



Published in final edited form as:

Spinal Cord. 2022 September ; 60(9): 799–804. doi:10.1038/s41393-022-00794-x.

Social participation as a mediator of the relationships of socioeconomic factors and longevity after traumatic spinal cord injury

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Abstract

Study Design: Cohort study.

Objective: Previous research has indicated that socioeconomic factors affect longevity after traumatic spinal cord injury (SCI). Our purpose was to evaluate whether social participation mediates the relationship between socioeconomic factors and survival status after SCI.

Setting: Medical university in the southeastern United States.

Methods: Participants (N = 1,540) met the following inclusion criteria: traumatic SCI of at least 1-year duration, minimum of 18 years of age, and having residual impairment from SCI. The main outcome measures were a) survival status as of December 31, 2019, identified by the National Death Index (NDI) search, b) socioeconomic status (SES), measured by education, employment status, and family income, and c) participation, measured by marital/relationship status, hours out of bed per day, days leaving home per week, and nights away home during the past year.

Results: Thirty nine percent of participants (n = 602) were deceased by the end of 2019. Socioeconomic factors were associated with longevity controlling for demographic, injury characteristics, and health status. However, the association of SES with longevity was mediated by three social participation mobility indicators (hours out of bed, days out of house, and nights away

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Authors' Contributions

YC was the lead author and was responsible for the analyses, methods, and results sections, and overall development of the manuscript. ND completed the literature review and contributed to the discussion and conclusions sections. MJ contributed to the literature, introduction, and editing of the manuscript. JK was the principal investigator and contributed to the discussion and conclusion sections, as well as the overall development and editing of the manuscript.

Data Archiving

The data sets generated and/or analyzed during the current study are not publicly available due to the privacy concerns of study participants and are not standardized to be in a publicly interpretable format.

Statement of Ethics

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

Conflicts of Interest

The authors have no conflict of interest to disclose.

Suppliers

a. SAS for Windows [computer program]. Version 9.4. Cary, NC: SAS Institute; 2015

from home), such that SES was no longer significantly related to longevity after inclusion of the participation variables.

Conclusions: Although socioeconomic factors are related to longevity, their relationship appears to be mediated by social participation mobility indicators. Intervention studies are needed to address the modifiable factors that may promote longevity, including promoting an active lifestyle.

Keywords

spinal cord injury; longevity; survival status; participation; socioeconomic factors

Introduction

Traumatic spinal cord injury (SCI) typically results in permanent changes in sensory and motor function, impacting activities and participation, employment, and quality of life, leading to increased risk of mortality and diminished life expectancy. With the advances in medicine and research, mortality rates of the first two years after SCI have decreased over the past 30 years. However, the mortality rates among those who survive the first two years do not appear to have changed significantly,¹⁻⁴ creating a widening gap in longevity compared with the general population. There is a well-established body of literature on mortality after SCI,⁵ focusing on what goes wrong leading to excess mortality. At the same time, there are few studies that have examined *longevity* and the factors that may influence a long life lived after SCI, including participation, employment, and quality of life.

Several studies have focused on the causes and trends of death after SCI,^{1,2,6,7} as well as the risk factors associated with mortality.⁸⁻¹⁴ Demographic characteristics, including chronologic age, sex, and race are risk factors for mortality after SCI,^{1,2,6,15-20} as are SCI factors.^{5,7,21,22} Other sets of factors, including socioeconomic and employment factors,²³⁻²⁶ health behaviors,²⁶⁻²⁹ health factors,^{23,30-32} and psychological factors^{33,34} have also been identified as predictors of all-cause and cause-specific mortality after SCI. To date, less attention has been given to the relative importance of participation and employment indicators on longevity, or the relationships between these factors.

An earlier study addressed the relationships between socioeconomic factors, including educational level and income, with longevity, and found socioeconomic status was highly predictive of life expectancy.²⁵ The findings were even more profound when adding employment status to better predict longevity after SCI.³⁵ However, we still do not know either the mechanism by which socioeconomic factors influence longevity, nor do we understand how participation and socioeconomic factors interact or whether factors such as participation may mediate the relationships between socioeconomic status and longevity.

Our purpose was to evaluate a mediational model to determine whether social participation, as measured by the “Up and About” scale in Craig Handicap Assessment Reporting Technique (CHART)-Short Form and marital/relationship status, mediates the relationships between socioeconomic factors and longevity after SCI. It builds directly upon previous research, which established significant relationships between demographic factors (age, sex, race ethnicity), injury severity, and socioeconomic factors with longevity.^{12,14,19,25,35}

It extends that research by evaluating the potential facilitating effect of participation on longevity, even considering the established relationships of SCI with longevity.

Methods

Participants

Institutional Review Board approval was obtained prior to enrolling participants in the SCI Longitudinal Aging Study.^{36–38} Participants were selected from two geographic regions, the Midwestern and Southeastern USA. Those from the Midwestern cohort were first enrolled in 1973, with additional cohorts added in 1984 and 1993. They were identified from a university hospital and a private rehabilitation hospital. Those from the Southeastern cohort were first enrolled in 1993 with a second cohort added in 2003, selected from a specialty hospital that was designated as an SCI Model System. The current study uses data from the 2003 assessment in conjunction with data on survival status taken in 2021.

There were three inclusion criteria at enrollment: (a) traumatic SCI, (b) at least one year post SCI, and (c) > 18 years old. There was a working sample of 2,010 potential participants. A total of 1,570 participants returned materials (78%). After 3 cases were eliminated because of missing age information and 27 additional cases were eliminated due to questionable diagnoses (i.e., not traumatic SCI), the final sample was 1,540 participants.

Procedures

Data were collected by mail. Multiple mailings were used to maximize participation, along with phone calls to nonrespondents. Updated addresses were requested from the post office for individuals who had moved and had undeliverable mail. Internet and hospital records were used as additional sources for updated records. Participants were offered \$25 compensation for their participation.

Survival status was identified using the National Death Index (NDI), which is the gold standard for mortality research. We submitted our NDI search request in July 2021, and got our participants' survival status as of December 31, 2019, because NDI has a 16–18-month lag between the end of the calendar year and the release of their final data set for determining mortality.

Measures

Demographic characteristics included age, biological sex, and race-ethnicity (grouped into Hispanic, Non-Hispanic Black, Non-Hispanic White and others). Injury and health factors included injury level (Cervical 1–4 level, Cervical 5–8 level, and Thoracic/Lumbar/Sacral level), ambulatory status (ambulatory vs. non-ambulatory), and self-reported health status (poor/fair health, good health, and excellent health). Three socioeconomic indicators were obtained, including years of education, employment status, and family income. Employment status was classified as unemployed, part-time job, and full-time job. Lastly, family income was also broken down into three categories: less than \$20,000, \$20,000 –\$49,999, and \$50,000 or more.

Participation was measured by four variables: 1) marital/relationship status, 2) hours out of bed per day, 3) days out of the house in a typical week, and 4) nights away from home during the past year. The latter three items were taken from the CHART-Short Form.³⁹ They were “Up and About” scale, representing the mobility domain in the CHART instrument. Marital/relationship status was broken down into three groups that included: (a) single, (b) married or co-habiting, and (c) divorced, separated, or widowed.

Analyses

We used the Statistical Package of SAS v9.4 (SAS Institute Inc, Cary, NC, USA) for all data analyses. Among 2,010 potential participants, 759 have been measured in the previous study. We found 158 of them did not respond to the current study. Since we know their detailed demographic and injury characteristics information from last measurement, we performed the sensitivity analyses between respondents (n=601) and non-respondents (n=158). Then we did the bivariate analyses to compare the independent variables between participants alive and participants who were deceased by December 31, 2019. The t-test for continuous variables and chi-square test were used to get p-value for the comparisons.

We then developed three person-year logistic regression models for the survival analyses.^{40,41} We built the person-year observation data by breaking individual's event history into separate observations, one for each year until death or censoring date (i.e., December 31, 2019).

We coded the outcome variable (survival status= 0,1) as 1 for deceased during that year, or 0 for each of the person-year observations. The age and years post injury variables were time-variant, therefore increased by one for each of the person-year observations. All the other independent variables were time-invariant, measured from the 2003 self-report assessment. The three logistic regression models were developed in hierarchical order. The first model included demographic, injury, and health status variables, the second model added socioeconomic status variables, and the third model added participation variables. We also calculated the pseudo partial correlation for all independent variables in the third model. Because the pseudo partial correlation indicated the explanatory value of a single independent variable after accounting for other variables, we used it to evaluate each variable's relevant importance in the third model. We also calculated the variance inflation factors (VIF) to check if the inter-relationships between independent variables had significant impacts on our final model.

Results

The comparison between respondents and non-respondents indicated respondents' years post injury (17.86 ± 8.85) was significantly longer than the non-respondents (16.17 ± 9.80) $p < 0.05$, but all the other demographic and injury characteristic comparisons were not statistically significant. Among the 1,540 participants, 602 were deceased by the end of 2019 (39%). The bivariate comparisons (Table 1) found significant differences between participants alive and participants who were deceased in all the independent variables, except for one variable: race/ethnicity.

The first multiple logistic model was used as the baseline (table 2). A greater odds of mortality was associated with age (being older), neurologic level (higher levels), ambulatory status (non-ambulatory), years since injury (fewer years), and health status (poor or fair). In model 2, higher income (50K or more) and full-time employment were associated with a lower odds of mortality after controlling for demographic, injury characteristics, and health status.

When the participation indicators were added in the third model, 3 of 4 were associated with longer survival: hours out of bed, days out of house, and nights away from home. Marital/relationship status was not statistically significant. After adding these participation indicators, the association between socioeconomic status variables (income and employment) were no longer significantly related to survival. Pseudo partial correlations indicated age (0.17) and ambulatory status (0.07) were the most important variables to predict survival status. The next important variables are one participation indicator and one injury characteristic indicator: cervical 1–4 injury level (0.04) and hours out of bed (0.04). The sex variable (0.03) and the other two participation indicator, days out of house (0.03) and nights away from home (0.02) followed. The comparison of Pseudo partial correlations suggested except for age, sex, ambulatory status, and injury level, the active participation variables were the most important predictors for longevity. The largest VIF is 2.3 for income, 2.1 for marital status, and all the other VIF were less than 2, indicating the collinearity problem was modest.

Discussion

The unique contribution of the study was the identification of the mediating effect of participation on the existing relationship between socioeconomic factors and mortality, while controlling for demographic, injury characteristics, and health status. This helps to potentially explain the mechanism by which socioeconomic factors lead to greater longevity, as observed consistently in previous research.^{19,24} An additional strength is the use of an aging cohort of participants that includes a sizable portion who have reached aging milestones. By building upon previous models, the findings clearly demonstrate the importance of participation factors and their potential as targets for prevention and intervention strategies to promote longevity.

Previous research had clearly documented relationships between demographic and injury factors with longevity, as well as finding that education, family income, and employment are associated with substantially greater life expectancy.^{14,19,25} For instance, under favorable socioeconomic conditions (\$75,000 or more family income, employed 30 hours or more per week, and a minimum of a four-year degree) life expectancy was more than double that for individuals who had unfavorable socioeconomic conditions (low income, unemployed, less than a high school certificate) for individuals who were younger and with more severe SCI.²⁴ Our preliminary models introducing socioeconomic factors generally supported those findings, even though socioeconomic factors were not significant in the final models after the introduction of participation indicators. These findings are new and strongly indicate the mediating effect of active participation (mobility domain) upon the relationship of socioeconomic status, and mortality.

Clinical and policy implications

The findings further support the importance of socioeconomic factors to survival and longevity, while extending those findings to suggest that the overall active lifestyle promotes longevity. This includes hours out of bed, days leaving home per week, and annual nights away from home. Policies that ensure funding for vocational rehabilitation, transition or return to work, job retention, and recreational opportunities have the potential to not only lead to a higher quality of life but may also lead to greater longevity. Individuals need resources to lead active lifestyles, which enhances longevity when these needs are addressed.

Similarly, clinical programs and practices that promote building strength to maximize time out of bed. They also promote longevity. A holistic rehabilitation approach that includes recreational therapies is also indicated, as participation factors clearly related to longevity. Lastly, although the importance of socioeconomic factors diminished with the introduction of participation factors, promoting socioeconomic well-being is essential to maximizing longevity. It may well be that opportunities for participation are enhanced. As individuals improve their education, go into work environments, and have greater economic resources to support their activity patterns. Early vocational rehabilitation interventions shown great promise for improving longevity among those with SCI.

Methodologic considerations

There are several key strengths. These include the use of a cohort of participants with significant longevity. Their average age was 45 and 35% of them were 50 years or older at the time of data collection. Therefore, the findings apply strongly to people who have survived their initial years after SCI onset. Building upon previous models, with established relationships with mortality, is also a strength. We verify those earlier models, while expanding upon them. The most important strength was the utilization of participation indicators in relation to longevity as this leads to new findings to help us understand, predict, and intervene to promote longevity.

The limitations include the sample size, which, although large for an aging cohort of people with SCI (over 1,500 cases), is relatively small for a study of survival. This limits the power to simultaneously consider large numbers of variables. Therefore, the study was restricted to isolating the effects of participation variables on top of demographic, SCI, and socioeconomic predictors. Other important predictors that have previously been linked to mortality after SCI, such as behavioral factors and quality-of-life factors could not be included in the design, largely because of our focus on promoting longevity through positive actions. Social participation has multiple domains, and the current study only measured the mobility domain and marital/relationship domain. Our findings cannot be generalized to other participation domains. Further, we found inter-relationships among employment status, family income, marital status, and active participation variables, but the VIF values indicated collinearity problem was modest. The collinearity is not surprising. Indeed, many of their predictors relate to different aspects of participation which we would anticipate would be correlated. The importance of the participation factors themselves raises interesting questions as to what drives people to get out of bed earlier, leave their homes more frequently, and spend over nights away from home. These all appear to be related

to having an active lifestyle, which appears driven by the employment and socioeconomic factors, all of which leads to greater longevity.

Additionally, just as it is a strength to have used an aging cohort that has survived the initial timeframe after SCI, the downside of using this cohort is that the findings are less sensitive to the timeframe shortly after SCI onset. Therefore, the findings generalize most strongly with older, more chronic cohorts of participants. Similarly, because the prospective data was collected nearly 18 years prior to survival status, patterns of participation, social support, and socioeconomic accomplishments certainly changed for many participants, and any such changes would weaken the overall strength of models and likely underestimate the importance of any given factor.

Lastly, we use self-report, which is susceptible to recall bias. There may also be an accuracy bias. This would not be a substantial consideration for demographic variables, but could introduce error in measurement when people need to recall and report, for example, the number of times leaving the home. Any such error would lead to an *underestimation* of the relationship of the predictive factors with longevity. Lastly, although we use the NDI, which is the gold standard for determining survival status, there are a small number of cases that will be misclassified, and any such misclassification also will introduce error which will result in an underestimation of the relationship of the predictors with longevity. These limitations are endemic studies of self-report and longevity, rather than being specific to the current study.

Future research

Whereas the current research identifies the relationship of participation variables taken at a single point in time with longevity, additional research is needed to identify the extent to which changes in participation, relate to longevity. Such studies are possible now that the basic relationships of participation variables with longevity have been established. It also will be important to identify whether having strong participation at one point in time leads to future longevity, even in the absence of maintenance of participation. In other words, will a history of participation lead to greater longevity, even if opportunities for participation diminish over time with factors such as aging and/or diminished health. It is only through continued efforts with multiple approaches and designs that we may be able to enhance longevity through promotion of societal participation and my improving socioeconomic status for people with SCI.

Funding

The contents of this publication were developed under grants from the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR), grant numbers 90IFRE0044, 90DPCP0009, 90IF0112, 90IF0015, H133G060126, and H133G020239. NIDILRR is a Center within the Administration for Community Living (ACL), Department of Health and Human Services (HHS). The contents of this publication do not necessarily represent the policy of NIDILRR, ADL, or HHS, and you should not assume endorsement by the funding agency or Federal Government.

List of Abbreviations

SCI	Spinal cord injury
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CHART	Craig Handicap Assessment Reporting Technique
NDI	National Death Index
VIF	Variance inflation factors

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Table 1.

Participant characteristics by their survival status

	Alive (n=938)	Deceased (n=602)	p-value
Current age (Mean (SD))	40.36 (11.89)	51.67 (13.83)	<.01
Years post injury (Mean (SD))	13.95 (9.87)	17.76 (11.46)	<.01
Sex (row %)			<.05
Female	65	35	
Male	59	41	
Race/ethnicity (row %)			0.45
Hispanic	50	50	
Non-Hispanic Black	63	37	
Non-Hispanic White and others	61	39	
Injury level (row %)			<.01
Cervical 1–4 level	56	44	
Cervical 5–8 level	57	43	
Thoracic, lumbar, and sacral level	65	35	
Ambulatory status (row %)			<.01
Non-ambulatory	56	44	
Ambulatory	75	25	
Health status (row %)			<.01
Poor or fair health	52	48	
Good health	62	38	
Excellent health	80	20	
Years of education (Mean (SD))	13.92 (2.77)	13.16 (3.11)	<.01
Household income (row %)			<.01
Less than \$20K	54	46	
\$20K-50K	61	39	
\$50K or more	73	27	
Employment status			<.01
Unemployed	55	45	
Part-time job	63	37	
Full-time job	78	23	
Marital/relationship status (row %)			<.01
Divorced, separated, widowed	50	50	
Single	65	35	
Married or co-habiting	63	37	
Hours out of bed/day (Mean (SD))	13.43(3.71)	11.03(4.46)	<.01
Days out of the house/week (Mean (SD))	4.97(2.13)	3.58(2.44)	<.01
Nights away from home in the past year (Mean (SD))	12.76(11.09)	7.44(9.79)	<.01

Table 2.

Person-year logistic regression models for the survival status

	Model 1			Model 2			Model 3			PPC*	
	OR	OR 95% CL	p-value	OR	OR 95% CL	p-value	OR	OR 95% CL	p-value		
Current age	1.06	1.05	1.07	<01	1.06	1.05	1.06	1.04	1.06	<01	0.17
Years post injury	0.99	0.99	1.00	<01	1.00	0.99	1.01	1.00	0.99	1.01	0.65
Male(ref=female)	1.11	0.92	1.35	0.25	1.19	0.97	1.45	1.30	1.05	1.61	<05
Hispanic (ref=Non-Hispanic White and others)	1.43	0.78	2.61	0.12	1.34	0.71	2.52	1.41	0.73	2.73	0.31
Non-Hispanic Black (ref=Non-Hispanic White and others)	1.04	0.83	1.29	0.42	0.89	0.70	1.13	0.82	0.64	1.05	0.11
Cervical 1–4 level injury (ref=other levels)	1.82	1.45	2.29	<01	1.80	1.42	2.29	1.51	1.18	1.94	<01
Cervical 5–8 level injury (ref=other levels)	1.42	1.18	1.70	<01	1.33	1.10	1.61	1.23	1.01	1.50	<05
Ambulatory (ref=non-ambulatory)	0.35	0.27	0.44	<01	0.38	0.30	0.49	0.48	0.37	0.61	<01
Good health (ref=poor or fair health)	0.77	0.63	0.94	0.01	0.85	0.69	1.04	0.96	0.77	1.18	0.67
Excellent health (ref=poor or fair health)	0.57	0.45	0.70	<01	0.67	0.53	0.84	0.85	0.66	1.08	0.18
Years of education											
Income 20K–49,999 (ref=less than 20K)					0.97	0.94	1.00	0.98	0.95	1.01	0.25
Income 50K or more (ref=less than 20K)					0.88	0.71	1.08	1.03	0.82	1.28	0.83
Part-time job (ref=others)					0.70	0.53	0.92	0.90	0.67	1.22	0.50
Full-time job (ref=others)					0.76	0.55	1.06	0.86	0.61	1.22	0.41
Single (ref=divorced, separated, widowed)					0.61	0.46	0.80	0.80	0.60	1.08	0.15
Married or co-habiting (ref=divorced, separated, widowed)								1.06	0.83	1.36	0.64
Hours out bed/day								0.88	0.70	1.10	0.27
Days out of the house/week								0.96	0.94	0.98	<01
Nights away from home in the past year								0.93	0.89	0.98	<01
								0.99	0.98	1.00	<05

* Pseudo partial correlation