REVIEW

Two valid and reliable short forms of the Singapore caregiver quality of life scale were developed: SCQOLS-10 and SCQOLS-15

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Abstract

Objectives: The Singapore Caregiver Quality of Life Scale (SCQOLS) comprises five domains and 51 items in total. This study aimed to develop and evaluate short forms of SCQOLS.

Study Design and Setting: Data were collected from 612 family caregivers of patients with advanced cancers in Singapore. Exploratory factor analysis and best subset regression were used to identify candidate items for each domain. The short forms were evaluated for measurement properties.

Results: Inclusion of at least two items per domain in the short form gave correlation coefficients of at least 0.8 with the corresponding domain scores in the full-length version. The short forms and full-length version had similar correlation coefficients with Negative Personal Impact and Positive Personal Impact measures. Two of the five domains of the 10-item version had Cronbach's alpha ≤0.50 and test-retest reliability ≤0.65. A 15-item version of the scale with two to four items per domain performed satisfactorily in all aspects evaluated.

Conclusion: A 15-item short form of the SCQOLS (SCQOLS-15) is valid and reliable for the assessment of the overall and domain-specific quality of life of family caregivers. A 10-item short form (SCQOLS-10) may serve as a quick, valid and reliable assessment of the overall level of quality of life. © 2020 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Keywords: Cancer; Caregiver; Measurement scale; Quality of life; Short form

1. Introduction

The assessment of the quality of life (QOL) is needed for public accountability, quality improvements, and effectiveness research on interventions to improve outcomes in patients with life-threatening diseases and their families [1]. Nevertheless, there has been a shortage of measurement scales for the assessment of caregiver's QOL [2], especially for use outside Europe and North America. There are at least two challenges to be met in the use of currently

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

Clinical trial registration: Not applicable.

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What is new?

Key findings
- The domain scores of both short forms have a strong correlation with the corresponding domain scores in the full-length version.

- The 15-item short form (SCQOLS-15) showed acceptable measurement properties for the assessment of the overall and domain-specific level of quality of life; the 10-item short form (SCQOLS-10) showed acceptable measurement properties for the assessment of the overall level of quality of life.

What this adds to what was known?
- Two valid and reliable short forms of the Singapore Caregiver Quality of Life Scale were developed.

What is the implication, and what should change now?
- Both short forms can be used to measure family caregivers' quality of life.

- The choice between the two short forms depends on the needs to assess the specific quality of life domains and the preferred questionnaire length.

available scales, (1) validity in the target population and (2) length of measurement scale.

Many QOL measurement scales were developed in primarily Caucasian populations. They may not be valid for use in other populations. In a qualitative study of family caregivers of advanced cancer patients in Singapore, we found substantial differences between the local caregivers' QOL concerns and the contents of existing QOL measurement scales developed in Western countries [3]. Similarly, a quantitative evaluation of the Chinese translation of the Caregiver Quality Of Life Index-Cancer (CQOLC) in China concluded that there was "only partial support for the relevance and construct validity of the scale for Chinese caregivers" [4].

The QOL measurement scales tend to include a multitude of items due to the multi-dimensionality of QOL and concerns for content validity. Lengthiness has been a problem that has plagued many QOL measurement scales, including those that are specific to caregivers. The Caregiver-Targeted Quality-of-Life Measure consists of 80 items [5]. The CQOLC, which is the only caregiver QOL scale developed in Western countries that has been translated into the Chinese language, is relatively short, but it still comprises 35 items [6]. Empirical research has demonstrated a lower response rate for longer questionnaires [7,8]. It is preferable to use shorter questionnaires if they can retain the desired measurement properties.

The inclusion of multiple domains and multiple items per domain is to address content validity. However, these items are likely predictive of each other. When a full dataset is available, it is possible to empirically identify the items that are most predictive of the QOL domains they belong to. Then one may shorten the scales with limited loss of information or precision. Some successful examples include the abbreviated version of the World Health Organization Quality of Life measure [9], the Functional Living Index–Cancer [10], and the Benign Prostatic Hyperplasia–Quality of Life Scale [11]. They demonstrated that it is possible to empirically remove over half of the items from the original version without major disadvantages. It has also been demonstrated that two to three items are often sufficient to represent a QOL domain [12,13].

The Singapore Caregiver Quality of Life Scale (SCQOLS) is a 51-item measurement scale recently developed and validated in Singapore [14]. The items were generated with inputs from family caregivers of patients with advanced cancers in Singapore [3]. It fills an important gap for caregiver assessment in Singapore and has the potential for wider adoption in Asia.

A 5-domain factor structure of the SCQOLS was established using exploratory factor analysis, representing Physical Well-being (PW; 12 items), Mental Well-being (MW; 10 items), Experience & Meaning (EM; 12 items), Impact on Daily Life (DL; 13 items) and Financial Well-being (FW; four items) [14]. The factor structure was found invariant between the English and Chinese versions. Despite relatively small subgroup sample sizes, the evidence tentatively supported the plausibility that the factor structure was also stable across ethnic Chinese and other ethnic groups. Furthermore, the English and Chinese versions achieved equivalence in mean scores, having conditioned on demographic and clinical covariates that can affect QOL [15]. However, the length of 51 items makes it challenging to implement in routine clinical settings and research that involves multiple instruments. An abbreviated version of the scale will be valuable for easier and wider implementation of caregiver QOL assessment.

This study aimed to develop a short form of SCQOLS and evaluate its measurement properties. In particular, it aimed to retain the 5-domain structure, with two to three items per domain, so that the new version would contain only about 10 to 15 items.

2. Methods

2.1. Study setting and design

The National Cancer Center Singapore is the largest public provider of cancer care in Singapore, with about

152,000 outpatient visits annually [16]. Patients who need inpatient care are mostly admitted to the Singapore General Hospital. This study was conducted at the National Cancer Center Singapore and Singapore General Hospital in 2016 and 2017. The Singapore Health Services Centralized Institutional Review Board approved the study (#2016/2243). Written informed consent was given by each participant.

Details of the study design have been previously reported [14]. In brief, it consisted of a baseline and a follow-up survey of family caregivers. The baseline survey included the SCQOLS and the Brief Assessment Scale for Caregivers, which comprised a Negative Personal Impact (NPI) and a Positive Personal Impact (PPI) subscale, among others [17]. Demographic and health background information was also collected, including a caregiver rating of the patient's performance status [18]. Caregivers were invited to self-administer the questionnaire. Some participants requested interviewer-administration. The follow-up survey was designed to assess test-retest reliability. It comprised the SCQOLS, a 7-point scale of the caregiver's self-perceived change in QOL since the baseline survey [19], and a question on the patient's performance status. The questionnaire, together with a postage-paid return envelope, was sent to the caregivers about 1 week after the baseline survey. Only caregivers who had self-administered the baseline survey were included in the follow-up survey.

2.2. Eligibility

Family caregivers of patients with stage III or IV solid tumors were invited to participate. In this study, we defined a family caregiver as a family member who took direct care of the patient's day-to-day and healthcare needs, or ensured provision of care to meet the needs, or was the decision-maker regarding the meeting of the patient's needs. In addition, participants must be at least 21 years of age, able to communicate in English or Chinese, and aware of the patient's diagnosis. Caregivers in the bereavement stage were not recruited.

2.3. Development of short forms

Factor analysis and correlation or regression analysis are two major approaches to the abbreviation of measurement scales [11,20]. The use of correlation or regression to select items bore the risk of correlated errors [11,20]. To prevent correlated errors causing undue influence, we developed the short forms in two steps. First, we capitalized on the exploratory factor analysis already published [14]. We identified the candidate items for the short form as the top four items that had the highest factor loadings within each domain in the long form (full-length version). This was based on the expectation that approximately two or three items per domain will be sufficient to capture most of the information for that domain [12,13]. However, if the correlation between the domain score of a short form and the corresponding domain score of the long form did not meet or exceed Pearson's correlation coefficient (r) of 0.8, we would consider the fourth item. Hence, the shortlisting of four items per domain. As the FW domain comprises only four items, for this domain, we identified the top three items as candidate items. Second, for each domain, we applied the best subset regression to the baseline data to identify the 1-, 2-, 3- and 4-item models (other than FW) that best explained the corresponding domain score in the long form [21]. The Akaike Information Criterion (AIC) was used to select the best fit model among candidate models with the same number of items. Therefore, each domain had four candidate models, except FW, which had three candidate models.

Prior to running the best subset regression, we checked the assumption of linearity between items and the corresponding domain. Using a multivariate fractional polynomial (FP) method [22], only three candidate items had a statistically significant departure from linearity ($P < 0.05$). However, using the FP transformations or using the items as categorical variables gave results practically similar to that based on the linearity assumption. Hence, we used linear forms in the best subset regression.

2.4. Evaluation of short forms

A score was calculated for each domain of a candidate short form by a simple mean of the item scores and multiplied by 25 to re-scale to a 0 to 100 scale. The scores were evaluated in terms of Pearson's correlation coefficient (r) with the corresponding domain scores from the long form, the Negative Personal Impact (NPI), and Positive Personal Impact (PPI), and internal consistency (Cronbach's alpha), using the baseline data. After determining the items to be included for each domain, a short form total score was generated by a weighted average of the short form domain scores, with weights proportional to the number of items in the domains in the long form. This weighted average procedure ensures that the short form total scores are compatible with the long form total score, which is calculated by the same weighted average procedure [14].

By using the follow-up data, the candidate short forms were assessed for test-retest reliability (intraclass correlation coefficient, ICC). Furthermore, the follow-up data were also used to estimate the Cronbach's alpha of the short forms and the correlation between the short forms and the long form. This was to assess whether the findings in the baseline data were reproducible.

For the estimation of test-retest reliability, in order to include only participants who were in stable conditions and expected to have no change in QOL, only participants who had returned the follow-up survey within 28 days from baseline, whose patients had not passed away, and who had reported no change in self-perceived QOL and patient's performance status were included.

Table 1. Candidate items for short form identified from exploratory factor analysis of the 51-item Singapore Caregiver Quality of Life Scale (SCQOLS)

Domains	Item no.	Brief description	Factor loading[a]
Physical Well-being	PW4	Aches and pains	0.77
	PW6	Poor appetite	0.90
	PW7	Weight loss	0.77
	PW8	Body has weakened	0.90
Mental Well-being	MW1	Constantly worried	0.67
	MW2	Fearful of losing the patient	0.83
	MW3	Feel sad	0.74
	MW8	Feel frustrated	0.53
Experience & Meaning	EM4	Thankful for good things	0.68
	EM7	Experienced positive changes	0.71
	EM11	Family closer together	0.71
	EM12	Caregiver role appreciated by family	0.70
Daily Life	DL2	Not able to leave home or hospital	0.76
	DL3	Not satisfied with time to myself	0.88
	DL4	No time for recreational activities	0.93
	DL5	Not able to do what I want	0.91
Financial Well-being	FW1	Depleting savings	0.83
	FW3	Uncertain about future financial situation	0.87
	FW4	Personal spending restricted	0.86

[a] Information extracted from Table 2 of reference [14].

While there is no universally applicable definition of what an "acceptable" level of internal consistency or reliability is, we interpreted the findings with reference to the often-cited 0.7 level in view [23,24].

Furthermore, we examined the equivalence of the mean scores of the English and Chinese versions among ethnic Chinese participants using linear regression with adjustment for the caregiver and patient determinants of caregiver QOL and using a predefined equivalence margin of ±0.3 SD (details in Online Supplementary File 1).

2.5. Conversion between short and long forms

We used the ordinary least squares regression method to obtain conversion formula between the short and long form scores.

3. Results

3.1. Descriptive summary

A descriptive summary of the participants has been previously reported [14]. In brief, 612 participants were recruited, of whom 304 and 308 administered the English and Chinese versions of the questionnaire package, respectively. The sample mean (standard deviation) age was 48 (14) years; 61.0% was female; 38.7% and 46.2% were spouses and sons/daughters of the patients, respectively.

The ethnic composition of the English-speaking participants was similar to that of the Singapore adult population, with 70%, 17%, and 6% ethnic Chinese, Malay, and Indian, respectively. Among the Chinese-speaking participants, all except one were Chinese by ethnicity.

3.2. Correlation between short form and long form domain scores

The items that had the highest factor loadings within each domain were identified as candidate items (Table 1). Table 2 shows the results of the best subset regression using these candidate items. It also shows the correlation coefficient between the sum of scores on the selected items and the corresponding domain scores in the long form. The AIC was smaller (better) for short forms with more items. However, for all five domains, using only two items was already sufficient to achieve the target of r ≥ 0.8. The incremental gain in r by including more than two items was small.

3.3. Measurement properties of candidate short forms

Table 3 shows the correlation of the sum of selected items' scores with NPI. The differences in correlation with NPI between 1-item scores and the corresponding long form domain scores ranged from 0.06 (FW) to 0.15 (PW). When two items were included per domain, the differences narrowed to a range from 0.02 (FW) to 0.11 (PW).

Table 2. Best subset regression analysis results and Pearson's correlation (r) between the domain scores in the candidate short forms and the domain scores in the long form

Domains	Items	AIC	r
Physical Well-being	PW8	4,732.9	0.81
	PW4+PW6	4,430.3	0.89
	PW4+PW6+ PW8	4,285.6	0.92
	PW4+PW6+ PW7+PW8	4,256.7	0.91
Mental Well-being	MW8	4,890.1	0.77
	MW2+MW8	4,473.3	0.89
	MW2+MW3+MW8	4,312.1	0.91
	MW1+MW2+ MW3+MW8	4,248.7	0.90
Experience & Meaning	EM7	4,991.5	0.68
	EM4+EM11	4,681.6	0.82
	EM4+EM7+EM12	4,459.7	0.88
	EM4+EM7+EM11+EM12	4,354.3	0.90
Daily Life	DL5	4,765.0	0.83
	DL2+DL5	4,570.6	0.88
	DL2+DL4+DL5	4,495.1	0.89
	DL2+DL3+DL4+DL5	4,489.6	0.89
Financial Well-being	FW4	4,860.7	0.91
	FW1+FW3	4,210.7	0.96
	FW1+FW4	3,860.1	0.99

Further increasing to include three or four items per domain did not make marked differences. We repeated the analyses with PPI scores, with a focus on the EM domain. This was because it had previously been shown that only the EM domain was strongly correlated with PPI, as both of them concerned positive aspects of QOL in adverse situations [14]. The correlation between EM short form and PPI was observed regardless of the number of items, r from 0.32 to 0.41 (each $P < 0.01$). The inclusion of more items per domain did not show a clear pattern of improved correlation with PPI.

For the PW, DL, and FW, inclusion of as few as two items could achieve a Cronbach's alpha ≥ 0.7 (Table 3). However, for MW and EM, it required three and four items, respectively, to achieve this level of internal consistency.

Out of 326 participants who completed the follow-up survey, 90 satisfied the inclusion criteria for inclusion in test-retest reliability estimation. The PW, DL, and FW achieved ICC ≥ 0.7 with only two items, while the EM required four items to achieve this level of test-retest reliability. The use of 3 and 4 MW items gave a similar level of ICC, at 0.69 and 0.70, respectively.

Based on the above findings and our intention to include no more than 15 items, we considered two short forms; a 10-item short form that includes two items for each of the five domains, and a 15-item short form that includes

three items for PW, DL, and MW, four items for EM, and two items for FW. The 10-item short form satisfied our intention to provide a short form that contains as few as two items per domain and still achieve correlation with the long form domain score of at least 0.8. The proposed 15-item short form additionally gave internal consistency and test-retest reliability of about 0.7 or higher in all domains, which are often considered acceptable levels. The total scores of the 10- and 15-item short forms had Pearson's correlation of 0.94 and 0.95 with the total score of the long form. Furthermore, they showed a strong correlation with NPI (≥ 0.75), an acceptable level of internal consistency (≥ 0.76) and a strong test-retest reliability (≥ 0.85) (Table 3).

We examined whether similar measurement properties of the 10- and 15-item short forms could be reproduced in the follow-up survey ($N = 326$). Table 4 shows the findings; they are similar to those obtained from the baseline survey. The correlation between the 10-item short form and its five domain scores and the corresponding scores in the long form was strong, ranging from 0.82 (EM) to 0.97 (FW). Cronbach's alpha for MW and EM was weak (≤ 0.5) but satisfactory for the others (≥ 0.74). The properties of the 15-item short form and all of its domains were satisfactory. The correlation coefficients with the target scores in the long form were at least 0.90. The Cronbach's alpha ranged from 0.75 (MW) to 0.89 (DL and FW).

The equivalence between the English and Chinese versions of the SCQOLS-15 and SCQOLS-10 in the total and all domain scores was confirmed, with the exception of inconclusive findings on the EM score of the SCQOLS-10 (Online Supplementary File 1).

3.4. Conversion formula

Table 5 shows formula derived from simple least squares regression to convert SCQOLS-15 scores to the corresponding total and domain scores in the long form and formula to convert SCQOLS-10 total score to the total score in the long form. For example, the conversion formula:

$$\text{SCQOLS total score} = 7.003 + 0.885 \times \text{SCQOLS-15 total score}$$

gave R2 (R-squared) 0.909. The inclusion of nonlinear (quadratic) terms had little impact on the model fit. For example, for conversion to the long form total score, the addition of the SCQOLS-15 total score quadratic term only changed the R2 to 0.910 (details not shown).

The use of multivariable regression with SCQOLS-15 domain scores as predictors and backward stepwise selection to retain significant ($P < 0.05$) independent variables improved the R2 only slightly. For example, the conversion to the long form total score using all SCQOLS-15 domain scores gave R2 0.919. For completeness, we provide the

Table 3. Measurement properties in the baseline survey

Domains	Items	r (NPI)[a]	r (PPI)[a]	Alpha	ICC
Physical Well-being	All 12 items (long form)	0.64	0.18	0.92	0.81
	PW8	0.49	0.12	-	0.61
	PW4+PW6	0.53	0.11	0.72	0.72
	PW4+PW6+ PW8	0.55	0.12	0.83	0.73
	PW4+PW6+ PW7+PW8	0.54	0.11	0.86	0.72
Mental Well-being	All 10 items (long form)	0.62	0.05	0.86	0.78
	MW8	0.56	0.16	-	0.47
	MW2+MW8	0.52	0.01	0.50	0.65
	MW2+MW3+MW8	0.54	0.00	0.75	0.69
	MW1+MW2+ MW3+MW8	0.53	−0.01	0.82	0.70
Experience & Meaning	All 12 items (long form)	0.18	0.40	0.86	0.74
	EM7	0.05	0.36	-	0.61
	EM4+EM11	0.15	0.32	0.49	0.64
	EM4+EM7+EM12	0.11	0.38	0.63	0.68
	EM4+EM7+EM11+EM12	0.13	0.41	0.74	0.72
Daily Life	All 13 items (long form)	0.77	0.21	0.91	0.86
	DL5	0.63	0.18	-	0.64
	DL2+DL5	0.69	0.18	0.82	0.80
	DL2+DL4+DL5	0.70	0.21	0.88	0.80
	DL2+DL3+DL4+DL5	0.70	0.22	0.91	0.80
Financial Well-being	All four items (long form)	0.56	0.12	0.91	0.78
	FW4	0.50	0.09	-	0.61
	FW1+FW3	0.54	0.12	0.83	0.77
	FW1+FW3+FW4	0.56	0.12	0.86	0.79
10-item Short Form	PW4+PW6+MW2+MW8+EM4+EM11 +DL2+DL5+FW1+FW3	0.75	0.23	0.76	0.85
15-item Short Form	10-item Short Form + PW8+MW3+EM7+EM12	0.77	0.26	0.79	0.86

[a] r(NPI) and r(PPI): Pearson's correlation coefficient with Negative Personal Impact and with Positive Personal Impact.

multivariable conversion formula and long form to short form conversion formula in Online Supplementary File 2.

4. Discussion

In Asian culture, it is usually expected that people who are ill should be cared for by their family members [25]. A meta-analysis showed that Asian American caregivers provided more caregiving hours than caregivers of other ethnicities [26]. With differences in culture between East and West and the known limitations of the validity of some QOL measurement scales in the Asian context, the recent development of the SCQOLS is a valuable addition. The availability of abbreviated versions of this instrument will further provide flexibility in its usage according to the context and needs.

There is a trade-off between questionnaire length and measurement properties. We have proposed two short forms, one with 10 items and the other with 15 items.

Table 4. Measurement properties in the follow-up survey

Short forms	Total and domain scores	r[a]	Alpha
10-item Short Form	Total score (10 items)	0.94	0.79
	Physical Well-being (2 items)	0.89	0.74
	Mental Well-being (2 items)	0.88	0.50
	Experience & Meaning (2 items)	0.82	0.48
	Daily Life (2 items)	0.90	0.82
	Financial Well-being (2 items)	0.97	0.89
15-item Short Form	Total score (15 items)	0.96	0.83
	Physical Well-being (3 items)	0.91	0.86
	Mental Well-being (3 items)	0.91	0.75
	Experience & Meaning (4 items)	0.91	0.76
	Daily Life (3 items)	0.90	0.89
	Financial Well-being (2 items)	0.97	0.89

[a] r: Pearson's correlation coefficient with the corresponding total score or domain scores in the long form.

Table 5. Conversion formula derived from ordinary least squares regression

Dependent variable[a]	α	β	Independent variable[a]	R2
SCQOLS Total	7.003	0.885	SCQOLS-15 Total	0.909
SCQOLS PW	9.931	0.801	SCQOLS-15 PW	0.838
SCQOLS MW	24.410	0.737	SCQOLS-15 MW	0.821
SCQOLS EM	15.411	0.740	SCQOLS-15 EM	0.806
SCQOLS DL	14.343	0.749	SCQOLS-15 DL	0.796
SCQOLS FW	5.991	0.909	SCQOLS-15 FW	0.913
SCQOLS Total	9.978	0.835	SCQOLS-10 Total	0.876

[a] SCQOLS: Full-length version of SCQOLS; SCQOLS-15: 15-item short form; SCQOLS-10: 10-item short form. All variables are scaled to the 0 to 100 range prior to the application of the conversion formula.

The 10-item short form demonstrated validity, reliability, and internal consistency as a measure of the overall level of QOL and the Physical Well-being, Daily Life, and Financial Well-being domains, but its performance was limited in terms of measuring the Mental Well-being and Experience & Meaning domains. We propose that, for practitioners who need a quick assessment of the overall level of QOL, they may consider using the 10-item short form.

The total and domain scores of the 15-item short form strongly correlated with the counterparts in the 51-item long form. It mirrors the long form's performance characteristics. It achieves acceptable level of measurement properties in all aspects evaluated. This is a useful alternative to the long form, and may be used to assess overall QOL and QOL domains.

A limitation of the present study is that we did not collect data using a 10-item or 15-item short form. What we administered was the 51-item long form. The interpretation of the findings here is based on an assumption of no context effects, that is, the 10 or 15 items selected perform as seen here regardless of whether they are administered as a short form or embedded in the full-length version. Prior research has repeatedly demonstrated that there was little context effect in QOL assessment [27−30]. As such, we consider this assumption valid. The forms have not yet been validated in other populations. Further evaluation of the short forms using other datasets and in other populations will help to improve understandings of them.

5. Conclusion

A 15-item short form of the Singapore Caregiver Quality of Life Scale (SCQOLS-15) is valid and reliable for the assessment of overall and domain-specific QOL in the Singapore population. A 10-item short form (SCQOLS-10) may serve as a quick assessment of the overall level of QOL. The formula for conversions between the short and long forms are available.

CRediT authorship contribution statement

Yin Bun Cheung: Conceptualization, Methodology, Formal analysis, Visualization, Supervision, Funding acquisition, Writing - original draft, Writing - review & editing. **Shirlyn H.S. Neo:** Conceptualization, Supervision, Project administration, Writing - review & editing. **Grace M. Yang:** Conceptualization, Supervision, Project administration, Writing - review & editing. **Geok Ling Lee:** Conceptualization, Writing - review & editing. **Irene Teo:** Conceptualization, Writing - review & editing. **Audrey R.X. Koh:** Investigation, Data curation, Project administration, Writing - review & editing. **Julian Thumboo:** Conceptualization, Writing - review & editing. **Hwee Lin Wee:** Conceptualization, Writing - review & editing.

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