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Development and Validation of Participation and Positive Psychologic Function Measures for Stroke Survivors

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Abstract

Bode RK, Heinemann AW, Butt Z, Stallings J, Taylor C, Rowe M, Roth EJ. Development and validation of participation and positive psychologic function measures for stroke survivors.

Objective—To evaluate the reliability and validity of Neurologic Quality of Life (NeuroQOL) item banks that assess quality-of-life (QOL) domains not typically included in poststroke measures.

Design—Secondary analysis of item responses to selected NeuroQOL domains.

Setting—Community.

Participants—Community-dwelling stroke survivors (n=111) who were at least 12 months poststroke.

Interventions—Not applicable.

Main Outcome Measures—Five measures developed for 3 NeuroQoL domains: ability to participate in social activities, satisfaction with participation in social activities, and positive psychologic function.

Results—A single bank was developed for the positive psychologic function domain, but 2 banks each were developed for the ability-to-participate and satisfaction-with-participation domains. The resulting item banks showed good psychometric properties and external construct validity with correlations with the legacy instruments, ranging from .53 to .71. Using these measures, stroke survivors in this sample reported an overall high level of QOL.

Conclusions—The NeuroQoL-derived measures are promising and valid methods for assessing aspects of QOL not typically measured in this population.

Keywords

Outcome measures; Quality of life; Rehabilitation; Stroke

As outlined by the World Health Organization, health is “not merely the absence of disease or infirmity.”¹ We define QOL building on the World Health Organization model of health

as a multidimensional concept that refers to a person's usual or expected physical, emotional, and social well-being. To study QOL in the medical context, it is customary to narrow the field of study to areas of life quality that can be related (directly or indirectly) to one's health. However, given the multidimensional nature of QOL, it may be useful to assess targeted life quality domains and domains less directly affected by the medical condition or its treatment. At its broadest, QOL encompasses not only disease symptoms and functional consequences, but also subjective domains, such as life satisfaction, happiness, and the value that one places on life. Patient-reported outcome instruments that assess this range of concepts are being emphasized increasingly in clinical trials and other areas of medicine.^{2,3}

Various measures have been developed to examine the functional status, participation levels, and QOL consequences of stroke. Among the more frequently used generic instruments are the Medical Outcomes Study 36-Item Short Form Health Survey,⁴ SIP,⁵ FIM,⁶ FAI,⁷ NHP,⁸ and LSQ.⁹ However, we know that stroke survivors often report a shift in social roles as a consequence of their event.¹⁰ As such, for stroke survivors, the social aspect of QOL may be captured better by using a specific measure of social support or participation. Most stroke survivors must depend on others for everyday activities.¹¹ Therefore, social relationships are critical to survival for stroke patients and become of critical importance to QOL.^{12,13} QOL assessment of stroke survivors arguably should include measurement of social participation, social roles, and more general positive psychologic function. Measures that do not directly address these aspects of functioning may be missing 1 of the most important dimensions of QOL for stroke patients.^{14,15} Most instruments consist of fixed-item surveys developed before the widespread adoption of modern measurement approaches, such as IRT.¹⁶ IRT approaches apply rigorous criteria in evaluating the measurement properties of individual items, allowing for an empirical understanding of how well items assess a concept along the continuum.

Funded by the National Institute of Neurological Disorders and Stroke, the NeuroQOL project seeks to develop a new generation of specifically tailored IRT-derived QOL instruments. NeuroQOL was designed to provide new insights into the burden of neurologic disorders, including stroke, and to standardize the assessment of QOL. NeuroQOL instruments are derived from item banks, which are scaled collections of survey items that measure the same underlying trait based on results of psychometric analysis. Because calibrated item banks provide information about the psychometric properties of individual items (as opposed to entire scales in traditional test construction), they can be used to create static short forms and CATs. An IRT-informed short form is a reduced-item version of an item bank, created on the basis of a specific assessment need (eg, inclusion of items that cover a broad range of the symptom or trait in question or for purposes of fine discrimination for a specific range). Given a calibrated bank of discriminating items of varying difficulty levels, it is possible to develop a computerized algorithm that systematically administers items to examinees to hone in on their scores. At each item administration, the algorithm estimates the examinee symptom/trait level and an associated SE, selecting the next item on the basis of the response to the previous item. When the SE achieves an acceptable level, the CAT is terminated, producing a patient's score range.^{16,17} Although CAT assessments are only starting to emerge in clinical applications, they are an exciting proposition for future research. CAT-administered assessments on average are half as long as paper-and-pencil measures, with equal or better precision.¹⁸⁻²⁰ As such, short forms and CAT applications allow for briefer more efficient assessments and assessment of more symptoms and domains of interest.

The goals of the present study were to examine NeuroQOL item banks measuring relevant domains typically not assessed with stroke survivors and evaluate their internal and external construct validity using a sample of stroke survivors after rehabilitation.

Methods

Participants

We recruited participants from the pool of stroke patients who were admitted for inpatient rehabilitation at the Rehabilitation Institute of Chicago between 1993 and 2007. A research registry covering discharges from 1993 to 2000 was used to identify 780 stroke survivors. This sample was supplemented by 912 stroke survivors who had been discharged from 2001 to 2007. Excluded from both samples were non-English speakers and persons with severe cognitive deficits or medical conditions that impaired the ability to participate in this study. Surveys were mailed to 1692 subjects. The Institutional Review Board of Northwestern University's Feinberg School of Medicine approved the protocol.

Description and Benefits of Item Banks

The building of an item bank begins with the development of a pool of items hypothesized to measure a particular trait. Items in these pools are administered to a sample of people who are representative of the population for which the bank is intended. Responses to the items are analyzed to assess their fit to a psychometric model. Items that fit the model constitute an item bank that then can be used to develop CAT platforms or multiple short forms using optimally informative sets of items. Regardless of the specific items from the bank selected for CAT or short forms, scores are on the same metric, allowing for comparisons across respondents.

Before the development of item banks, only fixed-item forms were used to assess QOL. Items in these instruments generally were selected to cover a wide range of the construct being measured, and it typically was necessary to administer all items of the survey to generate a scale score. To achieve greater reliability, fixed forms often were longer, thereby increasing respondent burden. In contrast, using IRT-optimized CAT or short forms, one can reduce respondent burden without sacrificing reliability.

Instruments

The NeuroQOL item banks are designed for use in clinical practice, trials, and neurologic research to assess concepts common to selected conditions. Six phases of NeuroQOL item development have been documented: identification of extant items, item classification and selection, item review and revision, focus group input on domain coverage, cognitive interviews with patients regarding their understanding of individual items, and final revision before field testing. Identification of items refers to the systematic search for existing questions in currently available scales. Expert item review and revision were conducted by trained professionals who reviewed the wording of each question and revised as appropriate for conventions adopted by the NeuroQOL group. Focus groups were asked to confirm domain definitions and identify new areas of item development. Cognitive interviews were used to examine individual items. Items that completed this process were sent to field testers and were evaluated psychometrically for inclusion in item banks or targeted scales for NeuroQOL. Based on input from patients, experts, and the published literature, NeuroQOL focused its efforts on the development of patient-reported outcomes of pain, fatigue, emotional distress, physical function, and social function. (For further information about the Neuro-QOL initiative, please visit <http://www.neuroqol.org>.)

The specific NeuroQOL domains selected for study were identified by stroke survivors and caregivers as reflecting important aspects of their QOL.¹⁰ Developing validated QOL item banks for stroke patients ensures that item content is relevant to this large and growing population, investigators have reliable and valid QOL endpoints for clinical trials, and clinicians have instruments that are sensitive to change during the course of clinical

encounters. Included in this study were (1) ability to participate in social activities (59 items); (2) satisfaction with participation in social activities (28 items); and (3) positive psychologic function (27 items). Ability to participate and satisfaction with participation are subdomains of social function, which is defined as involvement in and satisfaction with one's usual social roles in life's situations and activities. These roles may exist in marital relationships, parental responsibilities, work responsibilities, and social activities. Positive psychologic functioning embodies aspects of a person's QOL that relate to a sense of well-being, satisfaction with life, or overall sense of purpose or meaning. For the ability to participate and positive psychologic function items, stroke survivors rated items on a 5-point scale (never to always). The satisfaction-with-participation items also were rated on a 5-point scale (not at all to very much). For all domains, higher scores indicated better outcomes.

Four legacy instruments were administered. The FIM⁶ was designed to describe severity of functional limitations and the need for assistance. It assesses function on a 7-point scale that ranges from total assistance to complete independence, with higher scores indicating more functional independence. Interrater reliability evidence is excellent when raters are accredited to use the instrument consistently.²¹ Heinemann et al²² found that the FIM could be scaled as 2 interval measures: motor (self-care, sphincter management, mobility, locomotion) and cognitive (communication, social cognition). Only the 13 FIM motor items were administered in this study. The telephone-administered version of the FIM shows excellent psychometric properties for monitoring functional status in the community.²³

The FAI is a stroke-specific instrument used to assess instrumental activities of daily living,⁷ with higher scores indicating better performance of instrumental activities of daily living. This questionnaire consists of 15 multiple-choice questions about how often a person performs specific activities. Reliability is good ($>.60$ for 11 of 15 items).²⁴ The internal consistency reliability of the unweighted scores is adequate ($=.78-.87$), and construct validity is supported by significant correlations between the FAI and scores on the Barthel Index and SIP.

The NHP is a generic health-related QOL measure used to evaluate perceived distress.⁸ It is composed of 38 true/false questions that address aspects of physical and emotional health, with lower scores indicating better outcomes. It is a frequently used measure for patients with neurologic disorders that is quick to administer and has good test-retest reliability ($=.80$).²⁵ However, von Steinbuechel et al²⁶ noted that this measure requires further validation for use with people with stroke.

The LSQ originally was developed to measure perceived QOL in women with breast cancer.⁹ Subsequently, the LSQ has been used with various general and patient populations, including former stroke patients.²⁷ It is brief and shows good internal consistency reliability ($=.89$).^{9,28} The present study used a 10-item short form, with higher scores indicated more life satisfaction.

Procedures

We mailed invitation letters to former stroke rehabilitation inpatients. Patients were asked to provide written consent if they were interested in participating in the study and to return a signed consent form. Research staff then contacted the patient by telephone to schedule a time to complete the interview. Interviews were conducted by telephone or in person, or materials were mailed to the participant. Interviews typically required 45 to 90 minutes. Participants received a \$25 gift card to a local grocery store as an incentive.

Analysis

We completed psychometric analyses to produce interval-level measures for the scores on the 3 NeuroQOL domains and 4 legacy instruments. We used the Rasch²⁹ model because of its suitability with small samples. Most instruments used a rating scale; thus, we specified a rating scale analysis³⁰ model that also is appropriate for the 1 instrument (NHP) that consists of dichotomous items. First, we used Winsteps^a software to assess dimensionality by using residual PCA, and then calibrated the unidimensional items to assess fit to the Rasch model. The first consideration was whether the set of items measured a single or multiple dimensions. Unless the items measure a single dimension, scores cannot be interpreted meaningfully. Residual PCA was conducted to determine whether there was sufficient evidence to consider the item sets to be unidimensional. This residual PCA examines patterns in residuals after removing the Rasch measure (treated as the first dimension) and contrasts the items with positive and negative residuals. The existence of secondary dimensions is based on the amount of unexplained variance that is explained by these contrasted residuals, and the labels attached to potential secondary dimensions are based on the content of the contrasted items. Although the residual PCA is indicative, but not definitive, about the existence of secondary dimensions, item sets were considered unidimensional if the Rasch measure explained more than 60% of the unexplained variance and the eigenvalue for the first and subsequent contrasts was less than 3.0.³¹ When these criteria were not met, results were examined to determine whether meaningful multiple dimensions could be discerned, necessitating the development of separate banks for each identified dimension. The possibility of multiple dimensions was addressed by correlating measures obtained from splitting the items into the potential dimensions suggested by the residual contrasts. High correlations would suggest there was no evidence of multiple dimensions, but that these distinctions were trivial in nature and not meaningful in their effect.

We used several statistics from the rating scale analysis to describe measurement properties of the instruments, such as person and item separation reliability to describe the instruments' overall measurement quality (values $>.80$ are considered evidence of acceptable quality). Fit to the Rasch model was assessed by comparing observed responses with responses that would have been expected if the items fit the Rasch model, similar in concept to chi-square statistics. Infit and outfit mean square statistics were used to identify items that fit the Rasch model (values $>.70$ and <1.40 are considered evidence of acceptable fit).³²

We compared averages for the person and item measures to describe the performance of the sample on these instruments, with positive values indicating higher levels of the trait and negative values indicating lower levels. Using the interval measures from these calibrations, we used descriptive statistics to characterize the measures and Pearson product moment correlations to describe the relationships between the bank and legacy measures. Evidence of construct validity was assessed assuming the following relationships: (1) ability to participate is strongly and positively related to motor function (measured using the FIM), moderately and positively related to activity performance (measured using the FAI), and strongly and negatively related to health limitations (measured using the NHP); (2) satisfaction with participation is moderately and positively related to activity performance and ability to participate and strongly and positively related to general life satisfaction (measured using the LSQ); and (3) positive psychologic function is positively related to general life satisfaction and moderately and positively related to satisfaction with participation.

Results

Sample Demographic Characteristics

Of 1692 patients to whom we mailed recruitment materials, 111 agreed to participate and completed an interview. Those who were not enrolled were dead ($n=538$), refused to participate ($n=154$), met exclusion criteria ($n=30$), or could not be contacted by mail after extensive Internet searches ($n=859$). Many of the unlocated former patients may be dead or reside in institutional settings. Average $\pm$ SD age of participants was 65.7 ± 15.9 years, 55% of the sample were women, 58% were married, 16% were widowed, and 13% each were single or divorced. Of the participants, 75% self-reported as white; 17%, as black; and 8%, as Hispanic, Asian, or other races. Average time since discharge from inpatient rehabilitation was 5.9 ± 3.4 years. During that time, 52% of participants were rehospitalized and 8% reported another stroke. When interviewed, 99% were living at home and 41% were living with a spouse, housemate, or caregiver. Descriptive statistics for the new and legacy measures are listed in table 1.

Dimensionality of New Instruments and Legacy Measures

Ability to participate—The residual PCA showed evidence of multidimensionality, with the Rasch measure accounting for 55.6% of the variance and an eigenvalue of 6.6 for the first (and largest) residual contrast. Items measuring social role participation contrasted with items measuring social activity participation. For social role participation, the Rasch measure accounted for 64% of the variance, with an eigenvalue of 3.1 for the first residual, and for social activity participation, the Rasch measure accounted for 56% of the variance, with an eigenvalue of 2.0 for the first contrast. Correlations between items with positive and negative residuals in the first contrast were .84 for social role participation and .89 for social activity participation.

Satisfaction with participation—The residual PCA results showed evidence of multidimensionality, with the Rasch measure accounting for 59.7% of the variance and an eigenvalue of 4.4 for the first (and largest) residual contrast. The distinction was between items measuring social role satisfaction and items measuring social activity satisfaction. For social role satisfaction, the Rasch measure accounted for 65.5% of the variance, with an eigenvalue of 2.6 for the first residual, and for social activity satisfaction, the Rasch measure accounted for 57.2% of the variance, with an eigenvalue of 2.3 for the first contrast. Correlations between items with positive and negative residuals in the first contrast were .83 for social role satisfaction and .81 for social activity satisfaction.

Positive psychologic function—The residual PCA results, with the Rasch measure accounting for 53.4% of the variance and an eigenvalue of 3.2 for the first (and largest) residual contrast, suggest 2 dimensions that correspond to cognitive and affective components of well-being, but the evidence for the second dimension was weak. The first dimension had a common theme of life satisfaction, purpose, and meaning that involves subjective appraisal of one's life. The second dimension included items focused on positive mood states. Correlation between items with positive and negative residuals in the first (and largest) contrast was .80.

Legacy measures—For activity performance (measured using the FAI), the residual PCA results (Rasch measure explaining 51.7% of the variance and an eigenvalue of 2.3 for the first residual contrast) suggested 2 dimensions related to domestic and social activities. For general life satisfaction (measured using the LSQ), the residual PCA results (Rasch measure explaining 43.8% of the variance and an eigenvalue of 1.9 for the first residual contrast) suggested 2 dimensions related to family and work/leisure satisfaction. For health

limitations (measured using the NHP), the residual PCA results (Rasch measure explaining 28.6% of the variance and an eigenvalue of 3.6 for the first residual contrast) suggested multiple dimensions. For motor function (measured using the FIM motor), the residual PCA results (Rasch measure explaining 64.8% of the variance and an eigenvalue of 2.2 for the first residual contrast) suggested 2 dimensions, but the item subsets did not distinguish self-care versus mobility.

Calibration of New Instruments and Legacy Measures

For the calibration, we used all NeuroQOL positive psychologic function and ability-to-participate items and the positively worded satisfaction-with-participation items. Results of these analyses are listed in table 1. Item statistics for each bank are listed in Appendix 1. Within each bank, items are listed in their order of difficulty, with items more difficult to endorse listed first and those less difficult to endorse listed last.

Ability to participate—Four items misfit and were deleted from the subsequent analyses. We assessed model fit separately for items based on the hypothesized factors on which they loaded and developed separate banks for each subdomain. For the 23 social-role-participation items, model fit was good despite marginal misfit in 2 items (trouble meeting family needs mean squares, infit= 1.48 and outfit= 1.97; run errands without difficulty mean squares, infit=1.49 and outfit=1.79), and for the 32 social-activity-participation items, model fit was good despite marginal misfit in 1 item (do hobbies for shorter time mean squares, infit=1.49 and outfit=2.03).

Item difficulty estimates are shown for items at 3 difficulty levels (easy, average, and hard) and at 3 points in the rating scale (lowest, middle, and highest category).

Satisfaction with participation—One item showed misfit and was deleted from subsequent analyses. We assessed model fit separately for items based on the hypothesized factors on which they loaded and developed separate banks for each subdomain. For the 15 social-role-satisfaction items, model fit was good despite 1 misfitting item (run errands without difficulty mean squares, infit= 1.61 and outfit= 1.43), and for the 13 social-activity-participation items, model fit was good and no items misfit.

Positive psychologic function—We assessed model fit for all 27 positive psychologic function items. Model fit was good despite 3 marginally misfitting items (happy about future mean squares, infit=1.49 and outfit=1.40; sense of purpose in life mean squares, infit= 1.50 and outfit=1.48; and see humor in situations mean squares, infit=1.48 and outfit= 1.37).

Legacy measures—When FAI items were calibrated together, model fit for this sample was acceptable despite 1 misfitting item (pursuing hobbies mean squares, infit= 1.61 and outfit =1.46). When LSQ items were calibrated together, model fit for this sample was marginal, but no item misfit. In this sample, model fit for the NHP was acceptable and all items fit the Rasch model. When FIM motor items were calibrated together, model fit for this sample was marginal and 3 items misfit (bathing mean squares, infit=1.43 and outfit=0.89; grooming mean squares, infit=1.53 and outfit=0.93; and walk/wheelchair locomotion mean squares, infit=1.65 and outfit=1.97).

Construct Validity

Correlation coefficients between the 5 NeuroQOL measures and legacy measures are listed in table 2. Evidence of construct validity was found in the following results:

1. Ability to participate. Both ability-to-participate measures (social role participation and social activity participation) were related positively to motor function and activity performance and negatively to health limitations. Ability to participate was more highly related to activity performance than we expected.
2. Satisfaction with participation. Both satisfaction-with-participation measures (social role satisfaction and social activity satisfaction) were related positively to general life satisfaction and activity performance. Satisfaction with participation was more highly related to ability to participate than we expected.
3. Positive psychologic function. Positive psychologic function was related positively to general life satisfaction and both satisfaction-with-participation measures.

Discussion

In this study, we built 5 item banks that described aspects of the QOL of stroke survivors who were at least 1 year postrehabilitation. Our original intent was to develop 2 measures of participation: ability to participate and satisfaction with participation. However, in both domains, social role items loaded separately from social activity items. We therefore developed separate banks for the social role and social activity items and treated them as subdomains. This finding is consistent with other research in which similar items loaded on these 2 factors.³³ Given the results of dimensionality analyses, we believed that no further delineation of constructs was necessary. The relationship of the subdomain measures was strong ($r = .85$ for ability and $r = .87$ for satisfaction). Thus, it appears that these are separate but related constructs for stroke survivors.

In both ability-to-participate subdomains, a general construct was defined by the item hierarchies, varying by the extent of involvement outside the home. For social role participation, stroke survivors were more likely to be able to fulfill family responsibilities and less likely to be able to work. For social activity participation, stroke survivors were more likely to be able to do what was expected and less likely to be able to perform tasks outside of the home.

The 2 satisfaction-with-participation constructs were similarly defined by their item hierarchies. For social role satisfaction, stroke survivors were more likely to be satisfied with being able to do things for others and less likely to be satisfied with their ability to work. For social activity satisfaction, stroke survivors were more likely to be satisfied with their ability to do things for fun at home and less likely to be satisfied with their ability to do things for fun outside the home.

The item hierarchy also described a positive psychologic function construct. Items representing high levels of the trait reflect healthy coping, and those representing low levels of the trait indicate a change in goals as a result of complications secondary to stroke. Similar to survivors of trauma, persons who survive stroke may have the assumptive foundations of their world view disrupted.³⁴ People may cope effectively with adverse events and endorse the easier items because they are managing the short-term impact on their life effectively, but have yet to come to terms with the long-term consequences. The 2 positive psychologic function secondary dimensions correspond generally to cognitive and affective components of well-being. The first dimension has a common theme of life satisfaction, purpose, and meaning that involves a subjective appraisal of one's life, and the second focuses on positive feeling states. This distinction is consistent with research by Diener et al,³⁵ among others, on subjective well-being, which posits separate but related components to subjective well-being; low negative affect, high positive affect, and high life satisfaction.

Evidence of external construct validity was found in that scores for these domains were related to external criteria in the expected direction and essentially in the expected magnitude. To be able to participate in social activities, people need adequate physical function and to be free of substantial health limitations. Those relationships were supported in this sample. However, activity performance was not as different from ability to participate as we expected. We expected that people could be satisfied with their participation even though their activity performance and ability to participate were not high. Positive psychologic function was related equally to general and specific life satisfaction measures, although we expected the relationship to be stronger with general life satisfaction.

During stroke rehabilitation, short-term goals focus on reducing impairment and increasing function. Stroke recovery does not end at discharge from rehabilitation programs. Measuring the social participation of stroke survivors can provide useful insights on their ability to resume their previous level of social activity, a long-term rehabilitation goal of many persons with stroke.³⁶

Carefully constructed item banks allow for the selection of a smaller set of items that provide useful information while reducing respondent burden. Short forms are developed for this purpose. Short forms avoid repetition in item content and can maintain respondents' engagement. As currently constituted, these item banks are well suited to the development of short forms in that they show evidence of good reliability (see table 1), meet the requirements of the Rasch model, and measure the intended constructs. However, this study needs to be replicated on a larger sample to ensure generalizability to the stroke survivor population.

Study Limitations

Study limitations include recruitment of participants from a single inpatient rehabilitation hospital and exclusion of persons who had relocated and were lost to contact. However, the hospital serves a diverse community and its catchment areas include low-, moderate-, and high-income communities. The sample represents a unique subset of persons receiving inpatient rehabilitation in that they were alive an average of 6 years poststroke and had a sufficient level of communicative and cognitive function to participate in a telephone interview. Although there is little evidence of multidimensionality in the final banks, a marginal level of misfit to the Rasch model is present. Replication in a larger sample would confirm if this misfit persists or was solely a factor with this particular sample. Regarding the choice of the LSQ, it is used infrequently in stroke studies; better established stroke-specific QOL measures would be preferable.

Conclusions

In summary, we calibrated item banks for 5 QOL components not typically assessed in a stroke population. A single bank was developed for the positive psychologic function domain. However, because of multidimensionality in the ability-to-participate and satisfaction-with-participation domains, we developed separate banks for these subdomains. These NeuroQOL item banks are promising measures for assessing various aspects of QOL with good internal and external construct validity.

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Appendix 1

Rasch Item Statistics

Social Activity Participation					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
51. I am going out for entertainment less often than usual	.63	1.21	1.4	1.20	1.1
21. I am able to do all of the community activities that I want to do	.54	1.12	0.9	1.13	0.8
30. I have to limit the things I do for fun outside my home	.53	0.98	-0.1	1.12	0.7
23. I have to do my hobbies or leisure activities for shorter periods of time than usual for me	.39	1.49	3.1	2.05	4.7
31. I am doing fewer social activities with groups of people than usual for me	.36	1.14	1.0	1.23	1.3
24. I have to limit social activities outside my home	.35	1.21	1.5	1.16	0.9
26. I am able to participate in recreational activities	.34	1.18	1.3	1.38	2.0
53. Has your health interfered with your social activities?	.32	0.72	-2.1	0.70	-1.8
54. How much of the time has your health interfered with your social activities?	.29	0.71	-2.2	0.68	-1.9
52. I have to limit my social activity because of my health	.26	0.98	-0.1	0.89	-0.6
59. Were you limited in pursuing your hobbies or other leisure time activities?	.26	0.82	-1.3	0.72	-1.6
13. I feel limited in my ability to visit friends	.17	1.11	0.8	1.13	0.8
29. I am able to go out for entertainment as much as I want	.16	1.09	0.6	1.15	0.9
19. I have to limit my hobbies or leisure activities	.11	0.95	-0.3	0.88	-0.6
27. I can do all the leisure activities that I want to do	.06	0.88	-0.8	0.86	-0.7
28. I am able to do all of the community activities that people expect me to do	.06	1.24	1.6	1.17	0.9
50. I have to limit my family activity because of my health	.04	1.06	0.5	1.05	0.3
20. I am able to do my hobbies or leisure activities	-.05	0.73	-2.0	0.83	-0.8
14. I am able to do all of the activities with friends that I want to do	-.09	0.61	-3.1	0.56	-2.6
10. I have to limit my regular activities with friends	-.11	0.93	-0.4	0.92	-0.3
6. I am able to do all of the family activities that I want to do	-.12	1.36	2.4	1.61	2.7
4. I have to limit my regular family activities	-.12	0.92	-0.6	1.08	0.5
9. I am able to do all of my regular activities with friends	-.18	0.80	-1.5	0.78	-1.1

Social Activity Participation					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
18. I am able to do all of my regular leisure activities	-.24	0.87	-0.9	0.93	-0.3
22. I am able to do all of the leisure activities that people expect me to do	-.27	0.99	0.0	0.93	-0.3
3. I am able to do all of my regular family activities	-.30	0.98	-0.1	0.97	-.01
17. I can keep up with my social commitments	-.38	0.57	-3.6	0.97	0.0
Social Activity Participation (Cont'd)					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
12. I am able to do all of the activities with friends that people expect me to do	-.43	1.00	0.1	1.30	1.3
25. I have trouble keeping in touch with others	-.58	1.35	2.2	1.11	0.5
8. I am able to socialize with my friends	-.61	1.07	0.5	2.23	4.0
5. I am able to do all of the family activities that people expect me to do	-.63	1.11	0.8	1.52	2.0
7. I am able to maintain my friendships as much as I would like	-.76	1.01	0.1	0.96	-0.1
Social Role Participation					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
55. Health interferes with my ability to work (include work at home)	.67	1.13	0.9	1.27	1.3
43. I have to do my work for shorter periods of time than usual for me (include work at home)	.66	1.40	2.4	1.57	2.4
42. I am limited in doing my work (include work at home)	.56	0.82	-1.2	0.69	-1.6
49. I have to do my work for shorter periods of time than usual for me	.54	1.20	1.2	1.29	1.3
58. Were you limited in doing either your work or other daily activities?	.54	0.86	-0.9	0.79	-1.0
33. I am able to run errands without difficulty	.42	1.49	2.9	1.79	3.2
47. I am limited in doing my work	.30	0.47	-4.3	0.41	-3.5
39. I can do everything for work that I want to do (include work at home)	.27	0.86	-1.0	0.79	-1.0
37. I am accomplishing as much as usual at work for me (include work at home)	.26	0.76	-1.7	0.74	-1.3
46. I am able to do all of my usual work	.00	0.77	-1.6	0.70	-1.4
56. I have trouble doing my regular daily work around the house	.00	0.62	-2.9	0.58	-2.1
35. I am able to do all of my usual work (include work at home)	-.10	0.64	-2.7	0.58	-2.1
34. I can keep up with my work responsibilities (include work at home)	-.10	0.96	-0.2	0.86	-0.6
40. I have trouble doing my regular daily chores/tasks	-.12	0.70	-2.1	0.63	-1.8

Social Activity Participation					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
11. I can do everything for my friends that I want to do	-.13	1.08	0.6	1.55	2.2
57. I have trouble meeting the needs of my friends	-.17	1.24	1.5	2.37	4.3
41. I am able to do all of the work that people expect me to do (include work at home)	-.21	1.25	1.6	1.53	2.0
38. My ability to do my work is as good as it can be (include work at home)	-.23	1.18	1.2	1.07	0.4
36. I have trouble taking care of my regular personal and household responsibilities	-.28	0.85	-1.0	0.74	-1.1
48. I am able to do all of the work that people expect me to do	-.28	0.96	-0.2	0.76	-0.9
2. I have trouble meeting the needs of my family	-.76	1.48	2.7	1.97	2.7
1. I can keep up with my family responsibilities	-.92	1.19	1.1	1.64	1.8
32. I am able to perform my daily routines	-.93	1.38	2.1	2.61	3.7
Social Activity Satisfaction (Cont'd)					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
12. I am satisfied with my ability to do all of the community activities that are really important to me	.55	1.40	2.5	1.57	3.0
25. I am satisfied with my ability to work	.40	1.35	2.2	1.29	1.6
14. I am satisfied with my ability to do things for fun outside my home	.37	1.31	2.0	1.33	1.9
Social Activity Satisfaction (Cont'd)					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
8. I am satisfied with the amount of time I spend visiting friends	.17	1.24	1.6	1.31	1.8
15. I am satisfied with my current level of social activity	.14	0.85	-1.1	0.89	-0.7
26. I am satisfied with my level of activities with my friends	.13	0.71	-2.2	0.71	-1.8
11. I am satisfied with my ability to do all of the leisure activities that are really important to me	-.08	0.79	-1.5	0.80	-1.2
7. I am satisfied with my current level of activities with my friends	-.10	0.70	-2.3	0.71	-1.9
13. I am satisfied with the amount of time I spend doing leisure activities	-.10	0.77	-1.7	0.78	-1.4
28. I am able to maintain my friendships as much as I would like	-.20	1.06	0.4	0.96	-0.2
10. I am satisfied with my ability to do leisure activities	-.31	0.92	-0.5	0.95	-0.2
4. I am satisfied with my current level of activity with family members	-.35	0.89	-0.8	0.80	-1.1

Social Activity Participation					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
9. I am satisfied with my ability to do things for fun at home (like reading, listening to music, etc)	-.62	1.04	0.3	1.54	2.4
Social Role Satisfaction					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
16. I am satisfied with my ability to run errands	1.01	1.61	3.5	1.43	1.9
18. I am satisfied with my ability to work (include work at home)	.34	1.06	0.4	1.48	2.2
22. I am satisfied with how much of my work I can do (include work at home)	.26	1.04	0.3	1.25	1.2
21. I am satisfied with my ability to do household chores/tasks	.18	0.76	-1.7	0.74	-1.4
19. I am satisfied with my ability to do the work that is really important to me (include work at home)	.15	0.77	-1.6	0.68	-1.8
24. I am satisfied with the amount of time I spend performing my daily routines	.14	1.18	1.2	1.06	0.4
23. I am satisfied with the amount of time I spend doing work (include work at home)	.13	0.95	-0.3	0.98	0.0
20. I am satisfied with my ability to do regular personal and household responsibilities	.03	0.97	-0.1	1.01	0.1
6. I am happy with how much I do for my friends	-.18	1.19	1.2	1.46	2.1
5. I am satisfied with my ability to do things for my friends	-.18	0.81	-1.2	0.88	-0.6
17. I am satisfied with my ability to perform my daily routines	-.26	0.82	-1.2	0.78	-1.1
27. I am satisfied with my current level of family activity	-.29	1.24	1.5	1.40	1.8
3. I am satisfied with my ability to do things for my family	-.38	0.80	-1.3	0.73	-1.4
2. I am satisfied with my ability to meet the needs of those who depend on me	-.41	0.90	-0.6	0.99	0.0
1. I feel good about my ability to do things for my family	-.55	1.01	0.1	1.36	1.6
Positive Psychologic Function (Cont'd)					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
23. In most ways, my life was close to my ideal	1.42	1.02	0.2	1.08	0.6
1. I felt happy about the future	.60	1.49	3.1	1.40	2.2
16. I had a sense of balance in my life	.51	0.84	-1.1	0.87	-0.7
3. I felt a sense of purpose in my life	.50	1.50	3.1	1.48	2.5
21. I was living life to the fullest	.44	1.18	1.2	1.10	0.6
25. I had good control of my emotions	.19	1.14	1.0	1.43	2.1
15. My life was satisfying	.17	0.64	-2.7	0.60	-2.4

Social Activity Participation					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
9. I was able to relax	.15	0.91	−0.6	0.87	−0.6
Positive Psychologic Function (Cont'd)					
Item	Measure	Infit MnSq	Infit Zstd	Outfit MnSq	Outfit Zstd
22. I felt cheerful	.15	0.84	−1.0	0.90	−0.5
18. My life was peaceful	.14	1.20	1.3	1.14	0.8
5. I was able to be at ease and feel relaxed	.11	0.90	−0.6	0.89	−0.5
7. Many areas of my life were interesting to me	.11	1.13	0.9	1.09	0.5
14. I had a sense of well-being	.09	0.65	−2.6	0.57	−2.5
20. My life had purpose	.08	1.00	0.1	0.87	−0.6
2. I was able to enjoy life	.00	0.83	−1.2	1.17	0.9
17. My life had meaning	−.01	0.83	−1.2	0.70	−1.6
11. I felt confident	−.07	0.78	−1.6	0.78	−1.1
12. I felt hopeful	−.07	0.78	−1.5	0.70	−1.6
10. I felt lovable	−.09	1.21	1.4	1.14	0.7
6. I looked forward with enjoyment to upcoming events	−.18	0.96	−0.2	1.18	0.9
13. I had a good life	−.24	0.89	−0.7	0.73	−1.3
8. I felt emotionally stable	−.25	0.96	−0.2	1.49	2.0
24. I had good control of my thoughts	−.41	1.17	1.1	1.00	0.1
26. Even when things were going badly, I still had hope	−.62	0.81	−1.2	0.93	−0.2
4. I could laugh and see the humor in situations	−.82	1.48	2.7	1.37	1.3
27. I felt loved and wanted	−.93	1.11	0.7	1.19	0.7
19. My life was worth living	−.98	0.81	−1.2	0.52	−1.8

Abbreviations: MnSq, mean square; Zstd, standardized z score.

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List of Abbreviations

CAT	computerized adaptive test
FAI	Frenchay Activities Index
IRT	informed response theory
LSQ	Life Satisfaction Questionnaire
NeuroQOL	Neurologic Quality of Life
NHP	Nottingham Health Profile
PCA	principal component analysis
QOL	qualityoflife
SIP	Sickness Impact Profile

Table 1
Descriptive Statistics

Variable	N	Mean $\pm$ SD	Reliability	
			Person	Item
Neuro-QOL domains				
Social role participation	111	0.95 $\pm$ 1.88	.86	.93
Social activity participation	111	0.95 $\pm$ 1.74	.88	.90
Social role satisfaction	111	1.09 $\pm$ 2.29	.87	.88
Social activity satisfaction	111	0.91 $\pm$ 2.00	.85	.85
Positive psychologic function	111	1.83 $\pm$ 1.64	.89	.92
Legacy measures				
NHP *	111	- 1.57 $\pm$ 1.48	.83	.92
FAI	111	0.09 $\pm$ 0.82	.84	.97
LSQ	111	0.97 $\pm$ 1.29	.76	.94
FIM motor	106	1.99 $\pm$ 1.49	.67	.92

NOTE. Average item difficulty is set at zero and with the exception of NHP, in which low scores indicate better health, average person measures of zero indicate an average level of the trait; positive values indicate high overall levels and negative values indicate low overall levels.

* For NHP, the interpretation is reversed.

Table 2

Correlations Among Measures

	Role Participation	Activity Participation	Role Satisfaction	Activity Satisfaction	Positive Psychologic Function
Activity participation	.88 [*]				
Role satisfaction	.81 [*]	.86 [*]			
Activity satisfaction	.87 [*]	.84 [*]	.89 [*]		
Positive psychologic function	.55 [*]	.61 [*]	.64 [*]	.58 [*]	
FAI	.55 [*]	.53 [*]	.50 [*]	.57 [*]	.22 [‡]
NHP	-.67 [*]	-.71 [*]	-.69 [*]	.68 [*]	-.58 [*]
LSQ	.69 [*]	.73 [*]	.71 [*]	.69 [*]	.65 [*]
FIM	.55 [*]	.53 [*]	.46 [*]	.52 [*]	.15

NOTE. Higher scores represent higher motor function (FIM), more activity (FAI), greater satisfaction (LSQ), poorer health-related QOL (NHP), greater ability to participate, greater satisfaction with participation, and greater positive psychologic function. Sample size for correlation coefficients was 111, except for correlations involving the FIM, for which the sample was 106.

* Correlation is significant at the .01 level (2 tailed).

[‡] Correlation is significant at the .05 level (2 tailed).