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ORIGINAL ARTICLE

Diabetes increases financial burden of individuals with traumatic spinal cord injury (TSCI)

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Study design: Secondary analysis of existing data.
Objective: To estimate the association of diabetes with family income in a pooled 15-year cohort of individuals with TSCI.
Setting: A large specialty hospital in the southeastern United States.
Methods: A total number of 1408 individuals identified with TSCI were surveyed regarding family income as well as clinical and demographic factors. Due to income being reported in censored intervals rather than individual dollar values, interval regression was used to estimate models of the association of family income with diabetes.
Results: Approximately 12% of individuals with TSCI reported being diagnosed with diabetes. The most frequent family income interval in our sample was <$10 000, lower than the poverty threshold. The family income interval with the highest rate of diabetes was $15 000–$20 000. In an unadjusted model, diabetes was associated with a significant reduction of $8749 and in a fully adjusted model, diabetes was significantly associated with a reduction of $8560 in family income. Being a minority was also significantly associated with a reduction whereas educational attainment was associated with increased family income. TSCI severity was not significantly related to family income.
Conclusion: Diabetes imposes an additional financial burden on individuals with TSCI an already vulnerable population with high health care costs. The burden is more pronounced in minorities with TSCI. Providers should be aware of the higher prevalence of diabetes among patients with TSCI and pursue a policy of testing early and vigilant management. Further studies are needed regarding special interventions for managing diabetes in the TSCI population.
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INTRODUCTION

Individuals with traumatic spinal cord injury (TSCI) have been shown to be 1.7 times more likely to have diabetes than individuals without spinal cord injury.[1,2] TSCI has also been shown to be associated with higher mortality relative to the general population.[3] Diabetes has been shown to be a leading cause of heart disease, stroke, kidney failure, lower limb amputations and blindness.[4] Krause *et al.*[5] and Dismuke *et al.*[6] have shown that among individuals with TSCI, being a minority is independently associated with higher levels of poverty relative to the general population. Dismuke and Egede[7] have shown that diabetes is independently associated with lower levels of income than in the general population. However, it is currently unknown whether there is an additional financial burden of diabetes as a comorbidity in individuals with TSCI.

Our objective was to conduct a secondary analysis of a unique 15-year database to identify the association of diabetes comorbidity with family income after TSCI, before and after adjusting for demographic, education and injury covariates. Due to income being reported in intervals, we use a novel method for income estimation for TSCI.

We hypothesized that: (1) Diabetes will be significantly negatively related to family income in an adjusted model; (2) The relationship between diabetes and family income will be diminished but not become insignificant in a model fully adjusting for demographic, education and injury covariates.

MATERIALS AND METHODS

Participants

Upon approval of the Institutional Review Board, potential participants with TSCI were identified via three sources of records at a large specialty hospital in the southeastern United States. Potential participants were recruited via mailings from a large southeastern medical university. Individuals were considered eligible if they met three inclusion criteria: (1) 18 years or older at the time of assessment, (2) minimum of one year post SCI and (3) having SCI with residual effects. Of 2370 individuals meeting these criteria, 1544 (65.1%) responded to a mailed survey. We added a fourth criteria for our study, not having missing values on any of the following variables in the income models: family income at survey, diabetes status, TSCI severity, gender, age at survey date, race/ethnicity, marital status and education This reduced the sample to 1408 individuals with TSCI.

Procedures

Data were collected from 1995 to 2010. Participants received preliminary letters 4–6 weeks in advance of the packet of study materials. A second packet was sent to nonrespondents. Third mailings were sent to those who confirmed an

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interest in participation but had misplaced or discarded the materials. Participants received US$50 in remuneration.

Measures

The primary outcome variable was family income measured in 2010 dollars and the perspective is that of the family. Income was self-reported in the following intervals: (1) <$10 000, (2) $10 000–$15 000, (3) $15 000–$20 000, (4) $20 000–$25 000, (5) $25 000–$35 000, (6) $35 000–$50 000, (7) $50 000–$75 000, (8) $75 000–$100 000, (9) $100 000–$ 150 000 and (10) >$150 000. Diabetes was measured based on self-report by the individuals with TSCI to the question 'Have you ever been told you have diabetes?' Covariates included in the fully adjusted model were, gender, age at survey date, race/ethnicity, marital status, education and TSCI severity. Gender was measured as male = 1, female = 0.

Table 1 Pooled 15-year demographic and income characteristics of individuals with traumatic spinal cord injury (TSCI), 1995–2010

Class	*All*	*No diabetes*	*Diabetes*
N (%)	1408 (100%)	1239 (88%)	169 (12%)
Family income at survey			
<$10 000	16.55	87.98	12.02
$10 000–15 000	14.06	88.38	11.62
$15 000–20 000	7.46	82.86	17.14
$20 000–25 000	7.53	87.74	12.26
$25 000–35 000	9.09	85.16	14.84
$35 000–50 000	11.29	84.91	15.09
$50 000–75 000	12.93	87.36	12.64
$75 000–100 000	8.81	93.55	6.45
$100 000–150 000	7.24	90.20	9.80
>$150 000	5.04	95.77	4.23
Severity			
Ambulatory	33.74	88.21	11.79
C1C4	9.66	82.35	17.65
C5C8	23.79	91.04	8.96
Noncervical	32.81	87.23	12.77
Male			
Yes	73.72	88.38	11.62
No	26.28	87.86	12.14
Age at survey[a]			
20–39	30.04	96.45	3.55
40–48	24.79	87.97	12.03
49–58	24.01	82.84	17.16
59+	21.16	81.88	18.12
Race[a]			
NHW	73.93	90.01	9.99
NHB	21.09	83.50	16.50
Hispanic	2.20	77.42	22.58
Other	2.77	76.92	23.08
Married[a]			
Yes	52.54	85.81	14.19
No	57.46	89.62	10.38
Education			
<High school	25.21	90.42	9.58
High school	58.52	87.26	12.74
College and higher	16.26	86.90	13.10

Abbreviations: NHB, non-Hispanic Black; NHW, non-Hispanic White.
[a]Significant at $P<0.05$.

Age at survey was measured in four categories based on the quartile distribution of age as 20–39, 40–48, 49–58 and 59+. Race was measured in four categories as non-Hispanic White (NHW), non-Hispanic Black (NHB), Hispanic and other race. Marital status was measured as a binary indicator of married = 1 and unmarried = 0. Education was measured in three categories as <high school, high school diploma, college graduate and higher education. TSCI severity was classified into a categorical variable with four groups: C1–C4 cervical, C5–C8 cervical and noncervical nonambulatory and ambulatory.[8,9]

Statistical analysis

Frequency of the income intervals and income model covariates were computed for the entire sample and by diabetes status. χ^2 was used to test for differences in income model binary and categorical covariates by diabetes status. Since the primary outcome variable is reported in an interval instead of a point value, the data would need to be transformed and information would be lost if ordinary least squares or generalized linear models were used. Interval regression is a generalization of censored regression and uses the information on the minimum and maximum value of the intervals so that no information is lost in estimation. Interval regression also takes into account censored values either at the minimum or maximum value as the value tends toward negative or positive infinity.[10] The two extreme family income categories in our study have left (<$10 000) and right (>150 000) censoring. We used the intreg command in STATA 11 to test three models.[10] The first model is the unadjusted association of income with diabetes among individuals with TSCI. The second model adjusts for demographics of the individual with TSCI: gender, age at survey, race/ethnicity, marital status and education as well as diabetes status. The third model adjusts for TSCI severity as well as the aforementioned demographics and diabetes status.

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

Characteristics of individuals with TSCI from 1995 to 2010

The final study sample consisted of 1408 individuals with TSCI between 1995 and 2010. Table 1 shows that 16.5% had income <$10 000, 14.1% $10 000–15 000, 7.5% $15 000–20 000, 7.5% $20 000–25 000, 9.1% $25 000–35 000, 11.3% $35 000–50 000, 12.9% $50 000–75 000, 8.8% $75 000–100 000, 7.2% $100 000–150 000 and 5.0% >$150 000. In our sample, 169 (12.0%) of the individuals with TSCI self-reported being diagnosed with diabetes. Males comprised 73.7% of the sample and 42.5% were married. Based on the quartile age distribution, 30.0% were between the ages of 20–39, 24.8% were between the ages of 40–48, 24.0% were between the ages of 49–58 and 21.2% were >age 59. The distribution of race/ethnicity was 73.9% NHW, 21.1% NHB, 2.2% Hispanic and 2.8% were another race. The distribution of education was 25.2% <high school, 58.5% high school, 16.3% college degree and higher. Clinically, 9.7% had injury severity level C1–C4, 23.8% C5–C8, 32.8% noncervical nonambulatory and 33.7% were ambulatory.

Covariate differences by diabetes status

Table 1 also contains a χ^2-test of differences in family income interval categories and covariates by diabetes status. The family income intervals with the highest rate of diabetes were those with family income between $15 000–$20 000 (17.1%) and lowest rate of diabetes were those with family income >$150 000 (4.2%) but differences were not significant based on χ^2 at $P<0.05$. Significant differences based on χ^2 in diabetes status were found for age, race/ethnicity and marital status but not TSCI severity, gender or education. The highest rates of diabetes were found among the oldest, 59 and older (18.1%)

Table 2 Pooled 15-year interval regression income estimates of diabetes' impact on TSCI

	Unadjusted	*Demographic model*	*Demographic and clinical model*
Diabetes	−$8749[a] (−$15 681, −$1816)	−$8694[a] (−$14 785, −$2602)	−$8560[a] (−$14 667, −$2454)
Severity			
C5–C8			$602 (−$6824, −$8029)
Noncervical			$960 (−$6190, $8111)
Ambulatory			$3915 (−$3264, 11 096)
Reference C1–C4			
Male		−$3148 (−$7568, −$1272)	−$2882 (−$7321, $1556)
Age (years)			
40–48		$1402 (−$3929, $6735)	$1412 (−$3917, $6741)
49–58		−$3236 (−$8774, −$2301)	−$3168 (−$8707, $2371)
59+		−$3470 (−$9426, $2484)	−$3725 (−$9699, $2249)
Reference 20–40			
Race			
NHB		−$18 876[a] (−$23 801, −13 950)	−$18 964[a] (−$23 887, −$14 041)
Hispanic		−$14 019[a] (−27 272, −$766)	−$14 447[a] (−$27 705, −$1188)
Other		−$10 065 (−$21 999, −$1868)	−$10 148 (−$22 079, $1783)
Reference NHW			
Married		$27 211[a] ($23 010, $31 413)	$26 814[a] ($22 583, $31 045)
Education			
High school		$7211[a] ($2540, $11 882)	$7136[a] ($2462, $11 811)
College and higher		$33 507[a] ($26 880, $40 134)	$33 250[a] ($26 617, $39 883)
Reference <high school			

Abbreviations: NHB, non-Hispanic Black; NHW, non-Hispanic White.
[a]Significant at $P<0.05$.

and the lowest rates among the youngest, 20–39 (3.5%). For race/ethnicity, the highest rates of diabetes were found among other race (23.1%) and lowest among NHW (10.0%). For marital status, those who were married had higher rates of diabetes (14.2%) than the unmarried (10.4%).

Interval regression estimates of association of diabetes with income in unadjusted, clinical and clinical/demographic models

Table 2 consists of demographically unadjusted TSCI severity and demographically adjusted estimates of the association of diabetes with income. In an unadjusted model, diabetes was associated with a significant ($P<0.05$) reduction of $8749 (95% confidence interval (CI), $15 681, −1816) in family income relative to individuals with TSCI not reporting having diabetes. In a model adjusted for the demographic factors of age, gender, race/ethnicity and education, diabetes was significantly associated with a similar reduction of $8694 (95% CI −$14 785, −$2602) in family income. In a fully adjusted model of demographic factors and TSCI severity, diabetes was again found to be significantly associated with a similar reduction of $8560 (95% CI −$14 667, −$2454) in family income. In the demographic and TSCI severity-adjusted model, NHB (−$18 964 95% CI −$23 887, −$14 041) and Hispanic (−$14 447 95% CI −$27 705, −$1188) race/ethnicity were also found to be significantly associated with a reduction in family income. Being married ($26 814; 95% CI $22 583, $31 045) and attaining a high school degree ($7136; 95% CI $2462, $11 811), college degree or higher ($33 250; 95% CI $26 617, $39 883) relative to <high school were all associated with significantly higher family income.

DISCUSSION

Individuals with TSCI (12.0%) have a higher rate of diabetes prevalence than the general US population (9.3%). With respect to race, NHB individuals with TSCI (16.5%) and Hispanic individuals with TSCI (22.58%) have a higher prevalence of diabetes than NHW with TSCI (9.99%) as well as the NHW (7.6%), NHB (13.25%) and Hispanic (12.8%) US population.[11] The most frequent family income interval in our sample was <$10 000 (16.5%) which is lower than the U.S. federal poverty threshold ($10 830) for a family of one in 2010.[12] If most families have more than one individual then our estimates are very conservative as the poverty threshold increases the with number of family members. Unfortunately, we did not have data regarding number of family members to be able to calculate exact numbers below the poverty threshold. However, already a financially vulnerable population,[5,6] diabetes appears to significantly increase the financial burden for families of individuals with TSCI between $8560 and $8749. This result is robust to model specification being either unadjusted, demographic only or severity and demographic adjusted. Being Hispanic and NHB was associated with between $14 447 and $18 964 lower income relative to NHW. This is consistent with two previous studies of ours on TSCI.[5,6] Educational attainment is associated with increased income between $7136 and $33 250, with the highest income being associated with a college degree. This is also consistent with our previous TSCI studies.[5,6]

The limitations of this study include a population limited to one geographic part of the US, absence of adjustors regarding family participation in income and family size, and absence of more detailed clinical and environmental characteristics of individuals with TSCI. Even so, providers should be aware of the higher potential for diabetes

among their patients with TSCI and pursue a policy of testing early in order to reduce financial as well as clinical burden of this chronic disease in a vulnerable population, especially NHB and Hispanic minorities and those with less than a high school education.

In conclusion, diabetes imposes an additional financial family income burden on an already vulnerable population, individuals with TSCI. We estimated the financial burden of diabetes on family income of individuals with TSCI. We do not have information on insurance coverage in our study. However, we obtained the mean 2012 hospital charges for individuals with TSCI by insurance status from Healthcare Cost and Utilization Project (HCUP) data.[13] There was a mean of $85 423 for all TSCI discharges with 46.4% reimbursed by Medicare ($68 700), 7.9% reimbursed by Medicaid ($151 583), 31.1% reimbursed by private insurance ($95 013), and 8.2% uninsured ($79 369). Even with health insurance, deductibles and copayments can be a very high percentage of income for such expensive hospitalizations. Providers should be aware of the higher prevalence of diabetes among patients with SCI and pursue a policy of testing early and managing them more closely. Further studies are needed regarding special interventions for managing diabetes in the SCI population.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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