Qual Life Res
DOI 10.1007/s11136-017-1586-5

Relationships between environmental factors and participation in adults with traumatic brain injury, stroke, and spinal cord injury: a cross-sectional multi-center study

Alex W. K. Wong[1,2] · Sheryl Ng[2,3] · Jessica Dashner[1] · M. Carolyn Baum[4] · Joy Hammel[5] · Susan Magasi[6] · Jin-Shei Lai[7] · Noelle E. Carlozzi[8] · David S. Tulsky[9] · Ana Miskovic[10] · Arielle Goldsmith[10] · Allen W. Heinemann[10,11]

Accepted: 21 April 2017

Abstract

Purpose To develop and evaluate a model of environmental factors-participation relationships for persons with traumatic brain injury (TBI), stroke, and spinal cord injury (SCI), and test whether this model differed across three diagnostic groups, as well as other demographic and clinical characteristics.

Methods A cross-sectional observational study included 545 community-dwelling adults with neurological disorders (TBI = 166; stroke = 189; SCI = 190) recruited at three academic medical centers. Participants completed patient-reported measures of environmental factors and participation.

Results The final structural equation model had acceptable fit to the data (CFI = 0.923; TLI = 0.898; RMSEA = 0.085; SRMR = 0.053), explaining 63% of the variance in participation in social roles and activities. Systems, services, and policies had an indirect influence on participation and this relation was mediated by social attitudes and the built and natural environment. Access to information and technology was associated with the built and natural environment which in turn influence on participation ($ps < 0.001$). The model was consistent across

Electronic supplementary material The online version of this article (doi:10.1007/s11136-017-1586-5) contains supplementary material, which is available to authorized users.

✉ Alex W. K. Wong
wongal@wustl.edu

Sheryl Ng
ephsnhx@nus.edu.sg

Jessica Dashner
dashnerj@wustl.edu

M. Carolyn Baum
baumc@wustl.edu

Joy Hammel
hammel@uic.edu

Susan Magasi
smagas1@uic.edu

Jin-Shei Lai
js-lai@northwestern.edu

Noelle E. Carlozzi
carlozzi@med.umich.edu

David S. Tulsky
dtulsky@udel.edu

Ana Miskovic
amiskovic@ric.org

Arielle Goldsmith
agoldsmith@ric.org

Allen W. Heinemann
a-heinemann@northwestern.edu

1 Program in Occupational Therapy and Department of Neurology, Washington University School of Medicine, St. Louis, MO, USA

2 Program in Occupational Therapy, Washington University School of Medicine, 4444 Forest Park Ave, Campus Box 8505, St. Louis, MO 63108, USA

3 Saw Swee Hock School of Public Health, National University of Singapore, Singapore, Singapore

4 Program in Occupational Therapy, Department of Neurology and George Warren Brown School of Social Work, Washington University, St. Louis, MO, USA

5 Departments of Occupational Therapy and Disability and Human Development, University of Illinois at Chicago, Chicago, IL, USA

6 Department of Occupational Therapy, University of Illinois at Chicago, Chicago, IL, USA

sex, diagnosis, severity/type of injury, education, race, age, marital status, years since injury, wheelchairs use, insurance coverage, personal or household income, and crystallized cognition.

Conclusions Social and physical environments appear to mediate the influence of systems, services, and policies on participation after acquired neurological disorders. These relations are stable across three diagnostic groups and many personal and clinical factors. Our findings inform health and disability policy, and provide guidance for implementing the initiatives in Healthy People 2020 in particular for people with acquired neurological disorders.

Keywords Environment · Participation · Stroke · Spinal cord injury · Traumatic brain injury

Abbreviations

ADA	Americans with Disabilities Act
AIT	Access to information and technology
BNE	Built and natural environment
CFA	Confirmatory factor analysis
CFI	Comparative Fit Index
CPI	Community Participation Indicators
EFIB	Environmental Factors Item Banks
GCS	Glasgow Coma Scale
ICF	International Classification of Functioning, Disability and Health
PROM	Patient-Reported Outcomes Measures
PROMIS	Patient-Reported Outcomes Measurement Information System
QOL	Quality of life
RMSEA	Root mean square error of approximation
SCI	Spinal cord injury
SEM	Structural equation modeling
SRA	Social roles and activities
SRMR	Standardized Root Mean Square Residual
SSP	Systems, Services and Policies
TBI	Traumatic brain injury
TLI	Tucker-Lewis index
WHO	World Health Organization

[7] Departments of Medical Social Science and Pediatric, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

[8] Department of Physical Medicine and Rehabilitation, University of Michigan Medical School, Ann Arbor, MI, USA

[9] Department of Physical Therapy, University of Delaware, Newark, DE, USA

[10] Center for Rehabilitation Outcomes Research, Rehabilitation Institute of Chicago, Chicago, IL, USA

[11] Department of Physical Medicine and Rehabilitation, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

Introduction

Over 50 million adults in the United States, or 1 in 5, report a disability [1]. Neurological disorders are the most common cause of serious disability and one of the greatest threats to public health [2]. In the US, there are 6.5 million adults who ever had a stroke [3] and 2.8 million people who sustain a Traumatic Brain Injury (TBI) annually [4]. Approximately 282,000 individuals with spinal cord injury (SCI) are alive in the US [5]. Healthy People 2020, a template to guide public health action, includes goals to promote the health and well-being of people with disabilities including those with acquired neurological disorders [6]. The document highlights several areas for action to enhance the health of people who experience disabilities by removal of physical and policy barriers, increasing social participation, and increasing access to technology and assistive supports. The twenty-fifth anniversary of the passage of the Americans with Disabilities Act (ADA) in 2015 provided an opportunity to reflect on the achievements of the ADA in terms of improved quality of life (QOL) for individuals with disabilities [7]; however, the ADA has not eliminated all social and physical barriers that limit participation, posing a challenge to the fulfillment of the Healthy People 2020 goals [8]. The World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF) defines participation as an involvement in life situations including domestic life, interpersonal relationships, work, education, and community, social, and civic life [9]. Participation is beneficial to well-being and health-related QOL [10]. Institute of Medicine [11] highlights the role that environmental factors have on the health and participation of groups identified at risk for health disparities, including people with disabilities [12, 13]. Unfortunately, among all individuals with disabilities, the extent of participation of those with acquired neurological disorders, including TBI, stroke, and SCI, are largely influenced by environmental factors [14]. Following the onset of an acquired neurological disorder, individuals are more susceptible to experience a mismatch between their personal factors/capabilities and the demands of their environments. Stines et al. [15] indicated that optimal participation in life after SCI is primarily determined by the environment. Access to participation opportunities and having control over participation in the community are often restricted by physical, social, and system environmental barriers following stroke [16]. An earlier study reported that environmental barriers have a negative effect on participation outcomes following a TBI [17]. The environment can influence participation following TBI, stroke, or SCI. Less is known about the relationship between specific aspects of the environment and their influence on the lives of people in these populations.

Bronfenbrenner [18] and others exploring the social determinants of health [19] recognize the interaction within and between ecological units and emphasize that the health outcomes of individuals, communities, and social groups are influenced by physical, social, and policy factors in micro-to-macro-environments. Using mixed-methods research designs, our team [12] recently developed a transactional model describing how environmental factors influence everyday participation at the micro (immediate), mesa (community), and macro (societal) levels. These levels radiate out from an individual and represent distinct but related environments from immediate to distal influences. Table 1 describes environmental factors that we have studied at each of these levels. Closest to the individual, the micro (immediate)-environment (e.g., built environment and social attitudes) has more proximal influences to participation, followed by the mesa (community)-environment (e.g., information about community resources and technological access). Finally, the macro (societal)-environment or the larger societal and cultural context (e.g., systems & political influence) distally influence participation through the provision, choice, and availability of opportunities and resources for people with disabilities in micro (immediate)- or mesa (community)-environments. Barriers resulting from environmental factors can thus be addressed at a micro, mesa, or macro level to influence transactively participation, community engagement, and societal enfranchisement. We proposed a conceptual model for this study (Fig. 1). We hypothesized that social support and political influences (macro-environment) have distal influence on participation [20] and that this relationship is mediated by social attitudes, physical environmental barriers, and access and usability of information and technology [21]. For example, we expect that the ADA is a macro-level facilitator that influences mesa-level community changes to promote accessibility and increase participation opportunities for people with disabilities. When businesses fail to comply with ADA regulations, attitudinal and physical barriers persist that may limit participation. We expect that these mediating factors co-exist and are associated with other barriers to community living [12].

Additional studies support the pressing need to refine the theoretical and measurement foundation of environmental factors-participation relationships [13, 22]. Recently developed measures provide improved representation of environmental factors and participation for people with acquired neurological disorders [14] and are supported by work that operationalizes the ICF categories [23]. Therefore, the goal of this study was to examine relationships between environmental factors and participation constructs as represented by patient-reported outcome measures (PROM) among individuals with TBI, stroke and SCI.

Methods

Participants and procedures

As part of a larger study, community-dwelling adults with TBI, stroke, or SCI were invited to participate in a comprehensive, 2-day assessment at three Midwestern medical centers. We recruited participants through patient registries, outpatient clinics, newsletters, flyers, and affiliated hospital referrals. Inclusion criteria required participants to be at least 18 years of age, willing and able to participate in two days of testing, at least one year post-injury, and fluent in English at a fifth grade or higher level. We reviewed medical records enrollment to verify eligibility.

TBI eligibility criteria included a diagnosis of complicated mild [24], moderate [25], or severe TBI [25]. We used emergency department Glasgow Coma Scale (GCS) scores to categorize TBI severity; we defined severity as

Table 1 Environmental factors at the micro, mesa, and macro levels

Levels	Domains	Descriptions
Micro	Physical environment	Natural and built factors in the environment, including architectural features of buildings, land development (e.g., sidewalks and roadways), and environmental features (e.g., noise, crowds, indoor air quality)
	Social attitudes	Disability-related attitudes and behaviors, such as acceptance, stigma, and marginalization from society
Mesa	Information and Technology Access	Environmental features that influence the ability to access, understand, and use information technology, knowledge, and community resources
Macro	Systems, Services and Policies	Social services and health care policies related to employment, education, housing, independent living, and systems of delivery

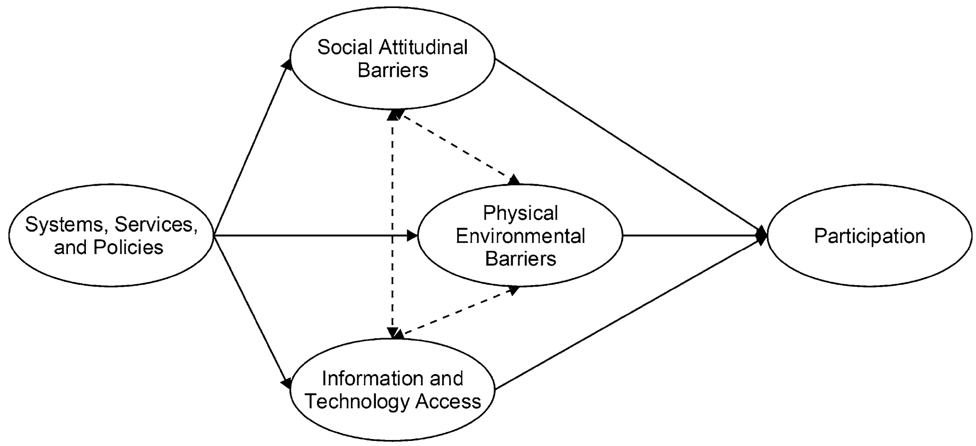

Fig. 1 Initial Conceptual Model. *Solid lines* represent hypothesized path relationships between two latent variables; *Dotted lines* represent hypothesized correlations between two latent variables; Factor loadings of indicators for each latent variable and error terms are omitted from the figure

the lowest GCS score within the first 24 h after injury not due to intubation, sedation, or intoxication. We defined complicated mild TBI as a GCS score of 13–15 with positive findings on neuroimaging, moderate TBI as a GCS score of 9–12; and severe TBI as a GCS score of 8 or less.

SCI eligibility criteria were an acute traumatic lesion of neural elements in the spinal canal resulting in either temporary or permanent sensory or motor disabilities. We characterized SCI as paraplegia or tetraplegia and as complete or incomplete according to the International Standards for Neurological Classification of SCI standards [26].

Stroke eligibility criteria were medically documented, rapidly developing clinical signs of focal or global disturbance of cerebral function with symptoms lasting more than 24 h and with apparent cause of vascular origin. We used the Modified Rankin Scale [27] to classify strokes as mild (scores of 1–2), moderate (3), or severe (4).

To ensure sufficient vision, literacy, and communication skills to complete assessments, additional inclusion criteria were a Lighthouse Near-Visual Activity Test score of less than 20/100 [28], ability to read the first 10 words of the Wide Range Achievement Test [29], and ability to communicate some of the main ideas of a story in the Frenchay Aphasia Screening Test [30]. Participants provided informed consent in compliance with the institutional review boards at the Rehabilitation Institute of Chicago, the University of Michigan, and Washington University in St. Louis. Participants received an honorarium to acknowledge their contribution to the research.

Measures

Participants completed the PROMIS Social Health item banks [31], Community Participation Indicators (CPI) [32], and the Environmental Factors Item Banks (EFIB) [14] via the NIH Assessment Center (www.assessmentcenter.net). These measures were developed using item response theory and Rasch measurement approaches which yield interval-level measures, and allow computer adaptive testing and short-form administration [33]. Participants completed additional environmental factor measures including: the Craig Hospital Inventory of Environmental Factors (CHIEF) [34] and the Home and Community Environment (HACE) [35].

Patient-Reported Outcomes Measurement Information System Social Health

We administered three item banks from the PROMIS Social Health domain [31]: Satisfaction with Participation in Social Roles and Activities (SRA), Ability to Participate in SRA, and Social Isolation. Detailed descriptions of these measures, scoring, and interpretation are provided in Appendix I.

Community Participation Indicators

We administered the CPI—Participation Enfranchisement items that reflect the extent to which individuals view their communities as valuing, respecting, and encouraging their participation [32]. We computed scores that tap two distinct components of participation enfranchisement: importance of participation and control over participation.

Environmental Factors Item Banks

We developed the EFIB based on the Rasch measurement model and used both focus groups and cognitive interviews to develop a conceptual framework and to verify item meaning from the perspectives of people with neurological disorders [14]. We administered four measures: (1) access to Information and technology, environmental features that influence the ability to assess and understand information; (2) the built and natural environment [36], the extent to which environmental features affect participation in home, outdoor and community; (3) social environment [37], disability-related attitudes and behaviors such as acceptance, stigma, and marginalization from society in general and members of respondents' social networks; and (4) systems, services, and policies [20], perceived access to and adequacy of system and service related to environmental support.

Legacy Measures of Environmental Factors

Craig Hospital Inventory of Environment Factors (*CHIEF*)—*Short Form* is a 12-item PROM designed to measure the frequency of encountering specific environmental barriers or facilitators and the magnitude of environmental influences on participation [34].

Home and Community Environment (HACE) describes properties of the environment such as the presence or absence of environmental barriers and rates the consequences of environmental features [35].

Demographic and clinical characteristics were based on self-report and confirmed with medical record reviews. They included: gender, education, diagnosis, years since injury, ethnicity, age, marital status, wheelchair use, insurance coverage, personal and household incomes, and employment status at the time of study. Participants completed the NIH Toolbox cognitive battery as part of assessment protocol [38]. We computed the fluid (capacity for new learning and information processing in novel situations) and crystallized cognitive (capacity dependent upon past learning experiences) composite scores for moderator analysis [39].

Data analysis

We computed descriptive statistics to characterize the sample and used structural equation modeling (SEM) to describe relationships among variables in a conceptual model, allowing for the simultaneous examination of relationships among multiple, conceptually related variables [40, 41]. We built the SEM model sequentially. First, we used confirmatory factor analysis (CFA) with single-factor models of (a) Participation (b) Systems, Services and Policies, (c) Social Attitudinal Barriers, (d) Physical Environmental Barriers, and (e) Information and Technology Access, to ensure each model had acceptable fit. Model estimation was carried out using the robust maximum likelihood methodology to account for the non-normality of some indicators used. Factor variances were fixed to 1, allowing all factor loadings to vary freely. Indicators were removed from the model if they were not statistically significant, or had a standardized factor loading below 0.4. Then we combined these factors into a single measurement model, with unconstrained covariance between factors and further refined for adequate model fit.

Next, we added paths to the measurement model to examine the conceptual relationship among constructs. We modified the structural models by removing paths which were not statistically significant and changing paths based on modification indices. The sequential Chi square difference test was used to ensure the final structural model was the best among competing models. A p value not exceeding 0.05 was considered statistically significant.

We examined multiple fit statistics at each stage of model building. We used the Comparative Fit Index (CFI) and Tucker-Lewis index (TLI) as indicators of incremental model improvement. Values of at least 0.90 indicate acceptable model fit, and values of 0.95 or higher indicate good model fit [42]. The root mean square error of approximation (RMSEA) represents closeness of fit; values of 0.08 or less and 0.06 or less indicate acceptable and good fit, respectively [43]. A Standardized Root Mean Square Residual (SRMR) less than 0.08 is considered good fit [44].

We examined group invariance in the final model (moderation analysis) across demographic and clinical characteristics. We classified participants into groups, such as gender (male vs. female) for such analysis. Metric, scalar, and residual invariance were tested in sequence. Invariance of a model component was tested by comparing the model with unconstrained parameters in that component against a model with the same parameters constrained to be equal across groups, using the sequential Chi square difference test [45]. Individual parameters that varied between groups were freed before testing the next component for invariance. Structural invariance was not tested due to model identification issues. The measurement invariant model was updated to include paths and tested for path invariance. We completed analyses with RStudio[1] and Mplus[2] software.

Results

Sample characteristics

The sample of 604 participants included 545 with complete data on variables used in SEM analyses. Primary diagnosis included SCI (190), TBI (166), and stroke (189). Participants with complete data and those with incomplete data ($N = 59$) did not differ in terms of gender ($\chi^2(1) = 0.053, p = 0.819$), race/ethnicity ($\chi^2(1) = 0.212$, $p = 0.645$), marital status ($\chi^2(1) = 1.747$, $p = 0.186$), education ($\chi^2(1) = 0.001$, $p = 0.980$), or primary impairment ($\chi^2(2) = 0.213$,

[1] RStudio Team (2015). RStudio: Integrated Development for R. RStudio, Inc., Boston, MA URL: http://www.rstudio.com/.

[2] Muthén, L. K., & Muthén, B. O. (1998–2011). Mplus User's Guide. Sixth Edition. Los Angeles, CA: Muthén & Muthén.

$p = 0.899$). However, participants with complete data were younger (mean age = 46.8 ± 16.0 years vs. 52.8 ± 18.2; $t(602) = -2.736$, $p = 0.006$) than those with missing data. Table 2 provides details about the sample.

Measurement models

Indicators entered into each of the five single-factor models are summarized in Table 3. The initial measurement model did not provide a good fit to the data. Table 4 shows fit indices for various models. Over the model building process, we removed Importance of Participation from the CPI; Service and Policy domains of CHIEF; Home Mobility, Community Mobility, Attitudes, Mobility Device, Communication Device, and Transportation domains of HACE due to small factor loadings. Access to Information and Technology had only a single indicator after model refinement [41]; thus, we corrected the measurement error in this indicator using sample variance and instrument reliability estimates from an earlier study [46]. The final measurement model exhibited marginal good fit (CFI = 0.923, TLI = 0.893, RMSEA = 0.087, SRMR = 0.052). Standardized factor loadings of all variables on the construct were ≥0.4. We used the final measurement model as the comparison for construction of the initial conceptual model.

Relationship between environmental factors and participation

Starting with the initial model (Fig. 1), we constructed paths from Social Attitudinal Barriers, Physical Environmental Barriers, and Information and Technology Access to Participation, as well as from Systems, Services, and Policies to Social Attitudinal Barriers, Physical Environmental Barriers, and Information and Technology Access. Covariance paths were included between Social Attitudinal Barriers and Physical Environmental Barriers, Social Attitudinal Barriers and Information and Technology Access, as well as Physical Environmental Barriers and Information and Technology Access. Although the initial model exhibited marginal good fit (CFI = 0.922, TLI = 0.893, RMSEA = 0.087, SRMR = 0.052), a Chi square difference between the initial conceptual and final measurement models was statistically significant ($\Delta\chi^2 = 4.104$, $p = 0.047$) indicating that the initial conceptual model did not provide a good fit with the data. We made post hoc model modifications, and the final conceptual model is shown in Fig. 2.

Table 4 shows the fit indices and Table 5 shows the standardized factor loadings of indicator variables in the final model. We made two revisions to improve model fit: (1) removing a direct path from Information and Technology Access to Participation, and (2) removing the covariance path between Social Attitudinal Barriers and Information and Technology Access due to lack of statistical significance of the parameters. The RMSEA value of 0.085 closely approached the acceptable threshold, and the CFI (0.923), TLI (0.898), and SRMR (0.053) were within acceptable limits. Coefficients of all paths were ≥0.4 and statistically significant ($p < 0.001$); modification indices did not suggest further changes. The R^2 values showed that 63% of the variance in participation, 51% of Social Attitudinal Barriers, 27% of Physical Environmental Barriers, and 62% of Access to Information and Technology were explained by the final model.

Testing demographic and clinical moderators

The final model was invariant across gender and education, suggesting that the final model is valid for women and men, and people with high and low education (Table 6). Measurement and path models were invariant across TBI severity (mild vs. moderate/severe) and SCI type (tetraplegia vs. hemiplegia). Measurement model structure differed by diagnosis, time since injury, ethnicity, age, marital status, wheelchair use, insurance coverage, personal and household incomes, and crystallized cognition. After accounting for the measurement model variation, the path structure did not differ, indicating that the path relationships between environmental factors and participation in the final model are valid regardless of primary disability (stroke, TBI and SCI); time since injury (≤4 vs. >4 years); race (white vs. non-white participants); age (<40, 41–60, and >60 years); marital status (married vs. not married); wheelchair use (vs. ambulator); insurance coverage (Medicare and Medicaid beneficiaries vs. non-beneficiaries); personal income (<$35,000 vs. ≥$35,000 annually); household income (<$35,000 vs. ≥$35,000 annually); and crystallized cognition (standardized t score ≥40 vs. <40).

Measurement and path structures differed by Social Security beneficiary and current employment status. After accounting for the measurement model variation, we observed a weaker relationship between Systems, Services, and Policies and Social Attitudinal Barriers for those receiving Social Security benefits (−0.676) compared with those not receiving benefits (−0.797). The relationship between Social Attitudinal Barriers and Participation was slightly stronger for those who were unemployed (−0.457) than those who were employed (−0.403). There was no relationship between Physical Environmental Barriers and Information and Technology Access for those who were employed ($p = 0.577$). Finally, there was no relationship between Physical Environmental Barriers and Participation for people with fluid cognition scores below a T score of 40 ($p = 0.976$).

Table 2 Demographic and clinical characteristics of study participants ($N = 545$)

	Total ($N = 545$)	SCI ($N = 190$)	TBI ($N = 166$)	Stroke ($N = 189$)
Age				
Mean (SD) by years	46.8 (16.0)	45.3 (14.0)	38.5 (16.8)	55.5 (12.4)
Age group				
<40	190 (34.9%)	70 (36.9%)	100 (60.2%)	20 (10.6%)
41–60	246 (45.1%)	92 (48.4%)	45 (27.1%)	109 (57.7%)
>60	109 (20.0%)	28 (14.7%)	21 (12.7%)	60 (31.7%)
Gender				
Male	350 (64.2%)	152 (80%)	105 (63.3%)	93 (49.2%)
Female	195 (35.8%)	38 (20.0%)	61 (37.7%)	96 (50.8%)
Ethnicity/race	$N = 541$	$N = 189$	$N = 165$	$N = 187$
White	304 (56.2%)	115 (60.8%)	116 (70.3%)	73 (39.0%)
Non-white	237 (43.8%)	74 (39.2%)	49 (29.7%)	114 (61.0%)
Education				
Below High School	56 (10.3%)	16 (8.4%)	18 (10.8%)	22 (11.6%)
High School or above	489 (89.7%)	174 (91.6%)	148 (89.2%)	167 (88.4%)
Marital status	$N = 506$	$N = 177$	$N = 150$	$N = 179$
Married/in a partnership	171 (33.8%)	62 (35.0%)	48 (32.0%)	61 (34.0%)
Others	335 (66.2%)	115(65.0%)	102 (68.0%)	118 (65.9%)
Employment	$N = 543$	$N = 189$	$N = 166$	$N = 188$
Yes	139 (25.6%)	52 (27.5%)	55 (33.1%)	32 (17.0%)
No	404 (74.4%)	137 (72.5%)	111 (66.9%)	156 (83.0%)
Personal annual income	$N = 448$	$N = 157$	$N = 135$	$N = 156$
<$35,000	346 (77.2%)	119 (75.8%)	103 (76.3%)	124 (79.5%)
≥$35,000	102 (22.8%)	38 (24.2%)	32 (23.7%)	32 (20.5%)
Household annual income	$N = 405$	$N = 142$	$N = 115$	$N = 148$
<$35,000	189 (46.7%)	63 (44.4%)	46 (40.0%)	80 (54.1%)
≥$35,000	216 (53.3%)	79 (55.6%)	69 (60.0%)	68 (45.9%)
Social Security beneficiaries	$N = 540$	$N = 187$	$N = 164$	$N = 189$
Yes	343 (63.5%)	143 (76.5%)	67 (40.9%)	133 (70.4%)
No	197 (36.5%)	44 (23.5%)	97 (59.1%)	56 (29.6%)
Medicare beneficiaries	$N = 540$	$N = 187$	$N = 164$	$N = 189$
Yes	195 (36.1%)	85 (45.5%)	35 (21.3%)	75 (39.7%)
No	345 (63.9%)	102 (54.5%)	129 (78.7%)	114 (60.3%)
Medicaid beneficiaries	$N = 540$	$N = 187$	$N = 164$	$N = 189$
Yes	155 (28.7%)	77 (42.2%)	28 (17.1%)	50 (26.5%)
No	385 (71.3%)	110 (58.8%)	136 (82.9%)	139 (73.5%)
Time since injury	$N = 544$	$N = 190$	$N = 166$	$N = 188$
Mean (SD) by years	7.0 (7.9)	12.1 (10.1)	6.0 (5.5)	2.8 (2.6)
Time since injury group	$N = 544$	$N = 190$	$N = 166$	$N = 188$
≤ 4 years	313 (57.5%)	62 (32.6%)	83 (50.0%)	168 (9.4%)
>4 years	231 (42.5%)	128 (67.4%)	83 (50.0%)	20 (10.6%)
Fluid cognition	$N = 497$	$N = 171$	$N = 157$	$N = 169$
Standardized t score <40	127 (25.6%)	24 (14.0%)	48 (30.6%)	55 (32.5%)
Standardized t score ≥40	370 (74.4%)	147 (86.0%)	109 (69.4%)	114 (67.5%)
Crystallized cognition	$N = 533$	$N = 188$	$N = 163$	$N = 182$
Standardized t score <40	89 (16.7%)	29 (15.4%)	26 (16.0%)	34 (18.7%)
Standardized t score ≥40	444 (83.3%)	159 (84.6%)	137 (84.0%)	148 (81.3%)

Table 2 continued

	Total (N = 545)	SCI (N = 190)	TBI (N = 166)	Stroke (N = 189)
Wheelchair usage	*N = 543*	*N = 190*	*N = 166*	*N = 187*
Wheelchair user	235 (43.3%)	166 (87.4%)	16 (9.6%)	53 (28.3%)
Ambulator	308 (56.7%)	24 (12.6%)	150 (90.4%)	134 (71.7%)

Table 3 Indicators in the initial and final measurement models

Measurement model	Initial indicators	Final indicators
Participation	CPI—Control over Participation	CPI—Control over Participation
	CPI—Importance of Participation	PROMIS—Satisfaction with Participation in SRA
	PROMIS—Satisfaction with Participation in SRA	PROMIS—Ability to Participate in SRA
	PROMIS—Ability to Participate in SRA	PROMIS—Social Isolation
	PROMIS—Social Isolation	
Systems, Services, and Policies	EFIB—Systems, Services and Policies' Health domain	EFIB—Systems, Services and Policies' Health domain
	EFIB—Systems, Services and Policies' Living domain	EFIB—Systems, Services and Policies' Living domain
	EFIB—Systems, Services and Policies' Community domain	EFIB—Systems, Services and Policies' Community domain
	CHIEF—Services domain	
	CHIEF—Policies domain	
Social Attitudinal Barriers	EFIB—Social Environment's Social Facilitators domain	EFIB—Social Environment's Social Facilitators domain
	EFIB—Social Environment's Social Barriers domain	EFIB—Social Environment's Social Barriers domain
	CHIEF—Attitudes domain	CHIEF—Attitudes domain
	HACE—Attitudes domain	
Physical Environmental Barriers	EFIB—Build and Natural Environment	EFIB—Build and Natural Environment
	CHIEF—Physical domain	CHIEF—Physical domain
	HACE—Home mobility domain	
	HACE—Community mobility domain	
Information and Technology Access	EFIB—Access to Information and Technology	EFIB—Access to Information and Technology
	HACE—Transportation domain	
	HACE—Mobility Devices domain	
	HACE—Communication Devices domain	

CPI Community Participation Indicators; *EFIB* Environmental Factors Item Banks; *PROMIS* Patient-Reported Outcomes Measurement Information System; *CHIEF* Craig Hospital Inventory of Environmental Factors; *HACE* Home and Community Environment: *SRA* Social Roles and Activities

Discussion

Relationships between environmental factors and participation

We developed and tested models to describe relationships between environmental factors and participation for community-dwelling adults with TBI, stroke, and SCI. The final model demonstrates adequate fit statistics and a parsimonious solution. It extends our understanding of the relationship between environmental factors and participation in adults with mobility impairments [22]. Our results provide support for social disability model [18] and social determinants of health [19] which describe participation and health outcomes as being influenced by physical, social, and policy factors in the micro-to-macro-environments. Specifically, we found that Information and Technology Access, the physical environment, social attitudes,

Table 4 Fit indices of measurement and structural models

	χ^2	DF	*P* value	RMSEA	CFI	TLI	SRMR
Measurement model							
Initial measurement	622.71	142	<0.001	0.079	0.862	0.833	0.063
Final measurement	289.48	56	<0.001	0.087	0.923	0.893	0.052
Structural model							
Initial conceptual	293.89	57	<0.001	0.087	0.922	0.893	0.052
Final conceptual	291.97	59	<0.001	0.085	0.923	0.898	0.053

DF Degree of Freedom; *RMSEA* Root Mean Square Error of Approximation; *CFI* Comparative Fit Index; *TLI* Tucker-Lewis Index; *SRMR* Standardized Root Mean Square Residual

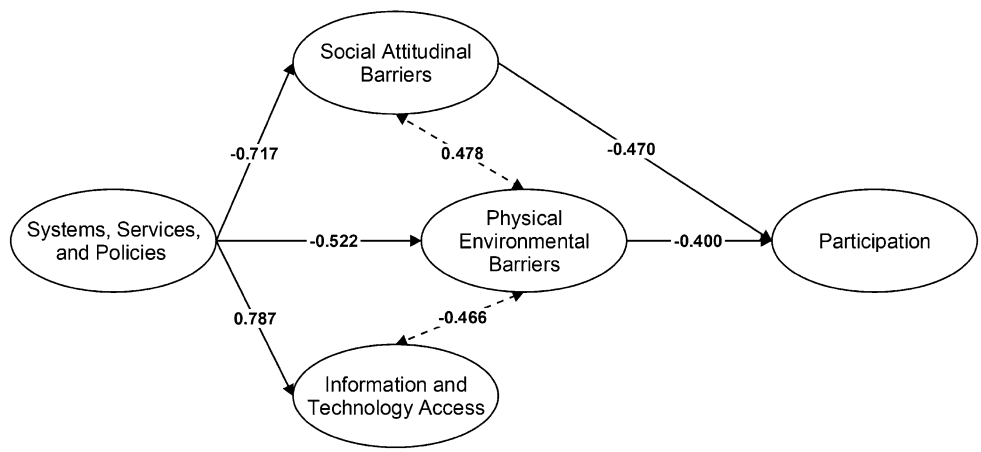

Fig. 2 Final Conceptual Model. All *p* values <0.001; *Solid lines* represent path relationships between two latent variables in which standardized regression coefficients are presented; *Dotted lines* represent correlations between two latent variables in which standardized correlation values are presented; Factor loadings of indicators for each latent variable and error terms are omitted from the figure

Table 5 Standardized factor loadings of final conceptual model

	Estimate	S.E	*p* value
Participation			
CPI—Control over Participation	0.758	0.023	<0.001
PROMIS—Ability to Participate in SRA	0.814	0.023	<0.001
PROMIS—Satisfaction with Participation in SRA	0.775	0.024	<0.001
PROMIS—Social Isolation	−0.760	0.024	<0.001
Systems, Services, and Policies			
EFIB—Systems, Services and Policies' Health domain	0.826	0.019	<0.001
EFIB—Systems, Services and Policies' Living domain	0.865	0.017	<0.001
EFIB—Systems, Services and Policies' Community domain	0.848	0.018	<0.001
Social Attitudinal Barriers			
CHIEF—Attitudes domain	0.467	0.048	<0.001
EFIB—Social Environment's Social Facilitators domain	−0.837	0.033	<0.001
EFIB—Social Environment's Social Barriers domain	−0.717	0.040	<0.001
Physical Environmental Barriers			
EFIB—Build and Natural Environment	0.699	0.046	<0.001
CHIEF—Physical domain	0.510	0.045	<0.001
Information and Technology Access			
EFIB—Access to Information and Technology	0.911	0.007	<0.001

CPI Community Participation Indicators; *EFIB* Environmental Factors Item Banks; *PROMIS* Patient-Reported Outcomes Measurement Information System; *CHIEF* Craig Hospital Inventory of Environmental Factors; *HACE* Home and Community Environment: *SRA* Social Roles and Activities; *S.E.* Standard Error

Table 6 Group invariance testing of final conceptual model

Grouping variable	Metric invariance[a]	Scalar invariance[a]	Residual invariance[a]	Path invariance[a]
Gender (male vs. female)	0.228	0.315	0.933	0.289
Education (Below High School vs. High School or above)	0.421	0.149	0.343	0.164
Race (white vs. non-white)	0.609	**<0.001**	**<0.001**	0.913
Age (<40 vs. 41–60 years)	**0.025**	**<0.001**	**0.002**	0.597
Age (<40 vs. >60 years)	0.094	**<0.001**	**0.044**	0.227
Age (41–60 vs. >60 years)	**0.008**	**<0.001**	0.465	0.320
Diagnosis (SCI vs. TBI)	**0.009**	**<0.001**	**0.019**	0.165
Diagnosis (SCI vs. stroke)	**0.016**	**0.013**	**0.046**	0.066
Diagnosis (TBI vs. stroke)	**0.021**	**<0.001**	0.183	0.407
Marital status (married/in a partnership vs. others)	0.120	**0.002**	0.914	0.782
Social Security benefit (yes vs. no)	0.383	**<0.001**	**0.009**	**0.028**
Time since injury (≤4 vs. >4 years)	0.655	**0.047**	**0.032**	0.211
Wheelchair use (vs. ambulator)	0.161	**<0.001**	**0.001**	0.075
Medicare beneficiaries (yes vs. no)	0.980	**0.032**	0.306	0.639
Medicaid beneficiaries (yes vs. no)	0.261	0.084	**0.019**	0.819
Fluid cognition (standardized *t* score ≥40 vs. <40)	**<0.001**	**0.002**	**<0.001**	**0.021**
Crystallized cognition (standardized *t* score ≥40 vs. <40)	0.893	**0.040**	0.085	0.409
Employment status (employed vs. unemployed)	**<0.001**	**<0.001**	**0.034**	**0.023**
Personal income (<$35,000 vs. ≥$35,000 annually)	0.493	0.327	**0.021**	0.725
Household income (<$35,000 vs. ≥$35,000 annually)	0.618	**0.004**	**0.001**	0.943
TBI severity (mild vs. moderate/severe)	0.315	0.245	0.443	0.153
SCI severity (paraplegia vs. tetraplegia)	0.806	0.256	0.942	0.400

[a] Statistically significant parameters are *bold*; only *p* values were reported, parameters tested and estimates could be shared upon request. Invariance of stroke severity was not tested as the residual variance for Environmental Factors Item Banks (EFIB)—Social Environment's Social Facilitators domain was found to be negative (estimate = −1.607) for the mild stroke subgroup and close to zero (estimate = 0.045) for the moderate stroke subgroup

and systems support have direct and indirect influences on participation in community activities. The model accounted for 63% of the variation in participation indicators.

We found that social environment barriers are associated with reduced participation. The relationship between social attitudes and participation is consistent with previous research, suggesting that barriers created by social attitudes negatively affect participation in education, employment, health care, and the public realm for people with disabilities [47]. Conversely, the availability of a social network provides many kinds of support and promotes social participation and community engagement. Social roles in familial, occupational, and community settings are reinforced through opportunities for engagement, which in turn provide a sense of connection, belonging, and attachment [48].

Limited access to information and technology was associated with greater barriers in the physical environment, which in turn had a direct influence on reduced participation. Previous studies have supported the hypothesis that inaccessible built environments create barriers to participation in major life activities [49]. Technology such as cell phones, computers, web platforms, and internet services enhances access to information that reduces barriers in the physical environment and may enhance participation opportunities. For examples, many web platforms such as the *Access Earth*, *Accomable*, and *Google Maps* data on accessible buildings and locations to help people with disabilities participate.

We found that perceived adequacy of systems, services, and policies has an indirect influence on participation. This relationship is mediated by social and physical environmental factors. Systems and services can affect participation at home, in the community and at work [10]. Physical barriers that affect persons with an acquired neurological disorder include inaccessible entryways, bathrooms, and transportation systems. Attitudinal barriers include negative beliefs about disability and negative reactions to people with disabilities. Social attitudes and interactions are tied to participation choice and control, and ultimately to the inclusion of people with disabilities in society [16]. These findings support civil rights initiatives that seek to enhance participation opportunities by developing policy and systems change strategies to reduce physical and social environment barriers.

The United Nations Convention on the Rights of Persons with Disabilities [50] and WHO's Global Disability Action Plan 2014–2021 [51] are directed toward social determinants of health, which prioritize removing physical, policy, and sociocultural barriers for individuals with disabling conditions. Our results showing relationships between environmental factors and participation among individuals with acquired neurological disorders have implications that support these priorities. Efforts to remove physical environmental barriers, reduce disability-related attitudinal barriers, extend access to information and technology, and inform policy and systems change pertaining to health and rehabilitation services are essential to optimize participation of people with disabilities [8].

Demographic and clinical moderators

Sex, diagnosis, severity/type of injury, education, race, age, marital status, years since injury, wheelchair use, insurance coverage, household incomes, and crystallized cognition were not related to the direction and strength of the relations between environmental factors and participation; therefore, initiatives to reduce environmental barriers may not need address these characteristics. We found statistically significant differences in the final model for Social Security beneficiaries, fluid cognition, and employment status. Further research is needed to understand how to tailor participation interventions for individuals receiving Social Security benefits, who are employed, and who have reduced fluid cognition.

Implications

Healthy People 2020 set goals to support the full inclusion and participation of people with disabilities by removing environmental barriers. Adoption of universal design accessibility principles can help reduce built environment barriers; public education strategies that highlight the contributions of people with disabilities to society should reduce negative attitudes. Empirical support of the environmental factors–participation model suggests ways to target barriers encountered by people with acquired neurological disabilities [13]. Interventions relevant to social support, technology access, public advocacy, and modifications of the built environment are examples of areas of research that could reduce environmental barriers.

Study limitations

The study sample may not be representative of the larger population of people with acquired neurological disorders living in the community. We recruited the sample from three Midwestern cities; thus, the results may not reflect the diverse characteristics of disability populations nationwide and in other settings. The cross-sectional, observational design prevents us from evaluating longitudinal relationships [40, 44]. Associations between environmental factors and participation should not be interpreted as a causal relationship without other supporting evidence. Further, participation outcomes are influenced by a wide range of predictors. SEM only tests the variables selected in a given model; a variety of unmeasured environmental and personal factors could modify the model. Future studies should use longitudinal designs to assess how participation reflects changes in environmental factors, body function, and other personal characteristics. However, the consistency of our findings with previous studies suggests that the associations reported here may reflect a causal influence of environmental factors on participation. Our use of PROMs developed using modern measurement approaches combined with powerful analytic strategies extends evidence of environment–participation relationships.

Conclusion

This study demonstrates the complex interplay between environmental factors and participation of persons with acquired neurological disabilities. The findings support the ADA and United Nations Convention's initiatives to reduce environmental barriers to health and participation of people with acquired neurological disorders and provide guidance on how to promote health in these populations. Healthy People 2020 creates opportunities for disability and public health stakeholders to address environmental factors by developing a knowledge base that promotes the well-being and quality of life for people with disabilities [6].

Acknowledgements The contents do not necessarily represent the policy of the Department of Health and Human Services or the Craig H. Neilsen Foundation. We certify that all financial and material support for this research and work are clearly identified in the title page of the manuscript. The first and last authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. We acknowledge Patrick Semik, BS at the Rehabilitation Institute of Chicago for data management and analysis. Additionally, we would like to acknowledge Megen Devine, MA, and Ojoyi Agbo, BS at Washington University School of Medicine for their editorial assistance.

Funding This study was supported by the National Institute on Disability, Independent Living, and Rehabilitation Research, the Administration on Community Living, the U.S. Department of Health and Human Services to the Rehabilitation Institute of Chicago (Grant No. H133B090024) and to Washington University in St. Louis (Grant No. H133F140037), and by the Craig H. Neilsen Foundation to Washington University in St. Louis (Grant No. 290474).

Compliance with ethical standards

Conflict of Interest All authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Courtney-Long, E. A., Carroll, D. D., Zhang, Q. C., Stevens, A. C., Griffin-Blake, S., Armour, B. S., et al. (2015). Prevalence of disability and disability type among adults—United States, 2013. *Morbidity and Mortality Weekly Report (MMWR), 64*(29), 777–783.
2. World Health Organization (2006). Neurological disorders: public health challenges. http://www.who.int/mental_health/neurology/neurological_disorders_report_web.pdf. Accessed April 8 2017.
3. Centers for Disease Control and Prevention (2017). National Center for Health Statistics. https://www.cdc.gov/nchs/fastats/stroke.htm. Accessed April 8 2017.
4. Taylor, C. A., Bell, J. M., Breidling, M. J., & Xu, L. (2017). Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths—United States, 2007 and 2013. *MMWR Surveillance Summaries, 66,* 1–16.
5. National Spinal Cord Injury Statistical Center (2016). Facts and figures at a glance. https://www.nscisc.uab.edu/Public/Facts%202016.pdf. Accessed April 8 2017.
6. Office of Disease Prevention and Health Promotion (2014). Healthy People 2020. https://www.healthypeople.gov/2020/topics-objectives/topic/disability-and-health. Accessed December 30 2015.
7. National Council on Disability (2015). As the U.S. Celebrates 25th Anniversary of the Americans with Disabilities Act, National Council on Disability Issues Annual Progress Report. https://www.ncd.gov/newsroom/us-celebrates-25th-anniversary-americans-disabilities-act-national-council-disability. Accessed January 18 2015.
8. Gostin, L. O. (2015). The Americans with Disabilities Act at 25: The highest expression of American values. *JAMA, 313*(22), 2231–2235.
9. World Health Organization. (2001). *International Classification of Functioning, Disability and Health-ICF*. Geneva: World Health Organization.
10. Hammel, J., Magasi, S., Heinemann, A., Whiteneck, G., Bogner, J., & Rodriguez, E. (2008). What does participation mean? An insider perspective from people with disabilities. *Disability and Rehabilitation, 30*(19), 1445–1460.
11. Field, M. J., & Jette, A. (2007). *The future of disability in America*. Washington, DC: National Academies Press.
12. Hammel, J., Magasi, S., Heinemann, A., Gray, D. B., Stark, S., Kisala, P., et al. (2015). Environmental barriers and supports to everyday participation: a qualitative insider perspective from people with disabilities. *Archives of Physical Medicine and Rehabilitation, 96*(4), 578–588.
13. Magasi, S., Wong, A., Gray, D. B., Hammel, J., Baum, C., Wang, C.-C., et al. (2015). Theoretical foundations for the measurement of environmental factors and their impact on participation among people with disabilities. *Archives of Physical Medicine and Rehabilitation, 96*(4), 569–577.
14. Heinemann, A. W., Magasi, S., Hammel, J., Carlozzi, N. E., Garcia, S. F., Hahn, E. A., et al. (2015). Environmental factors item development for persons with stroke, traumatic brain injury and spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 96*(4), 589–595.
15. Stiens, S. A., Kirshblum, S. C., Groah, S. L., McKinley, W. O., & Gittler, M. S. (2002). 4. Optimal participation in life after spinal cord injury: Physical, psychosocial, and economic reintegration into the environment. *Archives of Physical Medicine and Rehabilitation, 83,* S72–S81.
16. Hammel, J., Jones, R., Gossett, A., & Morgan, E. (2006). Examining barriers and supports to community living and participation after a stroke from a participatory action research approach. *Topics in Stroke Rehabilitation, 13*(3), 43–58.
17. Whiteneck, G. G., Gerhart, K. A., & Cusick, C. P. (2004). Identifying environmental factors that influence the outcomes of people with traumatic brain injury. *The Journal of head trauma rehabilitation, 19*(3), 191–204.
18. Bronfenbrenner, U. (1999). Environments in developmental perspective: Theoretical and operational models. In S. L. Friedman & T. D. Wachs (Eds.), *Measuring environment across the life span: Emerging methods and concepts* (pp. 3–28). Washington, DC: American Psychology Association Press.
19. Schulz, A., & Northridge, M. E. (2004). Social determinants of health: implications for environmental health promotion. *Health Education & Behavior, 31*(4), 455–471.
20. Lai, J.-S., Hammel, J., Jerousek, S., Goldsmith, A., Miskovic, A., Baum, C., et al. (2016). An Item Bank to Measure Systems, Services, and Policies: Environmental Factors Affecting People with Disabilities. *Archives of Physical Medicine and Rehabilitation, 97,* 2102–2112.
21. Bricout, J. C., & Gray, D. B. (2006). Community receptivity: The ecology of disabled persons' participation in the physical, political and social environments. *Scandinavian Journal of Disability Research, 8*(1), 1–21.
22. Hollingsworth, H., & Gray, D. B. (2010). Structural equation modeling of the relationships between participation in leisure activities and community environments by people with mobility impairments. *Archives of Physical Medicine and Rehabilitation, 91*(8), 1174–1181.
23. Heinemann, A. W., Miskovic, A., Semik, P., Wong, A., Dashner, J., Baum, C., et al. (2016). Measuring environmental factors: Unique and overlapping International Classification Functioning, Disability and Health coverage of 5 instruments. *Archives of Physical Medicine and Rehabilitation, 97*(12), 2113–2122.
24. Williams, D. H., Levin, H. S., & Eisenberg, H. M. (1990). Mild head injury classification. *Neurosurgery, 27*(3), 422–428.
25. Traumatic Brain Injury Model Systems National Data Center (2006). Traumatic Brain Injury Model Systems National Data Base Inclusion Criteria.
26. Kirshblum, S. C., Burns, S. P., Biering-Sorensen, F., Donovan, W., Graves, D. E., Jha, A., et al. (2011). International standards for neurological classification of spinal cord injury (revised 2011). *The Journal of Spinal Cord Medicine, 34*(6), 535–546.
27. Van Swieten, J., Koudstaal, P., Visser, M., Schouten, H., & Van Gijn, J. (1988). Interobserver agreement for the assessment of handicap in stroke patients. *Stroke, 19*(5), 604–607.
28. Bailey, I. L., & Lovie, J. E. (1976). New design principles for visual acuity letter charts. *American journal of optometry and physiological optics, 53*(11), 740–745.

29. Wilkinson, G. S., & Robertson, G. (2006). *Wide Range Achievement Test (WRAT4)*. Lutz, FL: Psychological Assessment Resources.
30. Enderby, P. M., Wood, V. A., Wade, D. T., & Hewer, R. L. (1986). The Frenchay Aphasia Screening Test: a short, simple test for aphasia appropriate for non-specialists. *Disability and Rehabilitation, 8*(4), 166–170.
31. Hahn, E. A., DeVellis, R. F., Bode, R. K., Garcia, S. F., Castel, L. D., Eisen, S. V., et al. (2010). Measuring social health in the patient-reported outcomes measurement information system (PROMIS): item bank development and testing. *Quality of Life Research, 19*(7), 1035–1044.
32. Heinemann, A. W., Magasi, S., Bode, R. K., Hammel, J., Whiteneck, G. G., Bogner, J., et al. (2013). Measuring enfranchisement: Importance of and control over participation by people with disabilities. *Archives of Physical Medicine and Rehabilitation, 94*(11), 2157–2165.
33. Hobart, J. C., Cano, S. J., Zajicek, J. P., & Thompson, A. J. (2007). Rating scales as outcome measures for clinical trials in neurology: problems, solutions, and recommendations. *The Lancet Neurology, 6*(12), 1094–1105.
34. Whiteneck, G. G., Harrison-Felix, C. L., Mellick, D. C., Brooks, C., Charlifue, S. B., & Gerhart, K. A. (2004). Quantifying environmental factors: a measure of physical, attitudinal, service, productivity, and policy barriers. *Archives of Physical Medicine and Rehabilitation, 85*(8), 1324–1335.
35. Keysor, J., Jette, A., & Haley, S. (2005). Development of the home and community environment (HACE) instrument. *Journal of Rehabilitation Medicine, 37*(1), 37–44.
36. Heinemann, A. W., Lai, J.-S., Wong, A., Dashner, J., Magasi, S., Hahn, E. A., et al. (2016). Using the ICF's environmental factors framework to develop an item bank measuring built and natural environmental features affecting persons with disabilities. *Quality of Life Research*. doi:10.1007/s11136-016-1314-6.
37. Garcia, S. F., Hahn, E. A., Magasi, S., Lai, J.-S., Semik, P., Hammel, J., et al. (2014). Development of self-report measures of social attitudes that act as environmental barriers and facilitators for people with disabilities. *Archives of Physical Medicine and Rehabilitation, 96*(4), 596–603.
38. Weintraub, S., Dikmen, S. S., Heaton, R. K., Tulsky, D. S., Zelazo, P. D., Bauer, P. J., et al. (2013). Cognition assessment using the NIH Toolbox. *Neurology, 80*(11 Supplement 3), S54–S64.
39. Casaletto, K. B., Umlauf, A., Beaumont, J., Gershon, R., Slotkin, J., Akshoomoff, N., et al. (2015). Demographically corrected normative standards for the English version of the NIH Toolbox Cognition Battery. *Journal of the International Neuropsychological Society, 21*(05), 378–391.
40. Kline, R. B. (2005). *Principles and practice of structural equation modeling*. New York: Guilford Press.
41. Wang, J., & Wang, X. (2012). *Structural equation modeling: Applications using Mplus*. West Sussex: Wiley.
42. Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. A. Long (Eds.), *Testing Structural Equation Models* (pp. 136–162). Thousand Oaks: Sage Publications.
43. Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55. doi:10.1080/10705519909540118.
44. Weston, R., Gore, P. A., Jr., Chan, F., & Catalano, D. (2008). An introduction to using structural equation models in rehabilitation psychology. *Rehabilitation Psychology, 53*(3), 340–356.
45. Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411–423.
46. Hahn, E. A., Garcia, S. F., Lai, J.-S., Miskovic, A., Jerousek, S., Semik, P., et al. (2016). Measuring Access to Information and Technology: Environmental Factors Affecting Persons With Neurologic Disorders. *Archives of Physical Medicine and Rehabilitation, 97*(8), 1284–1294.
47. Iezzoni, L. I., & Freedman, V. A. (2008). Turning the disability tide: the importance of definitions. *JAMA, 299*(3), 332–334.
48. Berkman, L. F., & Glass, T. (2000). Social integration, social networks, social support, and health. In L. F. Berkman & I. Kawachi (Eds.), *Social epidemiology* (Vol. 1, pp. 137–173). New York: Oxford University Press.
49. Gray, J. A., Zimmerman, J. L., & Rimmer, J. H. (2012). Built environment instruments for walkability, bikeability, and recreation: Disability and universal design relevant? *Disability and Health Journal, 5*(2), 87–101.
50. Lawson, A. (2006). United Nations Convention on the Rights of Persons with Disabilities: New Era or False Dawn? *Syracuse Journal of International Law and Commerce, 34,* 563–619.
51. World Health Organization. (2014). *WHO global disability action plan 2014–2021: better health for all people with disability*. Geneva: World Health Organization.