#3 ORIGINAL CONTRIBUTION

# Worklife After Traumatic Spinal Cord Injury

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**Abstract**

**Objective:** To develop predictive models to estimate worklife expectancy after spinal cord injury (SCI).

**Design:** Inception cohort study.

**Setting:** Model SCI Care Systems throughout the United States.

**Participants:** 20,143 persons enrolled in the National Spinal Cord Injury Statistical Center database since 1973.

**Intervention:** Not applicable.

**Main Outcome Measure:** Postinjury employment rates and worklife expectancy.

**Results:** Using logistic regression, we found a greater likelihood of being employed in any given year to be significantly associated with younger age, white race, higher education level, being married, having a nonviolent cause of injury, paraplegia, ASIA D injury, longer time postinjury, being employed at injury and during the previous postinjury year, higher general population employment rate, lower level of Social Security Disability Insurance benefits, and calendar years after the passage of the Americans with Disabilities Act.

**Conclusions:** The likelihood of postinjury employment varies substantially among persons with SCI. Given favorable patient characteristics, worklife should be considerably higher than previous estimates.

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**Key Words:** Spinal cord injuries; Economics; Employment; Rehabilitation; National Spinal Cord Injury Statistical Center

## INTRODUCTION

An econometric study of workforce participation of persons with spinal cord injury (SCI) was conducted using data from the National Spinal Cord Injury Statistical Center (NSCISC) database maintained at the Spain Rehabilitation Center, University of Alabama at Birmingham. The data set is unique in that it contains health, sociological, and economic data on a large SCI cohort over a long period (1).

The use of a database that includes an objective, medical measure of physical condition reduces the problems inherent in using data based on self-reported disability, such as that reported in the *Panel Study of Income Dynamics* (PSID), *The Current Population Survey* (CPS), and the *Survey of Income and Program Participation* (SIPP). These problems include the implicit assumption that a medical impairment is a disability, direction of causality, lack of comparability across subjects, and the use of a claim of disability by healthy individuals to retire early (2–5). Although these biases are well known and have been extensively studied in the literature on disability and work, forensic economists continue to use these data to construct worklife tables.

This study was designed to answer a question not before directly addressed in the postdisability employment literature: if a disabled individual can find work, how does that individual's worklife differ from that of the able bodied? This question is important, not only for forensic studies but also for policy makers considering changes in social programs that provide support and retraining for the disabled. Only with knowledge of worklife can social policies be made in a cost-benefit setting.

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### Previous Research

A threshold challenge to all studies of the effects of physical limitations on work is differentiating general measures of impairment that may limit most or all types of employment opportunities from specific measures of disability that may limit only certain types of work. For example, an inability to lift heavy weights above one's head would be disabling for a construction worker but vocationally irrelevant for a computer programmer.

Studies of the effects of injury characteristics on postinjury employment found in the vocational rehabilitation, SCI, and general trauma literatures tend to use data with more precise information or description on type of impairment than those found in the economic literature (6–15). The data sets used in these studies, however, have frequently been too small or specialized for inference to the general population, and the studies have not generally focused on the questions that most interest forensic economists. Finally, studies of labor force entry reported in the rehabilitation literature, although informative, do not provide guidance regarding the duration of postinjury employment. This leaves unanswered the key question of whether programs to train and place the disabled in jobs fully restore those individuals to their preinjury status and earnings potential.

Forensic economists have studied workforce participation of the disabled using data from the CPS and the SIPP. The CPS and SIPP rely on self-reported rather than objective measures of limitations on activities of daily living or ability to work and classify disability and degree of disability on the basis of the type and amount of government aid payments rather than some measure of ability to work. There has been a tendency for researchers to let the available data drive the analysis, however inappropriate to the task the data may be (4). The advantage of the NSCISC database that was used in the current study was that it had more specific objective measures of impairment (neurologic level and completeness of injury) than are available in the CPS and SIPP. Since 1996, the NSCISC database has also included the Functional Independence Measure (FIM) that is an objective measure of disability and limitations in activities of daily living.

There is also an inherent bias towards over-reporting disability by those who do not work due to incentives created by government transfer programs (16,17). Two specific factors that create a bias toward over-reporting disability are the loss of federally provided health insurance and the difficulty of re-establishing disabled status if the employment is unsuccessful in the long run. Another problem with the classification of disability is that early retirement and participation in a disability program can be due to legitimate specific occupational limitations rather than a general inability to work. Further, because payments under these programs can be substantial, there is a strong disincentive for recipients to enter the workforce (18).

There is also a bias towards underreporting disability by those who are employed. An employed individual adequately coping with a biomedical limitation may not consider herself/himself "disabled." Hence, the denominator of the employment rate calculation is inflated and the numerator deflated. Given the demonstrable biases in CPS and SIPP data, one can infer little from their analysis.

A common criticism of the use of worklife studies is that the broad diagnostic categories presented in the studies are of limited use in assessing outcomes for an individual. Specifically problematic in studies of the effects of disability on worklife is that factors found important in the rehabilitation literature, such as age at injury, time since injury, marital status, and medical indicators of disability, are not considered in the economic literature.

Previous forensic studies do not differentiate on the basis of whether the individual is in the workforce at the time of the evaluation despite the demonstrated importance of this factor in estimating worklife of the nondisabled. This shortcoming limits the usefulness of current disability-oriented worklife expectancy (WLE) tables, such as the *New Worklife Expectancy Tables* (19). Current workforce status is an important predictor of worklife, and there is no a priori reason that it is any less important for the "disabled" than for the able bodied.

Finally, the current study provided a unique opportunity to evaluate the effects of the implementation of the Americans with Disabilities Act (ADA), the general population unemployment rate, and the level of disability payments relative to average wages on the likelihood of obtaining and sustaining employment. Increasing understanding of these issues is important in the enhancement of the overall understanding of the employment process after SCI.

## METHODS

### Study Population

From 1973 to 1981, data on persons treated at any of the regional Model SCI Care Systems located throughout the United States were maintained at the National Spinal Cord Injury Data Research Center located in Phoenix, Arizona. Since then, the database has been maintained by the NSCISC (1). Eligibility criteria for inclusion in the NSCISC database and how those criteria have changed over time have been published previously (1). In general, persons must have had an SCI caused by a traumatic event, been treated at a Model SCI Care System within 1 year of injury, resided in the geographic catchment area of the Model SCI Care System, and given informed consent.

A subset of the NSCISC database limited to annual evaluations in which the person was age 18 to 65 years, not a student or incarcerated, and with abnormal neurologic status (not ASIA Impairment Scale E) was used. Neurologic status at discharge was substituted for any missing neurological data at annual evaluation. All

**Table 1.** Study Population Characteristics at Annual Evaluation

| | |
|---|---|
| Age ($\bar{x}$ years) | 37 |
| Male (%) | 82 |
| Race (%) | |
| White | 72 |
| African American | 19 |
| Other | 9 |
| Violent etiology (%) | 17 |
| Marital status (%) | |
| Single, never married | 37 |
| Married | 38 |
| Widowed/separated/divorced | 25 |
| Years since injury ($\bar{x}$) | 4 |
| Unemployed at injury (%) | 17 |
| Education (%) | |
| < High school graduate | 23 |
| High school graduate | 61 |
| Bachelor's degree | 15 |
| Professional/PhD | 1 |
| Cervical injury level (%) | 52 |
| ASIA impairment scale (%) | |
| A | 49 |
| B | 10 |
| C | 11 |
| D | 30 |

annual evaluations beginning in 1976 (the first year that annual evaluations were included in the NSCISC database) that met these criteria were used.

As of September 2000, when the data set for this study was constructed, the database contained records for 98,110 annual evaluations of 20,143 persons. Characteristics of the study population appear in Table 1.

## Data Collection

Data were collected during the initial hospitalization and during each annual evaluation and thus are longitudinal. These data included information on injury severity; hospitalization and inpatient rehabilitation period; medical and psychosocial outcomes; mortality; and such demographics as age when injured, education, sex, race, marital status, and employment status. Injury severity ranged from no residual neurological impairment to complete tetraplegia.

Two measures of injury severity were used. Neurologic level of injury was categorized as either cervical on at least one side of the body (tetraplegia) or lower on both sides of the body (paraplegia), while the ASIA Impairment Scale measured the level of residual neurologic function during the current annual evaluation. The current definitions of ASIA Impairment Scale categories are A (no sensory or motor function was preserved in the sacral segments S4-S5); B (sensory but not motor function was preserved below the neurological level and extended through the sacral segments S4-S5); C (motor function was preserved below the neurological level, and the majority of key muscles below the neurological level had a muscle grade less than 3); D (motor function was preserved below the neurological level, and the number of key muscles below the neurological level with a muscle grade 3 or greater was greater than or equal to the number of key muscles below the neurological level with grades less than 3); or E (sensory and motor function was normal) (20). Level A was considered to be a complete injury, whereas levels B, C, and D were considered to be incomplete injuries.

These definitions have changed slightly over the past 30 years. In all cases, the definition that was applicable at the time of data collection was used. It was not possible to adjust for any changes in definition during the analysis, creating a small degree of misclassification by current standards and likely biasing odds ratios for the ASIA Impairment Scale slightly toward the null.

Because the follow-up FIM was only added to the database in 1996, it was not used in this study. Including the FIM would have severely restricted sample size and limited the ability to assess trends in employment over time and the effects of ADA implementation.

## Data Analysis

*Predictive Models of Employment.* The structure of the data was a cross-sectional time series. The dependent variable was the self-reported employment status of the person at the time of the annual evaluation. It was coded as employed in the competitive labor market, homemaker, on-the-job training, sheltered workshop, student, retired, or unemployed. Persons who had more than 1 activity, such as a part-time student and part-time worker, were instructed to report their primary activity. Although the dependent variable did not distinguish between full-time and part-time employment, a previous study demonstrated that most persons in the database who were employed postinjury were employed full time (10). Nonetheless, for purposes of this study, a few part-time employed persons were probably misclassified into another employment status category.

The dependent variable was treated in a dichotomous manner, contrasting those who reported being employed in the competitive labor market with all others, except students and those who were retired preinjury. On-the-job training and sheltered workshops were grouped with the unemployed in a manner consistent with previous studies of employment after SCI because they are often temporary jobs and usually provide relatively low wages and high economic losses (10,13). In any event, the categories of on-the-job training and sheltered workshop combined make up less than 1% of the sample follow-up years and have minimal impact on overall study results.

Multiple logistic regression was used to estimate the probability of employment in the competitive labor market at the time of the annual evaluation by pooling data from all annual evaluations of nonstudent study participants given a set of medical and demographic characteristics. This corresponds to the literature in post-SCI employment studies and previous econometric studies of worklife. The data were then separated into 2 groups according to workforce participation during the previous evaluation. The first group consisted of annual evaluations for those who worked at the time of the previous year's evaluation and the second included those who were not employed at that time.

Because of missing data and persons being temporarily lost to follow up, including a 1995 change in follow-up protocol that only required data collection in years 1, 2, 5, and 10 and every 5 years thereafter except for a random sample of 125 patients from each model system whose data continued to be collected annually, the intervals between annual evaluations were not of equal duration. Therefore, in the second analysis, the data were limited to those observations for which there was an evaluation in the previous year. As a result, sample sizes for the stratified analyses were somewhat smaller and slightly weighted towards data collected prior to 1995, when data collection was required annually on all patients.

The definition of last period employment status that was used in this study is consistent with that typically used in worklife expectancy tables. It differs from the standard, however, in that no differentiation was made between those who were in the labor force and unemployed and those that were not in the labor force. Both were classified as not in the labor force.

The model to predict employment status at the time of the current annual evaluation was created using variables indicating neurologic impairment, current age, years since injury, sex, race, current education, current marital status, etiology of injury, employment status at injury, current percent general population employment, an indicator for passage of the ADA, and an indicator of benefit levels as a percent of earnings. All categorical predictor variables were recoded as dichotomous with 1 reference category omitted. No transformations of interval level variables were needed, and they were entered directly into the model. Four categories of neurologic impairment were created by combining injury level and ASIA Impairment Scale. The 4 groups were ASIA A, B, or C tetraplegia; ASIA D tetraplegia; ASIA A, B, or C paraplegia; and ASIA D paraplegia (the referent category).

Employment and population statistics were obtained from the Bureau of Labor Statistics web site (http://data.bls.gov/cgi-bin/srgate). Population and the number employed and unemployed were downloaded by age group, race, gender, year, and month. The relevant series were LFU11002011 through LFU70006532. This produced a data file with 58,000 rows that was merged with the annual evaluation data from the NSCISC database. This allowed the percentage of the general population employed for the calendar year of the annual evaluation, categorized by age, sex and race, to be matched to each NSCISC data record and tested for inclusion in the models. Also tested in the models were a time trend, measured as the number of years past 1970; a 5-year, phased-in dummy variable for the passage of the ADA; and a variable that measured the ratio of average Social Security Disability payment to average wage that assessed the degree to which disability benefits programs replaced earnings.

Because the employment rate increased at first with age, then declined, linear, quadratic, and cubic terms for age were tested. Interactions between age, race, education, ADA effect, and severity of injury were also tested for inclusion in the final model. Statistically insignificant ($P > 0.05$) variables, including categories of such variables as individual racial/ethnic groups, were dropped, except for the linear effect of age in situations in which a higher order age term was significant. The effect of dropping an insignificant category, such as Asian race, from a multi-category variable is to combine the dropped category with the reference category and to compare the newly combined reference group with other categories that remain in the model.

*Estimating Worklife.* In this study, expected worklife was assessed by summing the probability of being employed each year over the remaining life span. However, in addition to worklife expectancy, life expectancy is also reduced by SCI, with the degree of reduction depending on the neurologic level and completeness of the injury. Estimates of worklife for policy analysis purposes must incorporate the reduction in life expectancy, whereas those used for forensic purposes frequently do not. Therefore, in this study, worklife was computed using both normal and reduced life expectancy.

This study relied on calculations of reduced life expectancy published previously (20,21). In those studies, reduced life expectancy associated with SCI was calculated by applying standard statistical and actuarial methods to the NSCISC database that was augmented by additional patients who were treated at model systems but who were not eligible for enrollment in the NSCISC database (21,22) Briefly, a data set of person years for the 18,872 persons injured since 1973 who were not ventilator dependent and who survived at least 2 years postinjury was constructed, variables associated with survival were identified by using logistic regression, and then the model was used to compute age-specific mortality rates for any given profile of disability. These rates were used to construct a life table, which gave the life expectancy and the chance of living any number of additional years (21).

The annual probabilities of employment were estimated using both sets of models. The estimation procedure using the grouped model is straightforward;

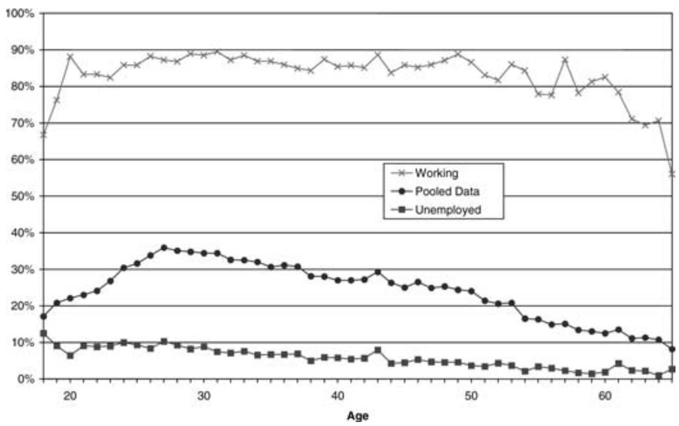


**Figure 1.** Employment rate by age and last year's employment status.

the time-dependent variables in the equation for each incremental year of life were simply changed, and the probability of working was then calculated. This probability was multiplied by the probability of being alive (either normal or SCI specific) and the products were then summed over the life span.

Using the two-state worklife model is more complex. The logit equations yield probabilities of future employment given the prior year employment status and the demographic characteristics and medical data that were used as explanatory variables in the model. The probability of employment next year was computed as using either the model for previously employed persons or the model for previously unemployed persons as appropriate.

After the current year, the previous year's employment status was no longer known. However, the equations were still used by multiplying the probability estimated with each equation by the probability of the corresponding employment status from the previous period.

As it turned out, the probabilities using the working, not working, and work status unknown models tended to converge over time in almost all scenarios. In some scenarios, the not working and work status unknown probabilities crossed and then converged.

## RESULTS

### Employment Rates

The variation of employment rates of persons in the NSCISC database by age and employment status in the previous period is shown in Figure 1. After age 20 until about age 55 years, roughly 85% of those employed in one period remained employed in the next. After age 55, that percentage began to drop sharply. This result does not differ dramatically from findings for the able bodied. Beyond age 20 years, approximately 10% of those who were unemployed at one annual evaluation were employed at the next. This percentage dropped steadily as age increased. Combined, these trends defined the trend of the overall employment rate, which peaked at age 27 years at about 36% and fell steadily thereafter. Clearly, current employment status is a very strong predictor of employment status in the next year.

Variation in the employment rate by age and impairment status is illustrated in Figure 2. As expected, employment rates are lower for persons with tetraplegia than for persons with paraplegia and lower for those with complete compared to incomplete deficits. Employment rates peak in the late 20s for all neurologic categories and decline thereafter.

### Predictive Models

Results for the whole sample, which does not split the observations based on the previous employment status, are presented in Table 2. Some basic findings were (a) generally, the more severe the injury, the less likely the person was employed; (b) higher education offsets impairment and greatly increases the likelihood of employment; (c) poorly educated persons with tetraplegia were particularly unlikely to find employment; (d) marriage was associated with a higher likelihood of successfully finding work; and (e) persons with SCI who had professional degrees were no less likely to be employed than the able bodied of similar educational attainment.

Unlike other studies, gender was not a significant predictor of employment, and there were no significant interactions between gender and other predictors. This is probably due to confounding between the gender variable and the percent general population employment variable because sex-specific rates of general population employment were used in this study to capture the lower likelihood that a woman will be in the labor force and employed than a male of comparable age and education. Therefore, in essence, the gender effect is embedded in the population employment variable.

Like previous research (13), this study revealed that African Americans with SCI were 25% less likely to find work than were Latinos or Asians and about 50% less likely than whites, even though, unlike previous studies,

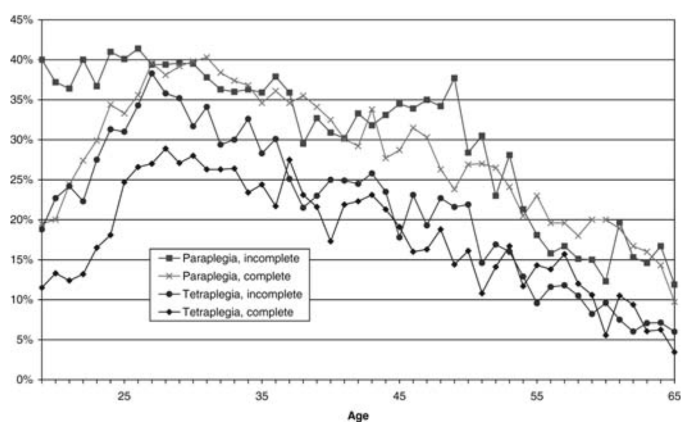


**Figure 2.** Employment rate by age and disability.

**Table 2.** Logistic Regression Model of the Probability of Competitive Labor Market Employment After Spinal Cord Injury: Entire Sample

| Variable | β | Odds Ratio | 95% Confidence Limits |
|---|---|---|---|
| Intercept | −2.935 | — | — |
| High school graduate | 1.030 | 2.80 | 2.59–3.03 |
| Bachelor's degree | 2.404 | 11.07 | 10.03–12.21 |
| Professional /PhD | 3.279 | 26.55 | 21.82–32.30 |
| ASIA ABC paraplegia | −0.216 | 0.81 | 0.74–0.87 |
| ASIA D tetraplegia | −0.293 | 0.75 | 0.69–0.81 |
| ASIA ABC tetraplegia | −0.596 | 0.55 | 0.51–0.60 |
| Non-HS graduate/ tetraplegia | −0.267 | 0.77 | 0.71–0.83 |
| Violent cause of injury | −0.188 | 0.83 | 0.77–0.90 |
| African American | −0.286 | 0.75 | 0.67–0.85 |
| White | 0.471 | 1.60 | 1.45–1.77 |
| Single, never married | −0.426 | 0.65 | 0.62–0.69 |
| Widowed/separated/ divorced | −0.455 | 0.63 | 0.60–0.67 |
| Years since injury | 0.200 | 1.22 | 1.20–1.25 |
| Current age | −0.019 | 0.98 | 0.97–0.99 |
| $(\text{Age} - \text{mean age})^2$ | −0.001 | 0.99 | 0.99–0.99 |
| Phased indicator for ADA | 0.217 | 1.24 | 1.17–1.32 |
| Unemployed at injury | −0.806 | 0.45 | 0.41–0.48 |
| Population percent employment | 1.205 | 3.34 | 2.54–4.39 |

a race-specific measure of unemployment was incorporated into the analysis. Employment after SCI was also found to be sensitive to economic conditions as measured by the percentage of the population cohort employed. This result has not been previously reported.

Consistent with prior research, the probability of working increased with age, to a point, after which it reached a plateau and then fell (7,10,13). Age had a typically nonlinear effect, and employment fell steeply with the advent of the typical retirement age.

Another finding that was consistent with previous research was that as the time postinjury approached 5 years, the probability of working increased and reached a plateau thereafter (7,10,13,23). Many possible explanations for this finding have been offered, including the need to complete education or retraining for new types of jobs that would be more consistent with the physical injuries and resulting functional capabilities of the individual, the need to adjust fully to one's new health status and functional limitations, and the need to overcome other short-term barriers and disincentives to work.

Work status prior to injury had a strong effect on subsequent likelihood of employment. Those who were employed when injured were twice as likely to be employed as a combined group of those who were unemployed or homemakers when injured. Finally, a new finding from this study was that implementation of the ADA coincided with a 3-percentage point or 20% increase in the likelihood of employment. All variables included in the final model were significant at better than the 5% level.

It is well known that the probability of an individual working in a subsequent period is highly correlated with his or her current workforce and employment status. Most worklife expectancy tables, therefore, are constructed so as to consider the current period status. To estimate this conditional worklife expectancy, models were developed for 2 groups: those currently employed and those not currently employed.

The results for the divided sample are shown in Tables 3 and 4. For those who were currently unemployed, more years of education, having a less severe injury, and older age were more strongly associated with the likelihood of being employed next year than they were for those who were currently employed. Overall, education was the key factor for effectively competing in the labor force. High school, college, doctorate, and professional degrees all increased the likelihood of work, whereas a master's degree was not significant at the margin. Injury severity was less important for those currently employed than for those who were unemployed. This is logical because a person with SCI who had found a job had probably found one that accommodated his or her impairment.

These results are consistent with expectations and the unconditional model results reported in Table 2. Of note is the magnitude and sign of the intercepts indicating the high likelihood of remaining in the same state from period to period. Education remained the most important factor in getting or keeping a job, although it was less important, as expected, for those who had a job. Those working were not affected by changes in economy-wide unemployment, implying that the physically impaired were not the "last hired and first fired." Higher disability benefits had the expected effect of reducing the likelihood that the unemployed would secure work, but the magnitude of the effect was surprisingly strong. If, for example, benefits as a percent of average wage were to move up 10 percentage points from 38% to 48%, the probability of employment for a person with SCI currently not employed would decrease by 1.4 percentage points, from 4.7% to 3.3%, a 30% decline. All variables were of the expected sign and all except age were significant at better than the 5% level. These models successfully predicted employment status in 86% and 93% of the cases for those working and not working in the previous period, respectively, compared with 79% for the pooled model.

**Table 3.** Logistic Regression Model of the Probability of Competitive Labor Market Employment After Spinal Cord Injury for Persons Who Were Employed During the Previous Year

| Variable | β | Odds Ratio | 95% Confidence Limits |
|---|---|---|---|
| Intercept | 0.840 | — | — |
| High school graduate | 0.369 | 1.45 | 1.17–1.78 |
| Bachelor's degree | 1.013 | 2.75 | 2.19–3.46 |
| Professional/PhD | 1.652 | 5.22 | 3.15–8.65 |
| ASIA ABC paraplegia | −0.149 | 0.86 | 0.75–0.99 |
| ASIA ABC tetraplegia | −0.388 | 0.68 | 0.58–0.79 |
| African American | −0.454 | 0.64 | 0.47–0.86 |
| White | 0.295 | 1.34 | 1.05–1.72 |
| Single, never married | −0.227 | 0.80 | 0.69–0.92 |
| Widowed/separated/ divorced | −0.348 | 0.71 | 0.61–0.82 |
| Years since injury | 0.120 | 1.13 | 1.07–1.19 |
| Current age | 0.004 | 1.00 | 0.99–1.01 |
| $(\text{Age} - \text{mean age})^2$ | −0.001 | 0.99 | 0.99–0.99 |
| Unemployed at injury | −0.480 | 0.62 | 0.50–0.76 |

The relationship between race and unemployment is troubling. Consistent with the overall model depicted in Table 2, nonwhites had a significantly lower probability of both finding and keeping a job than did whites, all else being equal (Tables 3 and 4). Previous research has also found this effect (7,10,13). Interestingly, employed African Americans were significantly less likely to remain employed the next year than a combination of Asians, Native Americans, Pacific Islanders, and Latinos (the reference category in Table 3). However, among the unemployed, no significant differences were observed among African Americans, Asians, Native Americans, Pacific Islanders, and Latinos in the likelihood of becoming employed next year (Table 4).

### Worklife Expectancy

Worklife results are presented for the sample case of a 30-year-old, married white male who was a student when injured 8 years ago. For illustration, it was assumed that the ratio of Social Security Disability Income to average annual wage was 35% and the unemployment rate was 5%.

Worklife expectancy was predicted using both normal life expectancy and reduced life expectancy resulting from SCI. Clearly, the more accurate prediction is the one that used the reduced life expectancy. However, in forensic applications, such as estimating lost income, the analyst must use a normal life expectancy to properly evaluate the magnitude of loss. For this reason and because the use of normal life expectancy allowed the effect on employment to be isolated, this presentation is also important.

Results are presented in Tables 5, 6, and 7 for 3 different levels of education. With a normal life expectancy, the difference in expected worklife between the able bodied and persons with SCI declined markedly with education and was economically insignificant for those with professional degrees. For the relatively uneducated, the difference was significant, ranging from 50% to 78%. The return on education was dramatic: a 4-year investment in education increased worklife by 10 years, and the additional years to receive a professional degree or PhD increased worklife by an additional 6 years.

Current work status was, not surprisingly, a more important predictor of worklife for persons with SCI than for the general public. Someone with SCI who was currently employed had an approximately 30% to 50% longer expected worklife than someone who was unemployed.

## DISCUSSION

Accurate estimates of worklife are critical for both policy analysis and estimation of economic loss in litigation. It is not possible to analyze the benefits of programs and policies designed to assist the physically impaired to enter the competitive labor market without some measure of the duration of employment. Similarly, policy makers

**Table 4.** Logistic Regression Model of the Probability of Competitive Labor Market Employment After Spinal Cord Injury for Persons Who Were Not Employed During the Previous Year

| Variable | β | Odds Ratio | 95% Confidence Limits |
|---|---|---|---|
| Intercept | −1.590 | — | — |
| High school graduate | 0.874 | 2.40 | 2.04–2.81 |
| Bachelor's degree | 2.057 | 7.82 | 6.51–9.40 |
| Professional /PhD | 2.871 | 17.65 | 12.17–25.62 |
| ASIA D tetraplegia | −0.175 | 0.84 | 0.73–0.96 |
| ASIA ABC tetraplegia | −0.311 | 0.73 | 0.62–0.87 |
| Non-HS graduate/ tetraplegia | −0.338 | 0.71 | 0.60–0.85 |
| White | 0.468 | 1.60 | 1.40–1.82 |
| Single, never married | −0.230 | 0.79 | 0.71–0.89 |
| Widowed/separated/ divorced | −0.223 | 0.80 | 0.71–0.91 |
| Age | −0.042 | 0.96 | 0.95–0.97 |
| Phased indicator for ADA | 0.271 | 1.31 | 1.14–1.50 |
| Benefits as percent of earnings | −3.606 | 0.03 | <0.01–0.69 |
| Unemployed at injury | −0.359 | 0.70 | 0.61–0.81 |
| Population percent employment | 1.108 | 3.03 | 1.82–5.03 |

**Table 5.** Expected Worklife (Years) When Current Work Status Is Unknown*

| Injury Severity | Normal Life Expectancy HS Grad | Normal Life Expectancy BA | Normal Life Expectancy PhD | SCI Life Expectancy HS Grad | SCI Life Expectancy BA | SCI Life Expectancy PhD |
|---|---|---|---|---|---|---|
| Paraplegia ASIA D | 13.8 | 25.2 | 31.8 | 13.2 | 23.9 | 30.0 |
| Paraplegia ASIA ABC | 12.1 | 23.6 | 30.7 | 10.8 | 20.6 | 26.1 |
| Tetraplegia ASIA D | 11.5 | 23.0 | 30.2 | 10.6 | 20.9 | 27.0 |
| Tetraplegia ASIA ABC | 6.1 | 18.0 | 26.1 | 5.1 | 14.6 | 20.3 |
| Normal | 28.0 | 31.6 | 33.6 | 28.0 | 31.6 | 33.6 |

* Assumes a 30-year-old married white man who was a student when injured 8 years ago. SSDI benefits = 35% of average annual wage and 5% population unemployment.

must know the magnitude of the costs of disincentives that discourage labor market entry by, for example, making the program difficult to re-enter once a participant has left to enter the workforce.

Forensic economists are frequently called upon to compare lifetime income "before and after" a disabling incident. As discussed earlier, the data on which economists rely to make these estimates are ill suited to that purpose and impart bias to their estimates.

In the forensic literature, the only published worklife tables for the disabled are those produced by Gamboa at Vocational Econometrics, Inc (VEI) (19). These tables were developed from workforce participation information from the CPS and life expectancy tables published by Richards (24). Like the tables produced in the present study, Gamboa's tables differ somewhat from the standard worklife presentation in that the "worklife" incorporates both probabilities of being in the workforce and being employed (19). For purposes of this study, this difference is unimportant. The Gamboa tables also do not differentiate on the basis of current employment status and are based on normal, not reduced, life expectancy.

Gamboa classified subjects as "severely disabled" or "not severely disabled" on the basis of the CPS disability criteria. He estimated worklife for these groups for 3 educational levels: 12 years of formal education (high school), 13 to 15 years (some college), and 16 years or more (college degree). This combined all persons with a college degree or greater so the educational classes do not correspond directly to those in the present study.

For the illustrative subject in the present study, the Gamboa estimates of worklife would be, respectively, 2.7 and 22.0 years for a severely and not severely disabled high school graduate and 5.3 years and 25.7 years for corresponding college graduates. The Gamboa worklife estimates for the "severely disabled" are approximately one third of the estimates derived from the present study for a high school graduate (6.1 years) and college graduate (18.0 years) with ASIA A, B, or C tetraplegia. Gamboa's estimated worklife for a not severely disabled college graduate is within a half year of the estimate derived from the current study for a person with ASIA D paraplegia and a bachelor's degree. His estimate for a not severely disabled high school graduate (22.0 years) is 30% to 80% higher than the estimate derived from the present study for a similarly educated person with ASIA D paraplegia.

Findings from the present study on the probability of working are consistent with the literature in disability research. The likelihood of finding work indeed increases with education and benefits from a stable marriage. The more severe the injury, the less likely an individual is to find work and, if found, the less likely to remain employed. Employment prospects for the physically impaired are affected by the state of the overall job market, and the disabled are not the last hired and first

**Table 6.** Expected Worklife (Years) When Currently Unemployed*

| Injury Severity | Normal Life Expectancy HS Grad | Normal Life Expectancy BA | Normal Life Expectancy PhD | SCI Life Expectancy HS Grad | SCI Life Expectancy BA | SCI Life Expectancy PhD |
|---|---|---|---|---|---|---|
| Paraplegia ASIA D | 11.9 | 22.9 | 29.9 | 11.3 | 21.7 | 28.2 |
| Paraplegia ASIA ABC | 10.7 | 25.5 | 28.9 | 9.4 | 18.7 | 24.5 |
| Tetraplegia ASIA D | 10.1 | 20.9 | 28.5 | 9.2 | 18.9 | 25.4 |
| Tetraplegia ASIA ABC | 5.3 | 16.3 | 25.6 | 4.3 | 13.1 | 18.9 |
| Normal | 26.1 | 30.5 | 32.8 | 26.1 | 30.5 | 32.8 |

* Assumes a 30-year-old married white man who was a student when injured 8 years ago. SSDI benefits = 35% of average annual wage and 5% population unemployment.

**Table 7.** Expected Worklife (Years) When Currently Employed*

| Injury Severity | Normal Life Expectancy HS Grad | BA | PhD | SCI Life Expectancy HS Grad | BA | PhD |
|---|---|---|---|---|---|---|
| Paraplegia ASIA D | 17.8 | 29.1 | 37.1 | 17.0 | 27.4 | 34.6 |
| Paraplegia ASIA ABC | 16.5 | 28.1 | 35.6 | 14.6 | 23.8 | 29.8 |
| Tetraplegia ASIA D | 16.9 | 28.4 | 36.7 | 15.5 | 25.3 | 31.9 |
| Tetraplegia ASIA ABC | 11.1 | 27.0 | 33.8 | 9.5 | 18.7 | 24.7 |
| Normal | 28.1 | 31.6 | 33.7 | 28.1 | 31.6 | 33.7 |

* Assumes a 30-year-old married white man who was a student when injured 8 years ago. SSDI benefits = 35% of average annual wage and 5% population unemployment.

fired. African Americans with SCI are even less likely to find work than are their white counterparts with the same disability. Some evidence that the ADA has improved the prospects for employment of persons with SCI was also found.

The results of this study suggest that job placement is almost as important as education in making persons with SCI economically productive and that policies that discourage postinjury employment have very substantial indirect costs. Once a person becomes employed, the probability of staying employed next year is much greater than the probability of an unemployed person's becoming employed. The life expectancy effects are predictable; people with SCI have substantially reduced life expectancy in all but the least severe cases, and that reduction in life expectancy reduces the economic payoff from education and job placement significantly.

This work extends the previous research on employment after SCI by providing an empirical basis for estimating how long an injured individual is likely to work. To estimate worklife expectancy for any individual, the characteristics of the person should be applied to the logistic regression models and the results summed over the remaining life expectancy, as was done in this study to produce Tables 5 to 7. The models of worklife on the basis of current employment status developed in this study provide a vehicle for performing cost-benefit analyses of employment placement programs.

These results differ substantially from the conclusions reached by VEI. Except in the extreme cases, results of the present study show that persons with SCI will have significantly more years of productive work than suggested by VEI, although it is agreed that severe disability can have a profound effect on worklife. It appears that one of the causes of this discrepancy is that VEI underestimated the impact of education on the ability of the physically impaired to work. This may result from the well-known problems with the CPS data upon which they relied.

Unfortunately, the magnitude of any effects of income support programs on the likelihood of being employed could not be completely assessed. Although the results of this study suggest that these programs provide a strong disincentive to work for those currently not working, actual income support information for the individuals in the database was not available.

Another limitation of this study was the lack of any way to control for or evaluate the effects of state programs targeted at increasing employment opportunities for the disabled or the potential impact of such programs as the Ticket to Work and Work Place Incentives Act. Although the database was national in nature, it was not population based, and certain states where model systems are located were overrepresented in the study population. More severe injuries and nonwhites have been demonstrated to be overrepresented in the NSCISC database (25).

Findings were also biased to some extent by losses to follow up and missing data that approximate 50% of eligible cases by the 20th postinjury year. Some losses to follow up result from discontinuation of funding for certain model systems over time. In those cases, all individuals are uniformly lost, and any bias other than possible geographical bias would not be expected. However, differential losses among the remaining model systems have also been demonstrated, with the less severely injured, unmarried persons, and the unemployed at injury being more likely to be lost to follow up (26). Based on the findings of this study, the first of these biases would lead to underestimation of overall post-SCI employment rates and worklife expectancies, while the latter 2 operate in the reverse direction and would lead to overestimation of the overall post-SCI employment rates and worklife expectancies. However, there is no reason to believe that the observed relationships between predictor variables and the likelihood of employment are affected by these loss-to-follow-up biases.

## CONCLUSIONS

Persons with SCI are far more likely to work than has been suggested by studies performed using the SIPP and CPS. Persons with paraplegia, who are classified under SIPP and CPS as severely disabled, have a workforce participation rate far higher than documented by previous studies. However, even less severely afflicted persons with

SCI, including those currently working (with the possible exception of those with professional degrees), do have significantly reduced worklives. It should be possible to extend these findings to forms of impairment other than SCI, although this extension should be done with caution given the unique nature of the health problems associated with living with SCI.

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