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Socioeconomic and Behavioral Risk Factors for Mortality: Do Risk Factors Observed after Spinal Cord Injury Parallel Those from the General USA Population?

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Abstract

Objective—To evaluate the association of demographic, behavioral, and socioeconomic factors with all-cause mortality while controlling for health status among a cohort of participants with severe disability related to spinal cord injury (SCI).

Study Design—Prospective cohort study.

Setting—Data were analyzed at a major medical university in the Southeast United States of America.

Methods—Participants included 1361 adults with traumatic SCI of at least one year duration who were recruited through a large specialty hospital in the Southeast United States of America. Three Cox proportional hazards models were generated relating the predictors to all-cause mortality.

Results—Age, disability, smoking, and income were significant in the final model. Both current (hazard ratio [HR]=2.03, 95% confidence interval [CI]=1.46–2.82) and former smokers (HR=1.58, CI=1.16–2.16) were at elevated hazard of mortality, as were those with incomes under $10,000 (HR=2.29, CI=1.53–3.44) and between $10,000–$35,000 (HR=1.47, CI=1.03–2.10).

Conclusions—Even after controlling for health and severity of disability, the coefficients for smoking and income were significant, exceeding that reported previously within the general population. The importance of these factors may be magnified after severe disability, even though life expectancy is already greatly diminished in this population.

Keywords

spinal cord injuries; socioeconomic factors; behavior; mortality; life expectancy; health status

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Conflict of Interest

The authors declare no conflict of interest.

Introduction

The ultimate goals of medicine are to cure disease and promote health and longevity. Diverse research methodologies are required, ranging from the most basic bench science identifying disease mechanisms at the molecular and cellular level to clinical trials applying that knowledge to surgical, pharmacological, and other therapeutic interventions. Epidemiologic research is essential for identifying patterns of risk and protective factors related to morbidity and mortality, so that proven intervention strategies may be targeted to those at greatest risk.

A growing body of research has linked socioeconomic factors to an elevated risk of mortality.[1–3] According to one theoretical perspective, socioeconomic factors are a *fundamental cause* of variations in health and mortality.[1] An alternative hypothesis is that socioeconomic factors are simply correlates of health and mortality, mediated by other confounding factors (e.g., health behaviors). Accordingly, the relationship between low socioeconomic status (SES) and greater risk of mortality would be attributed to differences in health behaviors between SES groups.

Spinal cord injury (SCI) is a severe disabling condition that has been associated with early mortality, the extent to which depends on the neurologic level and neurologic completeness of injury.[4] Two hypotheses could be forwarded regarding the importance of socioeconomic and behavioral risk factors and hazard for mortality associated with SCI. First, disability factors may account for the majority of variance, with diminished or little added hazard for socioeconomic and behavioral factors. From this perspective, relationships such as that between smoking and cancer[5] may not have time to develop due to the diminished longevity from SCI.[4] Alternatively, because SCI is associated with diminished health, the effects of socioeconomic and behavioral factors may be heightened. Again using the example of smoking, respiratory complications are a primary cause of death after SCI, so the importance of smoking may be greater after SCI.[4]

Lantz et al.[6] conducted a state-of-the-art investigation of socio-environmental, behavioral, and health factors and mortality in the United States (USA) using a population-based cohort of non-institutionalized persons aged 25 and older. A 3 tier modeling approach isolated the effects of different sets of predictors. The first model included only demographic and socio-environmental variables. Health behaviors were introduced in the second model, including smoking, drinking, body mass index (BMI), and physical activity. Two types of health factors were added to the final model to control for variations in physical impairment and self-rated health. The results indicated that age, gender, residence, income, smoking, drinking, low physical activity, physical impairment, and self-rated health were significantly related to mortality, whereas education and obesity were not. The three stage data analytic approach used in this manuscript provides an excellent methodology that can be applied to studies of SCI.

Studies of mortality after SCI have been guided by a theoretical risk model classifying risk factors into 4 levels: (a) demographic and disability factors, (b) psychological[7] and socio-environmental factors,[8] (c) behaviors,[9] and (d) health status variables.[10, 11] The contribution of any set of factors to the prediction of mortality is consistent with the relative proximity to mortality (i.e., health factors being most predictive, followed by behaviors, and psychological and environmental factors). There has been general support for the overall model and the relative importance of each set of factors.[12] These studies provide valuable insight into the risk and protective factors of mortality but do not have direct comparability to the general population literature due to differences in conceptualization and data analysis.

Given the latest epidemiological research, our purpose was to use mortality risk models developed in the general population by Lantz et al.[6] to directly guide the development of a risk model of all-cause mortality after SCI. The unique contribution is that we have evaluated the generalizability of the population-based model from the general population and applied it to severe disability (the first such analysis).

Materials and Methods

Participants

After obtaining institutional review board approval, participants were identified from records of a specialty hospital in the southeastern USA.[13] Persons included had a traumatic SCI with residual deficits, were a minimum of 18 years of age, and at least 1 year post-injury onset. From a pool of 1,929 potential participants, 1,386 (72%) participated. We excluded 25 based on questionable diagnosis or missing date of injury or age, leaving 1,361 for analysis.

Procedures

A prospective cohort design was utilized with data collected between August of 1997 and June of 1998. A preliminary cover letter described the study and alerted participants materials would be forthcoming. Actual materials were sent 4–5 weeks later. Follow-up procedures included 2 subsequent mailings and a phone call. Participants were offered $20 in remuneration and made eligible for drawings totaling $1500. Mortality status was determined as of December 31, 2008 using the National Death Index (NDI). NDI death records are available approximately 16 months after the conclusion of a given year.

Measures

We used several measures similar or identical to those identified by Lantz et al.[6] In the event that identical variables were not available, we used proxy variables. Demographic variables included gender, race (white, non-white), and age.

Socio-environmental factors were assessed according to: place of residence (i.e. rural, urban, super-rural), educational status (i.e. 0–11 years, 12–15 years, and 16+ years) and household income (<$10,000, $10,000–34,999, and $35,000+). Residence was classified as urban, rural, and super-rural through the classification scheme from the USA Center for Medicare and Medicaid Services using postal zip code.[14] Household income was coded into 3 categories to be consistent with the Lantz et al.[6] study, which used $10,000–$29,999 as the middle income category. These categories do differ from those used in previous SCI research where $75,000 and greater was the highest income category.[15] Therefore, this analysis applies to the effects of low income with mortality.

Behavioral variables included smoking (never, former smoker, and current smoker) and number of drinks per month (none; moderate, 1–79; and heavy, 80+). Because all data were collected by survey, we used a proxy variable in place of BMI. Participants were asked whether, for someone of their height, they would classify themselves as underweight, a bit underweight, average weight, a bit overweight, or overweight. These were recoded into underweight, about normal (the middle 3 categories), and overweight. A similar proxy variable was used for exercise. Participants were asked, “How much exercise do you get compared to other people with spinal cord injuries who are about the same severity of injury?” and were given six response options: much less, less, about the same, more, much more, or do not know.

Lastly, we included 2 health variables – injury severity and self-rated health. For injury severity, we followed a widely used classification scheme combining neurologic level and ambulatory status.[16] We formed a referent category with all participants who were ambulatory and classified the remaining participants into one of 3 groups based on highest neurologic level (C1–C4, C5 – C8; non-cervical). Ambulatory status is a proxy measure of motor functional recovery.[17] Self-rated health was categorized as excellent/very good, good, and fair/poor (consistent with Lantz).

Analyses

All analyses were conducted using SAS v9.2.[18] Cox proportional hazards regression was used to generate models relating the predictors with time to death. All persons not found deceased through the NDI as of December 31, 2008 were censored (presumed alive). Three hazard models were developed based on the analyses by Lantz et al.[6] The first included demographic and environmental variables. Next, behavioral variables, weight status, and physical activity were added. Lastly, physical impairment and self-rated health were included. The proportional hazards assumption was tested by graphing survival curves for each independent variable and looking for any intersection of the lines. The assumption of proportional hazards was satisfied for all variables. We assessed the overall fit of the model using the global Chi-square test. Hazard ratios (HR) and 95% confidence intervals (CI) were calculated.

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.

Results

Of the 1361 eligible participants, 327 had died (24.0%). Seventy-four percent of the total sample were male, and 75.0% were white (Table 1). The average age was 41.3±13.6, and the average number of years post-injury was 9.7±6.9. Twenty-one percent of participants were ambulatory. Of those not ambulatory, 13.2% of the full sample had C1–C4 injuries, 30.4%

were C5–C8, and 34.8% were non-cervical SCIs. Several variables were crudely associated with mortality (Table 1), including education, income, smoking, drinking, weight status, physical activity, severity, and self-rated health. Gender, race, and residence were the only variables *not* significantly related to mortality.

In the first regression model (Table 2), age and income were significantly related to mortality. Those with annual household income less than $10,000 per year had 2.91 greater hazard of mortality (CI=2.02–4.21) than the reference group ($35,000 or more). Those with income levels between $10,000 and $35,000 also had a greater hazard of mortality, although the hazard ratio was not as pronounced (HR=1.64, CI=1.19–2.27). None of the other predictors, including educational level, were significant.

In model 2 (addition of behavioral factors), age remained significant. Income of below $10,000 continued to be significantly related to mortality (HR=2.50; CI=1.68–3.72), although income of $10,000–$35,000 was no longer significant (HR=1.41, CI=0.99–2.01). Both current smokers (HR=1.83; CI=1.32–2.53) and former smokers (HR=1.54; CI=1.12–2.11) had a higher hazard of mortality. Drinks per month and physical activity were not significant. Weight status was also not significant largely due to the absence of a relationship between being overweight and mortality.

In the final model (model 3), injury severity was a powerful predictor of mortality, whereas self-rated health was not significant. Smoking and income remained significant after the addition of SCI severity and self-rated health. Both current (HR=2.03, CI=1.46–2.82) and former smokers (HR=1.58, CI=1.16–2.16) were at elevated hazard of mortality, as were those with incomes under $10,000 (HR=2.29, CI=1.53–3.44) and between $10,000–$35,000 (HR=1.47, CI=1.03–2.10).

Discussion

This study closes the gap between research in the general population and a cohort of those with severe traumatic disability due to SCI. The results apply to 2 distinct theoretical contexts: the view of socioeconomic factors as a fundamental cause of mortality[1] and the opposing view of socioeconomic factors as a rather distal predictor whose value as a predictor is mediated by other factors (e.g., access to care). This study allows us to make at least general statements regarding the importance of predictive factors to mortality between the general population and those with traumatic SCI.

There are distinct similarities between these results and those of the Lantz study[6] and other studies of the general population. Most important, both income and smoking were significant after controlling for other demographic, health behaviors, and health factors. Age and disability were also significantly associated with hazard of mortality in both studies. Although direct comparisons are difficult due to subtle differences in methodology, age and disability (SCI severity) were stronger predictors of mortality based on the size of the hazard ratio, whereas general health status was unrelated to hazard for mortality in our study. Considering *all* participants had some residual effects of SCI, disability would have been an even stronger predictor had a portion of the participants not had SCI or another disabling condition. The absence of a significant relationship between general health and mortality is likely a reflection of the association of SCI with health. Unlike previous research with the general population, we did not find significant hazard of mortality related to gender, urban-rural status, exercise, alcohol use, or weight status (although the latter approached significance).

Despite the importance of age and injury severity, the hazard ratios for smoking were higher than those previously reported by Lantz. This may relate to different patterns of cause specific mortality after severe disability. For instance, risk of mortality from pneumonia is elevated after SCI,[19] and it is possible that smoking elevates this risk to a greater degree among those already compromised with disability. Direct comparisons of income are tentative because the highest income group was $5000 higher than that reported by Lantz (>$35,000 compared with >$30,000). Nevertheless, the hazard ratio is substantially higher for the lowest income group in the current study. Taken together, the pattern of greater hazards for both smoking and income, along with the greater hazards for age and disability (i.e., severity), suggests the importance of *both* organic factors and economic and behavioral factors in relation to mortality. Despite the fact that risk of mortality is substantially elevated by SCI, smoking and income appear to have equal or greater associations with mortality then was observed in the general population. One explanation is that substantially higher incomes and resources are required to prevent mortality, given the complications imposed by severe disability.

Although this analysis was patterned after that reported in the general epidemiologic literature, there are important differences. First, our sample size was smaller than that used in studies of the general population, so statistical power was lower. Therefore, we did not have the same power to identify significant risk factors and therefore must look at the combination of the significance and the magnitude of the hazard ratios. Nevertheless, this is the largest sample of SCI reported in the literature including a sufficient diversity of variables for this type of analysis. The SCI Model Systems in the USA has a larger sample but does not include key variables. Second, all data are self-report. Therefore, we utilized several proxy variables, including those replacing BMI and exercise. Weight status approached significance and may be a better proxy variable than self-reported exercise. It is difficult to evaluate these factors in relation to mortality based on the nature of these variables in the current study. It may simply be that exercise does not vary sufficiently in the SCI population to have an effect, as there are many barriers to exercise for people with SCI.[20] Third, the participant cohort was identified from a clinical setting. This would likely have restricted the strength of the hazard ratios since all participants received some type of clinical services from a designated SCI Model System of care in the USA. Lastly, there may be censoring in the data as the sample averaged 9.7 years post-injury at the time of enrollment, so some mortality had already occurred prior to enrollment. This limitation would be of greater concern if the study were attempting to identify hazard of mortality from the onset of injury or to project life expectancy from inception, neither of which were goals of the current study. Somewhat similar concerns were identified in previous studies of socioeconomic factors and mortality in the general population where health status may have been diminished as a predictor because of differences in health *at the time of enrollment.* We controlled for potential changes in health between SCI onset and enrollment by including health status as a predictor in the third model, similar to that done by Lantz et al.[6]

While this study used cross-sectional data to assess the relationship of selected risk factors with mortality, future research should include longitudinal analyses of modifiable risk factors so that any change in risk factors can be assessed in relation to mortality after SCI. Future research would also benefit from utilization of the competing risk model that identified the relationship of the predictors with specific causes of mortality.

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Table 1

Characteristics of those known alive and those deceased at the time of data collection.

Variable	Mortality Status: Alive (n=1034)	Mortality Status: Dead (n=327)	p-value*
	Row Percent		
Age			
18–34	89.1	10.9	<.0001
35–44	80.5	19.5	
45–54	73.3	26.7	
55–64	51.9	48.1	
65–74	36.5	63.5	
75+	19.4	80.6	
Gender			
Female	78.1	21.9	0.2725
Male	75.2	24.8	
Race			
Nonwhite	75.0	25.0	0.6276
White	76.3	23.7	
Residence			
Super rural	78.6	21.4	0.6164
Rural	77.4	22.6	
Urban	75.2	24.8	
Education			
0–11 years	66.3	33.7	0.002
12–15 years	78.0	22.0	
16+ years	79.6	20.4	
Income			
<$10,000	72.4	27.6	0.0002
$10,000–34,999	80.8	19.2	
$35,000 +	85.7	14.3	
Smoking			
Current	72.6	27.5	<.0001
Former	69.2	30.8	
Never	83.6	16.5	
Drinks per month			
Heavy (80+)	72.1	27.9	0.0023
Moderate (1–79)	80.6	19.4	
None	77.6	22.4	
Weight Status			
Underweight	67.2	23.8	0.0452
Overweight	77.3	22.7	
Normal	74.2	25.8	

Variable	Mortality Status		p-value*
	Alive (n=1034)	Dead (n=327)	
Physical Activity			
Much less	63.5	36.5	
Less	71.0	29.0	
About the same	75.0	25.0	<.0001
More	84.0	16.0	
Much more	82.8	17.2	
SCI Level			
C1–C4, Non-ambulatory	63.3	36.7	
C5–C8, Non-ambulatory	74.3	25.7	<.0001
Non-cervical, Non-amb	76.6	23.4	
Ambulatory	85.0	15.0	
Self-rated health			
Excellent/very good	62.9	37.1	
Good	76.6	23.4	<.0001
Fair/poor	84.1	15.9	

* p-value from chi-square test

Table 2

Cox regression with three predictive models differentiating those known alive and those deceased.

Variable	Model 1	Model 2	Model 3
Age (vs. 18–34)	**<.0001**	**<.0001**	**<.0001**
35–39	2.10 (1.46–3.02)	1.78 (1.22–2.60)	1.76 (1.20–2.57)
45–49	3.22 (2.21–4.70)	2.61 (1.74–3.91)	2.57 (1.71–3.87)
55–59	7.08 (4.79–10.49)	6.49 (4.27–9.86)	7.18 (4.97–10.99)
65–69	8.62 (5.48–13.57)	8.82 (5.42–14.35)	11.04 (6.63–18.40)
75+	27.91 (16.65–46.79)	24.12 (14.02–41.49)	39.39 (21.97–70.63)
Gender (vs. male)	**0.1269**	**0.2580**	**0.7084**
Female	0.81 (0.61–1.06)	0.84 (0.62–1.14)	0.96 (0.71–1.30)
Race (vs. Nonwhite)	**0.0798**	**0.0806**	**0.1142**
White	1.29 (0.97–1.69)	1.31 (0.97–1.76)	1.27 (0.94–1.72)
Residence (vs. Super rural)	**0.0386**	**0.2231**	**0.2442**
Rural	0.72 (0.36–1.44)	0.77 (0.38–1.54)	0.75 (0.37–1.51)
Urban	1.01 (0.52–1.98)	0.97 (0.49–1.92)	0.94 (0.48–1.87)
Education (vs. 16+)	**0.9133**	**0.9505**	**0.8048**
0–11 years	1.03 (0.71–1.33)	0.94 (0.63–1.41)	0.87 (0.57–1.32)
12–15 years	0.97 (0.71–1.33)	0.95 (0.68–1.34)	0.92 (0.65–1.30)
Income (vs. $35,000+)	**<.0001**	**<.0001**	**0.0002**
<$10,000	2.91 (2.02–4.21)	2.50 (1.68–3.72)	2.29 (1.53–3.44)
$10,000–34,999	1.64 (1.19–2.27)	1.41 (0.99–2.01)	1.47 (1.03–2.10)
Smoking (vs. Never)		**0.0012**	**0.0001**
Current		1.80 (1.31–2.47)	2.03 (1.46–2.82)
Former		1.50 (1.10–2.05)	1.58 (1.16–2.16)
Drinks per month (vs. Moderate)		**0.9035**	**0.9693**
Heavy (80+)		0.91 (0.52–1.59)	0.93 (0.53–1.64)
None		1.02 (0.79–1.34)	1.00 (0.76–1.30)
Weight status (vs. normal)		**0.1461**	**0.1681**
Underweight		1.48 (1.00–2.19)	1.46 (0.99–2.16)
Overweight		1.03 (0.72–1.47)	1.02 (0.71–1.45)
Physical Activity (vs. Much More)		**0.0893**	**0.5950**
Much less		1.54 (0.84–2.84)	1.18 (0.63–2.23)
Less		1.40 (0.82–2.40)	1.17 (0.67–2.06)
About the same		1.35 (0.81–2.23)	1.15 (0.68–1.95)
More		0.89 (0.52–1.54)	0.88 (0.50–1.54)
SCI Level (vs. Ambulatory)			**<.0001**
C1–C4, Non-ambulatory			5.02 (3.23–7.81)
C5–C8, Non-ambulatory			2.83 (1.89–4.24)
Non-cervical, Non-ambulatory			2.57 (1.72–3.85)
Self-rated health (vs. Excellent/very good)			**0.1452**
Good			1.42 (1.00–2.01)

Variable	Model 1	Model 2	Model 3
Fair/poor			1.21 (0.88–1.67)

Note: p-values for the overall effect of each variable are given.