Strauss D, DeVivo M, Shavelle R, Brooks J, Paculdo D (2008). Economic factors and longevity in spinal cord injury: A reappraisal. Archives of Physical Medicine and Rehabilitation, 89:572-574.

ABSTRACT

Objective: In previous research, Krause et al. considered the effect of economic and other risk factors on life expectancy after spinal cord injury. In the present study the authors reviewed and reassessed the findings, using an expanded and updated database.

Design: Pooled person-year analysis.

Setting: Model Spinal Cord Injury Systems hospitals.

Participants: A total of 7,331 persons injured since 1973 who were enrolled in the National Spinal Cord Injury Database and received an evaluation between November 1995 and December 2005.

Interventions: Not applicable.

Main Outcome Measures: Mortality, determined by routine follow-up supplemented by information from the Social Security Death index. Logistic regression models based on the predictor variables were developed to estimate the chance of dying in a given year.

Results: As in the Krause study, life expectancies of persons with the greatest handicap in economic self-sufficiency were substantially shorter than average. However, the positive effect of favorable economics was much less than previously reported, largely because having health insurance coverage through Workers' Compensation was no longer a powerful (or statistically significant) predictor of survival.

Conclusions: The beneficial effect of favorable economics appears to be much less than previously reported. Further, the interpretation of the effects of modifiable factors (such as economics and social integration) is complicated by questions of cause and effect.

Key words: Life expectancy; Spinal cord injury; Mortality; Favourable economics; Economic risk factors.

INTRODUCTION

There is a considerable literature on life expectancy after spinal cord injury (SCI) that takes account of "demographic" factors: age, sex, level and grade of injury, ethnicity, etc.[1-3] A recent article by Krause et al.[4] went beyond this by considering other factors such as health, community integration, and economic indices. Such work may be significant in demonstrating how potentially modifiable factors relate to longevity.

Krause et al. considered a series of 4 models for predicting mortality, and hence life expectancy. The first included only demographic factors, while the fourth included the health, integration and economic factors that contributed significantly to prediction. They illustrated the results with the example of a 25-year-old man with a complete C6 injury. A striking finding was that whereas Model 3 (which included everything except economic factors) gave an estimate of 68% of normal life expectancy, the assumption of "favorable economics" in Model 4 resulted in an increase of 13 percentage points, to 81% of normal. Favorable economics here meant (a) a net family income (after out-of-pocket SCI expenses) of 150% or more of the poverty level, and (b) health insurance coverage through Workers' Compensation rather than through Medicare, Medicaid, private insurance, or other means.

We have recently been able to update and expand the database used in this study by adding more patients and increasing the length of follow-up of original patients. We then re-examined the findings. In the present report we summarize the new findings and comment briefly on their interpretation. We focus on economic factors because this aspect of the Krause study seems to have been the mostly widely cited.

METHODS

Participants and data

The data was drawn from the U.S. Model SCI Systems (MSCIS) database, maintained by Dr. Michael DeVivo at the University of Alabama. Subjects were 7,331 persons with SCI enrolled in the database who were alive and received an evaluation between November 1995 and December 2005; 744 subjects died by the end of the study follow-up period (December 2005).

Information on the subjects' health, social and economic status was taken from the first post-1995 evaluation with complete data. It was not possible to update the subjects' scores on health, economics, etc. during the 1995-2005 study period.

The economic variable available to Krause et al. and to us is based on an index of handicap from the CHART (Craig Hospital Assessment Reporting Technique).[5] This is computed from the ratio of {the total family income minus unreimbursed medical expenses} to the poverty level. The poverty level, which varies with family size, is defined by the Census Bureau and updated periodically. The economic handicap score is equal to 50 times this ratio, with a maximum of 100 and a minimum of 0. Thus, persons with a ratio of 2 or more have a score of 100. Because the variable is a measure of *handicap,* and a ratio of 2 is considered to be "no handicap", no distinction is made between ratios of 2 and higher. Thus the data contain no information about

the effect of having *extensive* economic resources rather than being merely at twice the poverty level.

Outcome Measures and Data Analysis

The unit of analysis was a *person-year*. Thus a subject who received an evaluation at, say, the end of 1998 contributed a person-year for 1999, a person-year for 2000, and so on until death or the end of the study period.

Each person-year was associated with a binary *outcome variable* and a set of *explanatory variables*. The outcome variable was whether the subject lived or died during that 12-month period. The explanatory variables included age, sex, ethnicity, level and grade of injury, together with health, social and economic variables (see below). The purpose of the analysis was to relate the outcome variable, mortality in a given year, to the various explanatory variables.

We used the same methods as Krause et al.[4] with one exception: the proportional life expectancy method[6] was used to estimate mortality rates at ages over 75.

RESULTS

Among the study population of 7,331 persons, there were 41,440 person-years of follow-up and 744 deaths. The average follow-up time was 5.1 years.

In the earlier study, Workers' Compensation was associated with a dramatic reduction in mortality (odds ratio = 0.43; 95% CI [0.25,0.73]), other factors being equal. However, the effect was somewhat unstable due to the number of patients with Workers' Compensation. In the updated database this factor had a much smaller effect (odds ratio = 0.80; 95% CI [0.59, 1.10]). Although this still suggests a beneficial effect, it is no longer statistically significant ($p > 0.15$). We therefore excluded it from our final revised analyses of the effects of income on life expectancy.

We applied regression methods to the economic handicap score to explore the possibility of constructing a linear (or other) scale based on this that would allow extrapolation to incomes exceeding twice the poverty level or higher (i.e., scores of 100 on the handicap scale). We found, however, that the mortality associated with scores of 100 was substantially greater than would be predicted from a linear regression fitted to scores less than 100. After further analysis, it appeared that the most appropriate use of the economic variable was that employed by Krause et al., namely a simple 3-point scale of scores of 0 to 50, 51 to 75, and 75 to 100. We therefore followed Krause et al. by basing "Favorable economics" on this scale.

The new estimates of the percentage of general population life expectancy for a 25 year old white man with a C6 ASIA A injury who has already survived at least one year post-injury are:

- Model 3 (good health and community integration but not taking account of economic sufficiency): 63%

- Model 4 (as above, plus *most favorable* economic category): 66%
- Model 4 (as above with *most unfavorable* economic category) 55%

Thus being in the most favorable economic category, rather than being "average", is associated with an increase of only 3 percentage points of general population life expectancy rather than with 13 points as in the previous study. However, being in the least favorable group (which corresponds to a net income at or below the poverty level) is markedly worse than being average. A similar pattern was observed for persons of age 50. Overall, the new data revealed slightly less favorable survival rates than were found in the original paper, which continued the trend reported in 1999.[3]

DISCUSSION

Our analysis confirms the finding in Krause et al. that those with the most severe handicap were subject to mortality well in excess of the average. It appears, however, that the positive effect of favorable economics on life expectancy of persons with spinal cord injury is less than previously estimated.[4] This is not surprising when one notes that the CHART economic self-sufficiency variable is only designed to measure economic *handicap*, and we are thus merely comparing persons in the most favorable economic category to those with an "average" handicap. The data available both to Krause et al. and ourselves does not distinguish adjusted family incomes that are twice the poverty level from much higher net incomes, and thus is not possible at present to comment on the effect of having unusually good economic resources.

Issues of cause and effect complicate the interpretation of these findings, and further research will be needed to disentangle the independent effects of these factors. For example, it cannot be assumed that the shorter life expectancy for those in the worst economic group solely reflects inadequate funding for care needs. It is conceivable that such persons are less likely to be compliant with medical advice, or more likely to have adverse health habits such as smoking or drug use. On the other hand, the effect of the economic factor may have been diluted in Model 4 because the health and community integration factors controlled for may to some extent reflect the *effects* of favorable economics.

One limitation of the data set is that ideally the variables should be updated for each current year rather than be assumed constant over the subject's time in the study period. For example the answer to "is your health this year worse than it was last year?" will surely change over the years. However, this is a practical limitation imposed by the available data: most subjects contribute only one or two interviews over the study period. It seems unlikely that this issue has had a major effect on the results.

CONCLUSIONS

The study of potentially modifiable risk factors for mortality in SCI is valuable. Our research provides further support for the very plausible hypothesis that those near the poverty level have shorter life expectancies than others. However, the study provides no evidence for or against the

proposition that those with large net incomes have better life expectancies than persons with adequate, though more modest, resources. In addition, although economic, social and health factors are statistically associated with survival, further research will be required establish the causal relationships between these factors.

From the Life Expectancy Project, San Francisco, CA (Strauss, Shavelle, Brooks, Paculdo); and the Department of Physical Medicine and Rehabilitation, University of Alabama, AL (DeVivo)

Supported in part by the National Institute on Disability and Rehabilitation Research, Office of Special Education and Rehabilitative Services, US Department of Education (grant nos. H133N000016, H133N000005, H133A011201).

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the authors or upon any organization with which the authors are associated.

REFERENCES

1. DeVivo MJ, Stover SL. Long-term survival and causes of death. In: Stover SL, DeLisa JA, Whiteneck GG, editors. Spinal cord injury: clinical outcomes from the model systems. 1st ed. Gaithersburg, MD: Aspen Pub; 1995. p 289-316.

2. DeVivo MJ, Kartus PL, Stover SL, Rutt RD, Fine PR. Seven-year survival following spinal cord injury. Arch Neurol 1987;44:872-875.

3. DeVivo MJ, Krause JS, Lammertse DP. Recent trends in mortality and causes of death among persons with spinal cord injury. Arch Phys Med Rehabil 1999;80:1411-1419.

4. Krause JS, DeVivo MJ, Jackson AB. Health status, community integration, and economic risk factors for mortality after spinal cord injury. Arch Phys Med Rehabil 2004;85:1764-1773.

5. Whiteneck GG, Charlifue SW, Gerhart KA, Overhosler JD, Richardson GN. Quantifying handicap: a new measure of long-term rehabilitation outcomes. Arch Phys Med Rehabil 1992;73:519-26.

6. Strauss DJ, Vachon PJ, Shavelle RM. Estimation of future mortality rates and life expectancy in chronic medical conditions. J Insur Med 2005;37:20-34.