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Brief Report

International comparison: Spinal cord injury in the USA and UK

Robert Shavelle[a,*], Michael DeVivo[b], Gordana Savic[c], Jordan Brooks[a] and David Strauss[a]
[a]*Life Expectancy Project, San Francisco, CA, USA*
[b]*University of Alabama at Birmingham, Birmingham, AL, USA*
[c]*National Spinal Injuries Centre, Stoke Mandeville Hospital, Buckinghamshire Healthcare, Aylesbury, UK*

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Abstract.
BACKGROUND: Long-term survival after spinal cord injury (SCI) has been extensively studied in the US and UK.
OBJECTIVE: To compare SCI epidemiology and survival results between the US and UK for the same time period and patient groups.
METHODS: We restricted attention to persons injured at ages 18 and older who had survived at least 2 years post injury and were not ventilator dependent. We performed survival analysis using logistic regression on person-year data with time-dependent covariates. The resulting mortality rates were used to construct life tables in order to obtain life expectancies.
RESULTS: The average age at injury, percentage male, and level/grade of injury were rather similar between the two countries. After adjustment for risk factors, UK mortality was 85% of that in the US (95% c.i. 80% to 91%, $p < 0.0001$). Mortality increased by 0.3% per year over the 1980 to 2012 study period (HR = 1.003); this was not statistically significant ($p = 0.44$). The US and UK life expectancies are nearly the same percentage of their respective general population values, differing by at most 2%.
CONCLUSION: Long-term mortality after SCI in the UK is roughly 15% lower than that in the US. The general population mortality in the UK is also approximately 15% lower, however, and thus the percentages of normal life expectancy in the two countries prove to be strikingly similar.

Keywords: Military, telehealth, rehabilitation, brain injury, TBI, outcomes, satisfaction, head injury, improvement, physical therapy, psychotherapy, speech therapy, interdisciplinary

1. Introduction

Long-term survival after spinal cord injury (SCI) has been extensively studied in the US and UK (Shavelle, 2015a; DeVivo, 1999; Savic, 2017). Recent studies have also been conducted in Germany (Thietje, 2021), Denmark (Noe, 2017), Norway (Hagen, 2010), and Australia (O'Connor, 2005). Limitations in comparing their results include differences in study periods, variables and groupings considered, and the analytic methods. The present study is, to our knowledge, the first to compare SCI epidemiology and survival results between countries for the same time periods and patient groupings. Our data are from the US and UK. Our principal aim is to determine whether, all else being equal, long-term survival after SCI varies between the two countries. A secondary aim is to examine whether there has been a trend toward improved survival over time.

2. Methods

The US data have been described in detail elsewhere (DeVivo, 1999). Briefly, there were 49,241

*Address for correspondence: Dr. Robert Shavelle, Life Expectancy Project, 1439 – 17th Avenue, San Francisco, CA, USA. E-mail: Shavelle@LifeExpectancy.org.

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persons with SCI injured 1973 to 2012 who were treated at any of the U.S. national model systems of care facilities. The UK data are the same as used by Savic et al. (2017), namely 5,483 persons with traumatic SCI who were injured 1943 to 2010, survived the first year post injury, were treated at the two oldest British spinal centers, and had residual neurological deficits.

For the survival analyses we restricted attention to persons injured at ages 18 and older who had survived at least 2 years post injury and who were not ventilator dependent. Survival of ventilator dependent persons is the subject of another study (Shavelle, 2022). In addition, we excluded persons with unknown neurological level or grade. We considered only the relatively recent calendar years, 1980 to 2012, that were common to the two countries. [Note: Savic et al. were concerned about the small sample size in their most recent calendar period, and a parallel study in the U.S. noted late reporting of deaths (Shavelle, 2022), two reasons to restrict attention to the years indicated above.]

As in the original US and UK studies, we used survival analysis with time-dependent covariates on the person-year data. With each person-year, an outcome variable indicating whether the person lived or died in that year was associated with explanatory variables such as age and severity of injury. We modeled the mortality rates using logistic regression analysis (Hosmer, 2000) to relate the outcome variable (lived/died) to the explanatory variables, which included age, sex, ethnicity, etiology of injury, level and grade of injury, time since injury, and calendar year. The model provided mortality rates, which we used to construct life tables (Arias, 2022) to obtain life expectancies. General population life expectancies from the US (Arias, 2022) and UK (Government Actuary, 2021) are shown for comparison.

3. Results

Descriptive statistics for the three cohorts are given in Table 1. As can be seen, the average age at injury, percentage male, and level/grade of injury are rather similar.

Table 2 provides the parameters from the final logistic regression survival model. Results from the 2015 US paper are also shown to indicate how inclusion of the UK data has slightly changed the estimates in some cases and led to greater precision (the 95% confidence intervals are each narrower). The final line of the Table shows that, all else being equal, UK mortality is 0.85 (85%) of that in the US (95% c.i. 0.80–0.91, $p < 0.0001$).

Table 1
Demographics and injury characteristics by country. Ages 18 and older at injury, for persons with known injury level and AIS Grade A, B, C, or D

Factor	US	UK
Year of injury	1946–2021	1943–2010
Sample size (n)	46,273	5,028
Deaths	15,745	2,305
Age at injury (years; mean ± SD)	37 ± 17	38 ± 16
Follow-up time (years; mean ± SD)	14 ± 13	19 ± 14
Male	81%	80%
C1-C4ABC	13%	7%
C5-C8ABC	19	24
Paraplegia ABC	34	40
Grade D (all levels)	28	28
Ventilator dependent (all levels)	6	2

Also shown in the table is the effect of calendar year (HR = 1.003, $p = 0.44$), indicating that – all else being equal – mortality increased by 0.3% per year over the 1980 to 2012 study period. This was not statistically significant. In what follows we drop the calendar year term from the model, and thus assume constant mortality over the period.

We used the model of Table 2 to compute mortality rates and the resulting life expectancies for various groups. These were the same functional groups considered in the earlier US paper. Table 3 provides the results for males aged 25 who survived 3 years post injury. As can be seen the US and UK life expectancies are nearly the same percentage of their respective general population values, differing by at most 2%.

4. Discussion

Life expectancy in the UK general population exceeds that of the US by several years, with the difference depending on both age and sex. However, these differences are entirely consistent with the 15% decrease in SCI mortality reported here.

The percentages shown in Table 3 are consistent with the result of Savic et al. (2017). For example, amongst males age 25, Savic reported 57% of normal for the C1-C4ABC group, whilst the values here range from 50% to 61% for C1-C3A to C4BC. For the C5-C8ABC group they reported 65%, whereas here the values are 58% to 67% for C5A to C6-8BC. Their figures for the paraplegia ABC and Grade D groups, however, are 77% and 87%, compared with our 71% and 83%. The figures from the present study

Table 2
Comparison of the prior and current logistic regression models for prediction of mortality. Time since injury 2 years or more. The prior model was based on U.S. data 1973-2012, and the current one on both U.S. and U.K. data 1980-2012

Variable	2015 US Model		Current US + UK Model	
	Odds Ratio	95% Limits	Odds Ratio	95% Limits
Male	1.33	(1.25, 1.40)	1.26	(1.20, 1.33)
White*	1.05	(1.00, 1.11)	1.00	(0.96, 1.05)
Violence*	1.21	(1.14, 1.30)	1.32	(1.24, 1.40)
Age, grades ABC (per year)	1.06	(1.06, 1.06)	1.065	(1.06, 1.07)
Age, grade D (per year)	1.07	(1.07, 1.08)	1.075	(1.07, 1.08)
C1-C3 A	7.47	(5.65, 9.88)	6.99	(5.37, 9.10)
C4 A	6.48	(5.26, 7.98)	6.45	(5.29, 7.87)
C5 A	4.59	(3.72, 5.64)	4.93	(4.05, 5.99)
C6-C8 A	4.18	(3.41, 5.13)	4.24	(3.49, 5.15)
C1-C3 BC	4.74	(3.52, 6.38)	4.73	(3.58, 6.25)
C4 BC	4.23	(3.38, 5.29)	4.31	(3.49, 5.33)
C5 BC	3.67	(2.94, 4.58)	3.67	(2.98, 4.53)
C6-C8 BC	3.37	(2.72, 4.18)	3.36	(2.74, 4.13)
T1-S5 ABC**	2.89	(2.37, 3.52)	2.80	(2.32, 3.39)
Grade D (all levels)	1.00		1.00	
Time since injury 2.0 to 3.0 years	1.15	(1.04, 1.27)	1.08	(0.99, 1.19)
Time since injury >3.0 years	1.00		1.00	
Calendar year			1.003	(1.00,1.01)***
UK adjustment			0.85	(0.79, 0.91)

*These variables not available in the UK data. **Subsets of this group were previously explored. The prior and current estimates are respectively T1-T6A 3.3 / 3.1, T1-T6BC 3.0 / 2.9, T7-S5A 2.7 / 2.7, T7-S5BC 2.7 / 2.5. ***If the data are instead restricted to the US cohort (for years 1980 to 2019), the odds ratio for calendar year is 0.996, with 95% CI = 0.994, 0.998.

Table 3
Life expectancies for 25-year-old white males, non-violent etiology, time since injury 3 years or more, by injury level and AIS grade. Comparison of US and UK values using the logistic regression model of Table 2

	Life Expectancy (% of normal)	
Group	US	UK
C1-C3 A	49%	50%
C1-C3 BC	57%	59%
C4 A	50%	52%
C4 BC	60%	61%
C5 A	57%	58%
C5 BC	64%	65%
C6-C8 A	60%	61%
C6-C8 BC	66%	67%
T1-S5 (paraplegia) ABC	70%	71%
Grade D (all levels)	83%	83%
General population values[a]	52.5 (100%)	54.7 (100%)

[a]Neither the US (Government Actuary, 2021) nor UK (DeVivo, 2007) baseline mortality rates were used in the computation of the SCI life expectancies.

should be preferred, however, as they are based on a larger combined dataset, which is evidently less subject to variation. In addition, the results here derive from a more parsimonious survival model restricted to recent calendar years.

Many prior studies have also shown no improvement in SCI survival in recent years (Shavelle, 2015ab; DeVivo, 2007). Indeed, general population mortality has been relatively stable since about 2010 (Arias, 2022; Government Actuary, 2021). Our choice to report the 2019 general population figures in Table 3 is thus equivalent to reporting the 2012 values.

Strengths of the present study include the large size of the study population, the fact that all severity levels are represented, and that the data span some 30 years. Another strength is that the methods used here are powerful, sensitive enough to identify comparatively small changes over time. Limitations include that the US source for mortality information (SSDI) is only 92.4% sensitive in the identification of deaths, and we do not at present have the comparable percentage for the UK data. The results given here are thus, if anything, overestimates of survival.

5. Conclusions

Long-term mortality after SCI in the UK is roughly 15% lower than that in the US. The general population mortality in the UK is also approximately 15% lower, however, and thus the percentages of normal life expectancy in the two countries prove to be strikingly similar. There was no evidence for improvement in survival over the 1980 to 2012 study period.

Conflicts of interest

None to report.

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