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## Understanding health-related quality of life in caregivers of civilians and service members/veterans with traumatic brain injury: Reliability and validity data for the TBI-CareQOL measurement system

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## Abstract

**Objectives**—To establish the reliability and validity of the newly developed TBI-CareQOL patient reported outcomes measures in caregivers of civilians and service members/veterans (SMVs) with traumatic brain injury (TBI) so that they can be used with confidence in clinical research and practice.

**Design**—Computer-based surveys delivered through an on-line data capture platform.

**Setting**—Three TBI Model Systems rehabilitation hospitals, an academic medical center, and a military medical treatment facility.

**Participants**—Five hundred and sixty caregivers of individuals with TBI; this included two different study samples: 344 caregivers of civilians with TBI and 216 caregivers of SMVs with TBI.

**Intervention**—Not Applicable

**Main Outcome Measures**—5 TBI-CareQOL item banks

**Results**—Reliabilities for the TBI-CareQOL measures were excellent (all Cronbach's  $\alpha > .88$ ); three-week test-retest reliability ranged from .75 to .90 across the two samples. Convergent validity was supported by moderate to high associations among the TBI-CareQOL measures and moderate correlations between the TBI-CareQOL measures and other measures of health-related quality of life (HRQOL) and caregiver burden. Discriminant validity was supported by low correlations between the TBI-CareQOL measures and less-related constructs (e.g., caregiver satisfaction). Known groups validity was supported: caregivers of individuals that were low functioning had worse HRQOL than caregivers of high functioning individuals.

**Conclusions**—Results provide psychometric support for the new TBI-CareQOL item banks. As such, these measures fill a significant gap in the caregiver literature where sensitive patient-reported outcomes (PRO) measures that capture changes in HRQOL are needed to detect improvements for interventions designed to assist family caregivers.

Traumatic brain injury (TBI) can lead to significant impairment in cognitive,<sup>1</sup> emotional,<sup>2,3</sup> behavioral,<sup>4,5</sup> and physical functioning,<sup>6,7</sup> particularly for those with more severe injuries. These impairments are often associated with dependence in everyday functional activities, and reduced participation in employment and social activities.<sup>8–11</sup> Family members often assume the caregiver role, and most are not fully prepared. Not surprisingly, caregivers of individuals with TBI undergo considerable stress<sup>12</sup> that negatively impacts their health-related quality of life (HRQOL), a multidimensional construct reflecting the impact of a disease, disability, or its treatment on mental, physical, and social well-being.<sup>13</sup> Negative sequelae for these caregivers can include depression and anxiety,<sup>14–16</sup> family system disruption,<sup>14</sup> decreased marital satisfaction and longevity,<sup>17,18</sup> social isolation,<sup>15,19,20</sup> increased need for mental health services,<sup>21</sup> and increased use of alcohol and drugs.<sup>21,22</sup> Caregiver stress is also related to poorer outcomes for the patients themselves.<sup>23–30</sup>

Qualitative work in caregivers of civilians<sup>31</sup> and service members/veterans (SMVs)<sup>32</sup> with TBI has recently highlighted a diverse array of HRQOL concerns. Consistent with previous research, several sources of caregiver stress were documented, including feelings of strain,<sup>33</sup> anxiety,<sup>34</sup> feeling trapped,<sup>35</sup> and grief/loss.<sup>36</sup> To date, there is no measure that comprehensively captures these caregiver-specific aspects of HRQOL. The TBI-CareQOL measurement system was developed to address this shortcoming.<sup>37-41</sup>

The TBI-CareQOL was designed to capture the unique aspects of HRQOL relevant to caregivers of individuals with TBI. Specifically, the TBI-CareQOL includes several new caregiver-specific measures that reflect important HRQOL constructs (i.e., strain, anxiety, feeling trapped, feelings of loss), as well as measures from the Patient Reported Outcomes Measurement Information System<sup>42</sup> (PROMIS), which assesses general symptoms and health concepts across diseases/conditions. All TBI-CareQOL measures were developed according to established measurement development standards<sup>43</sup> and can be administered as a static short form (SF; i.e., a set-number of fixed items), or as a computerized adaptive test (CAT; i.e., each item is selected based on the previous item response). The purpose of this report is to provide reliability and validity data for the SF and CAT administrations of the TBI-CareQOL measures. Reliability and validity data for the PROMIS measures are provided elsewhere.<sup>44-46</sup>

## Method

### Participants

Five hundred and sixty caregivers of individuals with TBI participated in this study (a detailed sample description is reported elsewhere<sup>37</sup>). Additionally, 145 caregivers completed a retest approximately 3 weeks after their initial study visit. Inclusion criteria specified that caregivers be 18 years old, able to read/understand English, and provide physical assistance, financial assistance, or emotional support to an individual with a TBI. Caregivers were required to be caring for an individual with a medically-documented TBI who sustained the TBI when they were 16 years of age, and 1 year post-injury. Caregivers of civilians were required to be caring for an individual that met TBI Model System inclusion criteria for a complicated mild, moderate or severe TBI.<sup>47</sup> Caregivers of SMVs were required to be caring for an individual that had a TBI documented by a Department of Defense or Veterans Affairs treatment facility. Data were collected as part of a larger study<sup>37</sup> and in accordance with local institutional review boards; caregivers provided consent prior to participation.

### Measures

**TBI-Caregiver Specific HRQOL**—Participants completed the following TBI-CareQOL<sup>37</sup> item banks: Caregiver Strain,<sup>39</sup> Caregiver-Specific Anxiety,<sup>41</sup> Feeling Trapped,<sup>38</sup> Feelings of Loss-Self,<sup>40</sup> and Feelings of Loss-Person with TBI.<sup>40</sup> Caregiver Strain includes 33 items pertaining to feelings of being overwhelmed, stressed or self-defeated related to the caregiver role. Caregiver-Specific Anxiety includes 27 items that examine feelings of worry and anxiety specific to general safety, health, and future well-being of the person with the injury. Feeling Trapped includes 15 questions assessing feelings that the

caregiver is unable to participate in activities outside the home due to caregiving responsibilities. Feelings of Loss–Self includes 30 items examining feelings of sorrow, mental suffering or distress over change that the caregiver has personally experienced related to the TBI. Feelings of Loss–Person with TBI includes 19 items that assess feelings of sorrow, mental suffering or distress related to changes in the person with the TBI. The static SFs for the TBI-CareQOL measures can be found in the Appendix. Details on SF selection, internal structure evidence, and item-level analysis can be found in complementary papers in this issue.<sup>37–41</sup>

Participants completed the full item banks for all TBI-CareQOL measures. Firestar software<sup>48</sup> was used to simulate CAT scores for each participant using data from the full item bank for each measure (CATs were simulated to administer a minimum of four but no more than 12 items, and to discontinue when  $SE < 3$ ). Simulated CAT scores and associated 6-item calibrated short form (SF) scores were examined for each measure. Scores reflect a T metric ( $M=50$ ,  $SD=10$ ); higher scores indicate worse functioning. T-scores are referenced to the combined sample of caregivers of civilians and SMVs.

**Generic HRQOL**—The RAND-12<sup>49</sup> was used to assess generic health status. Separate composite scores were generated for physical health (PHC) and mental health (MHC). Scores range from 0 (low health) to 100 (highest level of health).

**Caregiver Burden**—Caregiver burden was assessed using the Zarit Burden Interview (ZBI)<sup>50</sup> and the Caregiver Appraisal Scale (CAS).<sup>51</sup> The ZBI<sup>50</sup> is a 22-item measure used to evaluate perceptions of burden; total scores range from 0 (low burden) to 88 (high burden). The CAS<sup>51</sup> is a 47-item measure that assesses positive and negative aspects of caregiving: perceived burden, caregiver relationship satisfaction, caregiving ideology, and caregiving mastery.<sup>52</sup> Subscale scores were calculated using the recommendations of Struchen and colleagues<sup>52</sup> and coded so that higher scores on each subdomain reflect positive feelings and lower scores reflect negative feelings.

**Functional Status of the Individual with TBI**—The functional status of the individual with TBI was assessed using the Mayo-Portland Adaptability Inventory-Fourth Edition (MPAI-4).<sup>53</sup> MPAI-4 scores are on a T metric ( $M=50$ ,  $SD=10$ ) with higher scores indicating lower functioning.

## Data Capture

Data were collected using an online platform (<https://www.assessmentcenter.net>). Given the lengthy surveys of the broader study, participants were allowed to take breaks as needed and were given two weeks to complete the surveys. On average, caregivers of civilians took 2.18 hours and caregivers of SMVs took 1.98 hours to complete all assessments. Retest participants were also given two weeks to complete the survey.

## Data analysis

Sample size considerations were based on the broader study (reported elsewhere<sup>37</sup>). Due to the different eligibility criteria for civilian- and military-caregivers, and the different clinical

characteristics, we conducted analyses separately. Data were examined for skewness and kurtosis using Bulmer's criteria<sup>54</sup> prior to analysis; findings indicated that the data were normally distributed.

**Reliability**—Cronbach's alphas were calculated to determine internal consistency reliability for the TBI-CareQOL SFs and IRT-based reliabilities (i.e., marginal reliabilities) were calculated for the TBI-CareQOL CATs. Adequate reliability for group comparisons was specified as  $> 0.70$ .<sup>55</sup> Three-week test-retest reliability was examined for a subset of study participants ( $n=145$ ; 56 civilian, 89 SMV). Acceptable test-retest reliability was specified as Pearson  $r > 0.70$ .<sup>56,57</sup>

**Floor and Ceiling Effects**—Floor and ceiling effects were calculated by identifying the proportion of participants with the lowest or highest possible scores for the TBI-CareQOL. We specified minimal acceptable rates as  $> 20\%$ .<sup>58,59</sup>

**Administration Times**—Mean administration times were calculated. Participants that completed measures over multiple days were excluded from these analyses.

**Convergent and Discriminant Validity**—Convergent validity and discriminant validity were established by examining correlations between similar and dissimilar traits.<sup>60</sup> To support convergent validity, correlations between the TBI-CareQOL measures (which provide caregiver-specific measures of mental HRQOL) and measures of caregiver burden or mental HRQOL should be moderate to high (i.e.,  $> 0.6$ ). In contrast, discriminant validity, supported by correlations among measures that are less related, such as between TBI-CareQOL measures and physical health, and TBI-CareQOL measures and measures of positive aspects of caregiving, should be negligible to small (i.e.,  $0.0 - 0.3$ ).<sup>60</sup> As findings were virtually identical for the CAT and SF administrations of each measure, we only present one set of findings (CATs).

**Known Group Validity Analyses**—MPAI-4 scores were used to divide participants into two groups. Consistent with suggested cutoffs,<sup>61</sup> caregiver-reported MPAI-4 scores  $\geq 60$  were considered low functioning and caregiver-reported MPAI-4  $< 60$  were considered high functioning. Five separate t-tests were used to examine group differences for each TBI-CareQOL measure. Cohen's  $d$  analyses were used to test whether group differences were significant. Caregivers of individuals that are high functioning should report better HRQOL than those that are caring for someone who is low functioning. We also examined clinical impairment rates (participants whose scores were  $> 1$  SD above the sample mean; i.e., scores  $> 60$ ) for each measure. Known-groups validity is supported if caregivers of high functioning individuals have lower rates of impairment than those caring for lower functioning individuals.

**Missing Data**—Fifteen participants (3%) did not finish the survey;  $n=13$  had complete data on the TBI-CareQOL measures and were included in all analyses. The remaining  $n=2$  participants had missing data on Feeling Trapped, and one was also missing data on Caregiver-Specific Anxiety and Feelings of Loss –Self (SF).

## Results

### Participants

Three-hundred and forty-four caregivers of civilians with TBI and 214 caregivers of SMVs with TBI participated in this study (see Carlozzi et al.'s<sup>37</sup> paper for detailed demographic and injury characteristics). Briefly, caregivers of civilians were predominantly female (78%) and Caucasian (71.8%); they were most frequently spouses (36.6%), parents (35.8%), or other family members (19.2%). Caregivers of SMVs were predominantly female (98.1%), Caucasian (85.5%), and spouses (93.0%). Caregivers of both groups had high educational attainment (72.9% and 95.3% had at least some college for the civilian vs. SMV groups). Caregivers of civilians were older than those of SMVs ( $M=51.6$  years vs.  $M=37.2$  years),  $t(555.94)=15.04$ ,  $p<.01$ . There were no group differences for time providing care (6.9 years for civilians and 5.6 years for SMVs),  $t(513.244)=-.82$ ,  $p=.41$ . There were group differences between the full and retest samples: retest participants were ~4 years younger ( $t(704)=3.07$ ,  $p=.002$ ), more highly educated (51.9% vs 39.5% college graduate;  $\chi^2(2)=15.65$ ,  $p<.001$ ), more likely to be caring for someone who was younger (~3 years younger;  $t(700)=2.52$ ,  $p=.01$ ) and more impaired (MPAI-4  $M=54.14$  vs 51.30;  $t(690)=2.36$ ,  $p=.02$ ).

### Reliability

**Caregivers of Civilians**—All values for internal consistency for the TBI-CareQOL item banks exceeded .88, indicating excellent reliability for these scales (Table 1). Test-retest reliability ranged from very good to excellent for all five SF subscales ( $r$ 's ranged from .83 to .89; Table 1).

**Caregivers of SMVs**—Internal consistencies for all of the TBI-CareQOL item banks exceeded 0.88 (Table 1). Test-retest reliability was good to very good for all five SF subscales ( $r$ 's ranged from .75 to .83; Table 1).

### Floor and Ceiling Effects

**Caregivers of Civilians**—The TBI-CareQOL measures were free from floor or ceiling effects in excess of the established criterion (i.e., 20%), with the exception of the Feeling Trapped SF (ceiling effect of 33.2%; Table 1).

**Caregivers of SMVs**—None of the TBI-CareQOL measures had floor or ceiling effects in excess of the established criterion (i.e., 20%; Table 1).

### Administration Times

**Caregivers of Civilians**—Mean administration times for the TBI-CareQOL measures ranged from 45 to 67 seconds (Table 1).

**Caregivers of SMVs**—Mean administration times for the TBI-CareQOL measures ranged from 31 to 55 seconds (Table 1).

## Convergent and Discriminant Validity

**Caregivers of Civilians**—Intercorrelations among the TBI-CareQOL CAT measures (Table 2) and the other self-report measures supported convergent and discriminant validity. Correlations among the five TBI-CareQOL measures were moderate to high in the civilian sample ( $r$ 's ranged from .58 to .78), suggesting good convergent validity. Additional evidence can be found in the moderate correlations between the TBI-CareQOL measures and the RAND-12 MHC ( $r$ 's ranged from  $-.66$  to  $-.45$ ), the Zarit Burden Interview ( $r$ 's ranged from .65 to .79) and the CAS Burden subscale ( $r$ 's ranged from  $-.79$  to  $-.62$ ). Discriminant validity was supported by negligible to small correlations among the TBI-CareQOL measures and RAND-12 PHC ( $r$ 's ranged from  $-.20$  to  $-.16$ ), Caregiver Satisfaction ( $r$ 's ranged from  $-.42$  to  $-.19$ ), Caregiver Ideology ( $r$ 's ranged from .00 to .10), and Caregiver Mastery ( $r$ 's ranged from  $-.35$  to  $-.24$ ).

**Caregivers of SMVs**—The pattern of intercorrelations supported both convergent and discriminant validity for the caregivers of SMVs with TBI (Table 2). The general pattern of intercorrelations differed only slightly from that found in caregivers of civilians; however, some differences stood out. Correlations between the TBI-CareQOL measures and the RAND-12 PHC ( $r$ 's ranged from  $-.17$  to .03), Caregiver Burden ( $r$ 's ranged from  $-.40$  to  $-.32$ ), and Caregiver Mastery ( $r$ 's ranged from  $-.22$  to  $-.16$ ) were of lesser magnitude than in the caregivers of civilians.

## Known-Groups Validity

**Caregivers of Civilians**—T-tests indicated caregivers of low functioning individuals had worse functioning on all TBI-CareQOL measures (Table 3), with a generally large effect size ( $d$ 's ranged from .63 to 1.33).

**Caregivers of SMVs**—The findings in the military-caregiver sample were effectively identical to those in the civilian caregiver sample (Table 3). Similar to caregivers of civilians, caregivers of low functioning SMVs also had worse functioning on all TBI-CareQOL measures, with slightly weaker effect sizes ( $d$ 's ranged from .51 to 1.14).

**Impairment Rates**—As hypothesized, caregivers of persons that were low functioning consistently had higher clinical impairment rates than those that were caring for a high functioning individual (Table 3).

## Discussion

The study findings support the reliability and validity of the TBI-CareQOL in caregivers of civilians and SMVs with TBI. Since there are currently no comprehensive HRQOL measures that are specific to caregivers of individuals with TBI, this study contributes an important tool for researchers and clinicians to measure HRQOL in this population. The TBI-CareQOL measurement system not only addresses the need for a caregiver-specific assessment of HRQOL, but also provides a comprehensive measure of five aspects of caregiver stress.

Results provide support for the internal consistency reliability and the test-retest reliability of the TBI-CareQOL. Specifically, while internal consistency reliability coefficients for the TBI-CareQOL measures were excellent, CATs consistently outperformed the SFs. In addition, test-retest reliability was excellent for the SFs, indicating high temporal consistency between administrations (the lower test-retest reliability for Feeling Trapped may be attributed to high ceiling effects for this measure). Furthermore, with one exception (Feeling Trapped SF), all TBI-CareQOL measures were free of floor and ceiling effects for both civilian and SMV caregivers; again, the CATs outperformed the SFs. All TBI-CareQOL measures are brief, with average administration times less than 67 seconds.

Convergent and discriminant validity of the TBI-CareQOL measures was also supported for both the caregivers of civilians and those of SMVs. Specifically, convergent validity was supported by moderate to high correlations among the TBI-CareQOL measures (all measures of caregiver-specific mental HRQOL), as well as moderate to high correlations with measures of caregivers' perceived burden. Discriminant validity was supported by negligible to small correlations among the TBI-CareQOL (mental health) measures and physical health, as well as perceived positive aspects of caregiving. While the pattern of correlations was virtually identical for both samples, military-caregivers had less robust correlations among the TBI-CareQOL measures and caregivers' perceived burden as measured by the CAS. This pattern of findings is consistent with our proposed hypotheses and provides support for the validity of the TBI-CareQOL. It is possible that the less robust correlations for the caregivers of SMVs reflects that these caregivers have many other sources of stress - including having dealt with deployment - and possible co-morbid conditions/disabilities. In addition, as the civilian literature shows greater burden for spouses relative to parents,<sup>62,63</sup> it is possible that these differences are due to the greater number of spouses in the SMV sample.

Finally, caregivers of low functioning persons have significantly worse HRQOL than those caring for high functioning persons across all of the TBI-CareQOL measures. Impairment rates were consistently higher for caregivers that were caring for low functioning individuals. The magnitude of the group differences would also suggest that these findings are clinically significant (i.e., scores were generally 1 SD apart for the different groups). In summary, these findings strongly support known-groups validity.

### Study Limitations

While this study provides important reliability and validity data, there were several limitations. One limitation was the use of simulated rather than actual CAT scores. Future work is needed to confirm these findings in individuals that receive the actual CAT administration. In addition, given that most of the caregivers in the present study were Caucasian, women, and spouses of the person with the TBI, findings may not generalize to caregivers from different demographic groups. Caregivers also had to be caring for an individual who was at least 1-year post injury, limiting generalizability to caregivers of persons with more acute injuries. Differing eligibility criteria for the civilian and SMV samples is also a limitation (the SMV sample included caregivers of individuals with uncomplicated mild TBI and equivocal TBI, whereas the civilian sample did not). Finally,



TBI severity was unable to be documented for a large portion (60%) of our military sample, limiting the ability to fully characterize how TBI severity affects caregiver HRQOL. Future work is needed to examine responsiveness to treatment and change over time and to develop clinically relevant cut-points that might be more directly linked to clinical diagnoses and referrals.

## Conclusions

Regardless of these limitations, the TBI-CareQOL CATs and SFs provide brief, reliable, and valid assessments of caregiver HRQOL that are appropriate for use in both military- and civilian-TBI caregivers. As such, these measures can be used to identify caregivers that may need additional services or support. Specifically, while caregivers with scores  $\leq 60$  on any of these measures (suggesting HRQOL worse than 84% of their peers) may warrant additional follow-up, caregivers with scores  $\leq 70$  on any of these measures (suggesting HRQOL worse than 95.5% of their peers) would likely benefit from additional referrals (e.g., mental health services, support services). Furthermore, while there is strong psychometric support for both CAT and SF administrations, the CAT offered some advantages over the SF. These advantages need to be weighed against pragmatic limitations of using the CATs (e.g., the costs of using an on-line data collection platform) when choosing the administration format. These measures fill a significant gap in the caregiver literature where sensitive PRO measures that capture changes in HRQOL are needed to detect improvements for interventions designed to assist caregivers.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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## List of abbreviations

<b>CAS</b>	Caregiver Appraisal Scale
<b>CAT</b>	Computer Adaptive Test
<b>HRQOL</b>	Health-Related Quality of Life
<b>MHC</b>	Mental Health Composite of RAND-12
<b>MPAI-4</b>	Mayo-Portland Adaptability Inventory-Fourth Edition
<b>PHC</b>	Physical Health Composite of RAND-12
<b>PRO</b>	Patient-Reported Outcome

<b>PROMIS</b>	Patient-Reported Outcomes Measurement Information System
<b>SF</b>	Short Form
<b>SMV</b>	Service Member/Veteran
<b>TBI</b>	Traumatic Brain Injury
<b>WRNMMC</b>	Walter Reed National Military Medical Center
<b>ZBI</b>	Zarit Burden Inventory

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### Highlights

- The TBI-CareQOL measurement system is both reliable and valid
- TBI-CareQOL can distinguish caregivers for low versus high functioning individuals
- Caring for a person with a brain injury can negatively impact quality of life

**Table 1**

Descriptive Information and Reliability Data for Study Measures

TBI-CareQOL Measures	N	TBI-CareQOL Mean (SD)	Internal Consistency* (criterion > .70)	Test-retest reliability*	% of the sample with floor effects	% of the sample with ceiling effects	Mean # Items Administered	Administration Time seconds M(SD)	Mean Administration Time Per Item in seconds
CIVILIAN SAMPLE									
Caregiver Strain CAT	344	47.47 (9.77)	.94	–	0.0	3.2	5.3	45.2 (40.8)	8.5
Caregiver Strain SF	344	47.44 (9.82)	.90	.86	0.0	10.2	6	53.0 (117.5)	8.8
Caregiver-Specific Anxiety CAT	344	47.22 (9.29)	.94	–	0.0	4.1	5.9	55.5 (52.7)	9.4
Caregiver-Specific Anxiety SF	344	47.11 (9.20)	.88	.86	0.0	16.0	6	52.3 (180.1)	8.7
Feeling Trapped CAT	343	46.50 (9.23)	.92	–	0.0	20.6	6.8	59.6 (33.2)	8.7
Feeling Trapped SF	343	46.18 (8.36)	.92	.83	0.0	33.2	6	53.0 (151.1)	8.8
Feelings of Loss - Self CAT	344	48.19 (9.84)	.94	–	0.0	5.1	6.2	51.9 (36.5)	8.3
Feelings of Loss - Self SF	344	47.68 (9.78)	.93	.89	1.2	18.6	6	52.1 (100.4)	8.7
Feelings of Loss - Person with TBI CAT	344	49.62 (10.17)	.94	–	0.6	2.6	5.7	59.7 (52.3)	10.4
Feelings of Loss - Person with TBI SF	344	49.52 (10.39)	.91	.90	4.7	6.4	6	67.0 (205.5)	11.2
SERVICE MEMBER/VETERAN SAMPLE									
Caregiver Strain CAT	214	54.08 (7.94)	.95	–	0.0	0.0	4.5	30.9 (28.4)	6.9
Caregiver Strain SF	214	54.11 (8.91)	.88	.80	1.9	1.9	6	37.7 (38.5)	6.3
Caregiver-Specific Anxiety CAT	213	54.66 (8.45)	.95	–	0.9	0.5	4.6	35.1 (29.9)	7.6
Caregiver-Specific Anxiety SF	213	54.69 (9.45)	.89	.80	1.4	2.8	6	37.6 (43.3)	6.3
Feeling Trapped CAT	213	55.60 (7.27)	.95	–	0.0	3.7	4.5	31.9 (22.6)	7.2
Feeling Trapped SF	213	56.13 (9.37)	.92	.75	2.3	4.7	6	34.3 (27.0)	5.7
Feelings of Loss - Self CAT	214	53.14 (8.14)	.95	–	0.0	1.9	4.7	39.0 (67.5)	8.3
Feelings of Loss - Self SF	213	53.74 (9.20)	.90	.83	1.4	4.7	6	54.8 (140.7)	9.1
Feelings of Loss - Person with TBI CAT	214	50.59 (8.35)	.95	–	0.0	1.4	5.0	35.3 (28.5)	7.1
Feelings of Loss - Person with TBI SF	214	50.79 (9.29)	.90	.81	2.3	3.3	6	42.2 (32.0)	7.0

Note.

° = internal consistency for static short form measures are reported as Cronbach's alpha and for computer adaptive tests are reported as marginal reliabilities (i.e., an item-response theory based reliability estimate);

\* given that CAT's administrations do not include the same items across multiple administrations, test-retest reliability cannot be calculated.

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**Table 2**

for the TBI-CareQOL computer adaptive tests

	Convergent validity					Discriminant validity					
	Caregiver-Specific Anxiety CAT	Feeling Trapped CAT	Feelings of Loss- Self CAT	Feelings of Loss- Other CAT	RAND-12 Mental Health	Caregiver Appraisal Scale - Burden	Zarit Burden Interview	RAND-12 Physical Health	Satisfaction	Ideology	Mastery
**	-	-	-	-	-.66**	-.75**	.73**	-.16**	-.26**	.01	-.32**
**	-	-	-	-.50**	-.64**	-.69**	.69**	-.18**	-.42**	.00	-.24**
**	.58**	-	-	-.45**	-.78**	-.72**	.72**	-.17**	-.19**	.10	-.35**
**	.73**	.76**	-	-.58**	-.79**	-.79**	.79**	-.20**	-.29**	.04	-.33**
**	.61**	.58**	.74**	-.47**	-.62**	-.65**	.65**	-.18**	-.22**	.00	-.32**
**	-	-	-	-.54**	-.32**	.75**	.75**	-.17*	-.18**	.00	-.18**
**	-	-	-	-.60**	-.33**	.78**	.78**	.03	-.26**	.09	-.22**
**	.64**	-	-	-.43**	-.33**	.65**	.65**	-.07	-.11	.02	-.18**
**	.77**	.62**	-	-.56**	-.40**	.84**	.84**	-.08	-.31**	.03	-.21**
**	.64**	.52**	.77**	-.43**	-.32**	.69**	.69**	-.02	-.14*	.08	-.16*

**Table 3**

Known Groups Validity for TBI-CareQOL measures

TBI-CareQOL Measures	High Functioning (MPAI-4<60)		Low Functioning (MPAI-4 ≥ 60)		t	p	d
	Mean (SD)	% Impaired (T>60) <sup>f</sup>	Mean (SD)	% Impaired (T>60) <sup>f</sup>			
Civilian sample	N = 296		N = 42				
Caregiver Strain CAT	46.50 (9.50)	8.1	54.79 (9.01)	33.3	5.33*	.0001	0.90
Caregiver Strain SF	46.47 (9.35)	11.1	54.76 (10.20)	35.7	5.31*	.0001	0.85
Caregiver-Specific Anxiety CAT	46.57 (9.13)	6.8	52.22 (8.90)	21.4	3.76*	.0001	0.63
Caregiver-Specific Anxiety SF	46.28 (8.76)	7.4	53.21 (9.90)	28.6	4.72*	.0001	0.74
Feeling Trapped CAT	45.16 (8.50)	5.1	56.44 (8.44)	33.3	8.06*	.0001	1.33
Feeling Trapped SF	44.88 (7.31)	4.4	55.89 (9.30)	35.7	7.36*	.0001	1.32
Feelings of Loss -Self CAT	46.90 (9.28)	8.1	57.40 (8.46)	38.1	6.94*	.0001	1.18
Feelings of Loss -Self SF	46.28 (8.78)	8.8	57.78 (10.41)	45.2	7.75*	.0001	1.19
Feelings of Loss - Person with TBICAT	46.35 (9.86)	12.5	58.20 (7.80)	38.1	6.20*	.0001	1.33
Feelings of Loss - Person with TBISF	48.20 (10.01)	16.6	58.67 (8.35)	54.8	6.46*	.0001	1.14
Military sample	N = 106		N = 102				
Caregiver Strain CAT	51.76 (7.27)	8.5	56.31 (8.05)	29.4	4.28*	.0001	0.59
Caregiver Strain SF	51.74 (8.37)	17.0	56.16 (8.93)	30.4	3.68*	.0001	0.51
Caregiver-Specific Anxiety CAT	51.26 (7.59)	9.4	58.09 (7.90)	35.3	6.36*	.0001	0.88
Caregiver-Specific Anxiety SF	50.60 (8.03)	12.3	58.71 (9.00)	38.2	6.87*	.0001	0.95
Anxiety SF Feeling Trapped CAT	52.22 (7.15)	11.3	59.19 (5.47)	42.2	7.92*	.0001	1.09
Feeling Trapped SF	51.65 (8.71)	16.0	60.90 (7.48)	52.9	8.22*	.0001	1.14
Feelings of Loss -Self CAT	50.37 (7.89)	9.4	55.94 (7.60)	30.4	5.18*	.0001	0.72
Feelings of Loss -Self SF	50.35 (8.08)	11.3	57.15 (9.21)	39.2	5.65*	.0001	0.78
Feelings of Loss - Person with TBICAT	47.60 (7.85)	4.7	53.70 (7.76)	21.6	5.64*	.0001	0.78
Feelings of Loss - Person with TBISF	47.47 (8.26)	5.7	54.20 (9.07)	33.3	5.60*	.0001	0.78

Note. CAT = computer adaptive test; SF = short form; MPAI-4 = Mayo-Portland Adaptability Inventory-Fourth Edition.

<sup>f</sup> Scores in this column represent the proportion of participants who scored 60 or greater on the TBI-CareQOL measure