Research article

# Environmental barriers and subjective health among people with chronic spinal cord injury: A cohort study

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**Objective:** Although previous studies have found environmental barriers to be associated with social participation and life satisfaction after spinal cord injury (SCI), few studies exist reporting their effects on subjective health after SCI. Our purpose was to identify the prevalence of perceived environmental barriers and their effects on subjective health in persons with chronic SCI who completed two repeated measurements during a 5-year longitudinal study.
**Design:** This is a prospective cohort study. Environmental barriers were measured at baseline by the Craig Hospital Inventory of Environmental Factors-Short Form. Subjective health was measured at baseline and 5-year follow-up by days of physical and mental health not good. Other control variables included sex, race, age at injury, years since injury, and injury severity at baseline.
**Setting:** Data were collected at a specialty hospital and analyzed at a medical university in the Southeastern USA.
**Participants:** A total of 1635 participants completed both baseline and follow-up surveys.
**Results:** Twenty per cent of participants reported at least one policy barrier, 46% at least one physical and structural barrier, 22% at least one attitudinal and support barrier, 26% at least one barrier to services and assistance, and 13% at least one barrier at work or school. After controlling for sex, race, age at injury, years since injury, and injury severity, the physical and structural barriers, and services and assistance barriers measured at baseline significantly predicted subjective physical and mental health measured at follow-up.
**Conclusion:** Environmental barriers are prevalent among people with chronic SCI. They are important predictors for future subjective health.

**Keywords:** Spinal cord injuries, Health, Environment

## Introduction

Environmental barriers, such as lack of family support and accessibility issues, can have a profound impact on how one lives his or her life, especially for those living with a disability. The World Health Organization[1] states environmental barriers comprise several of the following categories: (1) products and technology; (2) natural environment and human-made changes to environment; (3) support and relationships, (4) attitudes, values, and beliefs; and (5) services, systems, and policies. Although national[2] and international[1] organizations have identified environmental factors as research priorities, there is little clarity[3] regarding environmental effects and their roles or influence on the outcomes on those living with disability. Thus, researchers have the daunting task of not only investigating and clarifying environmental factors in the aforementioned categories but also examining the role environmental factors have on outcomes of those living with disability.

According to Law *et al.*,[4] environmental barriers can be defined as social, physical, and/or institutional. For those living with disabilities, previous research studies have shown people's attitudes or social exclusion,[4–7] inaccessibility,[4,6,8] and poorly coordinated policies and services[4,6,7] are recurrent themes in discussions focused on environmental barriers. For example, someone living with spinal cord injury (SCI), which is a severe disabling condition that may result in permanent sensory and motor loss and, oftentimes, the use of a wheelchair, requires a specific physical ramp to access

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DOI 10.1179/2045772314Y.0000000275

buildings. If buildings lack this particular ramp, those with SCI encounter an environmental barrier to access a public place whether for employment or recreational purposes. As researchers and those living with disability identify various environmental barriers, it is imperative that researchers also examine various outcomes.

There has been an ongoing emphasis to not only identify environmental barriers but also examine their effects on outcomes of people living with a disability. Whiteneck *et al.*[7] report several outcomes by describing people living with a disability who experience environmental barriers tend to be less satisfied with life, have minimal social participation, and have less productivity and mobility. The environmental barriers are significantly related to the satisfaction with life scale (SWLS) with a −0.39 Pearson correlation coefficient and to the Craig handicap assessment and reporting technique (CHART) with a −0.38 Pearson coefficient among persons with traumatic brain injury.[7] For people with SCI who have at least one environmental barrier, the odds ratios of having lower CHART total score (<375) range from 1.30 to 1.85, and the odds ratios of having lower SWLS total score (<20) range from 1.77 to 1.95. In addition to decreased social participation, Noreau *et al.*[8] state reduced quality of life (QOL) is consistent with negative outcomes of environmental barriers for those living with SCI. Numerous studies explain how various environmental factors have a negative impact on social participation (e.g. declining social activity) for those living with a disability.[7–14] Aside from the actual disability or type of injury, a decline in social activity may result from fatigue,[9,11] unfavorable weather conditions (e.g. excessive cold or heat, snow, etc.),[8] and lack of appropriate transportation.[13] These environmental barriers and their subsequent outcomes create an adverse cycle which also affects life satisfaction and QOL for those living with a disability. According to numerous research studies, environmental factors such as isolation and declines in social activity negatively impact QOL[15] and have a profound effect on life satisfaction after disability.[16,17] For instance, if a SCI patient's CHART social integration score is lower than 75, he/she is 2.14 more like to have a low SWLS score (<20).[16]

While considerable literature has been published regarding the effects of environmental factors and outcomes related to participation, productivity, QOL, and life satisfaction, little information exists regarding the effects of environmental factors and outcomes on health among people with chronic disability. Literature in social epidemiology and medical sociology research indicates the environment in which people live and work affects physical and mental health.[18–21] Macintyre *et al.*[21] summarize five perspectives of environment that have impacts on people's health: (1) the physical environment; (2) the healthy environments at home, work, and play; (3) the availability of public and private services to support people's daily living; (4) the socio-cultural perspective of local areas; and (5) an area's reputation for its esteem, quality of material infrastructure, and level of morale. Since environmental barriers cause consequential negative outcomes for people with disability, including minimal social support,[22] limited participation,[23] lower QOL,[15] and life satisfaction,[16] which impacts long-term health, it is possible that environmental barriers also affect health among people living with disability such as chronic SCI.

Our purpose is to utilize longitudinal data to identify the effects of perceived environmental barriers' on subjective physical and mental health in persons with chronic SCI.

## Methods

### *Participants and procedures*

We used a cohort study design based on a longitudinal cohort identified from records of a rehabilitation specialty hospital in the Southeastern USA. The time 1 cohort was initially enrolled in 1997–1998, time 2 follow-up in 2007–2009, and time 3 in 2011–2014. As our variable of interest, environmental barriers, was only available in time 2, this study used the 2007–2009 survey ($n = 2548$) as the baseline measure, and 2011–2014 ($n = 1635$) as the follow-up assessment. The follow-up rate of this study is 64%. The inclusion criteria were: minimum of 18 years old at time of survey, traumatic SCI of at least 1 year duration, and residual impairment. They were mostly male (74%) and non-

**Table 1 Characteristics of respondents (*N*=1635)**

| | ***M* (SD) or %** |
|---|---|
| Days physical health *not* good measured at time 1 | 6.09 (8.45) |
| Days physical health *not* good measured at time 2 | 6.66 (8.62) |
| Days mental health *not* good measured at time 1 | 5.89 (8.17) |
| Days mental health *not* good measured at time 2 | 5.76 (8.02) |
| Age at injury at time 1 | 32.98 (13.83) |
| Years since injury at time 1 | 12.79 (9.61) |
| | % |
| Male | 74.01 |
| Race | |
| Non-Hispanic white | 72.97 |
| Non-Hispanic black | 21.77 |
| Others | 5.26 |
| Injury severity | |
| Non-ambulatory C1–C4 | 9.82 |
| Non-ambulatory C5–C8 | 24.98 |
| Non-ambulatory non-cervical | 33.95 |
| Ambulatory | 31.25 |

Hispanic white (73%), with an average of 13 years post-injury, and 31% of them could walk (Table 1).

Data were collected through the self-report. Introductory letters were sent to all potential participants describing the study approximately 4 weeks before mailing the first set of materials. Non-respondents were sent a second mailing within 2 months of the initial mailing. Attempts were then made to contact participants by phone, if possible, and when requested, an additional packet of materials was sent. Participants were offered $50 remuneration for participation. Institutional Review Board approval was obtained before initiating any data collection.

### *Measurement*

Our outcome, subjective health status, was measured by two health status items from the Behavioral Risk Factor Surveillance System Survey Questionnaire developed by the Centers for Disease Control and Prevention.[24] The first health item asked how many days physical health was *not* good within the past 30 days, and the second health item asked how many days mental health was *not* good within the past 30 days. Subjective health status is the most widely used measurement of health in population surveys.[25] Although some research suggests it is a conservative measure of health,[26–28] it is generally regarded as reliable and valid in survey research.[25,29–32]

Environmental barriers were measured at time 1 by the Craig Hospital Inventory of Environmental Factors-Short Form (CHIEF-SF), a well-validated 12-item scale to measure the frequency and magnitude of environmental barriers perceived by individuals.[33] The CHIEF-SF first asks participants the frequency with which they encounter barriers (daily, weekly, monthly, less than monthly, or never) on each of the 12 items. The frequency score ranges from 0 (never) to 4 (daily). If a participant indicates he/she encounters environmental barriers at any frequency other than never, a follow-up question is asked about whether they consider the barrier to be a big or a little problem (magnitude of impact score: little problem = 1 and big problem = 2). Each CHIEF-SF item score, ranging from 0 to 8, is the product of the frequency score and the magnitude of impact score. The total CHIEF-SF score is the average of the 12 items' product scores. Higher CHIEF-SF scores suggest greater frequency and/or magnitude of environmental barriers. There are five subscales identified from the CHIEF-SF: policy barriers, physical and structural barriers, work and school barriers, attitudes and support barriers, and services and assistance barriers.[34] As with the total CHIEF-SF score, each subscale score is the mean product score of all the items comprising that subscale.

Other controlling variables were measured at time 1, including sex, race (non-Hispanic white, non-Hispanic black, and others), age at injury, years since injury, and injury severity. Injury severity was measured by four categories: C1–C4 injury level/non-ambulatory, C5–C8 injury level/non-ambulatory, non-cervical injury/non-ambulatory, and ambulatory.

### *Analysis*

We first describe the demographic and injury characteristics variables and subjective health status using frequency distributions, means, and standard deviations. Then we present the descriptive statistics for each of the five CHIEF-SF subscales. We also dichotomized each CHIEF-SF subscale by using the cut-point of 1 (CHIEF-SF subscale > 1 or not).

Our outcome variables measured at follow-up, physical health not good and mental health not good, were analyzed by multivariate ordinary least squares (OLS) regression models. All predictors were measured at baseline. Our variables of interests are four subscales of the CHIEF-SF: policy barriers, physical and structural barriers, attitudes and support barriers, and services and assistance barriers. We removed one subscale, work and school barriers, from the regression models because a large proportion of participants were not employed or in school at the time of first survey, which led to a high missing rate (36%) on this subscale.

We implemented lagged-*Y*-regressor (or lagged-dependent variable) analysis for all the regression models. This added the outcome variable measured at baseline in the models as a controlling variable to estimate more specifically the unique explanatory power of predictors.[35,36] That means, we added subjective health status measured at first survey as a control in the OLS models, besides sex, race, age at injury, years since injury, and injury severity.

## Results

The average days of physical health not good within the past 30 days increased from 6 days to 7 days during the 5 years period (Table 1), which was statistically significant indicated by the paired *t*-test ($P < 0.01$). The average days of mental health not good remained relatively stable, with no statistically significant changes ($P = 0.57$).

The mean product scores of the CHIEF-SF subscales showed that physical/structural environmental barriers had the greatest reported association with the outcome measure, followed by services/assistance barriers then attitudes/support barriers (Table 2). If a subscale's

**Table 2 Scores on CHIEF-SF subscales measured at time 1**

| Variable | *N* | *M* (SD) or % |
|---|---|---|
| Policies subscale | 1328 | 0.63 (1.07) |
| Physical/structural subscale | 1409 | 1.51 (1.46) |
| Work/school subscale | 1043 | 0.48 (0.98) |
| Attitudes and support subscale | 1373 | 0.78 (1.13) |
| Services and assistance subscale | 1205 | 0.80 (1.01) |
| | | % |
| Policies subscale >1 | 1328 | 19.7 |
| Physical/structural subscale >1 | 1409 | 46.0 |
| Work/school subscale >1 | 1043 | 13.2 |
| Attitudes and support subscale >1 | 1373 | 22.4 |
| Services and assistance subscale >1 | 1205 | 26.0 |

score was larger than 1, we assumed the participant's life was affected by at least one barrier within the subscale items. According to Table 2, 19.7% of our participants reported impacts from policies barriers; 46% reported impacts from physical/structural barriers; 13.2% encountered work/school barriers; 22.4% had attitudes/support barriers; and 26% reported services/assistance barriers.

The multivariate analysis utilized four CHIEF-SF subscales measured at time 1 to predict the days of physical health and mental health not good at time 2. After controlling for physical health measured at time 1 and demographic and injury characteristics, two CHIEF-SF subscales were statistically associated with physical health at time 2 (Table 3). A one point increase of the physical/structural barriers impact score related to almost half day (0.42) physical health not good. One point increase of the services/assistance barriers impact score was associated with 1 day (1.07) physical health not good. As expected, the days of physical health not good measured at time 1 had significant relationship with that measured at time 2. The older the age at injury and the longer years post-injury were also positively related to days of physical health not good at time 2.

Physical/structural barriers and services/assistance barriers were also significant predictors of days mental health was not good measured at time 2 (Table 4). One point increase of the physical/structural barriers impact score related to 0.45 days of mental health not good. One point increase of the services/assistance barriers impact score was associated with 0.64 days of mental health not good. One day increase of mental health not good at time 1 related with 0.44 days of mental health not good at time 2. The age at injury and years post-injury were no longer significant predictors of mental health status.

## Discussion

Although we have a better theoretical understanding of the impacts of environmental influence on people's health from medical sociology and social epidemiology perspectives, this relationship has been insufficiently studied among people with chronic disability whose lives may be strongly affected by their social and physical environment. We believe this is the first longitudinal study focusing on impact of environmental barriers on the subjective health of people with chronic SCI. It is clear that environmental barriers are prevalent among people with chronic SCI. Two CHIEF-SF subscales, physical/structural barriers and service/assistance barriers, had significant relationships with subjective physical and mental health. These two subscales mainly reflect physical and material environment, while the other two subscales (policies and attitude/support subscales) are mostly social aspects of environment.

**Table 3 OLS regression analysis: predicting days of physical health not good at time 2**

| | Unstandardized coefficient | Standard error | P value |
|---|---|---|---|
| Intercept | −0.32 | 1.10 | 0.77 |
| Days of physical health not good at time 1 | 0.37 | 0.03 | <0.01 |
| Male | −0.08 | 0.58 | 0.90 |
| Race (ref.: non-Hispanic white) | | | |
| Non-Hispanic black | −0.02 | 0.65 | 0.98 |
| Others | −1.39 | 1.12 | 0.21 |
| Injury severity (ref.: ambulatory) | | | |
| Non-ambulatory C1–C4 | 1.49 | 0.89 | 0.10 |
| Non-ambulatory C5–C8 | −0.37 | 0.69 | 0.59 |
| Non-ambulatory non-cervical | −0.26 | 0.63 | 0.68 |
| Age at injury | 0.07 | 0.02 | <0.01 |
| Years since injury at time 1 | 0.07 | 0.03 | 0.01 |
| Policies subscale at time 1 | −0.05 | 0.29 | 0.87 |
| Physical/structural subscale at time 1 | 0.42 | 0.20 | 0.03 |
| Attitudes and support subscale at time 1 | −0.09 | 0.27 | 0.74 |
| Services and assistance subscale at time 1 | 1.07 | 0.31 | <0.01 |
| Adjusted $R^2$ | 0.18 | | |

**Table 4 OLS regression analysis: predicting days of mental health not good at time 2**

| | Unstandardized coefficient | Standard error | P-value |
|---|---|---|---|
| Intercept | 2.53 | 0.97 | <0.01 |
| Days of mental health not good at time 1 | 0.44 | 0.03 | <0.01 |
| Male | −0.31 | 0.51 | 0.54 |
| Race (ref.: non-Hispanic white) | | | |
| Non-Hispanic black | −0.64 | 0.57 | 0.26 |
| Others | −0.75 | 0.98 | 0.44 |
| Injury severity (ref.: ambulatory) | | | |
| Non-ambulatory C1–C4 | 1.02 | 0.79 | 0.19 |
| Non-ambulatory C5–C8 | 0.16 | 0.60 | 0.79 |
| Non-ambulatory non-cervical | 0.02 | 0.55 | 0.97 |
| Age at injury | 0.00 | 0.02 | 0.95 |
| Years since injury at time 1 | −0.04 | 0.02 | 0.08 |
| Policies subscale at time 1 | −0.07 | 0.25 | 0.77 |
| Physical/structural subscale at time 1 | 0.45 | 0.17 | <0.01 |
| Attitudes and support subscale at time 1 | 0.13 | 0.24 | 0.59 |
| Services and assistance subscale at time 1 | 0.64 | 0.28 | 0.02 |
| Adjusted $R^2$ | 0.27 | | |

Although the two social environment barriers were not statistically significant in our study, our 5-year study period is relatively short and may not allow the social environment's effects to fully unfold. Meanwhile, the physical environmental conditions external to people are partly determined by their social circumstances. The physical features of local environment, such as the quality of air and water, the access to basic utilities, neighborhood facilities, and medical service, may be located there for social reasons. For example, the toxic waste dumps, new freeways, and nuclear power stations are more likely to be built in areas where the residents are relatively politically and socially powerless.[37,38]

Whiteneck *et al.*[16] identified the top five environmental barriers reported by people with SCI: (1) natural environment, (2) transportation, (3) need for help in the home, (4) availability of health care, and (5) governmental policies. The first four barriers also belong to physical/structural and service/assistance domains which were found to have significant impacts on subjective health in our study. Since there is very limited literature to discuss whether some environmental barriers are more malleable than others and what is the intervention strategy to promote health after SCI through addressing the environmental barriers, we suggest both qualitative and quantitative studies to focus on the first four barriers and to investigate their malleability, thus presenting more immediate targets for future intervention programs.

### *Limitations*

This research has its limitations. First, the population studied was not representative of all persons with traumatic SCI, as participants were at least 1-year post-injury and 72% of the sample had lived with traumatic SCI for 5 years or more. Therefore, our study mainly reflects the relationship between environmental barriers and subjective health for those with chronic SCI. Participants were also selected through a clinical site, rather than being population based. Second, although the CHIEF-SF is a valid tool to measure environmental barriers, it does not take into account the environmental factors acting as facilitators to health. Future studies are needed to explore those facilitators, which can be used in the intervention program to improve the health status and longevity for people with SCI. Third, we have an attrition rate of 36%, which is respectable considering the 5 years follow-up period, but the readers should be aware of the possibility of selection bias resulting from non-random loss of respondents. Fourth, the coefficients of determination (adjusted $R^2$) are relatively low, 0.18 and 0.27 for our two OLS regression models, which shows our models can only explain 18% variance of physical health and 27% of mental health. This suggests that factors other than those that were the focus of this study are important to the prediction of mental health.

## Conclusion

People with chronic SCI report a range of environmental barriers and obstacles. The physical aspects of environment are associated with the subjective physical and mental health. The CHIEF may be a useful tool for understanding the environment's role in the lives of people with physical disability and identifying the general environmental domains where interventions are needed to reduce their negative impact.

## Disclaimer statements

**Contributors** All listed authors contributed significantly to the work submitted for consideration.

**Funding** This study was developed under a grant from the Department of Education, NIDRR grant numbers H133B090005, and grant SCIRF 11-006 from the South Carolina Spinal Cord Injury Research Fund.

**Conflicts of interest** None.

**Ethics approval** Institutional Review Board approval was received.

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