

Validation of the Quality of Life After Brain Injury in Chinese Persons With Traumatic Brain Injury in Taiwan

Yen-Nung Lin, MD, MS; Shu-Fen Chu, MS; Wen-Miin Liang, PhD; Wen-Ta Chiu, MD, PhD; Mau-Roung Lin, PhD

Objective: To determine the psychometric properties of the Quality of Life After Brain Injury (QOLIBRI) in Chinese persons with traumatic brain injury (TBI) in Taiwan. **Participants:** Three hundred one patients with TBI were interviewed face-to-face at baseline; of these, 132 completed a follow-up assessment 1 year later. **Settings:** Neurosurgery clinics of 6 teaching hospitals in northern Taiwan. **Measure:** The 37-item QOLIBRI, including 6 domains of Cognition, Self, Daily Life and Autonomy, Social Relationships, Emotions, and Physical Problems. **Results:** A small percentage (<1%) of responses were missing, except the Sex Life item under the Social domain (5.9%). The QOLIBRI achieved adequate percentages for the floor value (0%-4%), ceiling value (1%-3.3%), internal consistency (0.79-0.95), and test-retest reliability (0.81-0.89). For construct validity, correlation coefficients (r_s) for the QOLIBRI domains and selected clinical measures conceptually related to that domain were all 0.4 or more, except r_s for QOLIBRI Cognition and Mini-Mental State Examination scores. A principal components analysis found that one item (Loneliness) of the Emotions domain did not converge with its corresponding domain of the original QOLIBRI (loading score <0.4). Effect sizes of responsiveness to changes in the Glasgow Outcome Scale—Extended over the 1-year period were clinically meaningful for all the QOLIBRI domains except the Emotions domain. **Conclusion:** With modifications to the Emotions domain, the QOLIBRI would be suitable for use with Chinese people in Taiwan who have TBI. **Key words:** *psychometrics, quality of life, Taiwan, traumatic brain injury*

TRAUMATIC BRAIN INJURY (TBI) is a leading cause of mortality and morbidity worldwide.¹ Although the majority of patients survive, long-term impairments in multiple aspects of their health may occur, including motor and sensory difficulties, communication problems, cognitive dysfunction, and personality and behavioral changes.^{2–4} These impairments can seri-

ously impair the quality of life of individuals with TBI⁵ and impose a huge burden on their families and society.⁶

The health-related quality of life (HRQOL) is recognized as an important measure of one's health status as shaped by one's perceptions and expectations.⁷ Previous HRQOL research on persons with TBI typically employed generic instruments such as the 36-item Short Form Health Survey (SF-36),⁸ the Life Satisfaction Index-A,⁹ and the Brief Version of the World Health Organization Quality of Life.¹⁰ However, only a few generic instruments have specifically been validated for use with TBI patients.¹¹ Generic tools do not yield focused data for TBI-specific conditions such as cognitive impairment (eg, amnesia, inattention, and impaired comprehension) and emotional problems (eg, anxiety and depression).^{5,12} Insufficient HRQOL information on these specific conditions may render a generic HRQOL instrument insensitive to actual changes in the HRQOL, which may result in incorrect decisions about interventions for patients with TBI.¹³

Currently, there are no commonly accepted TBI-specific HRQOL measures that yield quantitative data. For example, the European Brain Injury Questionnaire essentially provides a checklist of symptoms or problems related to TBI, but not an actual measurement based on a patient's subjective functioning compared with his

Author Affiliations: Institute of Injury Prevention and Control (Drs Lin, Chu, Chiu, and Lin), and School of Public Health (Dr Chu), College of Public Health and Nutrition, Taipei Medical University, and Department of Physical Medicine and Rehabilitation, Wan-Fang Hospital (Dr Lin), Taipei, and Department of Biostatistics, College of Public Health, China Medical University, Taichung (Dr Liang), and Department of Neurosurgery, Shuang-Ho Hospital, New Taipei City (Dr Chiu), Taiwan, Republic of China.

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Corresponding Author: Mau-Roung Lin, PhD, Institute of Injury Prevention and Control, Taipei Medical University, 250 Wu-Hsing St, Taipei, Taiwan 11031, Republic of China (mrlin@tmu.edu.tw).

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or her expectations.¹⁴ Furthermore, the European Brain Injury Questionnaire was not developed or validated cross-culturally; hence, its applicability to patients with TBI in non-European countries is unknown.

Prompted by the limitations of existing generic and TBI-specific instruments, the Quality of Life After Traumatic Brain Injury (QOLIBRI) was developed cross-culturally.¹⁵ After being validated in European countries and Australia, the most recent version of the QOLIBRI contains 37 items in 6 domains of Cognition, Self, Daily Life and Autonomy, Social Relationships, Emotions, and Physical Problems.¹⁶ However, the QOLIBRI has not been validated for use with Chinese or other Asian populations. Moreover, the longitudinal construct–responsiveness–was not verified in previous studies. Hence, we examined the QOLIBRI score distributions and the instrument's psychometric properties (reliability, validity, and responsiveness) among Chinese persons with TBI in Taiwan.

METHODS

Participants and procedures

During a 3-year period from 2007 to 2009, 313 eligible subjects who received a diagnosis of TBI were recruited from the neurosurgery clinics of 6 teaching hospitals in the Taipei area (Mackay Memorial Hospital, National Taiwan University Hospital, Shin-Kong Wu Ho-Su Memorial Hospital, Shuang-Ho Hospital, Taipei Medical University Hospital, and Wan-Fang Hospital). A diagnosis of TBI was based on the presence of any of the following codes of the *International Classification of Diseases, Ninth Revision*: 800-801.9 (fracture of the skull), 803-804.9 (other and multiple fractures of the skull), and 850-854.9 (concussion, cerebral laceration, and intracranial injury or hemorrhage following injury). According to the QOLIBRI task force,¹⁵ a patient's inclusion criteria were being aged 15 years or older at the time of injury, having been injured 3 months to 18 years previously, and displaying a stabilized medical condition. Terminally ill patients, those who had sustained a spinal cord injury, and patients who were unable to understand or answer the questionnaire were excluded from the study. We also excluded patients with a Glasgow Outcome Scale–Extended (GOSE) score of less than 3.¹⁷ The research protocol was reviewed and approved by the institutional review board of Taipei Medical University, and written consent was obtained from each participant. All participants were interviewed face-to-face at the baseline assessment.

Quality of Life After Brain Injury

The QOLIBRI consists of 37 items across 6 domains: Cognition (7 items), Self (7 items), Daily Life and Autonomy (7 items), Social Relationships (6 items), Emotions (5 items), and Physical Problems (5 items).^{15,16} The items in the domains of Cognition, Self, Daily Life and Autonomy, and Social Relationships assess the patients' degree of satisfaction during the past week. Items in the Emotions and Physical Problems domains assess the patients' degree of negative feelings or dissatisfaction during the past week. All items are rated on a 5-point Likert scale (ie, not at all, slightly, moderately, quite, and very much), with 2 domains (Emotions and Physical Problems) being reverse scored. Raw domain scores were calculated by multiplying the mean of all item scores included in each domain by a factor of 4, with a possible range of 4 to 20 for each raw domain score. Each raw domain score was then transformed to a score on a scale from 0 to 100. The total QOLIBRI score was calculated as the average of the 6 domain scores. For each domain and the total score, a higher score indicates a better HRQOL.

Researchers who developed the Taiwanese version of the QOLIBRI followed World Health Organization recommended procedures for translating health status instruments.¹⁸ First, 2 neurosurgeons performed forward translations of items from English to Mandarin Chinese. Then, a native English speaker, fluent in Mandarin Chinese, performed a back translation into English. The translation was harmonized by examining all 3 versions (2 forward and 1 back translation). In addition, 2 focus group sessions were conducted to discuss the meaningfulness of the QOLIBRI items to Chinese patients with TBI in Taiwan. The first session included 8 healthcare professionals, namely 2 neurosurgeons, a psychologist, a psychiatrist, an epidemiologist, a physical therapist, and 2 nurses. At the second meeting, 2 researchers (M.R.L. and S.F.C.) and 8 members of the QOLIBRI task force discussed cultural meanings and nuances contained in the QOLIBRI items. Differences between European and Taiwanese societies were discussed, and the most appropriate Chinese wording was selected for the Taiwanese QOLIBRI items.¹⁹ In addition, 5 Chinese response descriptors for the items (indicating the degree of satisfaction or dissatisfaction) were selected by Thurstone's equal-appearing interval scaling procedures.²⁰

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Baseline assessment

Baseline data were collected from medical records and face-to-face interviews with patients. Information on injury-related characteristics, such as the date of injury and the Glasgow Coma Scale (GCS) score, at admission was extracted from medical records. The GCS score indicated TBI severity and was computed as the sum of the coded values for 3 behavioral responses: eye opening, verbal performance, and motor response. Possible scores of 3 to 8, 9 to 12, and 13 to 15 indicated severe, moderate, and mild injuries, respectively.²¹

Using face-to-face interviews with a structured questionnaire, information was collected on the patients' age, sex, educational level, marital status, employment, disability after TBI, dependency in activities of daily living (ADL), cognitive status, symptoms of depression and anxiety, and HRQOL. The GOSE provides information on general disability after a TBI. This scale assesses a patient's consciousness, independence, work, social interaction, and leisure activity. The resulting score classifies patients with TBI into 8 levels: death, vegetative status, lower and upper severe disability, lower and upper moderate disability, and lower and upper good recovery.¹⁷

The Barthel Index was used to measure dependency in ADL.²² Possible scores for this instrument range from 0 to 100, with scores of 0 to 60, 61 to 90, and 91 to 100 indicating severe, moderate, and slight or no dependency, respectively. The Mini-Mental State Examination (MMSE) was administered to assess cognitive function.²³ The cutoff in the MMSE scores was set to 27 to define cognitive impairment.²⁴ Depression and anxiety were assessed using the Hospital Anxiety and Depression Scale (HADS). Possible HADS scores for anxiety (HADS-Anxiety) or depression (HADS-Depression) range from 0 to 21 points in each case, with scores of 0 to 7, 8 to 10, 11 to 15, and 15 to 21 indicating normal, mild, moderate, and severe conditions, respectively.²⁵ The SF-36,²⁶ a widely used generic HRQOL instrument, was also administered so that we could conduct a validation analysis for the constructs in the QOLIBRI. The SF-36 consists of 8 health domains: Physical Functioning, Role Limitation Caused by Physical Problems, Bodily Pain, General Health, Vitality, Social Functioning, Role Limitations Caused by Emotional Problems, and Mental Health. The 8 domains form 2 distinct higher-order clusters, according to the common variance for physical and mental health, which are named the Physical Component Summary (PCS) and Mental Component Summary (MCS), respectively. Each component score ranges from 0 to 100, with a higher score indicating a better HRQOL. The appropriateness of using the Barthel Index, MMSE, HADS, and SF-36 for Chinese populations has been validated.²⁷⁻³⁰

The internal consistency for each domain of the QOLIBRI was tested using Cronbach α for which a figure of 0.70 or more is required for acceptable reliability.³¹ To assess the test-retest reliability, we selected a random sample comprising 10% of all participants (30 individuals) and readministered the QOLIBRI 2 weeks after the initial test. Intraclass correlation coefficients were calculated for the 6 QOLIBRI domains.

Known-groups validity

Because employment and other patient characteristics such as educational level, injury severity, and time

since injury were established as important predictors for quality of life among persons with TBI,^{9,32} we hypothesized that patients in our study who were employed and had higher educational levels, less-severe injuries, and a longer time lapse since their injury would tend to score more highly across the QOLIBRI domains than their counterparts. Student *t* test and a 1-way analysis of variance to compare the QOLIBRI domain scores among patient subgroups for the 4 characteristics mentioned were applied. A Bonferroni correction was applied to adjust the significance level of multiple comparisons and the corrected level was 0.0071 (ie, 0.05/7).

Construct validity

The convergent validity was tested by calculating the statistical correlations between the 6 QOLIBRI domains and a number of clinical measures: the patients' scores for the GOSE, GCS, MMSE, Barthel Index, HADS, and SF-36. Scores for the QOLIBRI domains and clinical measures that were conceptually related should show moderate to strong correlations. We hypothesized that moderate to high correlation coefficients (≥ 0.4) would be found between the following sets of scores: MMSE and QOLIBRI Cognition; GOSE, Barthel Index, SF-36 PCS, and QOLIBRI Daily Life and Autonomy; HADS-Anxiety, HADS-Depression, SF-36 MCS, and QOLIBRI Self; HADS-Anxiety, HADS-Depression, SF-36 MCS, and QOLIBRI Emotions; SF-36 PCS and QOLIBRI Physical Problems; and GOSE and QOLIBRI total. These hypotheses were tested by calculating Spearman correlation coefficients (r_s).

The original QOLIBRI comprises a 6-domain structure, and items relating to each domain load onto that particular domain.¹⁶ A principal components analysis with varimax rotation was applied to identify latent domains in the QOLIBRI results. The number of extracted factors was forced to be 6 in order to validate whether the Taiwanese version of the QOLIBRI showed the same 6-domain structure as the original QOLIBRI. Conventionally, loadings more than 0.4 of the QOLIBRI items onto an extracted factor indicate that those items converge on the underlying construct of the domain.³³ A confirmatory factor analysis was also applied to validate whether a 6-domain structure fit the data. Bentler's comparative fit index of 0.9 or more indicates an acceptable goodness of fit for that solution.³⁴

Responsiveness

To estimate the responsiveness of the QOLIBRI, we measured 135 patients' GOSE and QOLIBRI scores again 12 months after the baseline assessment. This subgroup of patients was drawn from 3 hospitals in the Taipei Medical University Healthcare System (Shuang-Ho Hospital, Taipei Medical University Hospital, and

Wan-Fang Hospital). Among the 132 patients who completed the GOSE and QOLIBRI at this follow-up assessment, 31 had deteriorated, 39 had improved, and 62 were unchanged in terms of GOSE scores during the 12-month period. To control for the potential effect of passage of time on the QOLIBRI responsiveness, patients who displayed no change in the GOSE score were treated as the reference group. Using the Guyatt³⁵ method, an effect size for responsiveness in each of the 6 QOLIBRI domains was calculated as mean changes in a QOLIBRI domain score over the 12-month period for participants who showed either an improvement or a decline in the GOSE score, divided by the mean change in that domain for the reference group. An effect size of 0.2 to 0.5 in responsiveness was considered small, 0.5 to 0.8 moderate, and more than 0.8 large.³⁶

All statistical analyses in the study were conducted using the SPSS software version 15.0 (SPSS, Chicago, Illinois).

RESULTS

Compared with the 301 participants, the 12 non-participants were more likely to have GOSE scores of 3 to 4, while other baseline characteristics had similar distributions. Furthermore, relative to the 132 participants who completed the follow-up for estimating the responsiveness of the QOLIBRI, those who did not have the follow-up assessment were more likely to be women and have GOSE scores of 3 to 4 (severe disability) and Barthel Index scores of 0 to 90 (severe/moderate dependency in ADL).

Distributions of sociodemographic variables and TBI-related characteristics among the participants are shown in Table 1. The mean age of participants was 40.2 years; the mean time since injury was 35.9 months; 60.8% of the study group patients were men. Of the 301 patients, at the time of injury, 21.2% received a GCS score indicating severe, 8.4% indicating moderate, and 70.4% indicating mild injury. At our baseline assessment, 40.6% of patients had GOSE levels indicating moderate or severe disability; and 44.5% were cognitively impaired.

Score distributions, internal consistency, and test-retest reliability of the 6 QOLIBRI domains are shown in Table 2. Mean scores for the QOLIBRI domains ranged from 56.4 to 77.6, and their interquartile points ranged from 15.0 to 32.1. Data for the QOLIBRI items were missing in less than 1% of cases, except for responses regarding Sex Life under the Social Relationship dimension, for which there were 5.9% missing responses. Ceiling and floor values were less than 4%. Cronbach α ranged from 0.79 to 0.95, and intraclass correlation coefficients ranged from 0.81 to 0.89. Differences were noted between the mean and median in each of the

TABLE 1 *Sociodemographics and injury-related characteristics among 301 patients with traumatic brain injury*

Characteristic	
Age, mean \pm SD, y	40.2 \pm 13.3
Time since injury, mean \pm SD, mo	35.9 \pm 38.5
Sex, <i>n</i> (%), men	183 (60.8)
Educational level, <i>n</i> (%)	
Elementary or below	58 (19.2)
High school	165 (54.8)
College or above	78 (26.0)
Marital status, <i>n</i> (%)	
Single	128 (42.4)
Spouse present	163 (54.2)
Widowed/divorced	10 (3.4)
Employment, <i>n</i> (%)	
Unemployed	100 (33.3)
Employed	177 (58.7)
Student	24 (8.0)
GCS score at injury (3-15 points), <i>n</i> (%)	
3-8 (severe)	64 (21.3)
9-12 (moderate)	22 (7.3)
13-15 (mild)	215 (71.4)
GOSE level at baseline (3-8 points), <i>n</i> (%)	
3-4 (severe disability)	51 (17.0)
5-6 (moderate disability)	71 (23.6)
7-8 (good recovery)	179 (59.4)
MMSE (0-30 points), <i>n</i> (%)	
<28	134 (44.5)
\geq 28	167 (55.5)
Barthel Index (0-100 points), <i>n</i> (%)	
0-90	25 (8.5)
91-100	276 (91.5)
HADS-Anxiety (0-21 points), mean \pm SD	4.3 \pm 4.1
HADS-Depression (0-21 points), mean \pm SD	5.2 \pm 4.3
SF-36 PCS (0-100 points), mean \pm SD	67.1 \pm 25.1
SF-36 MCS (0-100 points), mean \pm SD	65.4 \pm 21.9

Abbreviations: HADS, Hospital Anxiety and Depression Scale; GCS, Glasgow Coma Scale; GOSE, Glasgow Outcome Scale—Extended; MCS, Mental Component Summary; MMSE, Mini-Mental State Examination; PCS, Physical Component Summary.

6 QOLIBRI domains, and the score distributions were skewed to the right (see Figure 1).

Results of the known-groups validity assessment with regard to 4 characteristics of education, the GCS level, time since injury, and employment status are shown in Table 3. Patients with lower educational levels, higher GCS levels, and shorter time since injury and those who were unemployed displayed significantly lower scores in all 6 QOLIBRI domains than their counterparts.

The convergent validity was assessed by calculating r_s for patients' scores in each QOLIBRI domain plus their

TABLE 2 *Score distributions, internal consistency, and test-retest reliability for the 6 domains of the Quality of Life After Brain Injury among 301 participants*

Domain	Number of items	Mean (SD)	Median (IQR)	% Missing range	% Floor value	% Ceiling value	Cronbach α	Intraclass correlation coefficient
Cognition	7	58.4 (21.3)	64.3 (28.6)	0.3-0.7	1.3	2.0	0.94	0.87
Self	7	56.4 (21.5)	57.4 (32.1)	0.3-1.0	1.0	1.0	0.95	0.89
Daily Life and Autonomy	7	58.1 (21.8)	60.7 (28.6)	0.3-1.0	4.0	2.0	0.93	0.81
Social Relationships	6	65.3 (17.9)	75.0 (20.8)	0.7-5.9	0	3.3	0.90	0.81
Emotions	5	77.6 (14.6)	80.0 (15.0)	0.0-0.3	0	3.3	0.89	0.81
Physical Problems	5	68.6 (15.9)	73.3 (16.7)	<0.1	0	1.0	0.79	0.88

Abbreviation: IQR, interquartile range.

scores for the GOSE, MMSE, Barthel Index, HADS-Anxiety, HADS-Depression, and SF-36 (PCS and MCS). As shown in Table 4, all scores that were conceptually related yielded r_s values of 0.4 or more, with the exception of QOLIBRI Cognition and the MMSE ($r_s = 0.27$).

Results of the principal components analysis are shown in Table 5. The 6 extracted factors were found to correspond with the conceptual 6-factor structure of the original QOLIBRI. Specifically, factors 1, 2, 3, 4, 5, and 6 corresponded with Cognition, Daily Life and Autonomy, Social Relationships, Self, Physical Problems, and Emotions, respectively. Of the 37 items, 36 converged with a loading score of more than 0.4 on their corresponding domains of the original QOLIBRI; the exception was an item in the Emotions domain (Loneliness, with a loading of 0.362).

The initial confirmatory factor analysis to test the structure of the 6 independent domains showed that Bentler's comparative fit index was 0.825, indicating that the 6 independent domains for the particular items did not adequately fit our dataset. The comparative fit index increased to 0.856 when 5 pairs of error variances (Anxiety and Depression; Independence and Getting Out and About; Loneliness and Getting Out and About; Energy and Partner; and Concentrating and Decision Making) were allowed to covary.

The effect sizes of responsiveness for each domain of the QOLIBRI for changes in the GOSE score over the 12-month period are shown in Table 6. The responsiveness of the QOLIBRI to GOSE score deterioration was as follows: moderate effect sizes for Physical Problems (-0.62) and Total score (-0.60) and small effect sizes for Self (-0.41), Daily Life and Autonomy (-0.31), and Social Relationships (-0.35). The responsiveness of the QOLIBRI to a GOSE score improvement was as follows: moderate effect sizes for Cognition (0.50) and

Daily Life and Autonomy (0.52) and small effect sizes for Self (-0.36), Social relationships (0.29), and Total score (0.24).

DISCUSSION

The QOLIBRI task force has conducted international validation studies for the QOLIBRI in Europe, America, and Australia.^{15,16,37} The findings of this study, therefore, provide additional knowledge as to whether the QOLIBRI is valid for use with Asian populations with TBI. The Taiwanese version of the QOLIBRI demonstrated an acceptable score distribution, a low rate of missing data, excellent internal consistency and test-retest reliability, and good known-groups validity; however, its construct validity and responsiveness in the Emotions domain showed room for improvement. Overall, with some modifications to Loneliness in the Emotions domain, the QOLIBRI should be appropriate for use with ethnic Chinese patients with TBI in Taiwan.

Our finding of the score distribution being skewed to the right in the 6 QOLIBRI domains was similar to those of previous QOLIBRI studies.^{15,37} The skewing indicates a tendency for a ceiling effect, particularly in the Social and Emotions domains; this situation may have partly resulted from our inclusion criterion that all patients with TBI were eligible for the study. Moreover, scrutiny of the data revealed that 70.4% of our participants had received GCS scores of 13 to 15 (mild TBI) and 59.4% had GOSE scores of 7 to 8 (good recovery); these figures are in stark contrast with the 32% and 28%, respectively, reported by von Steinbüchel et al.¹⁶ The distributions of QOLIBRI domain scores became less skewed when we restricted the dataset to include only patients with moderate or severe TBI and those for whom less time had elapsed since their TBI (≤ 24 months, data not shown). This finding implies that patients with milder TBI or a longer time lapse since injury

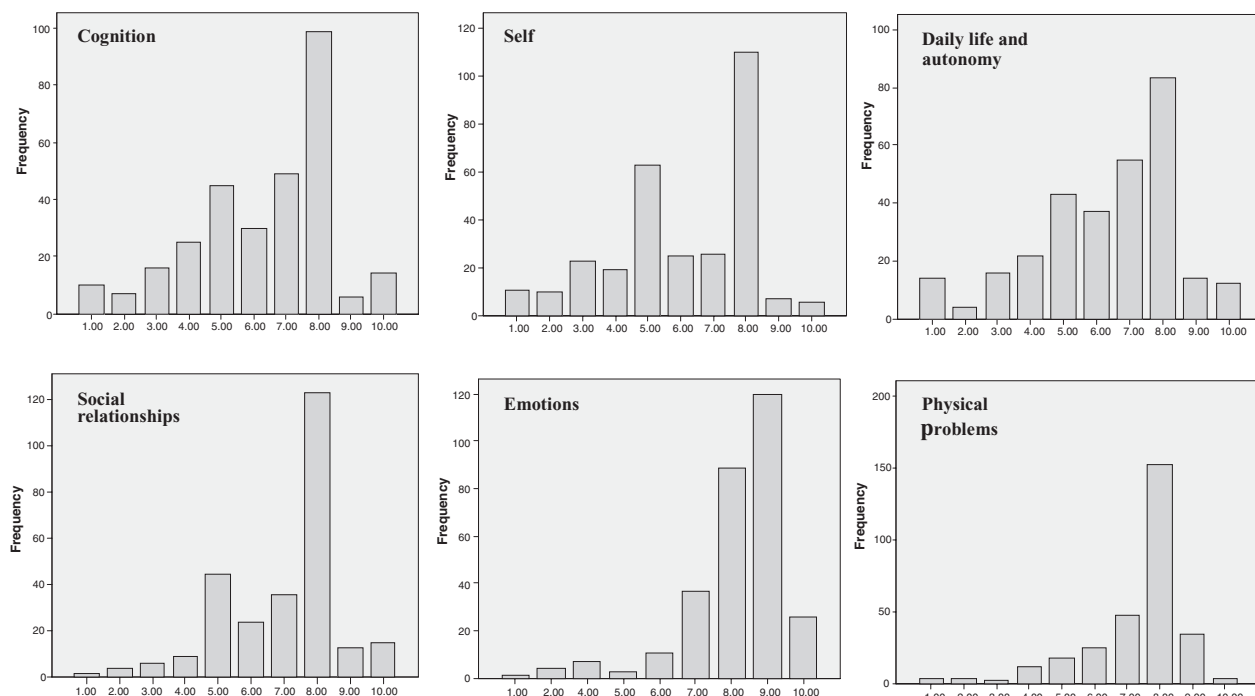


Figure 1. Score distributions for the 6 Quality of Life After Brain Injury domains.

might have recovered reasonably well from the injury by the time of our assessment. Alternatively or in addition, the result might have reflected a “response shift,” which refers to a change in one’s self-evaluation or ways of deriving meaning from the time of injury to later periods, because some patients adjust to chronic impairment by changing their internal standards, values, or assessments of their own HRQOL.³⁸ Further research could compare the psychometric performance of the QOLIBRI when used with different patient subgroups for TBI severity and time lapse since injury.

Emotions was the only domain with a mean score of more than 70, and it was the highest score among all 6 QOLIBRI domains. The mean Emotions domain score of our patients was higher than that of patients studied by von Steinbüchel et al¹⁶ (77.6 vs 71.7, $P < .001$), although the mean scores of our patients in other QOLIBRI domains were lower than or similar to those reported by von Steinbüchel et al.¹⁶ This discrepancy might be partly explained by ethnic and cultural differences in the expression of emotional disorders. For example, traditional assessment tools usually

TABLE 3 Spearman correlation coefficients between scores for domains of the QOLIBRI index and 7 other clinical measures among 301 participants^a

Characteristic	Cognition	Self	Daily life and autonomy	Social relationships	Emotions	Physical problems	QOLIBRI total
GOSE	0.44	0.41	0.45^b	0.33	0.37	0.43^b	0.48^b
MMSE	0.27^b	0.32	0.35	0.27	0.24	0.36	0.35
Barthel Index	0.22	0.36	0.41^b	0.24	0.36	0.35	0.36
HADS-Anxiety	−0.55	− 0.62^b	−0.52	− 0.54^b	− 0.54^b	−0.46	−0.63
HADS-Depression	−0.63	− 0.72^b	−0.68	− 0.60^b	− 0.58	−0.61	−0.75
SF-36 PCS	0.64	0.71	0.69^b	0.51	0.58	0.66^b	0.74^b
SF-36 MCS	0.65	0.73	0.70	0.57^b	0.60^b	0.60	0.76^b

Abbreviations: HADS, Hospital Anxiety and Depression Scale; GOSE, Glasgow Outcome Scale—Extended; MCS, Mental Component Summary; MMSE, Mini-Mental State Examination; PCS, Physical Component Summary; QOLIBRI, Quality of Life After Brain Injury; SF-36, 36-item Short Form Health Survey.

^a $P < .01$. All the values given in bold have reached the significance level of 0.001.

^bTheoretically expected to be ≥ 0.4 .

TABLE 4 Known-groups validity for domains of the Quality of Life After Brain Injury with regard to education, GCS level, time since injury, and employment among 301 participants

Characteristic	Statistic	Cognition	Self	Daily life and autonomy	Social relationships	Emotions	Physical problems	Total
Educational level								
Elementary	Mean	57.2	51.5	50.8	62.5	72.0	63.3	59.6
High school	Mean	56.5	54.2	56.2	63.4	76.6	66.5	62.0
College or higher	Mean	62.4	62.9	64.0	71.3	82.2	74.3	69.6
	<i>P</i>	.104	.002 ^a	.003 ^a	<.001 ^a	<.001 ^a	<.001 ^a	<.001 ^a
GCS level								
3-8	Mean	50.7	47.8	52.6	57.7	72.3	63.9	57.5
9-12	Mean	49.9	47.9	49.2	58.4	74.6	65.5	57.6
13-15	Mean	62.2	60.0	61.1	68.2	79.5	70.3	66.8
	<i>P</i>	<.001 ^a	<.001 ^a	.003 ^a	<.001 ^a	.002 ^a	.016	<.001 ^a
Time since injury, mo								
3-12	Mean	56.1	52.1	55.3	65.1	75.8	66.7	61.7
12-36	Mean	57.4	55.7	58.0	65.7	78.5	68.6	64.0
>36	Mean	63.7	63.5	62.2	66.5	80.3	72.3	67.9
	<i>P</i>	.060	.003 ^a	.122	.889	.102	.067	.048
Employment								
No	Mean	47.1	43.8	44.1	55.8	71.9	57.9	53.4
Yes	Mean	61.8	61.0	63.2	68.9	80.1	72.7	67.8
	<i>P</i>	<.001 ^a	<.001 ^a	<.001 ^a	<.001 ^a	<.001 ^a	<.001 ^a	<.001 ^a

Abbreviation: GCS, Glasgow Coma Scale.

^a*P* values are less than the corrected level (0.0071) of significance by Bonferroni method.

yield low prevalence rates for common psychiatric illnesses such as depression and anxiety when used with Chinese populations.^{39,40} Chinese people who experience depression or anxiety tend to display somatic symptoms (eg, boredom, discomfort, feelings of inner pressure, and symptoms of pain, dizziness, and fatigue) rather than emotional disturbances (eg, feeling sad or lonely).⁴¹ As a result, emotional disorders are often underdiagnosed among Chinese people. The QOLIBRI Emotions domain might not reflect the actual quality of life in Chinese patients who have emotional problems. In addition, ethnic and cultural differences in expressing emotional disorders might also partly explain the Loneliness factor loadings of 0.362 onto the Emotions domain and those of 0.421 and 0.420 onto the Self and Physical Problems domains, respectively. Some modifications (eg, removing the Loneliness item from the QOLIBRI or moving it to the Self or Physical Problems domain) might enhance the suitability of the QOLIBRI for use with Chinese patients with TBI. However, any modification to the QOLIBRI would require further validation studies.

Like Loneliness, 3 other items (Getting Out and About, Boredom, and Being Slow/Clumsy) had the highest factor loadings on domains other than their original domains, although their factor loading scores on the

original domains were 0.4 or more. This phenomenon might be accounted for by variations in sample characteristics, high correlations between some QOLIBRI domains, and ethnic and cultural differences. Compared with the von Steinbüchel et al¹⁵ sample, ours tended to be female (39.1% vs 28%) and have a shorter time since injury (35.9 vs 59.8 months), an employed status (58.7% vs 23%), milder TBI (70.4% vs 32%), good recovery (59.4% vs 28%), and independent living (91.5% vs 57%). Moreover, the 6 QOLIBRI domains are highly dependent on one another. For example, it is sensible to have a high correlation coefficient between Daily Living and Autonomy and Physical Problems ($r_s = 0.64$), because patients with serious physical limitations find it difficult to live independently. The relation between Self and Emotions was the same ($r_s = 0.71$). Finally, ethnic and cultural differences for Loneliness could also be responsible for the high factor loading of Boredom on the Self domain. We are not aware of any other specific ethnic and cultural differences between European and Chinese populations.

The QOLIBRI Cognition domain and the MMSE appear to assess a similar construct; thus, we expected a moderate to strong correlation between these measures. However, our analysis indicated only a weak one. Examining the 2 instruments more rigorously, we noted

TABLE 5 *Result of principal component analysis to assess construct validity of the Quality of Life After Brain Injury among 301 participants^a*

Domain	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Cognition	Finding One's Way	0.751	0.384	0.098	0.038	0.243	0.120
	About						
	Planning & Problem	0.760	0.225	0.261	0.143	0.185	.107
	Solving						
	Expressing Oneself	0.622	0.177	0.358	0.436	0.140	0.064
Self	Decision Making	0.697	0.404	0.241	0.184	0.117	0.181
	Speed of Thinking	0.734	0.245	0.189	0.309	0.209	0.134
	Concentrating	0.620	0.172	0.203	0.488	0.275	0.045
	Remembering	0.765	0.107	0.168	0.281	0.194	0.074
	Achievements	0.434	0.347	0.201	0.613	0.242	0.150
	Way One Looks	0.339	0.311	0.243	0.633	0.201	0.130
	Motivation	0.440	0.370	0.236	0.528	0.313	0.179
	Self-Perception	0.342	0.475	0.254	0.564	0.134	0.172
	Self-Esteem	0.343	0.370	0.370	0.528	0.162	0.225
	One's Own Future	0.377	0.399	0.329	0.601	0.137	0.185
Daily Life and Autonomy	Energy	0.400	0.084	0.303	0.531	0.391	0.257
	Getting Out and	0.442	0.401	0.268	0.265	0.450	-0.041
	About						
	Handling Personal	0.190	0.752	0.231	0.180	0.160	0.154
	Finances						
	Domestic Activities	0.324	0.669	0.299	0.005	0.245	0.056
	In Charge of One's	0.272	0.679	0.272	0.280	0.201	0.328
	Life						
	Independence	0.437	0.539	0.274	0.197	0.386	0.073
	Social & Leisure	0.345	0.642	0.238	0.357	0.186	0.161
Social Rela- tionships	Activities						
	Participation in	0.235	0.669	0.201	0.393	0.176	0.189
	Work						
	Family Members	0.141	0.170	0.786	0.035	0.056	0.296
	Affection for Others	0.154	0.247	0.744	0.249	0.000	0.013
	Friends	0.250	0.284	0.712	0.188	0.065	0.080
	Partner	0.152	0.057	0.763	0.133	0.297	0.254
	Attitudes About	0.365	0.216	0.614	0.272	0.051	0.225
	Others						
	Sex Life	0.222	0.242	0.648	0.264	0.208	0.221
Emotions	Loneliness	0.327	0.146	0.071	0.421	0.420	0.362
	Boredom	0.062	0.042	0.333	0.548	0.260	0.514
	Anxiety	0.081	0.253	0.140	0.145	0.161	0.849
	Anger/Aggression	0.189	0.232	0.350	0.211	0.406	0.640
	Depression	0.136	0.108	0.318	0.126	0.057	0.803
Physical Problems	Seeing/Hearing	0.145	0.037	0.005	0.069	0.616	0.174
	Being Slow/Clumsy	0.182	0.539	0.094	0.168	0.522	0.187
	Having Other	0.225	0.330	0.034	0.160	0.649	-0.156
	Injuries						
	Experiencing Pain	0.169	0.156	0.155	0.069	0.722	0.244
	TBI Effects	0.132	0.219	0.185	0.277	0.648	0.096

^aBold-faced factor loadings on a domain were expected to be high (≥ 0.4).

that QOLIBRI Cognition emphasizes thinking ability in daily life (ie, higher cognitive abilities such as working memory, executive functioning, and information processing), whereas the MMSE covers orientation, word recall, attention and calculation, language, and visuospatial functions but yields limited information on

higher cognitive abilities. Therefore, the MMSE may have low sensitivity to detect cognitive impairments in patients with TBI. An alternative explanation for the weak correlation might be differences inherent in subjective versus objective measures in assessing functional abilities; these differences may be evident, even for

TABLE 6 Responsiveness for QOLIBRI domains with regard to GOSE changes at 12 months after the baseline assessment among 132 participants

	Unchanged GOSE, mean \pm SD	Deteriorated GOSE, mean \pm SD	Improved GOSE, mean \pm SD	Effect size	
				Deteriorated	Improved
Cognition	3.37 \pm 19.84	-0.94 \pm 27.88	10.83 \pm 26.50	-0.05	0.50
Self	6.28 \pm 21.30	-7.24 \pm 20.78	7.98 \pm 23.38	-0.41	0.36
Daily Life and Autonomy	2.98 \pm 19.60	-6.24 \pm 24.83	12.18 \pm 23.93	-0.31	0.52
Social Relationships	-0.53 \pm 23.03	-7.20 \pm 26.28	5.58 \pm 21.27	-0.35	0.29
Emotions	-1.90 \pm 15.26	-0.97 \pm 20.83	0.69 \pm 19.50	-0.07	0.05
Physical Problems	-0.20 \pm 12.79	-9.76 \pm 22.72	1.97 \pm 22.83	-0.62	0.09
QOLIBRI Total	-0.30 \pm 12.97	-8.30 \pm 17.93	3.95 \pm 16.70	-0.60	0.24

Abbreviations: QOLIBRI, Quality of Life After Brain Injury, GOSE, Glasgow Outcome Scale—Extended.

populations without cognitive impairment.⁴² Instruments that measure HRQOL partly tap into personal achievements, reactions to achievements, and expectations of achievements.⁵ Patients with TBI might have relatively low expectations for their personal cognitive functioning, which could lead to an exaggerated high score for cognitive HRQOL. Further investigation of the mechanisms by which impaired cognition influences the cognitive and other dimensions of the HRQOL in TBI patients is warranted. Another alternative explanation might be the lack of insight displayed by many TBI patients.⁴³ Because of impaired self-awareness, patients' self-reports may create a false impression that they have made a better neurological recovery from TBI than is actually the case.⁴⁴ A recent study reported that poor self-awareness was significantly associated with higher estimates of subjective HRQOL, particularly in the cognitive domain.⁴⁵

Responsiveness is defined as the ability of an instrument to detect meaningful or important change (eg, in HRQOL) when it has occurred.⁴⁶ Responsiveness can be viewed as a form of longitudinal construct validity. The QOLIBRI should display good responsiveness if clinicians and patients are to rely on it when evaluating medical treatment options and making therapeutic decisions. In this study, the 6 QOLIBRI domains exhibited varying levels of responsiveness in parallel with the patients' improvement or deterioration as reflected in the GOSE score, with the Emotions domain obtaining the poorest result. We selected the GOSE as the anchor (reference) measure to assess the responsiveness of the QOLIBRI because the GOSE scores were found to display the greatest responsiveness and lowest ceiling effect among functional outcome measures for major trauma patients with or without TBI.⁴⁷ The level of responsiveness in most QOLIBRI domains (ie, Cognition, Daily Life and Autonomy, Physical Problems, and Total) differed according to the directionality of the GOSE score change. A smaller amount of change might be required

to achieve clinical significance when a patient is improving than when a patient is worsening.⁴⁸

Study limitations

Certain limitations of this study need to be addressed. First, the majority of participants displayed mild TBI with a good recovery; thus, the results might not be generalizable to patients with moderate or severe TBI or those with a shorter time lapse since injury. Second, the patients' preinjury characteristics and environmental factors were not measured or controlled for. Physical and psychosocial characteristics at preinjury and environmental barriers (eg, transportation, surroundings, government policies, and job opportunities) may have confounded differences in the QOLIBRI domain scores among groups with respect to the time since injury, employment situation, and independence in ADL. Third, associated injuries that might influence the HRQOL of patients with TBI were not accounted for in this study. Finally, survivors who were most disabled by TBI (eg, bedridden or in a vegetative state) and those who had recovered to preinjury levels or who were able to return to work would not present at neurosurgery clinics to the same extent as the mild-to-moderately injured population from which we drew our sample. Previous researchers found that TBI patients from socioeconomically disadvantaged groups, those who had a preinjury history of alcohol or other drug abuse, and those whose TBI had been caused by violence were less likely to be available for evaluation 1 to 2 years after TBI.⁴⁹

CONCLUSIONS

Appropriate TBI-specific HRQOL measures are important for monitoring changes in the various aspects of a patient's health. Such measures also help determine whether a specific medical treatment is effective in rehabilitation after brain injury. Although the QOLIBRI displays satisfactory psychometric properties

when used with TBI patients in European countries, when used with a Chinese TBI population in Taiwan, its Emotions domain may need some alterations.

Further research should compare the performance of the QOLIBRI among subgroups with respect to TBI severity and time lapse since injury.

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