Author: M. Thomas, C. Skilbeck and M. Slatyer
Title: Pre-injury estimates of subjective quality of life following traumatic brain injury
Journal: Brain Injury ISSN: 0269-9052 1362-301X
Year: 2009
Volume: 23
Issue: 6
Pages: 516-527

Abstract: Primary objective: To compare the pre-injury subjective quality of life (SQOL) estimates of a representative sample of adults with TBI, using the Quality of Life Inventory (QOLI) with the measure's generic US-based norms and identify a factor structure for the instrument within the local TBI population.Research design: A population-based, cross-sectional design conducted with data collected by the Neurotrauma Register of Tasmania (2003-2005).Methods and procedures: As soon as possible following their emergence from post-traumatic amnesia, 470 participants provided pre-injury estimates of their SQOL using the QOLI. The distribution of this sample was compared with the measure's normative distribution. The sample was separated evenly into two groups (n = 235) for separate exploratory and confirmatory factor analyses.
Main outcomes and results: Small differences were found between the pre-injury estimates and the QOLI's US-based normative distribution. Corrections were provided to clinical classification ranges for this population. Three factors were identified and confirmed for the QOLI in separate TBI samples .Conclusion: The results of this study support the use of the QOLI in measuring SQOL in TBI rehabilitation and outcomes research.

Author Address: mathomas@csu.edu.au
clives@utas.edu.au
slatyerm@netspace.com

URL: http://dx.doi.org/10.1080/02699050902926333

http://ejournals.ebsco.com/direct.asp?ArticleID=4C8682478D995A9B2AE5

http://researchoutput.csu.edu.au/R/-?func=dbin-jump-full&object_id=12133&local_base=GEN01-CSU01

http://unilinc20.unilinc.edu.au:80/F/?func=direct&doc_number=000400537&local_base=L25XX

CRO Number: 12133

Pre-injury estimates of subjective quality of life following traumatic brain injury

Thomas, M.D. (1*)

Skilbeck, C.E. (1)

Slatyer, M. (2, 3)

1. School of Psychology, University of Tasmania, Australia
2. School of Medicine, University of Tasmania, Australia
3. Royal Hobart Hospital, Tasmania, Australia

* Contact information: Dr Matt Thomas, Psychology, Charles Sturt University, Panorama Avenue, Bathurst, New South Wales, Australia. email: psychflyer@hotmail.com

Abstract

Primary objective: To compare the pre-injury subjective quality of life (SQOL) estimates of a representative sample of adults with TBI, using the Quality of Life Inventory (QOLI, [1]) with the measure's generic US-based norms and identify a factor structure for the instrument within the local TBI population.

Research design: A population-based, cross-sectional design conducted with data collected by the Neurotrauma Register of Tasmania (2003-2005).

Methods and procedures: As soon as possible following their emergence from post-traumatic amnesia, 470 participants provided pre-injury estimates of their SQOL using the QOLI. The distribution of this sample was compared with the measure's normative distribution. The sample was separated evenly into two groups (n=235) for separate exploratory and confirmatory factor analyses.

Main outcomes and results: Small differences were found between the pre-injury estimates and the QOLI's US-based normative distribution. Corrections were provided to clinical classification ranges for this population. Three factors were identified and confirmed for the QOLI in separate TBI samples.

Conclusion: The results of this study support the use of the QOLI in measuring SQOL in TBI rehabilitation and outcomes research.

Although traumatic brain injury (TBI) is a leading cause of death, improvements in emergency medicine the past thirty years have seen greater numbers of people survive TBI [2]. In Australia, it is estimated the rate of occurrence is 149 per 100 000 population per annum [3]. Those most at risk are males aged 15 to 29 years and older adults [3]. Major causes of TBI include motor vehicle accidents, assaults and sports injuries in adolescents and younger adults, with falls contributing to the major part of TBI accidents in older adults [4].

The effects of TBI can significantly disrupt the lives of those who are injured. Long-term physical, cognitive, psychological and emotional outcomes following TBI can affect the injured person's capacity to engage in meaningful work, relationships and leisure activity [4,5]. Impairments in emotional and cognitive abilities, as well as restrictions in activities of daily living are also common in less severe cases [2]. Such longer-term problems also come with a significant cost for families involved in caring for an injured relative and for communities in lost participation and productivity [4].

Rehabilitation for people with TBI is a focussed industry, taking on responsibility for optimising outcomes for people with TBI, their families and communities [6,7]. TBI rehabilitation has traditionally focussed on assessment of deficits and restoration of functioning following injury. In conjunction with medical rehabilitation, many services have been developed to assist in areas of community re-entry with supported work, accommodation and leisure programmes (e.g., [5,6]). Researchers and clinicians working in the TBI rehabilitation field have acknowledged the importance of an individual's quality of

life as a critical indicator of outcome following TBI (e.g. [2,7,8]). Many TBI rehabilitation services include the restoration or optimisation of quality of life as part of their service objectives (e.g. [7]).

Conceptualisation, definition and contribution of Subjective Quality of Life

A number of recent articles and an international consensus meeting have helped clarify conceptualisations and definitions of subjective quality of life (SQOL) in the context of recovery following TBI (e.g., [2,9,10]). Dijkers [11] explains various conceptual frameworks of QOL including objective and subjective views. In summary, the objective approach to measurement of quality of life involves an external rater forming a judgment about the quality the person of interest enjoys on key aspects of life such as their health, work, leisure activity, place of residence, financial status and relationships. The subjective approach asks the person of interest to consider and rate their own satisfaction with these key aspects of their life.

Whilst the objective and subjective approaches are utilised most commonly amongst researchers and clinicians in the TBI field, they each have strengths and limitations. For example, the rigour of an objective approach to QOL assessment is appealing. However, there has been debate about issues associated with the development and administration of objective QOL measures (see [11,12]), and the process of developing a disease specific QOL measure for use in the TBI rehabilitation area is ongoing (e.g. QOLIBIR, [13]).

The subjective approach to QOL measurement, equates QOL with subjective well-being. SQOL measures ask respondents to rate their satisfaction

with key aspects of their life. Ratings on these measures provide a greater understanding of an individual's perception of the fulfillment of their objectives, expectations, needs and desires [11, 14, 15]. This approach appeals strongly to those clinicians and researchers who value an understanding of the 'insiders' perspective' of how individuals rate their own well-being or satisfaction with life [16].

Several studies as well as a recent TBI/QOL consensus group have highlighted the value of the use of SQOL measures to understand individuals' outcomes following TBI, (e.g. [2,8,11,14]). A key study by Brown et al., [8] asserted the personal, insider-assigned meaning attached to objective conditions was very important, as biological impairment, symptoms and functional limitations to QOL were found to be mediated and modified by psychological, social and cultural factors. Consequently, the potential exists to significantly improve patients' QOL without any change in their functional ability or objective circumstances [12]. This is particularly important when considering current approaches to TBI rehabilitation, which aim to facilitate adjustment to injury [17].

Considerations in choosing an SQOL measure

There is a broad range of available measures of SQOL. To date, no systematic review has indicated which measures are most relevant to the TBI population. Indeed, very few measures have been the subject of research in the TBI context. However, the relevant literature does point out a number of important considerations in selecting SQOL measures. These include choosing a measure that utilises a concise, self-explanatory design that engages the

respondent, consideration of global or multidimensional approaches to measurement, importance weighting across QOL domains, and the importance of validation of generic measures within the TBI population. Following is a summary of these considerations.

A basic facility of any survey is its ability to pose questions of respondents that are easily understood and which facilitate a useful response. As people with TBI may be likely to suffer cognitive impairment reducing their attention and memory functioning, any measure designed for self-reporting purposes within this population will do well to include concise explanations of concepts and instructions that facilitate an appropriate response.

Global approaches to SQOL measurement ask an individual to give an overall rating of their satisfaction with their everyday life (e.g. [18]). This may involve the respondent indicating their perception of their quality of life on a likert scale using numbers or descriptions. Potential weaknesses with global approaches to SQOL assessment have included the ambiguity in the meaning of QOL for respondents, resulting in responses that may not have properly considered the defining aspects of SQOL. Also, as global approaches are relatively quick to administer and may be part of a larger survey battery, it may be likely that some respondents would provide a similarly brief response that lacks due consideration [11].

Another approach to SQOL questionnaire design has been the use of multidimensionality. Stemming from conceptual and definitional bases, the multidimensional approach to SQOL measurement seeks to assess life

experience broadly, across a number of defined factors such as work, relationships, finances, and leisure pursuits [14]. This approach recognises that SQOL may be fractionated and provides a structure within which the specific meanings of domains can be understood. Recent research recommends the use of multidimensional measures with TBI samples, as this may help to clarify meanings of SQOL domains with the respondent and serve to optimise reliability of self-reporting (e.g., [2, 14]).

Multidimensional SQOL measures may be used differently within TBI outcome research and rehabilitation contexts. In outcome research, a total or summary score may be of primary importance. Whereas, in the rehabilitation context, domain or factor/subscale scores may be the focus for a clinician who interprets variations between these, using them to assess the respondent's needs and resources, and to inform interventions that aim to remedy more specific psychosocial problems [12]. As such, an asset of an SQOL measure within the TBI context would include provision of domain or factor/subscale scores and a total average domain score.

Overall, the selection of an SQOL measure requires a multidimensional design with clear and simple definitions of its domains, and of the domain importance rating system. Practically, an appropriate measure requires minimal time to complete, and a focussed format to engage respondents and optimise reliability of self-reporting. Such a measure would be valuable in monitoring patients' progress within a rehabilitation context and for use in outcome research within the TBI population.

The QOLI as a measure of SQOL for people with TBI

One measure that has most of the desirable features discussed above is the Quality of Life Inventory (QOLI, [1]). This generic measure of life satisfaction is grounded in Frisch's quality of life theory [1,19], which in summary, taps subjective life satisfaction and reflects the degree to which 'an individual's most important needs, goals and wishes have been fulfilled' ([1], p. 2.) The QOLI has been shown to be sensitive and useful in a range of therapeutic applications including rehabilitation outcomes evaluation [20]. It was designed for broad use in mental health and other rehabilitation outcomes measurement, and includes sixteen relevant and well-defined domains. These include: Health, Self-esteem, Goals and Values, Money, Work, Play, Learning, Creativity, Helping, Love, Friends, Children, Relatives, Home, Neighbourhood, and Community [1].

The QOLI also provides a basic importance weighting facility, which allows respondents to indicate the value they place on each domain. In completing the QOLI, respondents are asked to rate importance on a three point scale ('Not important'=0, 'Important'=1, 'Extremely Important'=2) and satisfaction on a six point scale (from 'Very Dissatisfied'= -3 to 'Very Satisfied'=+3) for each domain. Multiplying importance scores by satisfaction scores produces weighted satisfaction scores for each domain. A total QOLI score is obtained by averaging domain scores. Total scores may be converted to T-Scores and percentile rankings when compared with the QOLI normative sample [1].

Only one published study was identified in which the QOLI was used in outcome research within the TBI population [15]. In a preliminary attempt to

provide distribution and psychometric information relevant to the TBI population, Kalpakjian et al. [15] utilized a cross sectional design with 50 adult participants, who had sustained severe TBI (Mean GCS = 8.74), and were more than five years post injury. With this modest sized sample, Kalpakjian et al. [15] reported a mean QOLI score in the Low Average range, compared with Frisch's (1994) generic distribution. This finding was generally consistent with previous SQOL findings on other measures such as the Satisfaction With Life Scale and Life Satisfaction Index (e.g., [21,22]).

The purpose and aims of the present study

As already mentioned, SQOL is an important construct in outcomes research and rehabilitation contexts. However, there has been very little work published that has examined SQOL measures and outcomes in general, and more specifically the QOLI, within the TBI population [2,15]. As such, fundamental questions about the application of the generic normative distribution of the QOLI and its structure within the TBI population need to be addressed. This is because some of the fundamental characteristics of the TBI population are known to be different, compared with the general population. For example, TBI occurs more frequently amongst males, and within adolescent and older adult age groups [3]. As such, it is conceivable that there may be some important differences between the pre-injury estimates of the TBI population and the normative distribution of the non-clinical population.

It is important that any differences in the pre-injury SQOL status of people with TBI are identified, as it forms critical baseline reference information in

studies of outcome and the efficacy of rehabilitation efforts. Without this basic reference information, Johnston and Miklos [14] point out that researchers and clinicians using generic measures '…can not make supportable decisions about the selection of instruments and interpretation of data when information is lacking about the distribution of scores and psychometric characteristics in a TBI sample, compared with normative samples' (p.256).

In addition to the pre-injury reference information, several studies in other clinical populations have demonstrated factor structures for the QOLI. As previously noted, the factor scores or subscales of the QOLI are likely to be useful for tracking specific aspects of SQOL outcome in both clinical research and rehabilitation contexts. The present study sought to provide both pre-injury normative reference information and the factor structure of the QOLI for use in TBI outcomes and rehabilitation contexts and had two aims. These were:

1. To compare pre-injury estimations of SQOL of a representative sample of people who recently suffered TBI in Tasmania, Australia, with the US-based QOLI normative information.
2. To identify and confirm the factor structure of the domains of the QOLI utilising the pre-injury estimates provided by this sample of adults who recently suffered TBI.

Methods and procedures

Design

This study utilized cross-sectional sampling of participants who had recently sustained a TBI. Data were collected within the first month or as soon as

possible following injury. The battery of variables collected included participant demographic, injury-related, medical history, cognitive, functional and psychosocial variables.

Participants

Participants were adult volunteers who had recently sustained TBI and who had consented to involvement in the TBI Outcome Study conducted by the Neurotrauma Register of Tasmania (NTR). The NTR commenced a population-based prospective TBI outcome study in December 2003. The project attempts to recruit all patients meeting specific criteria, who presented to the Department of Emergency Medicine (DEM) and other wards at the Royal Hobart Hospital (RHH), Tasmania, Australia. Eligibility criteria for inclusion in the NTR outcome study included a diagnosis of TBI. This diagnosis was made by a trained research assistant who, after interviewing the participant, concluded there was evidence of a period of loss of consciousness, transient confusion or post-concussive symptoms following trauma involving the head. Participants were excluded if they were younger than 16 years or had progressive neurological disease such as Dementia. Assessments were conducted in the offices of the NTR, on the RHH wards, and on domiciliary visits.

The participant group comprised 470 adults who had sustained a TBI within the preceding month. Approximately two thirds of the group was male (65%). Participants' mean age at injury was 34.75 years (*SD* = 16.44), and ranged from 16 to 84 years. The median age at injury was 30.64 years. Participants' reported having received an average of 11 years of education (*SD* =

2.31). Intellectual functioning prior to injury was estimated using the National Adult Reading Test (NART), and showed a normal distribution. Mean estimated pre-injury IQ was 96.84 (*SD* = 11.23), and the median was 97.20. Participants were injured in transport accidents (39%), assaults (29%), falls (18%), sports activities (6%) and other activities (8%).

The proportion of participants in each category of severity of injury was based on length of post-traumatic amnesia (PTA) [23] and is shown in Table 1. For inpatients, PTA was measured with the Westmead PTA Scale. However, where participants were outpatients, they provided a retrospective estimate of the duration of their PTA symptoms.

Insert Table 1 about here

These demographic characteristics were generally similar to TBI samples studied in previous Australian epidemiological research (e.g., [24, 25[). However, compared with previous research, there was an under representation of participants with more severe TBI and a higher proportion of the sample suffering assault.

Measures

The Quality of Life Inventory (QOLI, [1]) was used to provide ratings of participants' SQOL. Within a normative sample of 798 North American adults, the reliability and validity of the QOLI have been reported to be very good, with test-retest reliability coefficients of 0.73 ($p<.001$) and internal consistency for the sum of the weighted satisfaction ratings, α=0.79. The QOLI was shown to be positively and significantly correlated with the Satisfaction With Life Scale (r=.56,

p<.001), and Quality of Life Index (*r*=.75, *p*<.001) [1]. Further validation research has found consistent evidence to support the validity of the QOLI [26].

Procedure and analysis

The Emergency Department Information System (EDIS) at the Royal Hobart Hospital identified patients presenting with head injury, who were then interviewed by NTR staff to confirm their eligibility for the study. Consenting participants were initially screened with the Mini-Mental State Examination (MMSE, [27]) and if scoring 23 or greater, completed a battery comprising neuropsychological tests and other questionnaires. Participants experiencing more severe TBI were interviewed as soon as they were established to be out of PTA. The median time following injury until participants were assessed was 16 days (*SD* = 27.31). Participants QOLI raw scores were calculated and converted to T-Scores (M=50 and SD=10), for comparison with the normative distribution provided with the QOLI 1. A one-sample T-Test was conducted between the QOLI Total scores of the pre-injury estimates and Frisch's 1 distribution.

Four hundred and seventy participants provided pre-injury estimates on the QOLI. Exploratory factor analysis (EFA) was undertaken with the data of the first 235 participants, using a principal axis factor analysis. Tabachnick and Fiddel [28] explain that orthogonal rotation is best when solutions will be used for further group comparisons (p.622-623). As this research was undertaken to provide a structure that would be used in future longitudinal outcome and predictive modelling analysis, varimax rotation was used in this analysis. To ensure extracted factors accounted for reasonably large amounts of variance,

criterion were set at Eigen values >1. In addition, scree plots were examined. Determination of significant domain-factor loading was set at a coefficient level of .4 or greater, as this provided a level at which there was least sharing of domains between factors, balanced with meaningful interpretation of the resulting structure.

The model suggested by the EFA was assessed by a confirmatory factor analysis (CFA), using the second sub-sample of 235 participants and the Analysis of Moment Structures (AMOS) version 6 software package (in SPSS v.15). The model was initially assessed and subsequently refined using the resulting standardised regression weights found for each of the observed variables and modification indices. Multiple goodness of fit tests were used to evaluate the model [29].

Results

Results of this study are presented in four sections. First, the pre-injury ratings of SQOL and ratings taken subsequent to TBI are compared with Frisch's distribution. Second, the results of the exploratory factor analysis and confirmatory factor analysis models are presented. Finally, QOLI Total score and QOLI Factor Score outcomes over the time-points of the study to twelve months following injury are presented.

Comparison of QOLI Distributions

Table 2 compares the pre-injury ratings of adult Tasmanians who had recently sustained a TBI with the US-based generic distribution of the QOLI.

Insert Table 2 about here

In general, the pre-injury distributions of the participant group of the present study were similar to the generic US-based normative distribution provided by Frisch 1. Our Tasmanian TBI sample was well distributed across the range of possible QOLI scores. A slightly larger standard deviation was noted within our sample, compared with the generic US-based distribution. The mean and median, as well as the score at the 25th percentile appeared lower within our sample. The mean of our sample lay at the 40th percentile, compared with the US-based generic distribution.

Table 3 compares the raw score ranges of the generic US-based distribution with the Tasmanian TBI sample, within the clinical ranges of the QOLI. These ranges are described in the QOLI Manual [1].

Insert Table 3 about here

The comparison in Table 3 shows the differences between the US distributions and Tasmanian TBI distributions. The score required to enter the High Range is marginally higher in the Tasmanian TBI sample. There is a wider spread of scores within the Average Range. The Low and particularly the Very Low Range scores extend below the scores of the US-distribution. As such, a lower score is required to enter the Very Low ranges within the Tasmanian TBI distribution compared with the generic US distribution. Overall, these differences are minimal and there was no significant difference between Pre-injury estimates and Frisch's[1] mean of 2.60, t (465) = -1.07, p = .28.

Exploratory Factor Analysis

Table 4 presents the structure of the QOLI, as a measure of pre-injury SQOL within our sample of adults who had recently sustained TBI. In this rotated solution, three factors met criteria for extraction, with Eigen values >1, accounting for a total of 53% of the variance. Inspection of the scree plot supported these three factors as offering the best solution. As already noted, a factor loading greater than .40 provided a threshold level that provided the most meaningful structure.

Highest loadings on Factor 1 were from Community, Neighbourhood, Home, Love, Money, and Relatives. In this rotated solution, Factor 1 accounted for 37% of the variance and may be viewed as a 'Family and environment' factor. The second factor accounted for a further 9% of the variance and contained 'Self-actualisation' domains including Learning, Creativity, Helping, Play, and Goals & Values. The third factor showed highest loadings for Self-esteem, Health, Play, Work and Goals & Values. This third factor accounted for 7% of the variance and may be thought of as a 'Self-functioning and activity' factor.

Confirmatory Factor Analysis

The model suggested by the exploratory factor analysis was initially assessed and subsequently refined using the resulting standardised regression weights found for each of the observed variables and modification indices. In designing the initial model, circles represent latent variables and rectangles represent measured variables. Independence of error terms were specified and factors were allowed to be correlated. Assumptions of multivariate normality and

linearity were evaluated through SPSS and found acceptable. There were no missing data.

Multiple goodness of fit tests included the minimum sample discrepancy divided by degrees of freedom, known as Relative or Normal Chi-square (CMIN/DF; [30]), the Comparative Fit Index (CFI; [31]), the Goodness of Fit Index (GFI; [32]) and the Root Mean Squared Error Approximation (RMSEA; [33]). The initial model is shown in standardised form in Figure 1.

Insert Figure 1 about here

Maximum likelihood estimation was employed to estimate all models. The independence model that tests the hypothesis that all variables were uncorrelated was easily rejected, $\chi 2$ (91, N = 235) = 914.37, p <.01. The hypothesized model was tested next using the Chi-square test, $\chi 2$ (72, N = 235) = 181.91, p < .01. Whilst significance can indicate poor model fit, Ullman [30] indicates trivial differences between sample and estimated population covariance matrices can give inaccurate results. Such problems have necessitated development of a number of Goodness of Fit indices.

Ullman [30] explains the interpretation of frequently reported indices. Firstly, Normal Chi-square (CMIN/DF) with a value less than 2 is likely to indicate an adequate fit to the data. A Comparative Fit Index (CFI) and Goodness of Fit Index (GFI) greater than 0.90 indicates the model is a good fit to the data. A Root Mean Squared Error Approximation (RMSEA) with values of less than 0.08 indicates a good fit to the data, while values greater than 0.10 suggest strongly

that the model fit is unsatisfactory. Goodness of fit tests showed this initial model had potential to fit the data as shown in Table 5.

Insert Table 5 about here

The modification indices suggested reduction of the Chi-square score by 37.79 if the error terms e13 (on Neighbourhood) and e14 (on Community) were allowed to covary. Given the high correlation between these two variables, this was considered theoretically acceptable.

Also in this initial analysis, the following two pathways had non-significant regression estimates at the .05 level:

- Play and Self-functioning, $p = .06$.
- Goals and Self-actualisation, $p = .36$.

The model was therefore modified to remove these non-significant relationships and allow the specified error terms to covary. On testing this modified model, the Chi-square was significant, $\chi 2$ (73, N = 235) = 135.26, $p < .01$. Support for this modified model was found across the other Goodness of Fit test indices shown in Table 6.

Insert Table 6 about here

The indices shown in Table 6 indicated a sound fit for the data to the modified model, across the indices. High inter-correlations (.69 to .83) between the factors were also noted. The modified model is shown in standardised form in Figure 2.

Insert Figure 2 about here

Discussion

This study sought to provide basic reference information for the QOLI 1 for use within the Australian TBI population, using participants' pre-injury estimates of the their SQOL on the QOLI [1]. QOLI ratings were obtained from people who had recently sustained a TBI in Southern Tasmania and compared with the generic, US-based QOLI normative distribution. This study also sought to determine the factor structure of the QOLI within this clinical population, to further support the use of the QOLI in evaluating effectiveness of rehabilitation and in further clinical outcome research.

Comparison of the distributions of the pre-injury estimates of the Tasmanian TBI sample with the generic US normative sample [1] showed the local sample was distributed about a slightly lower mean and median score, with a larger standard deviation (see Table 2). It was noted that our group scored higher at the 75th percentile point and lower at the 25th percentile point than Frisch's [1] generic QOLI distribution. Overall, these results indicate there is little difference between the generic US-based distribution and local TBI sample on pre-injury estimates. However caution should be applied to interpretation of scores at the lower end of the distribution within the local TBI context. It is suggested the local classification corrections provided in this paper would be useful to clinicians and researchers in this clinical area (see Table 3).

As already described, Kalpakjian et al. [15] investigated SQOL following TBI using the QOLI. Kalpakjian et al.'s preliminary study surveyed 50 community-dwelling people with severe TBI, approximately five years following injury.

Compared with Kalpakjian et al.'s distribution, our Tasmanian TBI sample had a higher mean and smaller standard deviation (Kalpakjian et al.'s Mean=43.08, *SD*=17.24, Tasmanian TBI sample's Mean=48.18, *SD*=13.93). Based on Frisch's [1] distribution, the mean of the Kalpakjian et al.'s [15] sample was at the 21st percentile, on the border of the Low Range and Average Range. In comparison, the mean score of the Tasmanian sample was within the Average Range of Frisch's [1] distribution, at the 40th percentile. It is likely this difference was due to our sample rating their pre-injury SQOL estimates, with their SQOL being unaffected by TBI, whereas Kalpakian et al.'s sample had suffered severe TBI several years prior to assessment. Predictably, our sample's distribution more closely resembles Frisch's standardization sample, than Kalpakian et al.'s distribution of QOLI scores. This comparison also highlights the deterioration of SQOL and needs of people with more severe TBI over time following injury.

Pre-injury estimates were used to identify and confirm the factor structure of the QOLI. The factor analysis of the QOLI within our sample produced a three-factor solution. Some differences were noted between the structure of the QOLI for the Tasmanian TBI sample and structures of the QOLI in three published studies examining other clinical samples. Table 7 below shows some commonalities and differences between the structure of several clinical samples, and the Tasmanian TBI sample. Commonalities included the 'Environment' factor incorporating Neighbourhood and Community across all three samples. The 'Health' factor (Health, Self-esteem) identified in the chronic back pain group was similarly seen in the TBI group, where it was identified with the addition of Goals

and Values and Play. The Personal Growth factor identified in the TBI group to include Play, Learning, Creativity, Helping and Goals & Values was also identified in the other samples. There was also a factor encompassing relationships with family and friends across the samples.

Insert Table 7 about here

Subtle differences in the structures of the clinical samples were noted. For example, Claibourne et al [34] and Eng at al.'s [35] clinical samples each separated Accomplishment/Achievement domains from the Health domain, whereas the TBI sample and O'Cleirigh & Safren's [36] HIV sample included Health and Self-Esteem in these Achievement factors. This difference may be a reflection of the recent impairment and the resulting limitations of their injury and illness and the reduction in their participation in aspects of psychosocial activity such as work.

In summary, there was similarity in the factor structure of the QOLI across these clinical samples. The differences between clinical samples suggest there are subtle differences in the structure of SQOL between clinical groups and confirm the wisdom of calls in recent literature for validation of subjective measures of quality of life within specific clinical and disabled populations (e.g., [2, 9, 10]).

Limitations

There are a number of limitations to the present study that need to be considered. These include the possibility of inaccuracy in participants' estimates of pre-injury SQOL, some variations within our TBI sample compared with other

epidemiological studies that may affect the representativeness of the present sample, and the issue of the effect of national differences contributing to variation between distributions of the QOLI ratings.

It is acknowledged that some participants' estimates of their pre-injury SQOL following TBI may not have been entirely "accurate" due to cognitive impairment related to their injuries. Whilst the possibility of inaccuracies in this methodological approach is acknowledged, there was no practical alternative. Assessments were conducted as soon as possible following injury as delaying assessment of pre-injury estimates could have possibly led to contamination of results from post injury factors.

It was disturbing to note a higher proportion of TBI attributed to assault in this Tasmanian sample compared with previous Australian epidemiological studies by Hillier et al. [24] and Tate et al. [25] who reported approximately 9% of their samples suffered assault. Several sources suggest that since these epidemiological studies were conducted in the late 1980s, the rate of reported violent crime, including assault has increased substantially. For example, Moffat & Poynton [37] indicate a 105% increase in the rate of assaults reported each year in New South Wales since 1990. These researchers found the rate of reporting had remained unchanged over this period and concluded this rise in as an indicator of a genuine increase in the incidence of assault. Tasmanian Police statistics indicated a 43% increase in person related offences, including assault, between 2000/2001 and 2004/2005 [38].

The lack of participants in this study who had sustained an Extremely Severe TBI (PTA>4 weeks) compared with those with less severe TBI was also evident. In comparison with previous epidemiological studies, the proportions of severity of injury in the present sample more closely approximated the results of Tate et al.'s [25] study of country hospitals in Northern NSW, (58% mild, 20% moderate, 22% severe TBI). Hillier et al.'s [24] study reported a greater proportion of patients presenting to hospital in South Australia with mild TBI (82% mild, 9% moderate, and 9% severe TBI). The small numbers of participants with Extremely Severe TBI (PTA>28 days) in the current study is explained by the relatively low incidence of these injuries and also the inability of some with this level of injury to provide responses to the QOLI due to cognitive impairment.

It may be that national differences between people in the US and Australia contributed to the differences between these distributions of QOLI scores. There is a clear need for research to investigate differences between the SQOL of the general Australian and US populations using the QOLI. This would facilitate comparison of any differences between the Australian general population and the pre-injury estimates of the Australian TBI population. As already discussed, differences here may be due to the TBI population being younger, with fewer years of education, and from a lower socio-economic background than the general population [24]. It is recognised that other factors affecting SQOL such as history of mental illness and drug and alcohol abuse are risk factors for TBI [4]. Depression is also highly correlated with SQOL and may be more prevalent

prior to injury amongst those who sustain TBI [39-41]. Future research will investigate the relationship of these pre-injury risk factors on post TBI outcome.

Conclusions and directions for further research

This study has identified the pre-injury distribution and confirmed a three-factor structure for the QOLI within a sample who recently suffered TBI in Southern Tasmania, Australia. Some differences between the local sample who rated their pre-injury SQOL using the QOLI and the generic-US distribution provided by Frisch [1] were identified. As such, caution is recommended in interpreting QOLI results within the TBI population with reference to the US-based norms and clinical ranges. Reference information for this purpose is provided in Table 3. Further research conducted by the Neurotrauma Register of Tasmania will investigate SQOL outcome over time following injury and the role of a range of injury, demographic, physical, emotional, and cognitive variables in predicting SQOL outcome following TBI.

Acknowledgements

We would like to express our gratitude to the participants and staff involved in this study. This research was made possible by project funding for the Neurotrauma Register of Tasmania, by the Motor Accident Insurance Board (Tasmania, Australia).

References

1. Frisch MB. Quality of Life Inventory. Minneapolis, MN, USA: BCDE; 1994.
2. Bullinger M and the Traumatic Brain Injury Consensus Group. Quality of life in patients with traumatic brain injury - basic issues, assessment and

recommendations. Restorative Neurology and Neuroscience 2002;20:111-124.

3. Fortune N, Wen X. The definition, incidence and prevalence of acquired brain injury in Australia. Canberra: Australian Institute Of Health And Welfare; 1999.
4. Ponsford J, Sloane S, Snow P. Traumatic Brain Injury: Rehabilitation For Everyday Adaptive Living. UK: Psychology Press; 1995.
5. Kendall E, Buys N. An integrated model of psychosocial adjustment following acquired disability. Journal of Rehabilitation 1998;64(3):16-20.
6. Silver JM, McAllister TW, Yudofsky SC. Textbook of traumatic brain injury. Arlington, VA: American Psychiatric Publishing inc; 2005.
7. MWBIRP. The Development And Implementation Of The New South Wales NSW Brain Injury Rehabilitation Program. Bathurst: Mid Western Brain Injury Rehabilitation Program; 1999.
8. Brown M, Gordon W, Haddad L. Models for predicting subjective quality of life in individuals with traumatic brain injury. Brain Injury 2000;14:5-19.
9. Neugebauer E, Bouillon B, Bullinger M, Wood-Dauphinee S. Quality of life after multiple trauma - Summary and recommendations of the consensus conference. Restorative Neurology and Neuroscience 2002;20(3-4):161-167.
10. NIH. Rehabilitation of persons with traumatic brain injury. Journal of the American Medical Association 1999;282(10):974-983.

11. Dijkers MP. Quality of life after traumatic brain injury: A review of research approaches and findings. Archives of Physical and Medical Rehabilitation 2004;85(Suppl 2, April):S21-S35.

12. Frisch MB. Quality of Life Assessment/Intervention and the Quality of Life Inventory. In: Maruish ME, editor. The use of psychological testing for treatment planning and outcomes assessment. 2nd ed. Mahwah, NJ, US: Lawrence Erlbaum Associates; 1999. p 1277-1331.

13. von Steinbuechel N, Petersen C, Bullinger M, Group Q. Assessment of health reated quality of life in persons after traumatic brain injury - development of the QOLIBRI, a specific measure. Acta Neurochir Suppl 2005;93:43-49.

14. Johnston MV, Miklos CS. Activity-related Quality of Life in Rehabilitation and Traumatic Brain Injury. Archives of Physical Medicine and Rehabilitation 2002;83(Suppl 2):S26-S38.

15. Kalpakjian CZ, Lam CS, Toussaint LL, Hansen Merbitz NK. Describing quality of life and psychosocial outcomes after traumatic brain injury. American Journal of Physical and Medical Rehabilitation 2004;83:255-265.

16. Berger E, Leven F, Pirente N, Bouillon B, Neugebauer E. Quality of life after traumatic brain injury: A systematic review of the literature. Restorative Neurology and Neuroscience 1999;14(2-3):93-102.

17. Kendall E, Terry DJ. Psychosocial adjustment following closed head injury: A model for understanding individual differences and predicting outcomes. Neuropsychological Rehabilitation 1996;6(2):101-132.

18. Steadman-Pare D, Colantonio A, Ratcliff G, Chase S, Lee V. Factors associated with perceived quality of life many years after traumatic brain injury. Journal of Head Trauma Rehabilitation 2001;16(4):330-342.

19. Frisch MB. Quality of life therapy and assessment in health care. Clinical Psychology - Science and Practice 1998;5(1):19-40.

20. Frisch MB, Cornell J, Villanueva M, Retzlaff PJ. Clinical validation of the Quality of Life Inventory: A measure of life satisfaction for use in treatment planning and outcome assessment. Psychological Assessment 1992;4(1):92-101.

21. Brown M, Vandergoot D. Quality of life for individuals with traumatic brain injury: Comparison with others living in the community. Journal of Head Trauma Rehabilitation 1998;13(6):39-56.

22. Webb CR, Wrigley M, Yoels W, Fine PR. Explaining quality of life for persons with traumatic brain injuries 2 years after injury. Archives of Physical and Medical Rehabilitation 1995;76:1113-1119.

23. Russell WR. The Traumatic Amnesias. London: OLP; 1977.

24. Hillier SJ, Hiller JE, Metzer J. Epidemiology of traumatic brain injury. Brain Injury 1997;11(9):649-659.

25. Tate R, McDonald S, Lulham J. Incidence of hospital-treated traumatic brain injury in an Australian community. Australian and New Zealand Journal of Public Health 1998;22:419-423.

26. McAlinden NM, Oei TPS. Validation of the Quality of Life Inventory for patients with anxiety and depression. Comprehensive Psychiatry 2006;47:307-314.

27. Folstein ML, Folstein SE, McHugh PR. Mini-mental state: A practical method for grading the cognitive state of patients for the clinician. Journal of Psychiatry Research 1975;12:189-198.

28. Tabachnick BG, Fidell LS. Using multivariate statistics. MA: Allyn & Bacon: Boston; 2001.

29. Bentler PM, Bonnet DG. Significance tests and the goodness of fit in the analysis of covariance structures. Psychological Bulletin 1980;88:588-606.

30. Ullman JB. Structural equation modeling. In: Tabachnick LS, Fidell LS, editors. Using multivariate statistics. 4th ed. MA: Allyn & Bacon; 2001.

31. Bentler PM. Comparative fit indices in structural models. Psychological Bulletin 1988;107:238-246.

32. Joreskog KG, Sorbom D. LISREL 8 User's Reference Guide. Chicago: Scientific Software International; 1993.

33. Browne MW, Cudeck R. Alternative ways of assessing model fit. Testing structural equation models. Newbury Park, CA: Sage; 1993.

34. Claiborne N, Krause TM, Heilman AE, Leung P. Measuring quality of life in back clients: Comparison of the Health Status Questionnaire 2.0 and the Quality of Life Inventory. Social Work in Health Care 1999;28:77-94.

35. Eng W, Coles ME, Heimberg RG, Safren SA. Domains of life satisfaction in social anxiety disorder: Relation to symptoms and response to cognitive -behavioural therapy. Journal of Anxiety Disorders 2005;19(2):143-156.

36. O'Cleirigh C, Safren SA. Domains of life satisfaction among patients living with HIV: A factor analytic study of the quality of life inventory. Aids and behaviour 2006;10(1):53-58.

37. Moffat S, Poynton S. Long term trends in property and violent crime in New South Wales. Crime and Justice Bulletin 2006.

38. Tasmania Police. Crime Investigation. Volume 2006; 2006.

39. Abbey A, Andrews FM. Modelling the psychological determinants of life quality. Social Indicators Research 1985;16:1-34.

40. Corrigan JD, Bogner JA, Mysiw WJ, Clinchot D, Fugate L. Life satisfaction after traumatic brain injury. Journal of Head Trauma Rehabilitation 2001;16(6):543-555.

41. Vickery CD, Gontkovsky ST, Caroselli JS. Self-concept and quality of life following acquired brain injury: A pilot investigation. Brain Injury 2005;19(9):657-665.

Tables

Table 1

Severity of traumatic brain injury (based on Russell [23])

Severity	Duration of PTA	n	%
Very Mild	<= 5 minutes	125	28
Mild	5 to 60 minutes	108	24
Moderate	1 to 24 hours	127	28
Severe	1 to 7 days	65	14
Very severe	1 to 4 weeks	23	6
Extremely severe	> 4 weeks	2	<1

Table 2

Comparison of normative statistics for the QOLI

	Pre-injury estimates (*N*=470)		Generic US-based (*N*=798)	
	Raw	T-Score	Raw	T-Score
Mean	2.51	49.39	2.60	50.00
Standard Deviation	1.70	13.09	1.30	10.00
75th percentile	3.63	57.92	3.40	57.00
Median	2.75	51.15	2.70	51.00
25th percentile	1.66	42.77	1.80	43.50
Minimum	-3.94	-.29	-3.88*	NA
Maximum	5.88	75.19	5.88*	NA
Skew	.11	.11	NA	NA
Kurtosis	.75	.75	NA	NA

* Taken from clinical samples provided by Frisch [20]. *Note.* NA=Information not available.

Table 3

Comparison of pre-injury estimates with US-based norms

Overall QOL Classification	Raw scores Ranges		T-Scores Ranges	Percentile Range
	TBI	US-generic		
High	3.95 to 6.00	3.60 to 6.00	58 to 77	81st to 99th
Average	1.57 to 3.94	1.60 to 3.50	43 to 57	21st to 80th
Low	0.47 to 1.56	0.90 to 1.50	37 to 42	11th to 20th
Very Low	-6.00 to 0.46	-6.00 to 0.80	0 to 36	1st to 10th

Table 4

Factor Structure of the QOLI Using Importance Weighted Satisfaction Scores

Domains	Factors		
	I 37% variance (Family & environment)	II 9% variance (Self actualisation)	III 7% variance (Self-functioning & activity)
Health	.01	.13	**.57**
Self Esteem	.33	.18	**.59**
Goals & Values	.37	**.44**	**.44**
Money	**.45**	.22	.36
Work	.17	.31	**.44**
Play	.10	**.44**	**.57**
Learning	.12	**.74**	.23
Creativity	.35	**.60**	.18
Helping	.23	**.55**	.25
Love	**.45**	.25	.23
Friends	.31	.35	.37
Children	.34	.02	.23
Relatives	**.40**	.39	.19
Home	**.58**	.36	.33
Neighbourhood	**.66**	.20	.02
Community	**.68**	.16	.02

Note. Bold indicates that item loading on a factor is 0.40 or above.

Table 5

Initial Goodness of Fit test indices

	CMIN/DF	RMSEA	CFI	NFI	GFI
Fit to data if	<2	<.08	>.9	>.9	>.9
Initial model	2.53	.08	.87	.80	.90

Note. Fit to data indicates thresholds for adequate model fit for each test. Normal chi-square (CMIN/DF), Comparative fit index (CFI), Goodness of fit index (GFI), Root mean squared error approximation (RMSEA).

Table 6

Goodness of Fit test indices for the modified model

	CMIN/DF	RMSEA	CFI	GFI
Fit to data if	<2	<.08	>.9	>.9
Modified model	1.85	.06	.92	.92

Note. Fit to data indicates thresholds for adequate model fit for each test. Normal chi-square (CMIN/DF), Comparative fit index (CFI), Goodness of fit index (GFI), Root mean squared error approximation (RMSEA).

Table 7

QOLI factors and domains derived from other clinical populations.

Tasmanian TBI sample (CFA, n=235)	Chronic back pain (EFA, n=253) Claibourne et al. [34]	Social anxiety (EFA, n=138) Eng et al. [35]	HIV infection (EFA, n=152) O'Cleirigh & Safren [36]	Anxiety and depression (EFA/CFA, n=217) McAlinden & Oei [26]
1. **Family & environment:** Relatives, Love, Money, Home, Community, Neighbourhood. 2. **Self-actualisation**: Learning, Creativity, Helping, Play. 3. **Self-functioning & activity:** Health, Self-esteem, Work, Goals & Values.	1. **Family support:** Love, Friends, Children, Relatives. 2. **Environment:** Home, Neighbourhood, Community. 3. **Personal growth:** Learning, Creativity, Helping. 4. **Accomplishment:** Work, Goals, Money, Play. 5. **Health:** Health, Self-esteem.	1. **Social functioning:** Play, Love, Helping, Friends, Relatives. 2. **Surroundings:** Neighbourhood, Community. 3. **Personal growth:** Goals & values, Learning, Creativity 4. **Achievement:** Self-esteem, Money, Work, Home.	1. **Interpersonal:** Relatives, Children, Love, Friends, Helping. 2. **Environment:** Community, Neighbourhood, Home. 3. **Self-expression:** Learning, Creativity, Play. 4. **Achievement:** Self-esteem, Health, Money, Goals & values, Work.	1. **Self-orientated:** Self-esteem, Goals & values, Health, Learning, Work, Creativity, Play, Helping, Friends. 2. **Other orientated: Friends,** Neighbourhood, Community, Home, Relatives, Children, Love, Money, Relatives.

Figures

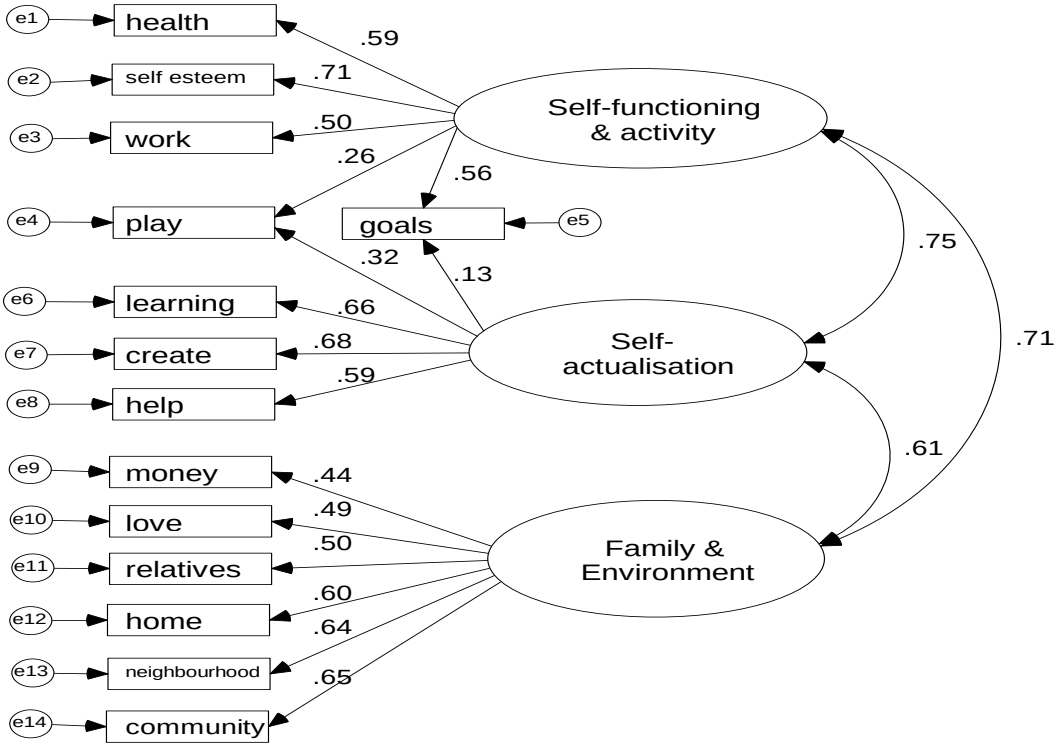

Figure 1. Initial model showing standardised regression weights.

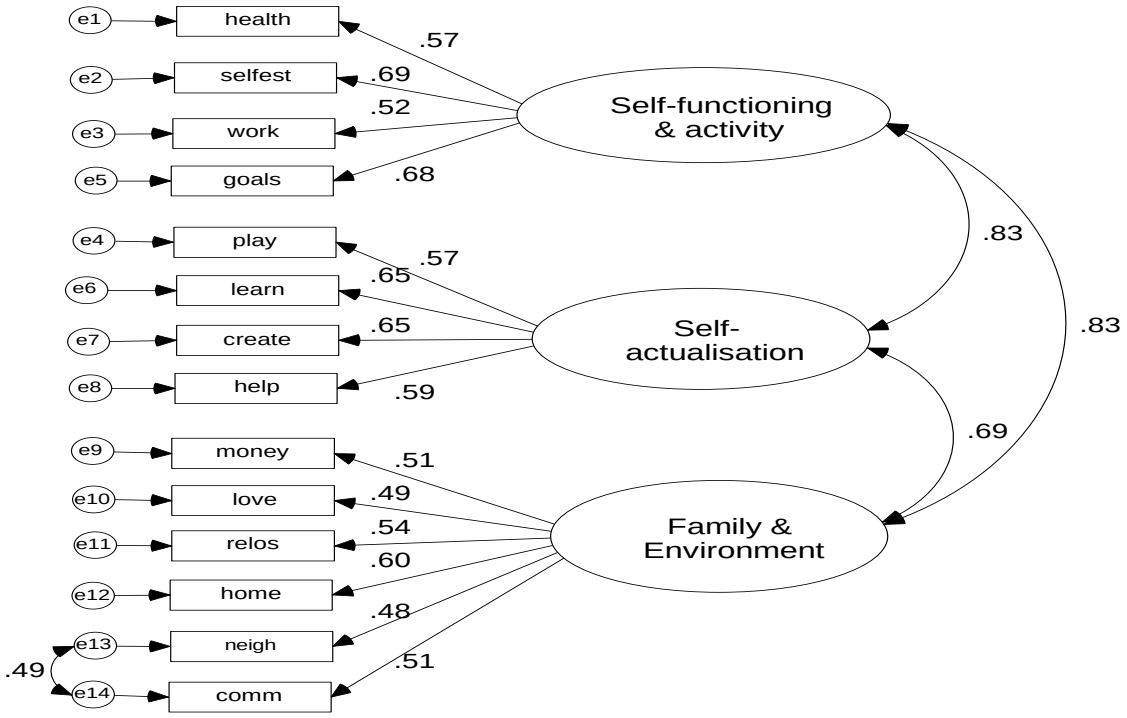

Figure 2. Modified model showing standardised regression weights.