age of 30 years have an estimated 28.7
199 to 45.1 years of life remaining with higher, more severe injuries equated with the greatest reductions in
200 residual life expectancy. Additionally, although older age is associated with a higher risk of mortality,
201 this study found that individuals injured at a younger age lost substantially more life years. Finally, this
202 study revealed that the risk of mortality following TSCI remains elevated across the life course of the
203 spinal cord injured individual, never returning to that of the general population.

204

205 In the present study, the LE for individuals with a TSCI and an attained age of 30 years old varied
206 between 53.1% and 88.0% of the LE of the Swiss general population (2017). Our results contribute to
207 consistent evidence in high income countries. For example, a study using data from the Model

208 Systems in the United States, estimated the LE for 25 year old white males, with an elapsed time of
209 three years since incurring a TSCI, to be between 52% and 88% that of the general population LE,
210 depending on lesion level and severity (Shavelle et al. 2015). Similarly, in a United Kingdom-based
211 study by Savic *et al*, the estimated LE after TSCI was between 57.1% and 86.9% of that of the general
212 population for men with an attained age of 25 years, who survived at least one-year post-injury
213 (excluding ventilator-dependent persons) (Savic et al. 2017). To note, both of these studies also
214 investigated trends in LE among individuals with TSCI and found either minimal or no improvement LE
215 across recent decades. This suggests that while the LE of the GP has been steadily improving across
216 high-income countries, improvements in long-term survival for individuals with SCI have remained
217 largely stagnant. Such reductions and lack of improvement in LE in comparison to the general
218 population are indicative of the large burden on the individual.

219 This study found that although older individuals are at a higher risk of mortality, individuals who
220 incur a TSCI at a younger age lose substantially more life years, particularly those who incur complete
221 tetraplegia. Reflecting the contracted LE of the Swiss SCI population, the measure of PYLL is an
222 additional, population-referenced indicator of the individual burden associated with SCI. The apparent
223 differential impact of lesion characteristics on PYLL in relation to age at injury could be in part due to
224 the consequences of aging with a SCI. Such differentials in survival that go beyond normal aging have
225 been evidenced in a previous study using data from the Swiss SCI population (Chamberlain et al.
226 2018). Allostasis adaptation – or the biochemical, physiologic, and psychological changes undergone
227 to maintain or restore homeostasis – in response to chronic disease may serve as a catalyst for
228 accelerated aging (Juster et al. 2016; Shiels et al. 2017). Allostatic load (AL) – or the accumulative
229 wear-and-tear on the body – has been linked to an increased risk of comorbidities as well as mortality,
230 and is evidenced to be impacted by events across the life course, including traumatic events (e.g.,
231 child abuse), social (e.g., socioeconomic status), or even personality traits influencing stress response
232 (Juster et al. 2016; Castagné et al. 2018). It is therefore conceivable that the physiological
233 dysregulations associated with level and completeness of the spinal cord lesion contribute to the
234 accumulation of AL with increasing time since injury, and importantly to the differential accumulation
235 over time. In order to better understand the synergistic effect of time since injury on allostatic load, and
236 thereby identify targets for reducing AL and subsequent health outcome differentials, longitudinal
237 studies are needed that investigate trajectories of biomarkers instrumental to the AL hypothesis (e.g.,

238 telomere length, parameters of immune function/immune senescence) and risk factors for increased
239 AL across the life course of persons with SCI.

240 In comparison to individuals who incurred an incomplete paraplegia, complete tetraplegia was
241 associated with nearly seven times more excess deaths – or deaths beyond what is expected based
242 on GP mortality rates. This is considerably higher than the roughly four-fold increase in risk of mortality
243 estimated when using standard methods (i.e., methods not taking into account background GP
244 mortality rates). Additionally, if considering solely standard hazard ratios, it would appear that the
245 oldest age group (76 years and older) has by far the highest risk of mortality; however, when
246 accounting for background mortality in the GP, the excess hazard is attenuated and similar to that of
247 individuals between 61 and 75 years of age. Such information may change targets for interventions
248 as, in the example of age, this points towards the need to equally target these two age groups in
249 efforts to minimize or reduce premature mortality. When considering the elevated risk associated with
250 complete tetraplegia, the further accentuation when accounting for background mortality in the GP
251 points towards an influence of age and sex on lesion characteristics; i.e., younger individuals are more
252 affected by complete tetraplegia. This suggests the need to potentially reassess and invest more
253 resources towards reducing disparities in risk of premature mortality and to mitigate individual-level
254 burden associated with lesion characteristics, particularly targeting younger individuals who have
255 incurred a complete tetraplegia. Given that the burden associated with TSCIs is expected to augment
256 in the future due to the projected increase in the incidence rate of TSCIs among older individuals
257 primarily due to falls, refining and reevaluating high risk group definitions is essential to ensure the
258 intended prevention or reduction of premature mortality (Ahn et al. 2017).

259

260 *Strengths & limitations*

261 Estimates of the contribution of pre-specified risk factors on all-cause mortality due to SCI can be
262 misleading given the influence of the background mortality experienced by the general population.
263 Therefore, a strength of this study is the provision of relative estimates of survival and mortality, which
264 provide unbiased indicators of mortality due to sustaining a TSCI through standardization to the GP by
265 age, sex, and decade. Although individuals within this study were included within the mortality rates for
266 the GP, given that TSCI is rare the impact on estimates is negligible. A potential limitation of this study,
267 however, is the limited follow-up time of roughly 20 years. At the end of the study period, the majority
268 of individuals were still alive, therefore in order to model remaining life years, this study was forced to

269 rely on model assumptions for estimation, for example restricting the maximum age to 90 years.
270 Extended follow-up in the context of the SwiSCI cohort study will facilitate validation. Additionally, it
271 was not possible to adequately investigate trends in LE or other mortality-related outcomes. Given the
272 paucity and conflicting evidence on trends in improvements of mortality-related outcomes, country-
273 specific analyses are needed.

274

275 *Conclusion*

276 Population health indicators such as residual life expectancy, life years lost, relative survival and
277 excess mortality can serve to inform health systems regarding burden and expected associated costs
278 across the life course of individuals with a SCI. This study provides the first Swiss-specific estimates of
279 PYLL and LYR after SCI; the two components needed for the calculation of disease-specific DALYs.
280 This study further provides evidence of an extended LE following a TSCI, even for the most severe
281 lesions, thereby justifying the provision of specialized care post-SCI to support improved long-term
282 functioning and health. Furthermore, the estimates of relative survival and excess hazard ratios can be
283 used for health policy and raising awareness of potential inadequacies in the continued care for
284 persons with chronic TSCI.

285

286 **Statement of Ethics**

287 The SwiSCI cohort study has been approved by local ethics committees (reference numbers: 1008
288 [Luzern]; 37/11 [Basel]; CCVEM 015/11 [Valais]; 2012-0049 [Zürich]). All authors confirm that they
289 have no conflict of interest to declare.

290

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294

295 **Author Contributions**

296 **JDC**, **MWGB** and **MZ** were responsible for initial conceptual framing. **AB** and **MWGB** provided
297 statistical support and critical feedback on manuscript content. **HPG**, **KH**, **XJ**, and **SM** provided clinical
298 support and feedback of the present manuscript. **MZ** and **AM** provided statistical support for analyses,

299 as well as critical evaluation of statistical methods implemented. **JDC** was responsible for all analyses,
300 drafting, and finalization of manuscript. All authors have supported and approved the final manuscript.

301

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308 Group can be found here: www.swissnationalcohort.ch).

309

310 **Tables & Figures**

311

312 **Table 1 Study characteristics according to vital status**

313 *Those with a discharge destination of "Death" were discharged after study end (i.e., post-September*
314 *30 2011).*

315

316 **Table 2 Marginally adjusted estimates of life years remaining according to attained age**

317 *Life years remaining (LYR) estimates stratified by injury severity exclude individuals who incurred a*
318 *TSCI pre-2000.*

319

320 **Table 3 Excess mortality per 1'000 person-years, stratified by lesion characteristics**

321 *Excess mortality presented as the average excess mortality with 95% confidence intervals.*

322

323 **Fig. 1 Potential years of life lost (PYLL) according to age at injury, stratified by lesion**
324 **characteristics**

325 *The solid black line indicates potential years of life lost (PYLL) for complete tetraplegic lesions, the*
326 *dashed dark grey line indicates PYLL for incomplete tetraplegic lesions, the dashed light grey line that*
327 *for complete paraplegic lesions, and finally the solid light grey line the PYLL for incomplete paraplegic*
328 *lesions.*

329

330 **Fig. 2 Comparison of estimated hazard ratios and excess hazard ratios**

331 *The unfilled circle represents the reference category. The black-filled circle corresponds to estimated*
332 *hazard ratios (HR), while the grey-filled circle corresponds to the estimated excess hazard ratio (eHR).*
333 *The 95% confidence intervals (95% CI) are represented by the solid lines on either side of the circle*
334 *representing the HR or eHR. All estimates are adjusted for lesion level and completeness, attained*
335 *age, and sex. To note, the left-hand y-axis corresponds to the HR and eHRs estimated for attained*
336 *age; the right-hand y-axis corresponds to the HR and eHRs for all other variables.*

337

338 **Fig. 3 Marginally adjusted survival and relative survival probabilities, stratified by lesion**
339 **characteristics**

340 *The solid black line indicates the marginally adjusted survival and relative survival probability for*
341 *incomplete paraplegia; the dashed line that for complete paraplegia; the light grey, dotted line that for*
342 *incomplete tetraplegia; and finally the dashed-dotted line for complete tetraplegia.*

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Table 1. Study characteristics according to vital status

Those with a discharge destination of "Death", but who are categorized as "Alive", were discharged after study end (i.e., post-Sept 30 2011). * AIS scores are only available post-2000.

Characteristics [missings]	Alive N=1,907	Dead N=379	Missing Vital Status N=206
Age at injury, years: mean; S.D. (IQR)	40.5; 17.2 (27)	62.6; 17.9 (26)	47.0; 20.2 (35.5)
Length of stay, months: mean; S.D. (IQR)	5.8; 7.8 (4.3)	4.9; 3.6 (5.1)	5.0; 4.2 (4.7)
Sex [1]			
Male	1420 (74.5)	260 (68.6)	152 (73.8)
Female	486 (25.5)	119 (31.4)	54 (26.2)
Age at injury			
16-30	678 (35.8)	27 (7.2)	58 (28.6)
31-45	527 (27.8)	44 (11.7)	46 (22.7)
46-60	391 (20.6)	76 (20.2)	41 (20.2)
61-75	233 (12.3)	122 (32.4)	34 (16.7)
76+	67 (3.5)	108 (28.6)	24 (11.8)
Etiology [2]			
Sports and leisure	501 (26.3)	41 (10.8)	20 (9.7)
Transport	596 (31.3)	71 (18.8)	63 (30.6)
Falls	602 (31.6)	209 (55.3)	92 (44.7)
Other cause	207 (10.9)	57 (15.1)	31 (15.0)
SCI Type [13]			
Tetra	1076 (56.7)	158 (41.8)	105 (52.0)
Para	703 (37.0)	204 (54.0)	83 (41.1)
Cauda equina	120 (6.3)	16 (4.2)	14 (6.9)
Completeness [101]			
Complete	1264 (68.4)	234 (65.0)	130 (70.7)
Incomplete	583 (31.6)	126 (35.0)	54 (29.3)
Lesion Level & Completeness [56]			
Paraplegia, incomplete	638 (36.4)	85 (24.6)	60 (34.3)
Paraplegia, complete	423 (24.1)	68 (19.7)	41 (23.4)
Tetraplegia, incomplete	534 (30.5)	135 (39.0)	61 (34.9)
Tetraplegia, complete	157 (9.0)	58 (16.8)	13 (7.4)
AIS Score* [968]			
AIS A	372 (29.4)	57 (33.1)	20 (23.3)
AIS B	149 (11.8)	27 (15.7)	11 (12.8)
AIS C	194 (15.3)	41 (23.8)	18 (20.9)
AIS D/E	551 (43.5)	47 (27.3)	37 (43.0)
Injury Severity* [1,324]			
C1-C4 ABC	88 (8.6)	16 (15.8)	6 (12.5)
C5-C8 ABC	86 (8.4)	11 (10.9)	1 (2.1)
T1-S3 ABC	294 (28.9)	27 (26.7)	4 (8.3)
AIS D/E	551 (54.1)	47 (46.5)	37 (77.1)
Destination after discharge [75]			
Private residence	1612 (86.6)	164 (45.1)	131 (68.6)
Hospital	78 (4.2)	45 (12.4)	19 (9.9)
Nursing home/assisted living	154 (8.3)	86 (23.6)	39 (20.4)
Other (e.g., hotel)	15 (0.8)	2 (0.5)	2 (1.0)
Death	3 (0.2)	67 (18.4)	0 (0.0)
Ventilator Assistance [74]			
No	1843 (98.0)	291 (85.8)	193 (97.5)
Yes	38 (2.0)	48 (14.2)	5 (2.5)

Table 2. Marginally adjusted estimates of life years remaining according to attained age

Estimates adjusted for attained age, sex, level and lesion of spinal cord injury. Estimates according to AIS score are restricted to injuries that were incurred post-2000.

	Attained age			
	30	40	50	60
Sex				
Male	41.7 (37.9-45.5)	33.6 (30.0-37.2)	24.4 (22.2-26.6)	17.4 (14.8-19.9)
Female	42.8 (40.1-45.5)	34.8 (32.3-37.2)	26.1 (23.5-28.6)	18.8 (16.4-21.1)
SCI Type				
Para incomplete	45.1 (42.1-48.2)	36.4 (32.1-40.7)	27.3 (24.8-29.8)	20.6 (18.0-23.3)
Para complete	40.4 (36.0-44.7)	32.5 (28.3-36.7)	23.5 (19.7-27.3)	16.3 (13.6-18.9)
Tetra incomplete	42.8 (38.4-47.2)	34.6 (31.8-37.5)	25.4 (22.7-28.0)	17.6 (14.6-20.6)
Tetra complete	28.7 (25.4-31.9)	21.7 (17.4-26.1)	13.6 (9.3-17.9)	9.8 (8.3-11.2)
AIS				
All D/E	48.3 (43.0-53.6)	38.4 (34.4-42.4)	29.2 (26.1-32.3)	21.1 (17.1-25.1)
C1-C4 ABC	37.0 (23.4-50.7)	26.8 (19.1-34.5)	18.7 (13.2-24.3)	13.4 (6.7-20.0)
C5-C8 ABC	34.3 (26.2-42.4)	24.5 (17.7-31.3)	17.3 (10.9-23.7)	11.0 (7.7-14.3)
T1-S5 ABC	41.4 (36.2-46.5)	31.6 (24.7-38.4)	23.9 (18.9-28.8)	16.8 (11.3-22.3)

Table 3. Excess mortality per 1'000 person-years, stratified by lesion characteristics*Excess mortality presented as the average excess mortality with 95% confidence intervals.*

	Paraplegia		Tetraplegia	
	Incomplete	Complete	Incomplete	Complete
Sex				
Female	5.06 (2.01-12.93)	8.09 (3.39-19.68)	9.51 (3.76-24.51)	24.62 (11.00-56.12)
Male	3.45 (1.43-8.53)	6.49 (2.98-14.54)	6.53 (2.90-15.08)	15.95 (7.55-34.61)
Age				
16-30	0.55 (0.15-2.04)	1.33 (0.38-4.65)	0.71 (0.19-2.59)	3.59 (1.07-11.98)
31-45	1.91 (0.79-4.61)	4.46 (2.14-9.33)	2.56 (1.07-6.15)	11.68 (5.64-24.30)
46-60	3.19 (1.27-8.08)	7.53 (3.44-16.61)	4.62 (2.01-10.69)	20.86 (9.71-45.08)
61-75	10.77 (4.83-24.16)	22.69 (10.85-47.78)	14.39 (6.94-30.00)	78.66 (39.56-157.24)
76+	13.02 (4.36-39.06)	29.12 (9.83-86.60)	19.06 (6.69-54.49)	102.34 (35.26-297.82)

Figure 1. Potential years of life lost (PYLL) according to age at injury, stratified by lesion characteristics

The solid black line indicates potential years of life lost (PYLL) for complete tetraplegic lesions, the dashed dark grey line indicates PYLL for incomplete tetraplegic lesions, the dashed light grey line that for complete paraplegic lesions, and finally the solid light grey line the PYLL for incomplete paraplegic lesions.

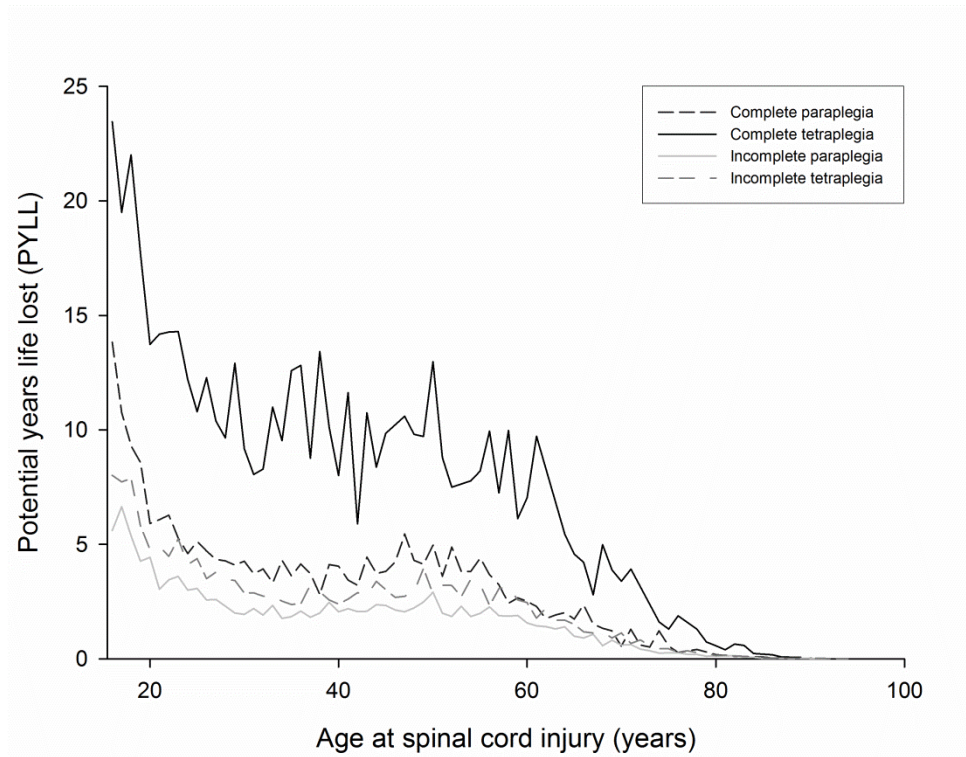


Figure 2. Comparison of estimated hazard ratios and excess hazard ratios

The unfilled circle represents the reference category. The black-filled circle corresponds to estimated hazard ratios (HR), while the grey-filled circle corresponds to the estimated excess hazard ratio (eHR). The 95% confidence intervals (95% CI) are represented by the solid lines on either side of the circle representing the HR or eHR. All estimates are adjusted for lesion level and completeness, attained age, and sex. To note, the left-hand y-axis corresponds to the HR and eHRs estimated for attained age; the right-hand y-axis corresponds to the HR and eHRs for all other variables.

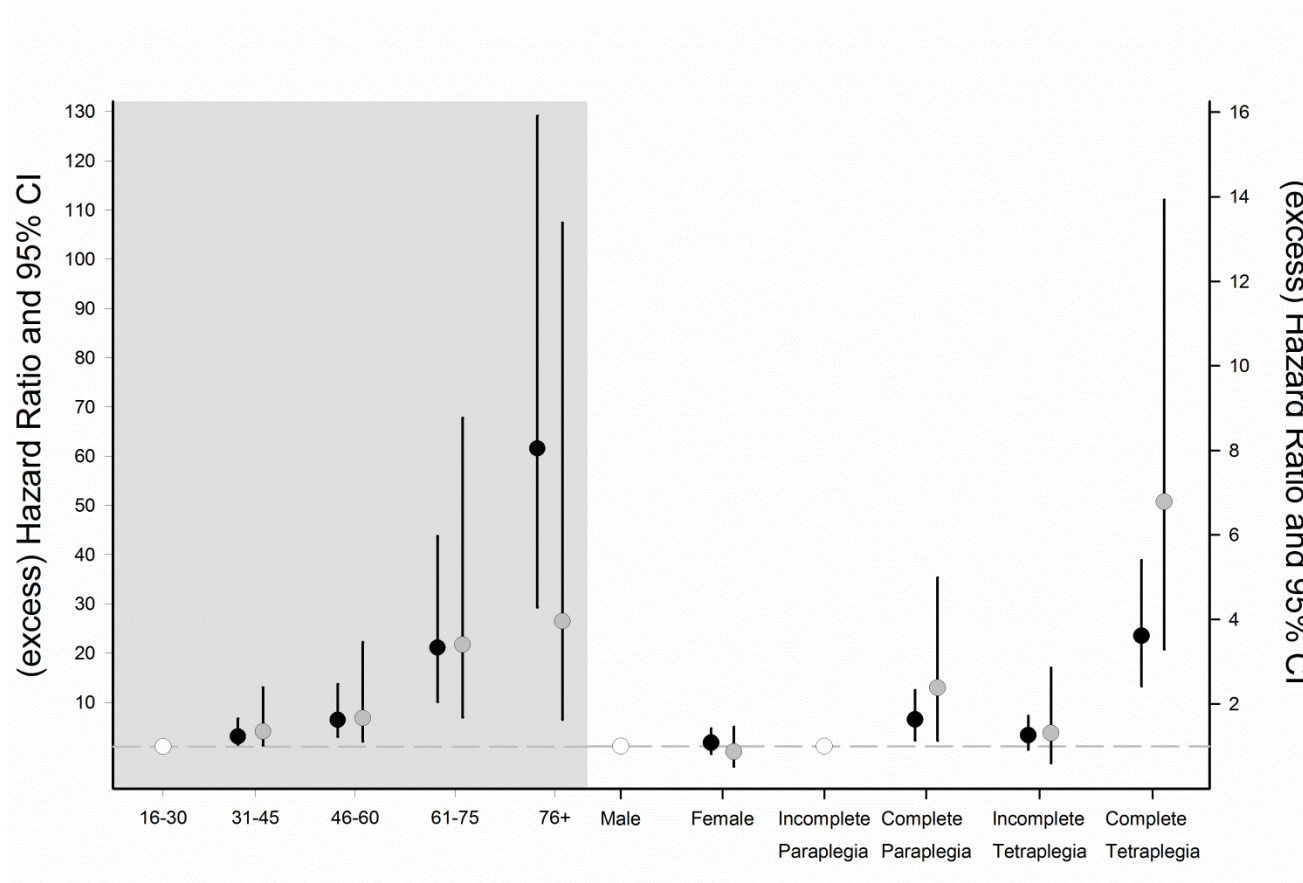


Figure 3. Marginally adjusted survival and relative survival probabilities, stratified by lesion characteristics

The solid black line indicates the marginally adjusted survival and relative survival probability for incomplete paraplegia; the dashed line that for complete paraplegia; the light grey, dotted line that for incomplete tetraplegia; and finally the dashed-dotted line for complete tetraplegia.

