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ORIGINAL ARTICLE

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

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Abstract

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

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

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

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

Keywords Mortality · Burden · Life expectancy · Potential years life lost · Excess mortality · Spinal cord injury

Introduction

The 2017 Global Burden of Disease (GBD) report identified non-communicable diseases (NCDs) as the leading contributor to mortality as well as to disability-adjusted life years (DALYs), a comprehensive measurement of disease burden that has globally seen a 40% increase between 1990 and 2017 (Cao et al. 2018; GBD 2017 DALYs and HALE Collaborators 2018). While previous GBD reports have reported positive trends of improved health and life expectancy virtually universally, the recent 2017 report presents a sobering picture with reductions in progress towards improved health and projected escalations in the burden of disease due to NCDs (Cao et al. 2018; GBD 2017 DALYs and HALE Collaborators 2018). To curb this trend, it is necessary to quantify the burden of disease in order to set priorities for resource management and targeting improvement. To this aim, estimates of life expectancy or potential years of life lost are important parameters of

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individual and societal burden. These indicators evaluate the integral impact of health conditions or health states on human functioning insomuch as they serve as a censor, aid in planning of resources and service needs, and contribute to the evaluation of DALYs (2018). Additionally, relative measures—including relative survival or excess mortality—can be used to account for background mortality in the general population in order to quantify the true impact of spinal cord injuries (SCIs) on risk of premature mortality.

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

Methods

Study population

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

Statistical analysis

For this study, level and completeness of the spinal cord lesion were grouped together into a four-level variable, including paraplegia incomplete; paraplegia complete; tetraplegia incomplete; and tetraplegia complete. Age was included as a categorical variable according to ISCoS guidelines to ensure comparability with previous research (DeVivo et al. 2011). For the estimation of excess mortality rate ratios (eHRs) and relative survival, we used splitting techniques to partition follow-up time of individuals with SCI with respect to age class and year, thus facilitating proper benchmarking to the mortality data of the GP by age, sex and calendar year. Given the high mortality rate during the months immediately following injury, estimates were restricted to individuals that survived at least 6 months post-injury. GP mortality rates—stratified by age, sex and year of death—were merged with attained age, sex and attained year of death of the SCI cohort. This was similarly performed for estimation of potential years life lost (PYLL), with the exception that age and year at injury were used in place of attained age and year.

Time at risk started with date of SCI, with study start on date of admission to the first rehabilitation. Individuals exited the study on date of death or end of study (September 30, 2011), whichever came first. Individuals LTFU were censored on the last date of known vital status. To prevent over-parameterization of models, confounders were identified using directed acyclic graphs (DAGs) informed by theory, previous evidence and data availability; included confounders were: age, sex, level and completeness of lesion (Greenland et al. 1999). Excess mortality and relative survival were modelled using a flexible parametric survival model (FPM) (Dickman and

Coviello 2015). The Bayesian Information Criterion (BIC) value was used to identify best-fitting models given the degrees of freedom (df); 3 df were determined for the best fit. The proportional hazards assumption was assessed using a likelihood ratio test comparing models with and without inclusion of time-dependent effects. A FPM was used to predict life years remaining (LYR) using restricted mean survival time at attained ages: 30; 40; 50; and 60 years. A maximum attained age of 90 years which is close to the oldest ages observed in the study population was used in modelling. A FPM was similarly used to model the PYLL; level and completeness of injury, age at injury as a continuous variable using splines and sex were controlled for in the model. Pre-2000, information on the American Spinal Injury Association (ASIA) Impairment Scale (AIS) score (Roberts et al. 2017) was not regularly collected; estimates stratified by injury severity (a combination of AIS score and level of lesion) thereby exclude individuals who incurred a TSCI pre-2000. Hazard ratios (HRs) and excess hazard ratios (eHRs) were modelled using a FPM and are presented with 95% confidence intervals. Excess hazard ratios and standard HRs can be interpreted similarly, with the addition that eHRs account for variation in the background mortality rates of the GP. For example, an eHR of 1.2 for males relative to females would indicate that males have a 20% higher risk of mortality after controlling for the background variation in GP mortality.

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

Results

This study includes 2′492 individuals, of which 379 (15.2%) had a known date of death. Of those individuals that died, 149 (39.3%) died within the first 2 years post-injury, 87 (23.0%) between 2 and 5 years, 81 (21.4%) between 5 and 10 years, and 62 (16.4%) between 10 and 21 years. Additionally, more than half were male (68.6%), nearly two-thirds of the population were over the age of 60 years at time of death (60.1%), and roughly 40% had an incomplete tetraplegia (Table 1).

Life years remaining and potential life years lost

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

For individuals injured between 1990 and 2011, there is an estimated total of 8486.5 PYLL due to TSCI, of which 75% is attributable to TSCIs incurred between 16 and 45 years of age. Figure 1 provides a visualization of PYLL according to lesion characteristics across different ages at injury. Individuals with incomplete and complete paraplegia as well as with incomplete tetraplegia exhibited similar PYLLs, with an average estimated PYLL at 20 years of 4.4, 5.9 and 4.8, respectively (Fig. 1). In comparison, a complete tetraplegia incurred at 20 years of age, reduced LE by nearly 14 years (Fig. 1). This gap in PYLL according to lesion level and completeness persisted across differing ages at injury.

Relative survival and excess mortality

Estimated excess mortality per 1′000 person-years is provided in Table 3. Across sociodemographic characteristics, excess mortality is impacted by lesion level and completeness. For example, the excess mortality rate for individuals aged between 16 and 30 years with an incomplete paraplegia was 0.6 (95% CI = 0.15–2.04) per 1′000 person-years, while for individuals with complete tetraplegia the excess mortality was roughly four additional deaths per 1′000 person-years (95% CI = 1.07–11.98) (Table 3). This divergence increased with age. A comparison of HRs and eHRs is presented in Fig. 2. When accounting for background mortality in the GP, effect sizes for the 31–45 year old age group increased slightly, while eHRs for the oldest age group were attenuated, accounting for the higher risk of mortality with older ages experienced by the general population (Fig. 2). Differences in risk of mortality according to lesion level and completeness were similarly exaggerated when accounting for background GP mortality rates, with an excess mortality rate nearly sevenfold higher for individuals with complete tetraplegia in comparison with persons with incomplete paraplegia (eHR = 6.78; 95% CI = 3.29–13.93) (Fig. 2). Comparisons of standard survival estimates and relative survival estimates demonstrate the mortality attributable to TSCI by accounting for the expected mortality among persons with SCI, estimated from age- and sex- stratified mortality rates in the GP (Fig. 3). For example, individuals with a complete tetraplegia who survived at least half a year post-injury had

Table 1 Study characteristics according to vital status

Characteristics (missings)	Alive $N = 1907$	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)
Aetiology [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 and 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* [1324]			
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)

Table 1 (continued)

Characteristics (missings)	Alive $N = 1907$	Dead $N = 379$	Missing vital status $N = 206$
Yes	38 (2.0)	48 (14.2)	5 (2.5)

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. Switzerland, 1990–2011

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

	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)

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. Switzerland, 1990–2011

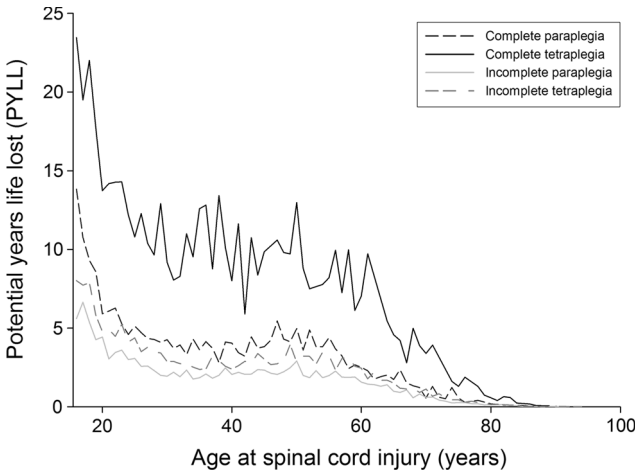

Fig. 1 Potential years of life lost (PYLL) according to age at injury, stratified by lesion characteristics. The solid black line indicates potential years of life lost (PYLL) for complete tetraplegic lesions, the dashed dark grey line PYLL for incomplete tetraplegic lesions, the dashed light grey line that for complete paraplegic lesions and finally the solid light grey line the PYLL for incomplete paraplegic lesions. Switzerland, 1990–2011

an estimated 10-year survival probability of roughly 75% (Fig. 3). When accounting for background mortality rates in the GP, relative survival estimates showed that excluding the possibility of mortality due to any other disease or external factor, 20% of persons with complete tetraplegia will have died due to their diagnosis 10 years post-injury (Fig. 3).

Discussion

Summary

In Switzerland, persons with a traumatic SCI and an attained age of 30 years have an estimated 28.7–45.1 years of life remaining with higher, more severe injuries equated with the greatest reductions in residual life expectancy. Additionally, although older age is associated with a higher risk of mortality, this study found that individuals injured at a younger age lost substantially more life years. Finally, this study revealed that the risk of mortality following TSCI remains elevated across the life course of the spinal

Table 3 Excess mortality per 1′000 person-years, stratified by lesion characteristics

	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)

Excess mortality presented as the average excess mortality with 95% confidence intervals. Switzerland, 1990–2011

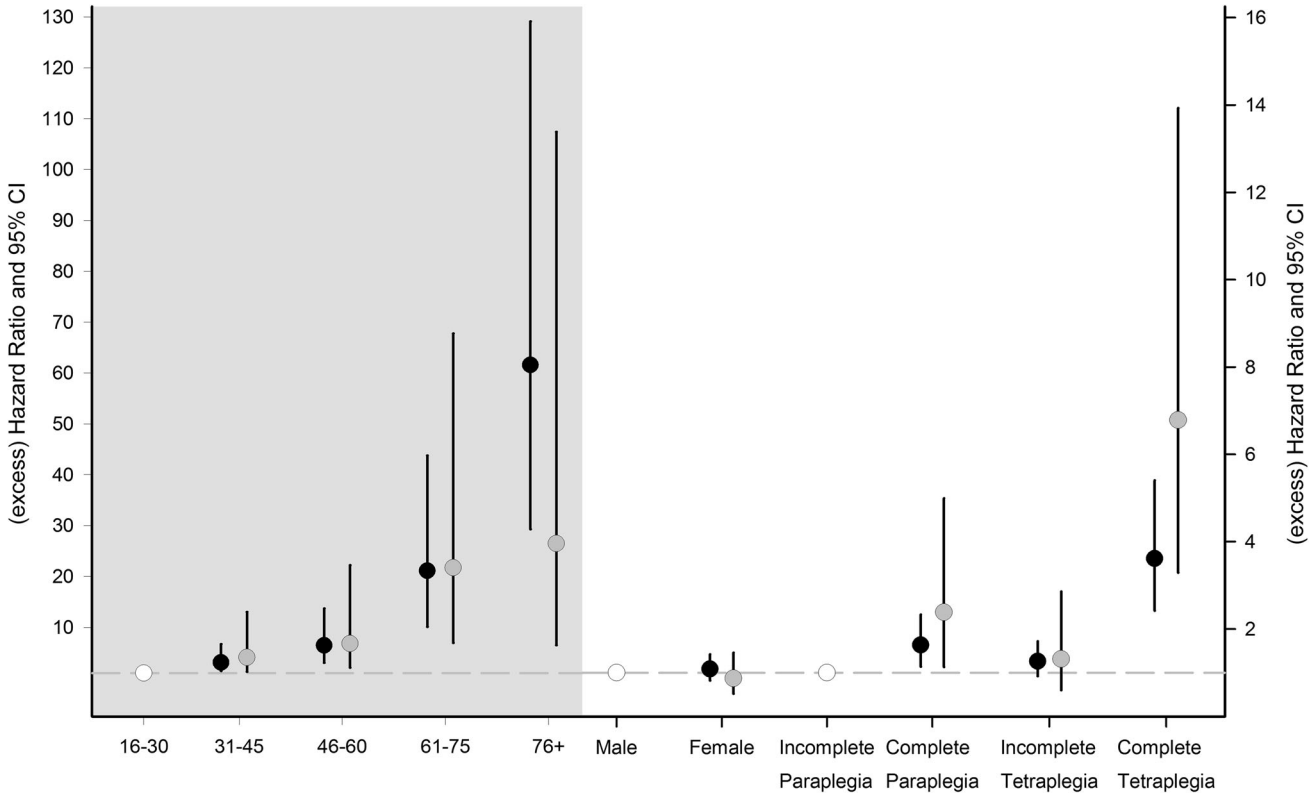

Fig. 2 Comparison of estimated hazard ratios and excess hazard ratios. The unfilled circle represents the reference category. The black-filled circle corresponds to estimated hazard ratios (HR), while the grey-filled circle corresponds to the estimated excess hazard ratio (eHR). The 95% confidence intervals (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. Switzerland, 1990–2011

cord injured individual, never returning to that of the general population.

In the present study, the LE for individuals with a TSCI and an attained age of 30 years old varied between 53.1 and 88.0% of the LE of the Swiss general population (2017). Our results contribute to consistent evidence in high-income countries. For example, a study using data from the Model Systems in the USA estimated the LE for 25 years old white males, with an elapsed time of 3 years since incurring a TSCI, to be between 52 and 88% that of the general population LE, depending on lesion level and severity (Shavelle et al. 2015). Similarly, in a UK-based study by Savic et al., the estimated LE after TSCI was between 57.1 and 86.9% of that of the general population

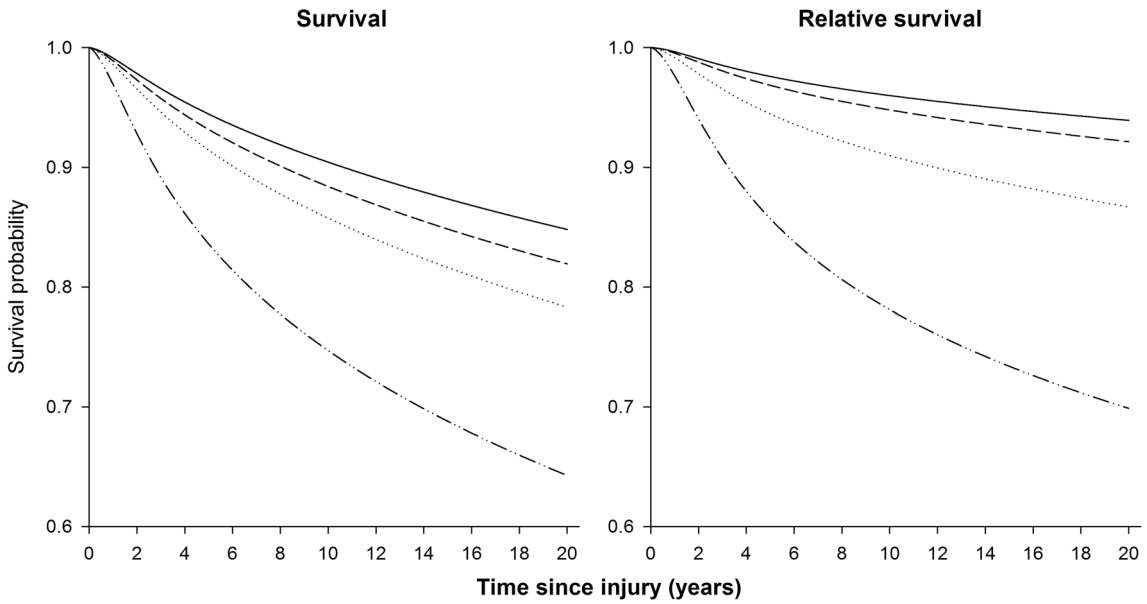

Fig. 3 Marginally adjusted survival and relative survival probabilities, stratified by lesion characteristics. The solid black line indicates the marginally adjusted survival and relative survival probability for incomplete paraplegia; the dashed line that for complete paraplegia; the light grey, dotted line that for incomplete tetraplegia; and finally the dashed–dotted line for complete tetraplegia. Switzerland, 1990–2011

for men with an attained age of 25 years, who survived at least one year post-injury (excluding ventilator-dependent persons) (Savic et al. 2017). To note, both of these studies also investigated trends in LE among individuals with TSCI and found either minimal or no improvement LE across recent decades. This suggests that while the LE of the GP has been steadily improving across high-income countries, improvements in long-term survival for individuals with SCI have remained largely stagnant. Such reductions and lack of improvement in LE in comparison with the general population are indicative of the large burden on the individual.

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

In comparison with individuals who incurred an incomplete paraplegia, complete tetraplegia was associated with nearly seven times more excess deaths—or deaths beyond what is expected based on GP mortality rates. This is considerably higher than the roughly fourfold increase in risk of mortality estimated when using standard methods (i.e. methods not taking into account background GP mortality rates). Additionally, if considering solely standard hazard ratios, it would appear that the oldest age group (76 years and older) has by far the highest risk of mortality; however, when accounting for background mortality in the GP, the excess hazard is attenuated and

similar to that of individuals between 61 and 75 years of age. Such information may change targets for interventions as, in the example of age, this points towards the need to equally target these two age groups in efforts to minimize or reduce premature mortality. When considering the elevated risk associated with complete tetraplegia, the further accentuation when accounting for background mortality in the GP points towards an influence of age and sex on lesion characteristics, i.e. younger individuals are more affected by complete tetraplegia. This suggests the need to potentially reassess and invest more resources towards reducing disparities in risk of premature mortality and to mitigate individual-level burden associated with lesion characteristics, particularly targeting younger individuals who have incurred a complete tetraplegia. Given that the burden associated with TSCIs is expected to augment in the future due to the projected increase in the incidence rate of TSCIs among older individuals primarily due to falls, refining and re-evaluating high-risk group definitions are essential to ensure the intended prevention or reduction in premature mortality (Ahn et al. 2017).

Strengths and limitations

Estimates of the contribution of pre-specified risk factors on all-cause mortality due to SCI can be misleading given the influence of the background mortality experienced by the general population. Therefore, a strength of this study is the provision of relative estimates of survival and mortality, which provide unbiased indicators of mortality due to sustaining a TSCI through standardization to the GP by age, sex and decade. Although individuals within this study were included within the mortality rates for the GP, given that TSCI is rare, the impact on estimates is negligible. A potential limitation of this study, however, is the limited follow-up time of roughly 20 years. At the end of the study period, the majority of individuals were still alive; therefore, in order to model remaining life years, this study was forced to rely on model assumptions for estimation, for example restricting the maximum age to 90 years. Extended follow-up in the context of the SwiSCI cohort study will facilitate validation. Additionally, it was not possible to adequately investigate trends in LE or other mortality-related outcomes. Given the paucity and conflicting evidence on trends in improvements in mortality-related outcomes, country-specific analyses are needed.

Conclusion

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

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Author contributions JDC, MWGB and MZ were responsible for the initial conceptual framing. AB and MWGB provided statistical support and critical feedback on manuscript content. HPG, KH, XJ and MS provided clinical support and feedback of the present manuscript. MZ and AM provided statistical support for analyses, as well as critical evaluation of statistical methods implemented. JDC was responsible for all analyses, drafting and finalization of manuscript. All authors have supported and approved the final manuscript.

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Compliance with ethical standards

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

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