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Risk of Mortality and Life Expectancy After Spinal Cord Injury: The Role of Health Behaviors and Participation

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Abstract

Purpose—To identify the relationships between health behaviors and participation and life expectancy after spinal cord injury (SCI), while controlling for biographic and injury factors.

Methods—Data for this prospective cohort study were collected by mailed survey. Participants included 1,361 adults with traumatic SCI, 1 or more years post injury. Participants were enrolled an average of 9.7 years after injury, and mortality was determined at the end of 2007. There were 294 deaths by follow-up. Life expectancy was calculated utilizing person-years and logistic regression.

Results—When evaluating each factor while controlling for biographic and injury characteristics, it was found that smoking history, binge drinking, number of drinks consumed, and psychotropic prescription medication use were related to increased mortality risk, whereas exercise and weekly outings were associated with a lower mortality risk. In the final model, only smoking history, binge drinking, psychotropic prescription medication use, and weekly outings were predictive of mortality and life expectancy.

Conclusion—Several behaviors identified may become targets of prevention strategies to promote longevity, including smoking cessation, stopping binge drinking, avoiding overreliance on psychotropic prescription medications, and promoting daily activities away from home.

Keywords

health behaviors; *mortality*; *psychosocial*; *risk*; *spinal cord injury*

Advances in medicine have led to a reduction in mortality rates during the first year after spinal cord injury (SCI) onset, but rates after the first year have remained substantially higher than in the general population.[1-4] The majority of studies of risk factors for early mortality have utilized demographic or injury-related factors as predictors.[1,2] These studies have been invaluable for tracking trends in mortality rates and their relationship with factors such as age and injury severity, but they do not readily translate into interventions to enhance longevity.

Epidemiologic studies may enhance longevity by identifying persons at risk for early mortality and allowing clinicians to better apply proven intervention methods. Behavioral factors may be of primary importance. According to one theoretical risk model,[5] the relationships between behaviors and mortality are mediated by health status, such that behaviors impact health which, in turn, affects mortality. Identifying behaviors related to early mortality and quantifying their relationship in terms of differential life expectancy provides an excellent foundation for the development of interventions.

Studies of health behaviors and mortality after SCI are rare. Preliminary studies used retrospective analysis or assumed maladaptive behaviors based on causes of death. For instance, studies of causes of death showed that 28% of deaths appeared highly preventable, resulting from pressure ulcers, sepsis, other infections, or accidental deaths.[1] A violent etiology was linked to greater mortality,[1] and this can be used to identify individuals at greater risk of mortality.

In a retrospective study of hospital records, Garshick and associates[6] identified 4 health risk factors for mortality, including smoking and 3 health status factors (diabetes, heart disease, reduced pulmonary function). In a prospective cohort design with 1,386 participants, it was found that smoking, binge drinking, psychotropic prescription medication use, and time out of bed were significantly related to mortality.[7] In an analysis of all components of the theoretical risk model, binge drinking and psychotropic prescription medication use remained significant along with 4 health factors and income.[8] None of the aforementioned studies of behaviors quantified life expectancy.

The purpose of this 1O-year prospective cohort study was to identify the relationship of mUltiple behavioral variables with risk of mortality and differential life expectancy. We improved upon earlier studies by quantifying each behavior in relation to life expectancy.

Methodology

Participants

Participants were identified in 1997-1998 from records of a specialty hospital in the southeastern United States. There were 4 inclusion criteria: traumatic SCI, residual deficits, minimum of 18 years of age, and 1 year post 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

After receiving institutional review board approval, a preliminary cover letter described the study and alerted participants that materials would be forthcoming. Actual materials were sent 4 to 5 weeks later. Follow-up procedures included 2 subsequent mailings and a phone call. Participants were offered $20 in remuneration and were eligible for drawings totaling $1,500. Data collection began July 1997 and ended April 1998. Mortality status was determined as of December 31, 2007, using the National Death Index (NDI).[9] NDI death records are available approximately 16 months after the conclusion of a given year.

Measures

We used several measures from a large-scale follow-up study.[8] Demographic variables included gender and age. Injury severity was classified as C1-C4, C5-C8, or noncervical for all nonambulatory; all ambulatory cases formed a fourth group. We categorized psychotropic prescription medication use based on the number of conditions (pain, spasticity, sleep, and stress or depression)[10] for which participants used medication on at least a weekly basis (0, 1 or 2, 3 or 4). We identified the number of days within the past month of binge drinking (5 or more drinks per occasion) and total drinks consumed per week. Smoking history was ascertained with 3 items: ever having been a regular smoker, time since they had smoked, and number of cigarettes smoked per day (if a current smoker). We asked how much exercise participants had compared to other people with SCI who are about the same severity of injury (less, the same, or more). One item was used from the Craig Handicap Assessment and Reporting Technique[11]–average number of days per week getting out of the house and going somewhere.

Analyses

Logistic regression with person-years (each follow-up year was a separate observation) was used to generate models relating the predictors with mortality.[12,13] All persons not found deceased through the NDI as of December 31, 2007, were assumed to be alive at that date.

The base model included injury severity, gender, chronological age, and years lived since injury. Referent groups included women (gender) and ambulatory persons (injury severity). Each predictor was evaluated while controlling for demographic and injury factors, with separate logistic models developed for each predictor variable, followed by development of a comprehensive model.

We defined variables categorically to aid in the interpretation of life expectancy. For prescription medication, we defined the number of problems treated on at least a weekly basis: 0, 1-2,3-4 (0 was the referent group). Similarly, number of days with weekly outings was broken down into 4 groups: 0, 1-3,4-6, 7 (referent group was 7). Smoking status was classified as (a) never regularly smoked, (b) quit a year ago or more, (c) quit within the past year, (d) smokes less than one pack per day, and (e) smokes more than one pack per day. For exercise, participants reported whether they exercised less, about the same, or more than the average person with SCI (referent group). Binge drinking reflected the number of episodes within the past 30 days.

Hosmer-Lemeshow and global chi-square tests were used to assess goodness of fit of the model.[14] The C statistic, measuring area under the receiver operating characteristic curve, was used to assess discriminatory ability.[14] Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. We reported example life expectancies by calculating the probability of survival for each year through age 100.[1]

Results

Participant characteristics

Fifty-eight participants had missing data on one of the covariates, resulting in a final sample of 1,303 (294 participants were deceased). Seventy-four percent were male, and 74.8% were white. Average age attime of injury was 31.7 (13.8) years. Average years post injury was 9.7 (6.9) years. Primary etiology was motor vehicular crashes (51.0%). Twenty-two percent were ambulatory, and, of the rest, 43.4% had cervical injuries and 34.8% had noncervical injuries.

No differences were noted in mortality as a function of missing data (χ^2= 3.35, P = .0673). Persons who were non-white were more likely to have missing data (χ^2= 7.76, P = .0053), although no differences were observed for injury severity (χ^2= 2.65, P = .4480), gender (χ^2= 0.002, P = .9653), age (t = -1.31, P = .1946), or years since injury (t = 0.36, P = .4646).

Modeling

All biographic and injury characteristics were significant in the base model, except for gender (**Table 1**). Risk of mortality was associated with a greater chronological age, more years post injury, and greater injury severity. Each of the behavioral predictor variables was statistically significant in the preliminary model that evaluated one behavioral predictor at a time.

Four behaviors were retained in the final model (**Table 2**). Compared with persons who never smoked regularly, those who smoked more than a pack a day had 1.96 greater odds of mortality (P < .01). This decreased to 1.84 among those who smoked less than a pack per day. Participants who had quit smoking more than a year ago had 1.50 greater odds of

mortality (those who quit within the past year were not significantly different). Binge drinking was significant (OR, 1.03 per episode; $P < .05$). Using medications to treat 3 or 4 conditions was significant (OR, 2.36), although using medications to treat 1 or 2 conditions was not (OR, 1.28; 95% CI, 0.94-1.75). Last, compared to leaving home an average of 7 days per week, those who were homebound had 2.35 greater odds of mortality and those who left their homes 1 to 3 times per week had 1.65 greater odds of mortality (4 to 6 times was not significant). The final model had good fit ($\chi^2_8 = 8.73$, $P = .3656$) and acceptable discriminatory ability (C = 0.771).

Life expectancy

We calculated life expectancies for an example case of a 20-year old male with a C1-C4 nonambulatory injury (**Table 3**). Life expectancy under favorable conditions was 43.03 years but decreased with unfavorable status on each of the behaviors. Each individual behavior was associated with a substantial reduction in life expectancy. Weekly psychotropic medications to treat 3 or 4 conditions decreased life expectancy to 31.21 years. Life expectancy decreased to 33.74 years for pack or more a day smokers, 34.63 years for less than a pack, 36.41 for those who quit in the past year, and 37.46 years for those who quit more than 1 year ago. Being homebound (no outings) was associated with a life expectancy of 31.26 years, whereas 1-3 weekly outings resulted in a life expectancy of 36.16 years. We calculated life expectancy based on 5, 10, or 15 binge drinking episodes in the last 30 days, and life expectancy ranged from a high of 40.76 years for those with 5 episodes to 36.21 years for those with 15 episodes.

The risk behaviors are not highly prevalent (**Table 4**). For instance, 14.27% reported weekly psychotropic prescription medication use to treat 3-4 conditions; 9.44% smoked a pack or more per week; 2.46% reported 15 or more binge drinking episodes; and 7.44% were homebound.

Discussion

This study adds to an emerging body of research identifying differential risk of life expectancy after SCI. Four significant behavioral predictors were identified, 3 of which were linked to mortality in previous research (smoking, binge drinking, and psychotropic prescription medication use),[7] and 1 new variable (weekly outings). Of particular importance, this is the first study quantifying the relationships between risk behaviors and life expectancy. The findings are profound-life expectancy decreases substantially with the presence of each risk behavior.

It is important to consider that the relative frequency of any given risk behavior is rather small and the portion of individuals with multiple risk behaviors is even smaller. Similarly, risk of mortality only increased at certain levels of behaviors. For instance, 4 to 6 outings per week was not significantly different than 7 outings, and taking weekly psychotropic prescription medication to treat 1 to 2 conditions was not significantly different than taking no weekly medications. The total number of drinks consumed was only significant during preliminary analyses. Individuals on the borderline of risk, such as using 1 or 2 psychotropic medications or getting out only 4-6 days per week, have the opportunity to avoid slipping into more serious behavioral patterns before experiencing a decline in life expectancy.

Implications

Interventions that successfully eliminate smoking, reduce binge drinking, reduce psychotropic medication use, and promote activities outside the home have promise for improving longevity. Because life expectancy estimates have been attached to various

behaviors, we can discern the maximum likely effect of any intervention under optimal conditions. That is, an intervention can only change life expectancy consistent with the strength of relationship of the change variable with life expectancy.

Clinical programs need to directly address risk behaviors as a component of the rehabilitation process using well-established intervention protocols (eg, smoking cessation). Unfortunately, as lengths of stay have decreased, rehabilitation programs have become focused on fewer areas; yet shorter lengths of stay do not provide adequate justification for failing to address critical risk behaviors that may undermine the rehabilitation program and lead to secondary conditions,[10] as well as diminished life expectancy. Alcohol misuse frequently contributes to the onset of the initial SCI itself,[15,16] so continued alcohol misuse must be of grave concern and the focus of intervention. Overuse of prescription medications may be a result of lack of time and resources for basic therapies for pain, sleep loss, spasticity, and depression. If rehabilitation is to be successful, we must address behavioral areas critical to longevity.

Limitations

First, the sample is not population-based and consisted of voluntary participation among a sample drawn from clinical records. Therefore, life expectancy estimates are sample bound. Whereas the relative differences in life expectancy attributable to any particular characteristic are likely stable, the point estimate of life expectancy is likely affected by sampling issues. Second, the data were left censored, with participants enrolled at different points post injury. We do not know the extent to which deaths may have occurred prior to drawing the sample. Third, we cannot assume causality. In fact, based on other research and the theoretical risk model,5,8 we expect health factors to mediate the relationship between risk behaviors and mortality. For example, the relationship between psychotropic prescription medication and mortality may be attributable to differences in health that require medication (eg, antidepressant medications to treat an underlying disorder). Fourth, we have not attempted to identify the effects of multiple risk behaviors considered simultaneously. Fifth, recall bias may have influenced the accuracy of the reports of behaviors. This would lessen our ability to identify true relationships between the predictors and mortality leading to an underestimation of the strength of the relationships. Last, data on behaviors were only collected once, 10 years prior to determination of mortality status. This may also have led to an underestimation of the strength of the true relationship between the predictors and mortality because the behaviors may have changed over the intervening time. However, it is also possible that behavioral risk factors take several years before they may potentially affect life expectancy in our sample averaged 9.2 years post injury at enrollment.

Future research

We need to better identify the relationship of protective behaviors with mortality. We only identified one significant protective behavior. Second, we need to develop additional models that test the effects of multiple risk behaviors considered simultaneously. Third, research is needed linking risk and protective behaviors with specific causes of death, rather than simply all-cause mortality. This would require competing risk models and larger sample sizes. Finally, intervention studies are needed that utilize the information from this and other studies linking risk behaviors with morbidity and mortality. The simplest intervention would be to share this information with persons with SCI and their families to empower them to make informed decisions that affect their longevity. However, systematic interventions that are a critical component of the rehabilitation program are needed.

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Table 1

Participant characteristics and crude odds ratios (OR) for the demographic and injury characteristics

Demographic/injury characteristics	Mortality			
	Yes (n=276)	No (n=l,027)		
	Row %		OR (95% CI)	*P* value
Gender				
Male	21.8	78.24	1.15 (0.84-1.56)	.3868
Female	19.5	80.5	Reference	
Injury severity				
C1-C4	32.2	67.8	3.28 (2.04-5.28)	<.0001
C5-C8	21.9	78.1	1.94 (1.26-2.97)	
Noncervical	21.6	78.4	1.90 (1.25-2.89)	
Ambulatory	12.6	87.4		
Years post injury	10.9 (7.7)	9.3 (6.5)	1.03 (1.01-1.05)	.0008
Chronological age	50.1 (15.3)	38.7 (11.7)	1.07 (1.05-1.08)	<.0001

Table 2

Adjusted odds ratios (OR) and 95% confidence intervals for the risk variables from the final model

Behaviors	Final model		
	OR[a]	95% CI	*P*
Smoking (vs never regular)			.0027
One year or more	1.50	1.09-2.07	
Within 1 year	1.62	0.86-3.05	
≤Pack/day	1.84	1.28-2.65	
> Pack/day	1.96	1.29-2.99	
Binge drinking	1.03	1.01-1.06	.0232
No. of prescription medications (vs none)			<.0001
1-2	1.28	0.94-1.75	
3-4	2.36	1.66-3.37	
Days out of the house (vs every day)			.0011
0 days	2.35	1.51-3.66	
1-3 days	1.65	1.14-2.38	
4-6 days	1.28	0.88-1.85	

[a]Controlling for age, gender, years post injury, and injury severity.

Table 3

Life expectancies (LE) of a 20-year-old male as a function of status on each of four behaviors

	LE	Lost LE[a]	% of highest[b]
No risk behaviors	43.03		
Smoking (pack or more)	33.74	9.29	78.4
Binge drinking (15 days)	36.21	6.82	84.2
Psychotropic medications (3-4 weekly)	31.21	11.82	72.5
Days out of house (0 days)	31.26	11.77	72.6

[a] Lost LE compared with those who report no risk behaviors.

[b] LE compared with those who report no risk behaviors.

Table 4

Percentage of participants reporting specific and multiple risk factors

Behaviors	%
Smoking (pack or more)	9.44
Binge drinking (15 days or more)	2.46
Psychotropic medications (3-4 weekly)	14.27
Days out of house (0 days)	7.44
No. of behaviors reported	
1	23.41
2	4.30
3	0.54
4	0.00