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Environmental Barriers and Social Participation in Individuals With Spinal Cord Injury

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Abstract

Objective—The study aimed to examine the relationship between environmental barriers and social participation among individuals with spinal cord injury (SCI).

Method—Individuals admitted to regional centers of the Model Spinal Cord Injury System in the United States due to traumatic SCI were interviewed and included in the National Spinal Cord Injury Database. This cross-sectional study applied a secondary analysis with a mixed effect model on the data from 3,162 individuals who received interviews from 2000 through 2005. Five dimensions of environmental barriers were estimated using the short form of the Craig Hospital Inventory of Environmental Factors—Short Form (CHIEF-SF). Social participation was measured with the short form of the Craig Handicap Assessment and Reporting Technique—Short Form (CHART-SF) and their employment status.

Results—Subscales of environmental barriers were negatively associated with the social participation measures. Each 1 point increase in CHIEF-SF total score (indicated greater environmental barriers) was associated with a 0.82 point reduction in CHART-SF total score (95% CI: −1.07, −0.57) (decreased social participation) and 4% reduction in the odds of being employed. Among the 5 CHIEF-SF dimensions, assistance barriers exhibited the strongest

negative association with CHART-SF social participation score when compared to other dimensions, while work/school dimension demonstrated the weakest association with CHART-SF.

Conclusions—Environmental barriers are negatively associated with social participation in the SCI population. Working toward eliminating environmental barriers, especially assistance/service barriers, may help enhance social participation for people with SCI.

Keywords

participation; integration; environmental barrier; spinal cord injury

Introduction

Spinal cord injury (SCI) usually occurs in young adults and in most cases leads to long-term disability (DeVivo, Go, & Jackson, 2002; National Spinal Cord Injury Statistical Center, 2005). Approximately 40 cases of SCI per one million persons per year occur in the United States, and only 1% of patients with SCI discharged from the hospital will have no residual neurological impairment (DeVivo et al., 2002; National Spinal Cord Injury Statistical Center, 2005). Encountering environmental barriers (e.g., in policies, physical structures, assistances, attitudes and discrimination) and inadequate social participation (e.g., difficulty in participating at home, work, or school, or reestablishing relationships and friendships) have been reported in the SCI population (Charlifue & Gerhart, 2004; Hammel et al., 2015; Whiteneck, Meade, et al., 2004). Environmental factors and participation are two of the central concepts used by the World Health Organization (WHO) to define disablement (Whiteneck & Dijkers, 2009; WHO, 2001). The WHO model of disability holds that environmental factors can either facilitate or hinder social participation (WHO, 2001). Although qualitative analysis has described a link between environmental barriers and participation in people with spinal cord injury (Hammel et al., 2015), demonstrating this interaction with statistical analysis has remained inconclusive (Charlifue & Gerhart, 2004; Dijkers, Yavuzer, Ergin, Weitzenkamp, & Whiteneck, 2002; Hammel et al., 2015; Lysack, Komanecy, Kabel, Cross, & Neufeld, 2007; Reinhardt, Ballert, Brinkhof, & Post, 2016; Whiteneck, Meade, et al., 2004).

Craig Hospital Inventory of Environmental Factors—Short Form (CHIEF-SF) and Craig Handicap Assessment and Reporting Technique—Short Form (CHART-SF) are two commonly used measurement instruments for studies in SCI (Noreau & Boschen, 2010; Whiteneck & Dijkers, 2009). Using these two instruments, Sekaran et al. (2010) observed lower social participation and higher environmental barriers for individuals from rural India compared to the results found in surveys of other Western countries (Kennedy, Lude, & Taylor, 2006; Sekaran et al., 2010). Comparing individuals with SCI from the National Spinal Cord Injury Database (NSCID) in the United States with individuals with SCI in Turkey ($n = 66$), Dijkers et al. (2002) observed a crude association between greater perceived environmental barriers and lower participation. However, this finding of association did not hold up when a multivariate analysis was adjusted for age, sex, time since injury, motor ability, Functional Impairment Measurement (FIM), and participants' country (Dijkers et al., 2002). Similarly, Whiteneck, Meade, et al. (2004) observed no

statistical association between environment and participation in a similar analysis of a cohort of SCI participants in NSCID data from 2000 to 2002.

Conceptual and methodological issues concerning the measurement of environmental factors and participation in people with disability is still under debate (Noreau & Boschen, 2010; Whiteneck & Dijkers, 2009). Recently, researchers employed various measurement instruments (i.e., Community Integration Measure (CIM), Nottwil Environmental Factors Inventory Short Form (NEFI-SF) and Spinal Cord Injury Measure Self Report (SCIM-SR) and demonstrated a modest association between environmental barrier and participation with controlling of personal-level factors, such as sociodemographic variables or injury characteristics (Lysack et al., 2007; Reinhardt et al., 2016). However, Reinhardt et al. directly accessed the International Classification of Functioning, Disability, and Health (ICF) component using a Case Record Form and revealed that the barrier is not exactly linked to lower level of participation and that facilitator is not exactly linked to higher level of participation (Reinhardt et al., 2011).

The purpose of our study was to reexamine the NSCID data (from 2000 to 2005), which includes CHIEF-SF and CHART-SF for measurement. CHIEF-SF and CHART-SF were developed based on ICF taxonomy. They have the advantage of comprehensiveness and have been used extensively in the world in a variety of disability groups. We propose that including more years of data with a greater sample size and employing different modeling techniques to address possible cluster effects may reveal the association between environmental barriers and participation. Because work is a domain of participation in ICF taxonomy (e.g., mobility, occupational function, and interpersonal skills), we also evaluated the association between barriers and employment status (Lidal, Huynh, & Biering-Sørensen, 2007; Ville, 2005). Furthermore, this study tried to identify the principal environmental barrier to social participation in the SCI population.

Method

Participants

Regional centers of the Model Spinal Cord Injury System (MS-CIS) in the United States contribute to the NSCID, a longitudinal database established in 1970 to follow individuals with traumatic SCI admitted to one of the regional centers (DeVivo et al., 2002; National Spinal Cord Injury Statistical Center, 2005). The data were collected both at the time of initial acute and rehabilitation hospitalizations and at follow-up (interviews by phone or mail, or in person) in the second year and every five years postinjury. By 2006, the NSCID collected data from 24,762 participants. A total of 22,070 participants received a follow-up interview. All data contained in the NSCID and all data used in this study were de-identified. The data were supplied under the approval of the Institutional Review Board of the University of Louisville.

We retrieved the data from the follow-up interviews performed during 2000–2005, the years in which CHART-SF and CHIEF-SF were both employed by the NSCID. We included the participants, aged between 18 and 90 years, who had residual neurological SCI impairment, had completed the CHIEF-SF and CHART-SF forms, and had all covariate data for the

analyses. For the participants who had more than one follow-up interview, the latest available data during 2000–2005 were used. This study utilized data from 3,162 participants, and a flowchart of the selection process from the NSCID subjects is shown in Figure 1. The composition of our participants based on gender and injury type is similar to the composition of the excluded individuals and the whole database. Some variables, such as CHART-SF, CHIEF-SF, and some covariates needed for the analysis were only collected by NSCID for a specific time period. Therefore, patients injured prior to collection who did not have a follow-up conducted during the collection period and patients who were injured after the data collection ceased were excluded.

Measures

The CHIEF-SF measures perceived environmental barriers and consists of 12 items from the following five dimensions: policies, physical/structural, work/school, attitudes/support and assistance/ services (Whiteneck, Harrison-Felix, et al., 2004). Each CHIEF-SF item measures two domains pertaining to the frequency of a problem caused by the environment (scored from *never* = 0 to *daily* = 4) and the magnitude of the effect of this problem (scored from *minimal* = 1 to *major* = 2), with a range in score (the product of the frequency and magnitude of the problem scores) from 0 to 8, with a higher score indicating a greater perceived barrier (Whiteneck, Harrison-Felix, et al., 2004). Each dimension was examined in our analysis. To facilitate interdimension comparison, we calculated the average item score for each dimension (subscore of the dimension divided by the number of items in the dimension, ranging from 0 to 8), because each dimension consists of a different number of items. The work/school dimension was excluded when forming the total score because the CHIEF-SF work/school related questions could only be answered by people who were working or in school (G. G. Whiteneck, Harrison-Felix, et al., 2004). The sum of the item scores from all the dimensions (excluding work/school) formed the total CHIEF-SF score (CHIEF-t), with a maximum score of 80 indicating the greatest level of environmental barriers.

Social participation was measured using the CHART-SF and employment status. The CHART-SF is a six-dimensional scale that has been well validated as a measure of community participation (e.g., the number of days spent outside the home, the number of friends or business associates contacted at least once a month) by individuals with disabilities and has an estimated test–retest reliability coefficient ranging from 0.80 to 0.95 for each dimension (Hall, Dijkers, Whiteneck, Brooks, & Krause, 1998; Whiteneck, Charlifue, Gerhart, Overholser, & Richardson, 1992; Whiteneck, Meade, et al., 2004). Each subscale (subscore) has a maximum score of 100, with lower scores indicating a lower degree of participation. The entire CHART-SF has been applied by the NSCID to participants aged 18 years and older since 2000. In 2006, the NSCID excluded the cognitive independence and economic self-sufficiency subscales from the CHART-SF, and we selected only the remaining subscales (physical independence, mobility, occupation, and social integration), with a total of 16 items included. The total score of each subscale is 100. Therefore, we only applied analysis on the remaining four subscales. We added the subscores to give the total CHART-SF score (CHART-t) (Whiteneck et al., 1992).

Employment status of the participants was categorized as employed, in training (job training or in school), or unemployed.

The participant's current age, sex, age at injury, years since injury (the duration of postinjury to the interview date), level of education post injury, severity of neurological injury, secondary conditions, and neurological/physical/functional impairment were considered as covariates in the present analyses because these factors were demonstrated to be associated with participation and perceived environmental barriers in previous studies (Benavente et al., 2003; Charlifue & Gerhart, 2004; Conroy & McKenna, 1999; Franceschini, Di Clemente, Rampello, Nora, & Spizzichino, 2003; Hall et al., 1998; Jensen, Hoffman, & Cardenas, 2005; Kennedy et al., 2006; Lidal et al., 2007; Noreau, Dion, Vachon, Gervais, & Laramee, 1999; Sekaran et al., 2010; Whiteneck, Harrison-Felix, et al., 2004; Whiteneck, Meade, et al., 2004). People with pain and less independent bladder control were related to lower level of participation (Hicken, Putzke, & Richards, 2001; Jensen et al., 2005), so bladder measurement and pain were also included as covariates. We estimated the neurological severity using the motor neurological level of injury (MNLI) and the American Spinal Cord Injury Association Impairment Scale (AIS), and the physical/ functional impairment using the summary score of manual muscle testing for upper and lower limbs and the FIM score. We made the assumption that there would be regional differences in weather, geography, and infrastructure associated with different regional SCI centers. Therefore, we analyzed the individual MSCIS regional centers as spatial variables.

This was a cross-sectional, secondary analysis on NSCID (Lysack et al., 2007; Whiteneck, Meade, et al., 2004), therefore a univariate negative binomial regression model was employed for purposes of examining the association of covariates with the CHIEF-t score. Two-level, univariate mixed effect linear regression analyses were used to evaluate the association between the covariates and the CHART-t score, because (a) the CHART-t score was symmetric and nearly normally distributed as shown by P-P plot, and (b) there was a possible correlation of the dependent variable within each regional center. For the multivariate analysis, a two-level, mixed effect model was also used to address possible correlation of the dependent variable within each regional center. We conducted a mixed effects logistic regression model to estimate the association between environmental barriers and employment status. The employment status was dichotomized as "employed" or "other" in the mixed model. Then, the mixed effects linear regression model was used to estimate the association among each dimension of CHIEF-SF and each subscales of CHART-SF. We included covariates into the multivariate model according to the current knowledge for the spinal cord injury, and employed a backward elimination process in which we retained any covariate having $p < .05$ in the likelihood ratio tests (Kleinbaum, Kupper, & Muller, 1988). The selected covariates are participants' age, years since injury, sex, current educational level, MNLI, AIS, bladder management, and level of pain. In this study, an alpha level of 0.05 was applied for all hypothesis testing, and 95% confidence intervals were reported.

Results

The demographic characteristics of the study population are shown in Table 1. Seventy-eight percent of participants were male. The average age of the sample was 38.9 years. The

average length of time since injury was 3.7 years. On the environmental barrier variables, the sample demonstrated higher scores in physical/ structure barrier (CHIEF-SF average item score 1.32), and lower scores in work/school barrier (CHIEF-SF average item score 0.32). Participants demonstrated higher levels in social integration and lower levels in occupation in the social participation dimensions. The bivariate analyses indicated that the population characteristics were all statistically associated with perceived environmental barriers. Age at the time of interview, age at injury, and years since injury were inversely correlated with CHIEF-t score. Being a woman was positively related to CHIEF-t score. Higher educational level and current employment were negatively related to the CHIEF-t score. Higher levels of injury, lower muscle strength in upper/lower extremities, higher pain levels, and applying no assistive devices for bladder management were positively related to CHIEF-t. The similar association between some vulnerable subgroups and having higher perceived level of barriers have also been noted in previous studies (Noreau & Boschen, 2010; Whiteneck & Dijkers, 2009; Whiteneck, Meade, et al., 2004).

As shown in Table 2, the CHIEF-t score was negatively associated with the CHART-t score. For each one point increase in CHIEF-t score there is an associated 1.41 point reduction in CHART-t (95% CI [-1.69, -1.14]). With the exception of a participant's gender, the other population characteristics were statistically associated with social participation. Age at the time of interview and the age at injury were inversely correlated with participation, whereas the time since the injury was positively correlated. Higher educational level positively correlated to the CHART-t score. Lower level of injury and higher muscle strength in upper/lower extremities were positively related to the CHART-t score. Higher pain levels and the use of assistive devices for bladder management were negatively related to the CHART-t score.

Table 3 shows the multivariate mixed effect model of social participation with environmental barriers. The CHIEF-t was inversely related to the CHART-t score. For each one point increase in CHIEF-t score there was 0.83 point reduction in CHART-t score (95% CI [-1.08, -0.58]). Among the CHIEF-SF dimensions, the assistance/services barrier had the strongest negative association with the CHART-t score as compared to other dimensions (β -coefficient: -8.18, 95% CI [-10.11, -6.24]). Work/school was the only CHIEF-SF dimension that was not significantly associated with the CHART-t score. The model on employment found that for each one point increase in CHIEF-t score, there was an associated 4% reduction in the likelihood of employment (95% CI [0.95, 0.98]). All CHIEF-SF dimensions, except the work/school barrier dimension, were negatively related with employment. Likewise, the assistance barrier dimension ($OR = 0.76$, 95% CI [0.68, 0.84]) had the strongest association with unemployment compared with the other dimensions.

Table 4 shows the multivariate mixed effect model of the CHART-SF subscales with the CHIEF-SF. For each one point increase in average item score of CHIEF-SF non-work-related dimension there was an associated reduction of CHART-SF subscores by 1.4 points in physical independence (95% CI [-2.4, -0.4]), 3.1 points in mobility (95% CI [-3.9, -2.4]), 2.2 points in occupation (95% CI [-3.4, -1.0]), and 1.6 points in social integration (95% CI [-2.4, -0.9]). In the analysis across the CHIEF-SF dimensions and CHART-SF subscales, the CHIEF-SF assistance/support is the only dimension that had a negative

association to all the CHART-SF subscales. The magnitude of association from high to low were as follows: mobility (β -coefficient: -2.83 , 95% CI $[-3.43, -2.23]$), occupation (β -coefficient: -2.4 , 95% CI $[-3.33, -1.47]$), social integration (β -coefficient: -1.75 , 95% CI $[-2.33, -1.16]$), and physical independence (β -coefficient -1.22 , 95% CI $[-2.03, -0.41]$). CHIEF-SF physical/structure was associated with two CHART-SF subscales (physical independence and mobility), and CHIEF-SF attitude/support was also associated with two CHART-SF subscales (mobility and social integration). The policies dimension was only associated with CHART-SF mobility, and CHIEF-SF work/school was only associated with CHART-SF social integration.

Discussion

Findings from this study suggest that in a population of persons with SCI, the level of perceived environmental barriers is inversely associated with social participation and employment.

Some of the previous studies did not analyze data at the individual level (Dijkers et al., 2002; Kennedy et al., 2006; Sekaran et al., 2010). However, the apparent association between the barrier in a locality (e.g., developing country or developed country) and the level of participation (e.g., lower or higher participation) might result from the composition of the characteristics for the individual participant. Analyses at the individual participant level with adjustment for personal factors are needed to study the association between environmental barrier and participation. Dijkers et al. (2002) and Whiteneck, Meade, et al. (2004) applied CHIEF-SF and CHART-SF as measurement and revealed a statistically insignificant association between environmental barrier and participation (Dijkers et al., 2002; Whiteneck, Meade, et al., 2004). Our study, applying the same instruments, yielded a statistically significant result that may have resulted only from the use of a larger sample and some differences in methodologies. Our CHIEF-SF and CHART-SF scores were continuous variables rather than dichotomized variables (Whiteneck, Meade, et al., 2004). We fit one variable that represents CHIEF-SF total score (CHIEF-t) in the model rather than fit all CHIEF-SF subscales separately in one model (Whiteneck, Meade, et al., 2004). Although each CHIEF-SF dimension was conceptually a distinct aspect of environmental condition (Whiteneck & Dijkers, 2009) and no obvious evidence of collinearity was identified in our preliminary analysis, we assumed that the level of “perceived” environmental barrier from different dimensions might be correlated in some way and could not be fit in one model. To reduce the information bias and selection bias, we also removed the CHIEF-SF work/school dimension from the total CHIEF-SF score, as had previous studies (Lysack et al., 2007; Whiteneck, Meade, et al., 2004). This was because the CHIEF-SF work/school related questions could only be answered by people who were working or in school, but the post-SCI return-to-work rate was low and resulted in a large amount of missing data (Lidal et al., 2007; Whiteneck, Harrison-Felix, et al., 2004; Whiteneck, Meade, et al., 2004).

The CHIEF-SF was used to estimate perceived environmental barriers by the individual, but an environmental barrier could be an objective condition in an area rather than subjective perception. An objective parameter to estimate the environmental barrier was not available in the NSCID database. Although using independent observers measuring the objective

environmental barriers, such as the accessibility of building, needs enormous work and time (Whiteneck & Dijkers, 2009), some objective conditions of a locality, such as economic indicators, (Botticello, Chen, & Tulsy, 2012; Lawton, 1982; Reinhardt et al., 2011) were found to relate to the level of participation. Botticello et al. (2012) studied area economic indicators extracted from census data in predicting employment after SCI and found that the employment rate was associated with area socioeconomic status and urbanicity. Reinhardt et al. (2011) also found that in countries with lower resources and unequal distribution, vulnerable groups (i.e., tetraplegics or the elderly) reported more problems in participation. The characteristics of a locality (i.e., weather, geology, industry type, infrastructure, attitudes toward disabilities, and socioeconomic condition) relate not only to one's perception of environmental barriers, but also interact with personal factors and affect one's response to participation and activity (Botticello et al., 2012; Lawton, 1982; Reinhardt et al., 2011). Therefore, we applied the mixed linear model that takes into consideration the correlated nature of the outcome variables within the same regional center. The results were statistically different from the results of the regular linear model that did not take into account the correlated nature of the data.

The average CHIEF-SF item score (1.32) in our study was very low, as in previous studies (Lysack et al., 2007; Whiteneck, Harrison-Felix, et al., 2004; Whiteneck, Meade, et al., 2004). Although our study showed significant association between environmental barriers and participation, the effect size was small. The modest association was also found while using various measurement instruments (CHIEF-SF, CIM, NEFI-SF, and SCIM-SR; Lysack et al., 2007; Reinhardt et al., 2016). In addition, we applied a univariate regression model on the CHART-t variable and found that the variance of CHART-SF measures explained by CHIEF-SF ($R^2 = 3.6$) was less than that explained by the participant characteristics, which was also similar in previous studies (Lysack et al., 2007; Whiteneck, Harrison-Felix, et al., 2004; Whiteneck, Meade, et al., 2004). Additionally the partial correlation analysis found that compared to other factors, the environmental barrier still has a lower correlation to the social participation when controlling for the correlation between factors. If the "barrier reduces participation" theory is true, the unsatisfied study results remind us of the methodologic weakness of using instruments. Although these instruments are developed according to the WHO model of disability, (Whiteneck et al., 1992; Whiteneck, Harrison-Felix, et al., 2004; WHO, 2001) the validity of measuring perceived environmental barriers or measuring self-report participation without considering personal preference is questioned (Whiteneck & Dijkers, 2009). Furthermore, according to the equation represented by $B = f(P, E, P \times E)$; i.e., behavior is a function of the person, the environment, and the interaction between the person and the environment (Lawton, 1982), we might ask whether CHIEF-SF is measuring the "actual environment" or some kind of "interaction between person and the environment." If the former is true, CHIEF-SF might be insensitive to differences in environmental barriers. If the latter is true, we might need a light tool (Lysack et al., 2007) for objectively measuring the environment. Barrier-participant paradox (Whiteneck & Dijkers, 2009) also affects the level of perceived environmental barriers. For example, in our study we found work/school barrier was positively related to the CHART-SF occupation subscale and employment. We suggested that people with higher participation in the occupation aspect might cause them to experience more barriers at work and school.

The conceptual and methodological issues concerning participation and environmental factors are still under debate (Noreau & Boschen, 2010; Whiteneck & Dijkers, 2009). Nevertheless, a perceived environmental barrier remains the extrinsic factor that might be modified for improved participation in the SCI population.

Implementations

Our analyses of the associations across the CHIEF-SF and CHART-SF subscales helped identify the types of barriers that should be prioritized in attempts to improve participation by the SCI population. Whiteneck, Meade, et al. (2004) showed associations between the assistance barrier and some CHART-SF dimensions by cross-dimension analysis, but some associations were not statistically significant. Based on our results from cross-dimension analysis, compared to other type of barriers, the assistance/service barrier has relatively stronger negative associations with all aspects of participation. Interventions focused on overcoming assistance barriers may help improve social participation. Removing assistance barriers covers a broad range of topics, including increasing the accessibility of transportation, practical and understandable information, health care services and medical care, and home caregiver services (Hammel et al., 2015). Therefore, a qualitative and quantitative analysis is needed to scrutinize the reason for having these barriers and how these barriers impact people's lives. Among five dimensions, people with SCI perceived the highest barrier to be physical/structure environmental factors (i.e., nature, environment, and aspects of people's surroundings). Increasing the accessibility of public accommodations by enforcing and reviewing current implementation and enforcement of legislation is very important. For example, it has been more than two decades since the Americans with Disabilities Act (ADA) was signed into law, and we may examine the ADA Standards for Accessible Design in all facilities.

Our study demonstrated a significant association between certain environmental barriers and employment status. Therefore, actions to remove the barrier preventing people with SCI from employment are still needed. One point worth mentioning is the apparent low barrier to work/school in this sample and lack of association between work/school barrier and social participation. This might only be true for the individuals who were working or attending school. Considering 70% of participants were neither working nor attending school, the level of perceived work/school barrier from the few people who were working or attending school cannot be applied to the whole SCI population.

Limitations

The limitations of the study included the possibility of information bias because of the strict selection criteria, the use of a self-report questionnaire, and discarding the contribution of the CHIEF-SF work/school dimension from the CHIEF-SF total score. Generalizability was limited to people who were admitted to a MSCIS regional center. No causality could be made because no temporal relationship existed between the exposure to an environment and participation. The measurement instrument for environmental barrier is subjective, and both CHIEF-SF and CHART-SF are self-reported.

Conclusion

Environmental barriers are negatively associated with social participation in the SCI population. Assistance barriers are the principal obstacles to social participation in the SCI population and should be the focus of efforts to improve participation. Physical/ structure barrier is still the highest perceived barrier among people with SCI. A close examination of current policy and regulation is needed, especially in identifying the weakness in addressing assistance and physical barrier.

Future studies might aim to develop a light and valid tool to objectively estimate local environmental barriers, possibly using Geographic Information Systems for analyzing and presenting the geographical data.

References

- Benavente A, Palazón R, Tamayo R, Morán E, Alaejos J, Alcaraz A. Assessment of disability in spinal cord injury. *Disability and Rehabilitation*. 2003; 25:1065–1070. <http://dx.doi.org/10.1080/0963828031000137775>. [PubMed: 12944161]
- Botticello AL, Chen Y, Tulsy DS. Geographic variation in participation for physically disabled adults: The contribution of area economic factors to employment after spinal cord injury. *Social Science & Medicine*. 2012; 75:1505–1513. <http://dx.doi.org/10.1016/j.socscimed.2012.06.010>. [PubMed: 22818491]
- Charlifue S, Gerhart K. Community integration in spinal cord injury of long duration. *NeuroRehabilitation*. 2004; 19:91–101. [PubMed: 15201468]
- Conroy L, McKenna K. Vocational outcome following spinal cord injury. *Spinal Cord*. 1999; 37:624–633. <http://dx.doi.org/10.1038/sj.sc.3100904>. [PubMed: 10490853]
- DeVivo MJ, Go BK, Jackson AB. Overview of the national spinal cord injury statistical center database. *The Journal of Spinal Cord Medicine*. 2002; 25:335–338. <http://dx.doi.org/10.1080/10790268.2002.11753637>. [PubMed: 12482178]
- Dijkers MP, Yavuzer G, Ergin S, Weitzenkamp D, Whiteneck GG. A tale of two countries: Environmental impacts on social participation after spinal cord injury. *Spinal Cord*. 2002; 40:351–362. <http://dx.doi.org/10.1038/sj.sc.3101310>. [PubMed: 12080463]
- Franceschini M, Di Clemente B, Rampello A, Nora M, Spizzichino L. Longitudinal outcome 6 years after spinal cord injury. *Spinal Cord*. 2003; 41:280–285. <http://dx.doi.org/10.1038/sj.sc.3101457>. [PubMed: 12714990]
- Hall KM, Dijkers M, Whiteneck G, Brooks CA, Krause JS. The Craig Handicap Assessment and Reporting Technique (CHART): Metric properties and scoring. *Topics in Spinal Cord Injury Rehabilitation*. 1998; 4:16–30. <http://dx.doi.org/10.1310/V5RU-FRFE-50E6-E2NA>.
- Hammel J, Magasi S, Heinemann A, Gray DB, Stark S, Kisala P, Hahn EA. Environmental barriers and supports to everyday participation: A qualitative insider perspective from people with disabilities. *Archives of Physical Medicine and Rehabilitation*. 2015; 96:578–588. <http://dx.doi.org/10.1016/j.apmr.2014.12.008>. [PubMed: 25813890]
- Hicken BL, Putzke JD, Richards JS. Bladder management and quality of life after spinal cord injury. *American Journal of Physical Medicine & Rehabilitation/Association of Academic Physiatrists*. 2001; 80:916–922.
- Jensen MP, Hoffman AJ, Cardenas DD. Chronic pain in individuals with spinal cord injury: A survey and longitudinal study. *Spinal Cord*. 2005; 43:704–712. <http://dx.doi.org/10.1038/sj.sc.3101777>. [PubMed: 15968299]
- Kennedy P, Lude P, Taylor N. Quality of life, social participation, appraisals and coping post spinal cord injury: A review of four community samples. *Spinal Cord*. 2006; 44:95–105. <http://dx.doi.org/10.1038/sj.sc.3101787>. [PubMed: 16130026]

- Kleinbaum, D., Kupper, L., Muller, K. Applied regression analysis and other multivariable methods. 2. Belmont, CA: Duxbury Press; 1988.
- Lawton, M. Competence, environmental press, and the adaptation of older people. In: Byerts, T., Lawton, M., Windley, P., editors. Ageing and environment: Theoretical approaches. New York, NY: Springer; 1982. p. 33-59.
- Lidal IB, Huynh TK, Biering-Sørensen F. Return to work following spinal cord injury: A review. *Disability and Rehabilitation*. 2007; 29:1341–1375. <http://dx.doi.org/10.1080/09638280701320839>. [PubMed: 17729082]
- Lysack C, Komanecky M, Kabel A, Cross K, Neufeld S. Environmental factors and their role in community integration after spinal cord injury. *Canadian Journal of Occupational Therapy. Revue Canadienne d'ergothérapie*. 2007; 74(Suppl):243–254. <http://dx.doi.org/10.1177/000841740707405S03>.
- National Spinal Cord Injury Statistical Center. Spinal cord injury facts and figures at a glance. *The Journal of Spinal Cord Medicine*. 2005; 28:379–380. [PubMed: 16396388]
- Noreau L, Boschen K. Intersection of participation and environmental factors: A complex interactive process. *Archives of Physical Medicine and Rehabilitation*. 2010; 91:S44–S53. <http://dx.doi.org/10.1016/j.apmr.2009.10.037>. [PubMed: 20801279]
- Noreau L, Dion SA, Vachon J, Gervais M, Laramée MT. Productivity outcomes of individuals with spinal cord injury. *Spinal Cord*. 1999; 37:730–736. <http://dx.doi.org/10.1038/sj.sc.3100918>. [PubMed: 10557130]
- Reinhardt JD, Ballert C, Brinkhof MW, Post MW. Perceived impact of environmental barriers on participation among people living with spinal cord injury in Switzerland. *Journal of Rehabilitation Medicine*. 2016; 48:210–218. <http://dx.doi.org/10.2340/16501977-2048>. [PubMed: 26926923]
- Reinhardt JD, Mansmann U, Fellinghauer BAG, Strobl R, Grill E, von Elm E, Stucki G. Functioning and disability in people living with spinal cord injury in high- and low-resourced countries: A comparative analysis of 14 countries. *International Journal of Public Health*. 2011; 56:341–352. <http://dx.doi.org/10.1007/s00038-010-0222-8>. [PubMed: 21165668]
- Sekaran P, Vijayakumari F, Hariharan R, Zachariah K, Joseph SE, Kumar RK. Community reintegration of spinal cord-injured patients in rural south India. *Spinal Cord*. 2010; 48:628–632. <http://dx.doi.org/10.1038/sc.2010.6>. [PubMed: 20142832]
- Ville I. Biographical work and returning to employment following a spinal cord injury. *Sociology of Health & Illness*. 2005; 27:324–350. <http://dx.doi.org/10.1111/j.1467-9566.2005.00445.x>. [PubMed: 15953211]
- Whiteneck GG, Charlifue SW, Gerhart KA, Overholser JD, Richardson GN. Quantifying handicap: A new measure of long-term rehabilitation outcomes. *Archives of Physical Medicine and Rehabilitation*. 1992; 73:519–526. Retrieved from [http://www.archives-pmr.org/article/0003-9993\(92\)90185-Y/fulltext](http://www.archives-pmr.org/article/0003-9993(92)90185-Y/fulltext). [PubMed: 1622299]
- Whiteneck G, Dijkers MP. Difficult to measure constructs: Conceptual and methodological issues concerning participation and environmental factors. *Archives of Physical Medicine and Rehabilitation*. 2009; 90:S22–S35. <http://dx.doi.org/10.1016/j.apmr.2009.06.009>. [PubMed: 19892071]
- Whiteneck GG, Harrison-Felix CL, Mellick DC, Brooks CA, Charlifue SB, Gerhart KA. Quantifying environmental factors: A measure of physical, attitudinal, service, productivity, and policy barriers. *Archives of Physical Medicine and Rehabilitation*. 2004; 85:1324–1335. <http://dx.doi.org/10.1016/j.apmr.2003.09.027>. [PubMed: 15295760]
- Whiteneck G, Meade MA, Dijkers M, Tate DG, Bushnik T, Forchheimer MB. Environmental factors and their role in participation and life satisfaction after spinal cord injury. *Archives of Physical Medicine and Rehabilitation*. 2004; 85:1793–1803. <http://dx.doi.org/10.1016/j.apmr.2004.04.024>. [PubMed: 15520974]
- WHO. International classification of functioning, disability and health. Geneva, Switzerland: WHO Press; 2001.

Impact and Implications

A statistical association between environmental barriers and social participation has not been consistently observed in previous investigations in spinal cord injury (SCI) using CHIEF-SF and CHART-SF for the measurements (Hammel et al., 2015; Whiteneck, Meade, et al., 2004). This study extends previous research and demonstrates the negative association between perceived environmental barriers and social participations in people with SCI by analyzing a large database. Recognition of the role environmental barriers play in hindering social participation may help researchers identify key issues for which interventions are needed to increase social participation for people living with SCI. Our preliminary cross-dimension analysis among environmental factors and participation found that, compared to other dimensions of barriers, assistance/services barriers have the strongest association with reducing participation. Working toward eliminating environmental barriers, especially assistance/service barriers, may help enhance the social participation of people with SCI. A close examination of current policy and regulation is needed, especially in identifying what is missing in addressing assistance barriers.

Figure 1.

Flowchart of selection process from the National Spinal Cord Injury Database. From 22,070 participants that received follow-up interviews, 6,917 had available CHIEF-SF and CHART-SF information for the years from 2000 to 2005. From these, we selected 3,162 participants who had complete information on covariates for multivariate analysis.

Table 1

The Characteristics of the Participants and the Associations of the Participants' Characteristics With CHIEF-T (n = 3,162)

Variable	Study population	CHIEF-t	
		Coef.	95% CI
Age at injury, <i>M</i> (<i>SD</i>)	35.2 (14.6)	-.002	[-.005, -.001]
Current Age, <i>M</i> (<i>SD</i>)	38.9 (14.6)	-.003	[-.005, -.0003]
Years since injury, <i>M</i> (<i>SD</i>)	3.69 (3.12)	-.019	[-.033, -.005]
Sex, men, <i>N</i> (%)	2,454 (77.61)	.213	[-.105, .322]
Current educational level, <i>N</i> (%)			
<high school ^a	489 (15.46)		
= high school	1,738 (54.97)	-.091	[-.221, .039]
>high school	935 (29.57)	-.149	[-.291, -.007]
Current employment status, <i>N</i> (%)			
Unemployed ^a	2,207 (69.8)		
In training status	320 (10.12)	-.343	[-.495, -.192]
Employed	635 (20.08)	-.562	[-.677, -.448]
MNLI, <i>N</i> (%)			
High tetraplegic (C1-C4) ^a	695 (22.18)		
Low tetraplegic (C5-C8)	1,049 (33.48)	-.073	[-.197, .052]
Paraplegic	1,389 (44.33)	-.042	[-.160, -.076]
AIS classification, <i>N</i> (%)			
C, D or E (vs. A or B)	1,165 (36.89)	-.284	[-.379, -.191]
Upper limbs' sMMTs, <i>N</i> (%)			
<20	638 (20.18)		
20 & <50	1,156 (36.56)	-.262	[-.387, -.136]
50	1,368 (43.26)	-.148	[-.270, -.026]
Lower limbs' sMMTs, 20, <i>N</i> (%)	898 (28.40)	-.240	[-.341, -.139]
Bladder management, <i>N</i> (%)			
No assistive devices ^a	918 (29.03)		
ICP w/o EUC or CI	1,206 (38.14)	-.217	[-.105, -.329]
EUC w/o CI	330 (10.44)	-.235	[-.072, -.399]
CI and others	708 (22.39)	-.378	[-.251, -.505]
Level of pain, 5, <i>N</i> (%)	1,168 (36.94)	-.541	[-.450, -.633]
Total FIM (n = 2,912), <i>M</i> (<i>SD</i>)	65.34 (24.83)	-.008	[-.010, -.006]
CHART-SF			
CHART-t, <i>M</i> (<i>SD</i>)	296.48 (87.96)		
Physical, <i>M</i> (<i>SD</i>)	74.15 (35.38)		
Mobility, <i>M</i> (<i>SD</i>)	77.16 (25.2)		
Occupational, <i>M</i> (<i>SD</i>)	57.41 (38.13)		
Social integration, <i>M</i> (<i>SD</i>)	87.75 (22.4)		

Variable	Study population	CHIEF-t	
		Coef.	95% CI
CHIEF-SF average item score			
Non-work/school related dimensions, $M(SD)$	.89 (1.07)		
Physical/structure, $M(SD)$	1.32(1.71)		
Assistance/services, $M(SD)$	.90 (1.33)		
Work /school (n = 981), $M(SD)$	.32 (.86)		
Attitude/support, $M(SD)$	.61 (1.26)		
Policies, $M(SD)$	.71 (1.51)		

Note. The association between CHART-SF and CHIEF-SF is listed in Table 2. CHIEF = Craig Hospital Inventory of Environmental Factors—Short Form; CHART = Craig Handicap Assessment and Report Technique—Short Form; CHIEF-t = CHIEF-SF total score without the contribution of work/school dimension; CHART-t = CHART-SF total score from dimensions of physical independence, mobility, occupation, and social integration. Employed: working in a competitive job; in training status: on-the-job training or student; unemployed: unemployed, homemaker, retired, or at a sheltered workshop. Coef. = regression coefficient; MNLI = motor neurological level of injury; AIS = American Spinal Cord Injury Association Impairment Scale; sMMTs = sum of manual muscle test scores; ICP = intermittent catheterization program; EUC = external urine collector; CI = catheter indwelling; w/o = without.

^aReference group.

Table 2

Univariate Mixed Linear Regression for the Factors Associated With CHART-T (n = 3,162)

Variable	CHART-t	
	Coef.	95% CI
Age at injury	-1.27	[-1.47, -1.07]
Current age ^b	-1.18	[-1.38, -.98]
Years since injury ^b	2.36	[1.29, 3.33]
Sex, women, (vs. men) ^{ab}	-.29	[-7.42, 6.85]
Current educational level ^b		
<high school ^a		
=high school	29.70	[21.13, 38.26]
>high school	63.98	[54.64, 73.32]
NMLI		
High tetraplegic (C1-C4) ^a		
Low tetraplegic (C5-C8)	27.93	[19.53, 36.35]
Paraplegic	67.28	[51.07, 69.49]
AIS classification, C or D, (vs. A or B) ^b	26.76	[20.65, 36.86]
Upper limbs' sMMTs		
<20 ^a		
20 & <50	67.46	[59.84, 75.08]
=50	87.12	[79.69, 94.56]
Lower limbs' sMMTs, 20 (vs. <20)	33.98	[27.46, 40.51]
Bladder management ^b		
No assistive devices ^a		
ICP w/o EUC or CI	-17.97	[-24.95, -11.00]
EUC w/o CI	-40.85	[-51.28, -30.42]
CI and others	-77.50	[-85.53, -69.46]
Pain level, 5 (vs. <5) ^b	-20.99	[-27.12, -14.86]
Total FIM (n = 2,912)	2.04	[1.94, 2.14]
CHIEF-t score	-1.41	[-1.69, -1.14]

Note. All the results of the mixed linear model taking into consideration the correlated nature of the outcome variable within the same region were significantly different from the results of the regular linear model. CHIEF-t = CHIEF-SF total score without the contribution of work/school dimension; CHART-t = CHART-SF total score from dimensions of physical independence, mobility, occupation, and social integration. Employed: working in a competitive job; in training status: on-the-job training or student; unemployed: unemployed, homemaker, retired, or at a sheltered workshop. CHIEF = Craig Hospital Inventory of Environmental Factors—Short Form; CHART = Craig Handicap Assessment and Report Technique—Short Form; Coef. = regression coefficient; NMLI = motor neurological level of injury; AIS = American Spinal Cord Injury Association Impairment Scale; sMMTs = sum of manual muscle test score; ICP = intermittent catheterization program; EUC: external urine collector; CI: Catheter indwelling; w/o = without.

^aReference group.

^bCovariates selected into multivariate analysis model. $p > .05$.

Table 3

The Multivariate Mixed Effect Regression Model^a for the Association of the Measurement of Environmental Barriers With Social Participation (n = 3,130)

Environmental barriers	Social participations	
	CHART-t	Employment status
Analysis	Coef. (95% CI)	OR (95% CI)
1. CHIEF-t score	-.831 [*] [-1.08, -.58]	.96 [*] [.95, .98]
CHIEF-SF average item score		
2. Non-work/school related dimension	-8.32 [*] [-10.76, -5.87]	.70 [*] [.61, .79]
3. Physical/structure	-2.86 [*] [-4.38, -1.37]	.84 [*] [.78, .90]
4. Assistance/services	-8.18 [*] [-10.11, -6.24]	.76 [*] [.68, .84]
5. Work/school (n = 967)	-2.34 [-5.65, .97]	1.17 [.96, 1.42]
6. Attitude/support	-3.25 [*] [-5.29, -1.20]	.89 [*] [.81, .98]
7. Policies	-1.52 [-3.20, .159]	.91 [*] [.84, .98]

Note. All analysis adjusted for age, years since injury, ex, MNLI, AIS, current educational level, bladder management, and pain level. All the results from the mixed linear model taking into consideration the correlated nature of the outcome variable within the same region were significantly different from the results of the regular linear model. CHIEF-t = CHIEF-SF total score without the contribution of work/school dimension; CHART-t = CHART-SF total score from dimensions of physical independence, mobility, occupation, and social integration. Employment status: Employed or others. CHIEF = Craig Hospital Inventory of Environmental Factors—Short Form; CHART = Craig Handicap Assessment and Report Technique—Short Form; Coef. = regression coefficient; CI = confidence interval.

^aThe mixed linear regression model was used in the analysis for CHART-t, and the mixed logistic regression model was used in analysis for employment status.

^{*}
p < .05.

Table 4

The Multivariate Mixed Linear Regression Model for the Association of CHART-SF Subscales With the Measurement for Environmental Barriers (n = 3,130)

Environmental barriers by the CHIEF-SF average item score	CHART-SF subscales			
	Physical independence	Mobility	Occupation	Social integration
	Coef. (95% CI)	Coef. (95% CI)	Coef. (95% CI)	Coef. (95% CI)
1. Non-work/school related dimension	-1.4 [-2.42, -.37] *	-3.1 [-3.86, -2.35] *	-2.2 [-3.38, -1.03] *	-1.64 [-2.38, -.9] *
2. Physical/structure	-.94 [-1.57, -.32] *	-1.24 [-1.71, -.78] *	-.59 [-1.31, .13]	-.12 [-.58, .33]
3. Assistance/services	-1.22 [-2.03, -.41] *	-2.83 [-3.43, -2.23] *	-2.4 [-3.33, -1.47] *	-1.75 [-2.33, -1.16] *
4. Work/school (n = 967)	-1.21 [-2.85, .44]	-.27 [-1.25, .71]	.97 [-.59, 2.53]	-2.05 [-3.09, -1.00] *
5. Attitude/support	-.31 [-1.16, .54]	-1 [-1.64, -.37] *	-.93 [-1.91, .05]	-1.04 [-1.66, -.43] *
6. Policies	-.06 [-.76, .64]	-.85 [-1.37, -.33] *	-.22 [-1.03, .58]	-.39 [-.9, .12]

Note. The analyses were performed by mixed linear regression model adjusted by age, years since injury, sex, MNLI, AIS, current educational level, bladder management, and pain level. All the results from the mixed linear model with taking into consideration the correlated nature of the outcome variable within the same region were significantly different from the results of the regular linear model. CHART-SF = Craig Handicap Assessment and Reporting Technique—Short Form; Coef. = regression coefficient; CI = confidence interval.

* $p < .05$.