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ARTICLE

The association between secondary health conditions and indirect costs after spinal cord injury

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Abstract

Study design Cross-sectional.

Objective Identify the association between secondary health conditions (SHC) and the indirect costs of traumatic spinal cord injury (SCI) based on the pre-injury and post-injury changes in employment and earnings.

Setting Medical university in the southeastern United States (US).

Methods A population-based cohort of 304 participants met the following eligibility criteria: received treatment for acute SCI within the state, residual effects resulting from traumatic SCI, at least 1-year post injury, age between 23 and 64 years at the time of injury onset, and younger than 65 years at the time of study measurement. The indirect costs estimate was measured by the annual forgone earnings and fringe benefits calculated as the difference in the sum of earnings and benefits between before injury and after injury adjusting for inflation in 2019 US dollars. We considered seven SHC in this study: bowel accidents, urine accidents, urinary tract infections, pressure sores, unintentional injury, severe pain, and depressive disorder. We used multivariate ordinary least squares regression models to examine their relationship controlling for age, sex, race/ethnicity, marital status, years of education, injury level, and ambulatory status.

Results The indirect costs were significantly associated with the total number of SHC and with the individual conditions of bowel accidents, urine accidents, pressure sores, and depressive disorder after controlling for age, sex, race/ethnicity, marital status, years of education, injury level, and ambulatory status.

Conclusions Preventing SHC relates to better economic consequences for individuals, their families, and society, even after accounting for differences in severity of SCI.

Introduction

Spinal cord injury (SCI) not only results in direct costs of medical care expenses but also indirect costs including losses in wages, fringe benefits, and productivity [1–5]. The most recent estimate of SCI indirect costs was based on pre- and post-injury employment and earnings changes, which found the average annual indirect costs were $29,354 in 2019 United States (US) dollars [1]. The same study also indicates lifetime indirect costs for persons injured at age 25 vary by severity of injury, ranging from 0.5 to 2.3 million US dollars. Lifetime indirect costs for persons injured at age 50 range from 0.3 to 0.6 million US dollars. In the United Kingdom, a recent study shows the average total lifetime cost per SCI case is about 1.1 million pounds in 2016 (1 British pound was about 1.3 US dollars in mid-2016), and 29% of lifetime costs are due to reduced employment and career time [2]. Based on another study from Canada, the lifetime indirect costs of SCI range from 0.7 million to 1.3 million (2011 Canadian dollars) for persons injured at age 35, and indirect costs account for 41% of the 2.67 billion total economic burdens associated with SCI in Canada (1 Canadian dollar was about 1.03 US dollar in mid-2011) [6].

An individual with SCI will also experience lifelong increased risk of secondary health conditions (SHC), such as pressure ulcers and urinary tract infections, which are related to the SCI. The consequences of SHC include reduced participation in society, lower quality of life [7–9],

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higher mortality, and diminished life expectancy [10, 11]. Other studies have examined the impact of SHC on employment outcomes as well, such that the pressure ulcer was associated with lower odds of job retention [12]. Krause et al. [13] found severity of pain and pain medication usage had significant adverse effects on employment rate and employment quality.

However, these studies did not quantify the relationships between SHC, changes in employment after SCI, and the indirect costs related to lost employment and wages. The current study investigated the association between SHC and the indirect costs of SCI based on the most recent estimates. We explored the social perspectives of SHC and increase awareness about preventing them for people with SCI.

Methods

Participants

Participants were retrieved from South Carolina (SC) SCI Outcomes Database, which collects follow-up data from individuals in the SCI Surveillance System Registry. All participants in the database met the following criteria: received treatment for acute SCI within the state, self-reported residual effects resulting from traumatic SCI, and at least 1-year post injury. Data were collected using a self-report assessment (SRA). Participants were mailed an introductory letter to let them know the SRA would be forthcoming, followed by up to two subsequent mailings of SRA materials and a follow-up phone call. To estimate the indirect cost, we had the extra age inclusion criteria: age between 23 and 64 years at the time of injury onset, and younger than 65 years at the time of study measurement. We send the SRA to 1024 potential participants in the database, and 607 responded (59% response rate). Because there were 254 respondents who did not meet the age inclusion criteria and 46 respondents had missing data, we had 307 participants with indirect cost estimate. After approval from the Institutional Review Board, we linked indirect cost estimates for these participants with measures of SHC. After removing three unmatched cases, our final sample for analyses was 304 participants. Their median length of time since injury was 8 years, and the mean length was 9 years.

Measures

The annual indirect costs estimate for participants was retrieved from the previous study [1], where the annual forgone earnings and fringe benefits were calculated as the difference in the sum of earnings and benefits between before injury and after injury, adjusting for inflation in 2019 (March) dollars. This indirect cost estimate was a simple indicator to reflect both employment and earnings changes after SCI. Seven SHC were measured: bowel accidents, urine leaking or accidents, urinary tract infections, pressure sores, unintentional injury, severe pain, and depressive disorder. The first five variables were measured using an instrument developed for the SCI Longitudinal Health Study [14, 15]. Bowel accidents, urine accidents, and urinary tract infections were measured by asking "During the past 12 months, about how many times did you have the following problems?" Pressure sores was assessed by "all totaled, how many different open pressure sores have you had in the past year?" Unintentional injury was based on the question, "in the past year, how many different times have you been injured seriously enough to receive medical care in a clinic, emergency room, or hospital?" All these conditions were dichotomized into "yes vs. no" in the analyses. Participants rated their pain by circling the one number (0–10) that best describes their pain on average (0 = no pain, 10 = pain as bad as you can imagine) [16]. Severe pain was defined by a rating higher than 5. Depressive disorder was measured by "has a doctor or other health care provider EVER told you that you have a depressive disorder (including depression, major depression, dysthymia, or minor depression)?" [17]. Other covariates included age at time of measurement, sex (male vs. female), race/ethnicity (non-Hispanic White vs. others), marital status (married vs. others), years of education, neurologic level of injury (cervical level, thoracic level, and all other levels including both lumbar and sacral levels), and ambulatory status (ambulatory vs. non ambulatory).

Analyses

All analyses were conducted using SAS version 9.4. We ran the bivariate comparison of indirect costs between participants with and without the SHC, and *t* test was used to assess the difference between the two groups. We developed seven multivariate ordinary least squares (OLS) regression models for each of the SHC to identify the average difference of indirect costs between the two groups after controlling for age, sex, race/ethnicity, marital status, years of education, injury level, and ambulatory status. We then calculated the total number of SHC for each participant and entered it in the OLS regression models as the variable of interest. In our OLS models, age, total number of SHC, and years of education were used as continuous variables, and all the other variables were categorical.

Results

The average annual indirect costs among the 304 participants were $29,293 (std = $42,458) in 2019 US dollars. The bivariate comparison showed bowel accidents, urine accidents, urinary tract infections, and pressure sores were

Table 1 Comparison of average annual indirect costs for participants with and without secondary health conditions (SHC).

Occurrence of SHC		Average annual indirect costs Mean (SD)	*p* value
Bowel accidents	No	22,963 (42,845)	<0.01
	Yes	38,608 (40,272)	
Urine accidents	No	24,237 (42,822)	0.03
	Yes	35,138 (41,419)	
Urinary tract infections	No	24,953 (39,741)	<0.01
	Yes	38,417 (46,574)	
Pressure sores	No	24,724 (41,619)	<0.01
	Yes	45,457 (41,739)	
Unintentional injury	No	30,501 (43,484)	0.37
	Yes	25,329 (38,928)	
Severe pain	No	26,479 (41,410)	0.2
	Yes	32,724 (43,608)	
Depressive disorder	No	26,726 (40,819)	0.06
	Yes	37,565 (46,703)	

Table 2 Unstandardized coefficient of individual secondary health conditions (SHC) on indirect costs.

SHC	Unstandardized coefficient of annual indirect costs[a]	*p* value
Bowel accidents	13,965	<0.01
Urine accidents	10,806	0.04
Urinary tract infections	11,856	0.07
Pressure sores	20,666	<0.01
Unintentional injury	779	0.90
Severe pain	5301	0.31
Depressive disorder	13,356	0.03

[a]Generated from multiple regression models controlling for age, sex, race/ethnicity, education, marital status, injury level, and ambulatory status.

associated with higher indirect costs (Table 1). After controlling for age, sex, race/ethnicity, marital status, years of education, injury level, and ambulatory status, bowel accidents were associated with $13,956 more indirect costs on average, urine accidents associated with $10,806 more indirect costs, pressure sores associated with $20,666 more indirect costs, and depressive disorder associated with $13,356 more indirect costs (Table 2). All these associations were statistically significant ($p < 0.05$). We put the detailed information for each of these seven regression models in the Supplementary Appendix 1.

The frequency of SHC indicated 78% of participants had at least one SHC, and 63% of participants had two SHC or more (Table 3). In the multivariate regression model (Table 4), the number of SHC was positively associated

Table 3 The frequency of secondary health conditions (SHC).

Number of SHC	*n*	%	Cumulative %
0	67	22.04	22.04
1	46	15.13	37.17
2	58	19.08	56.25
3	44	14.47	70.72
4	45	14.8	85.52
5	30	9.87	95.39
6	13	4.28	99.67
7	1	0.33	100
Total	304	100	100

Table 4 Multiple regression model for annual indirect costs.

	Unstandardized coefficient	Standardized coefficient	*p* value
Intercept	2620	0.00	0.90
Age	681	0.17	<0.01
Female (vs. male)	−9944	−0.10	0.12
Non-Hispanic White (vs. others)	4507	0.05	0.40
Married (vs. others)	−4189	−0.05	0.43
Years of education	−448	−0.02	0.70
Cervical level (vs. other levels[a])	−10,231	−0.12	0.19
Thoracic level (vs. other levels[a])	1627	0.02	0.85
Ambulatory (vs. non ambulatory)	−8234	−0.10	0.12
Number of SHC	5074	0.22	<0.01

[a]Other injury levels include lumbar and sacral levels.

with annual indirect costs after controlling for age, sex, race/ethnicity, marital status, years of education, injury level, and ambulatory status. Having one more SHC was associated with $5074 indirect costs on average. Older age was also associated with higher indirect costs. The standardized coefficients in Table 4 compared the effect strength of the independent variables on the dependent variable. The number of SHC had the highest standardized coefficient (0.22) in the model, which indicated a strong association with indirect costs.

Discussion

The unique contribution of this study is the quantification of the relationship of SHC with indirect costs due to employment and earnings changes after SCI, controlling for demographic status and SCI severity. We found several SHC were significantly related to higher indirect costs

including bowel accidents, urine accidents, pressure sores, and depressive disorder. These findings indicate indirect costs will vary with SHC as a primary indicator of health.

Considering an earlier study found a relationship between severe pain and employment outcomes [13], it was a surprise not to find a significant association between severe pain and indirect costs in the current study. One possible reason is that our indirect costs considered pre-injury employment outcomes. The average adjusted unconditional earnings in 2019 US dollars for those without severe pain decreased from $58,683 pre injury to $32,204 post injury and decreased from $45,687 to $12,963 for those who experienced severe pain. If only investigating post-injury earnings, the gap was close to $20,000 between the two groups. However, the gap narrowed to $6245 after controlling for pre-injury earnings. This might imply that people with better employment status pre-injury (possibly higher socioeconomic status) could have received better health care to treat pain and had better employment outcomes post injury.

Some SHC, such as pressure ulcers, are prevalent and related to substantial direct medical costs among people with SCI. The annual incidence of pressure ulcers in the SCI population ranges between 23 and 33% [18], and 25% of the total lifetime health care expenses for a person with SCI is related to pressure ulcers [19]. The current findings also suggest each one of the SHC is associated with substantial indirect costs ($5074 on average). This is a valuable reminder for people with SCI, their family, health care professionals, and policy makers about the importance of preventing and treating SHC.

Implications

There are several important implications of the study findings. First, it is noteworthy that age was correlated with indirect costs. Older individuals have a much more difficult road to returning to employment after SCI but not necessarily lower earnings when employed. However, they do still have greater indirect costs [20]. Second, many people with SCI live in poverty, and the risk of poverty is greater among non-Hispanic Blacks [21]. Therefore, high levels of indirect costs due to lost earnings is of significant concern. Although there is a strong tendency to talk about financial disincentives, perspective research identified problems with pressure ulcers as being a primary predictor of future employment [22]. Health factors, therefore, serve as prominent barriers to employment and add to the likelihood of indirect costs and poverty. Lastly, we must develop policies and practices that support employment after SCI and other severe disabling conditions. Vocational rehabilitation services target return to employment; whereas indirect costs occur over the lifetime for the person with SCI and are affected by quality of employment. Studies of earnings clearly indicate the importance of furthering education to improve quality employment [20]. The current findings add to that body of work and suggest the importance of policy development that considers the interrelationships between health, disability, and employment.

Methodological considerations

There were several important methodologic considerations. First, the data used from this study are from a state population-based registry and, therefore, do not have the limitations associated with identifying participants from clinical institutions for which admission criteria may be selective. Clinical settings also are more likely to underrepresent racial/ethnic minorities and over represent those who are ambulatory. Previous research has indicated that those identified through surveillance systems may have a greater risk of at least one type of SHC—unintentional injuries [23]. Therefore, use of population-based data has a distinct advantage for capturing individuals who may otherwise fall through the cracks of a specialty care system.

There were important limitations. First, the sample was relatively small ($n = 304$). This limited the statistical power to consider more variables in the multivariate analyses. In particular, we would have liked to add chronic conditions into the OLS models. Second, all data were self-report. This may have led to recall bias both with SHC and with indicators of indirect costs. Third, the data were cross-sectional and cannot provide a causal link from SHC to the indirect costs. It is possible that the economic hardship after SCI might result in poor health care, which leads to the occurrence of SHC. Ultimately, our goal is to measure indirect costs over a longer period and to be prospectively studied. Fourth, the costs of SCI are country specific; our estimations are specific to the US and may not be generalizable to other countries. It is important to identify data sources that can be used to compare outcomes across countries. Fifth, the indirect cost value was calculated based on earnings, which were not normally distributed. We transferred the indirect cost to normal distribution by using the square root function and then verified all the statistical tests with the transferred value. All the tests had similar results with minor changes and did not have impacts on our conclusion. In our paper, we still used the dollar value of indirect cost because it was easier for readers to interpret the results.

Future research

Further research is needed to help us understand better the relationships between multiple additional factors and indirect costs of SCI with the consideration of broader household perspectives, such as losses of family member productivity

due to the caregiver role. There is also a need to apply similar models to other populations with neurologic disorders, such as traumatic brain injury. Lastly, international research is needed that identifies indirect costs of SCI due to lost earnings and benefits that may be applied more globally.

Conclusion

The results suggest the total number of SHC, and the individual SHC such as bowel accidents, urine accidents, pressure sores, and depressive disorder are associated with higher indirect costs. The prevention and precaution for SHC may not only improve the quality of life and health status of people with SCI but also relate to better economic consequences for individuals, their families, and society.

Data availability

The data sets generated and/or analyzed during the current study are not publicly available due to the privacy concerns of study participants and are not standardized to be in a publicly interpretable format.

Author contributions YC was the principal investigator and was responsible for the introduction, analyses, and research methods sections, as well as contributing to the results, discussion, and conclusion. JK was responsible for the discussion and contributed to the overall development and editing of the paper.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

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