Abbreviated assessment of psychopathology in patients with suspected seizure disorders

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Abstract

Objectives: Psychopathology is common in patients undergoing investigation for seizure-related disorders. Psychometric examination using self-report instruments, such as the SCL-90-R, can assist diagnosis. The SCL-90-R, however, is a lengthy instrument and might not be tolerated by all patients. We assessed several abbreviated forms of the SCL-90-R in patients undergoing video encephalographic monitoring (VEM).

Methods: 687 patients completed the SCL-90-R and scores were computed for the full SCL-90-R and five abbreviated forms. Correlations and mean differences were computed between different forms. Classification accuracy was assessed via receiver operating characteristic (ROC) curves, and measurements models were examined using confirmatory factor analysis (CFA).

Results: All abbreviated forms were strongly correlated with the SCL-90-R for general psychopathology (r = .93 – .99), depression (r = .89 – .95), and anxiety (r = .97 – .98). Classification performance was similar across forms, showing high negative predictive values for depression and anxiety (.90 – .94), but lower positive predictive values (.34 – .38). Differences were observed between the full SCL-90-R and its abbreviated forms across most domains (d = 0.00 – 0.65). The published measurement model was most strongly validated for the SCL-27, SCL-14, and the SCL-K-9.

Conclusions: These five SCL-90-R abbreviated forms show high convergent validity with the full version. In patients undergoing investigation for seizure-related disorders, the BSI or BSI-18 are most appropriate where screening for both depression and anxiety is required. The SCL-K-9 is appropriate when only a single measure of global psychological distress is required. Caution should be exercised when making direct comparisons across the different forms.

Keywords: epilepsy, depression, anxiety, psychiatry, screening, psychometrics

Psychiatric comorbidity is common in patients with epilepsy and related disorders. It is estimated that up to 30% of patients with epilepsy meet criteria for a major psychiatric disorder, and rates of depressive and anxiety related disorders in particular are high compared to the general population (Karouni et al., 2010; Rai et al., 2012; Tellez-Zenteno, Patten, Jetté, Williams, & Wiebe, 2007; Weatherburn, Heath, Mercer, & Guthrie, 2017). The rate of comorbid psychopathology is also high in patients with psychogenic non-epileptic seizures. Between 53 and 100 percent of patients with PNES are estimated to meet criteria for an additional major psychiatric disorder, with notable elevations in the rates of post-traumatic, personality, anxiety, and depressive disorders relative to patients with epilepsy (Diprose, Sundram, & Menkes, 2016). The rates of psychopathology in patients undergoing video encephalographic monitoring (VEM) are likely higher than the general epilepsy population, with up to 50% of patients meeting criteria for a comorbid major psychiatric disorder (Blumer, Montouris, & Hermann, 1995). VEM patients, in particular, are highly likely to have disruption of key cognitive networks underpinning depressive symptomatology (Rayner, 2017). Taken together, there is a clear and present need to assess psychiatric comorbidities in patients undergoing investigation for epilepsy.

While full neuropsychiatric assessment during VEM admission is the gold-standard for psychiatric diagnosis, this process is time consuming, costly, and might not be available in all centres (Agrawal, Turco, Goswami, Faulkner, & Singh, 2015). The use of valid, reliable, and comprehensive psychometric instruments provides a practical approach to screen for psychiatric symptomatology, thus facilitating efficient use of formal neuropsychiatric assessment (de Oliveira et al., 2014; Jones et al., 2005). The Symptom Checklist 90 Revised (SCL-90-R) is a comprehensive self-report instrument of psychiatric symptomatology, consisting of 90 questions that takes approximately 20 minutes to complete (Derogatis, 1992). Unlike many brief screening instruments, the SCL-90-R covers nine psychiatric domains, making it useful for detecting a broad range of psychopathologies. A large body of evidence has investigated the reliability and validity of the SCL-90-R across a number of settings (Brophy, Norvell, & Kiluk, 1988; Derogatis & Savitz; Rauter, Leonard, & Swett, 1996; Schmitz et al., 2000; Wiebe, Rose, Derry, & McLachlan, 1997).

The length of the SCL-90-R, however, might make it impractical in some clinical contexts. To address this, several abbreviated forms of the SCL-90-R have been developed. These include the SCL-27 (27 items; Hardt & Gerbershagen, 2001), SCL-17 (14 items; Harfst et al.,

2002), SCL-K-9 (9 items; Klaghofer & Brähler, 2001), BSI (53 items; Derogatis, 1993), and BSI-18 (18-items; Derogatis, 2000). Several studies have shown that these abbreviated forms show excellent correspondence with the long form SCL-90-R in general psychiatric populations (Müller, Postert, Beyer, Furniss, & Achtergarde, 2010; Prinz et al., 2013; Sereda & Dembitskyi, 2016). The BSI, in particular, has been shown to be an appropriate substitute for the SCL-90-R when time limitation is a factor. No studies, however, have directly compared the SCL-90-R to any of the abbreviated forms in a population of patients undergoing investigation for presumed seizure-related disorders. There is a paucity of research comparing these different forms amongst English-speaking patients. As such, there is no strong evidence to inform decisions regarding the use of these abbreviated instruments in VEM settings.

The overall aim of this study was to directly compare the SCL-90-R to its various abbreviated forms in a large sample of patients undergoing VEM. The primary focus was on the ability for these instruments to detect symptoms of depression, anxiety, and global psychopathology. Following Prinz and colleagues (2013), it was hypothesised that all abbreviated forms would show strong correspondence with the long form, but that some versions would show better classification performance when benchmarked against gold-standard neuropsychiatric diagnosis. Using confirmatory factor analysis, we also expected to find evidence for the measurement models proposed by the test developers for the various forms of the SCL-90-R.

Methods

Participants

Participants were patients admitted for prolonged VEM at the Royal Melbourne Hospital, Melbourne, Australia between 2002 and 2017. Patients were eligible if they: (a) had undergone VEM and formally been discussed during the consensus meeting, (b) had undergone formal neuropsychiatric evaluation during admission, (c) completed the SCL-90-R during admission, (d) were aged 18 years or over at the time of admission, and (e) had sufficient English language proficiency to complete the SCL-90-R and other psychometric instruments. This study was approved by the Melbourne
Health Ethics committee (HREC# QA2012044).

Epilepsy diagnosis

VEM consensus diagnosis was made by a multidisciplinary team meeting of neurologists, neuropsychiatrists, neuropsychologists, neuroradiologists, and neurophysiology scientists. The patient's clinical history, VEM results, neurological examination, neuropsychological profile, neuropsychiatric assessment, and neuroimaging findings (where applicable) were all considered when formulating a final diagnosis. Epilepsy was defined as the presence of two or more unprovoked seizures or one seizure with enduring risk for seizure occurrence of >60% (Fisher et al., 2014). Psychogenic non-epileptic seizures (PNES) were defined as sudden, involuntary changes in behaviour, sensation and/or motor activity, with or without alterations in conscious state, associated with psychosocial distress and without electrographic correlate (Lesser, 1996). For the purposes of this research, patients were classified into one of five categories: epilepsy, PNES, concomitant epilepsy and PNES, other non-epileptic events, and non-diagnostic.

Psychiatric diagnosis

All patients admitted for VEM underwent formal psychiatric assessment by a specialist neuropsychiatrist. Diagnosis was informed by the Diagnostic and Statistical Manual of Mental Disorders 4th edition (DSM-IV-TR; American Psychiatric Association, 2000) or 5th edition (DSM-5; American Psychiatric Association, 2013). Patients were categorised as currently having: any major psychiatric disorder (axis 1 or equivalent), any depressive disorder, or any anxiety disorder. SCL-90-R scores were not known to the clinician during diagnostic formulation. These categories were chosen because they represent the major psychiatric diagnoses observed in this population. Depression was chosen, in particular, because of its association with suicidal ideation and behaviour, and the need to detect these symptoms and provide early intervention and assessment.

Psychometric instruments

Patients were administered the long form Symptom Checklist 90 Revised (SCL-90-R; Derogatis, 1992), which is a 90-item self-report inventory of psychological symptoms. The SCL-90-R measures symptomatology along nine domains: somatisation, obsessive compulsive symptoms, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism. Participants respond to the stem 'for the past week, how much were you bothered by:' on a 5-point Likert scale from 0 (*Not at all*) to 4 (*Extremely*). Each domain is scored by summing the items and dividing by the number of

non-missing responses. A global severity index (GSI) is computed by summing all 90 items and dividing by the number of non-missing responses.

Scores for five abbreviated forms of the SCL-90-R were computed, each using a subset of items from the full SCL-R-90. These included the SCL-27 (27 items; Hardt & Gerbershagen, 2001), SCL-17 (14 items; Harfst et al., 2002), SCL-K-9 (9 items; Klaghofer & Brähler, 2001), BSI-53 (53 items; Derogatis, 1993), and BSI-18 (18-items; Derogatis, 2000). As with the long form SCL-90-R, each domain was scored by summing the items and dividing by the number of non-missing responses. A GSI was computed for each abbreviated form.

A subset of patients also completed the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983), which is a 14-item screening instrument for depression and anxiety. Patients rate each item on a 4-point Likert scale ranging from 0 to 3. The scores are summed across 7 items each for the depression and anxiety domains to form subscale scores.

Statistical analyses

All analyses were performed in R (R Core Team, 2019). Cohen's (1988) *d* was computed to examine the difference between full SCL-90-R and abbreviated form test scores, and to compare scores between diagnostic groups. Pearson's (1895) product moment correlation coefficient (r) was computed to examine the correlation between full SCL-90-R and abbreviated form test scores. Classification performance was examined by computing receiver operating characteristic (ROC) curves using the *pROC* package (Robin et al., 2011). The area under the curve (AUC) was computed. An optimal cut-off was determined using Youden's (1950) J statistic, and the sensitivity, specificity, negative predictive values (NPV), and positive predictive value (PPV) computed. Statistical inference was performed via 95% confidence intervals.

Confirmatory factor analysis (CFA) was performed using the *lavaan* package (Rosseel, 2012). Oblique models were specified as per the structure proposed by the test authors. Cross-loadings and residual covariances were fixed to zero. Robust estimation was performed using full-information maximum likelihood (ML) with Huber-White standard errors and scaled test statistic that asymptotically approach the Yuan-Bentler statistic. Reliability was computed for the latent variables using the omega coefficient (formula 21; Green & Yang, 2009). Model fit was determined using the following robust indices: χ^2 (Jöreskog, 1969), root

mean squared error of approximation (RMSEA; Steiger & Lind, 1980), standardised root mean residual (SRMR; Bentler, 1995), Tucker-Lewis index (TLI; Tucker & Lewis, 1973) and the comparative fit index (CFI; Bentler, 1990). Acceptable fit was considered to be: RMSEA < .06, SRMR < .08, TLI > .95, and CFI > .95 (West, Taylor, & Wu, 2012). All data and code are available at: [URL removed for blind peer review].

Results

Sample characteristics

Of the original 687 patients with available demographic, clinical, and psychometric data, 611 (89%) had ≤ 20% missing data on the SCL-90-R and were included in the final sample. The majority of patients had no missing SCL-90-R items (*n* = 545, 89%). 36 patients had one missing item (6%), 16 had two missing items (3%), and seven participants had between three and 12 missing items (2%). There was no obvious pattern to the missing items. The majority of participants were female (*n* = 387, 63%) and the mean age was 39 (*SD* = 15, *Range* = 18 – 87). The most common diagnosis was epilepsy (*n* = 286, 47%), followed by psychogenic non-epileptic seizures (*n* = 151, 25%), other non-epilepsy events (*n* = 34, 6%), and concomitant epilepsy and psychogenic non-epilepsy seizures (*n* = 33, 5%). A diagnosis could not be reached for 107 patients (18%). Neuropsychiatric assessment revealed that 209 (34%) patients met criteria for a current major psychiatric disorder. Of all patients, 126 (21%) met criteria for a depressive disorder, while 122 (20%) met criteria for an anxiety disorder.

Differences and similarities between long and short forms

Table 1 shows the relationship between the SCL-90-R scores and the relevant scores on the abbreviated forms. A GSI is shown for all the abbreviated forms, and scores are also shown for the depression and anxiety domains where the short form has a comparable scale. As shown in *Figure 1*, there was a high concordance between the GSI across difference forms of the test. The relationships were slightly weaker for the depression (*Figure 2*) and anxiety (*Figure 3*) domains. The correlation between the SCL-90-R scores and the short form scores was very high, ranging between .89 for the depression score of the SCL-27 to .99 for the GSI on the BSI. Nevertheless, differences between mean scores were observed for all scales except for the GSI derived from the BSI-18. The greatest difference was between the SCL-27 depression score and the SCL-90-R depression score, which was a medium to large effect size (*d* = .65) by Cohen's estimation (1988).

Convergent validity

The majority of patients (n = 593, 97%) completed the HADS, which was used to examine the convergent validity of the SCL-90-R and abbreviated forms. The HADS depression score was highly correlated with the depression scores from the SCL-90-R (r = .70 [95%CI = .66, .74]), SCL-27 (r = .63 [95%CI = .58, .67]), SCL-14 (r = .68 [95%CI = .63, .72]), BSI (r = .68 [95%CI = .63, .72]), and the BSI-18 (r = .68 [95%CI = .63, .72]). Similarly, the HADS anxiety score was highly correlated with the anxiety scores on the SCL-90-R (r = .75 [95%CI = .72, .79]), BSI (r = .76 [95%CI = .72, .79]), and the BSI-18 (r = .76 [95%CI = .72, .79]).

Criterion validity

The mean differences between psychiatric diagnostic groups was used to evaluate the criterion validity of the SCL-90-R and its short forms. *Table 2* shows the mean differences on GSI scores between patients with any major psychiatric diagnosis and those without. Also shown are mean differences on depression scores between patients with and without a depressive diagnosis, and mean differences on anxiety scores between patients with and without an anxiety diagnosis. As shown, all instruments showed large (d > .80) differences between groups.

Classification performance

Receiver operating characteristic (ROC) curves were computed to evaluate the ability of the SCL-90-R and its short forms to classify patients according to psychiatric diagnosis. As shown in *Table 3*, all instruments demonstrated statistically significant areas under the curve (AUC) suggesting that each was sensitive to the relative diagnostic group. The sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV) are also shown based on an optimal cut-off score derived using Youden's (1950) J statistic. As shown, the sensitivities and specificities were generally low (< .80) across measures. The only exception was the anxiety score from the SCL-90-R which exhibited a sensitivity of .84 for detecting patients with an anxiety disorder. The PPVs were relatively low across measures (.34 - .58), indicated a relatively low probability that a patient screening positively would subsequently meet diagnostic criteria. The NPVs, however, were much higher (.80 - .94) suggesting that a negative screen was significantly predictive of a patient not meeting criteria for a psychiatric diagnosis. As shown in *Figure 4*, the ROC curves were comparable

across instruments, suggesting little difference in their ability to classify patients in terms of psychiatric diagnosis.

Measurement structure

Confirmatory factor analysis (CFA) was performed to evaluate the measurement structure for the SCL-90-R and the various short forms. As shown in *Table 4*, the various forms of the instrument varied in their fit to the data. The SCL-27, SCL-14, and K9 provided good fit across all indices. The BSI and BSI-18 exhibited marginal fit. While the RMSEA and SRMR were acceptable, the CFI and TLI were slightly below the acceptable range. The SCL-90-R exhibited the worst to the data. Again, while the RMSEA and SRMR were acceptable, the CFI and TLI indicated poor fit to the data. Reliability coefficients for each scale are included in *Appendix A*. Reliabilities were high for the global severity indices (GSI) across all instruments (ω = .89 - .97). Domain scores showed adequate reliability for the SCL-27 (ω = .80 - .85), SCL-14 (ω = .75 - .89), BSI (ω = .79 - .91), and BSI-18 (ω = .81 - .91).

Discussion

In this large study of patients undergoing investigation of presumed seizure disorders, we directly compared the SCL-90-R to five commonly used abbreviated form measures. Three key findings emerged. First, very high correlations were observed between the short forms and long form in the domains of general psychopathology, depression, and anxiety. This strongly suggests that the various short forms measure these same constructs as the full SCL-90-R. Second, we confirmed that all forms of the SCL-90-R produced equivalently large effect sizes when comparing cases and controls across general psychopathology, depression, and anxiety domains. This suggests that the different short-forms are equally appropriate for detecting differences is psychopathology at the group level. Third, the various abbreviated forms showed similar classification performance when compared to gold-standard neuropsychiatric diagnosis.

Taken together, these findings suggest that the various abbreviated forms of the SCL-90-R can be substituted for the full version in many contexts. For example, in situations where a continuous outcome measure is required for a clinical trial, any one of the short forms would be appropriate. The determining factor is the desired coverage of the available psychopathology domains. For example, if measurement of all nine domains is required, then

the BSI is appropriate because it is the only short form measurement with the same content as the full SCL-90-R. If, however, only depression and anxiety domains are of interest, then either the BSI or BSI-18 short forms are appropriate, as these are the only two short forms that explicitly contain depression and anxiety domains. If a single measure of global psychopathology is required, then any of the short-forms would provide an appropriate substitute. The SCL-K-9, the shortest instrument considered here with only 9 items, was highly correlated with the SCL-90-R's global severity index. These findings are consistent with previous work in non-epilepsy populations that demonstrated strong inter-instrument correlation between the SCL-90-R and its various short forms (Müller et al., 2010; Prinz et al., 2013; Sereda & Dembitskyi, 2016).

It is important to note that, while all of these instruments correlated highly with the relevant SCL-90-R scale, there were mean differences in test scores. This suggests that, while short forms can be used in place of the long form SCL-90-R, the scores cannot be treated as exchangeable. It would not be appropriate, for example, to compare scores on the long-form SCL-90-R with scores on the short form. A single instrument must be administered to all participants in order for comparisons to be valid.

The various short forms of the SCL-90-R showed similar classification performance compared to clinical diagnosis. It is important to note, however, that the accuracy of these instruments was not optimal for diagnostic purposes. The overall accuracy of these instruments, as indicated by the ROC analyses, was statistically significant, but limited. The low PPVs indicate relatively low probabilities that a patient classified as a 'positive' case actually has the relevant disorder. In contrast, the high NPVs indicate that 'negative' cases are highly likely to not have the relevant disorder on formal psychiatric assessment. The practical implication is that patients below the relevant cut-off can reasonably be assigned a lower priority for formal psychiatric assessment (Cut-off scores are shown in *Table 3*). These findings are consistent with previous research investigating the screening accuracy of the SCL-90-R in neurological disorders (Aben, Verhey, Lousberg, Lodder, & Honig, 2002; Leathem & Babbage, 2000; Ruis et al., 2014).

Investigation of latent measurement models across the various instruments produced mixed results. For each instrument, we tested the oblique measurement model proposed by the original authors. Correlations between the latent variables were free to correlate. Cross

loadings and residual covariances were fixed to zero. This represented the 'ideal' measurement model for each instrument. Only three instruments fitted this model adequately, namely the SCL-27, SCL-14, and SCL-K-9. The remaining instruments came close to fitting this model form but produced relative fit statistics that brought the latent variable into question. These findings are consistent with previous work raising questions as to the most appropriate measurement model for the SCL-90-R (Cyr, McKenna-Foley, & Peacock, 1985; Rauter et al., 1996; Urbán et al., 2014; Vassend & Skrondal, 1999).

The practical implications of these findings depends on the specific application. For screening purposes, the appropriateness of the psychometric instrument depends more on the empirical question of classification accuracy and less on the specific latent variable structure of the instrument. As discussed above, for screening of depression and anxiety, there is little difference between the SCL-90-R and its various short forms in VEM populations. In situations where the accurate measurement of well-defined psychopathological traits is required, the SCL-27, SCL-14, and SCL-K-9 are preferable over the other instruments with less understood measurement models. Future work is required to fully examine the measurement invariance of these instruments in epilepsy and related populations (Meredith, 1993).

Our study had a number of strengths. Not only was it conducted in a large sample of patients, but psychiatric diagnosis was confirmed via gold-standard neuropsychiatric assessment occurring in a multi-disciplinary VEM setting. The convergent validity between the full SCL-90-R and the abbreviated forms was examined using multiple statistical approaches, which included a comparison to clinical diagnosis and symptomatology measured using the HADS. While psychiatric diagnosis was informed by the dominant nosology, a formal semi-structured interview was not used. Future research aimed at validating the SCL-90-R and its abbreviated forms is required to confirm predictive validity of the instruments against a formal diagnosis derived from such means. While we investigated the measurement models of the SCL-90-R and its short forms, a more complete analysis of the latent variable structure of these instruments was beyond the scope of this study. Future work might more comprehensively investigate the covariance structure of these instruments, with a particular focus on demonstrating measurement invariance across different VEM diagnostic groups.

In summary, these results indicate that several abbreviated forms of the SCL-90-R are appropriate for use in clinical and research settings where more lengthy self-report instruments are contraindicated. In settings where a single measure of global psychopathology is warranted, the 9-item SCL-K-9 provides a valid and reliable solution. In situations where depression and anxiety are of research interest, or where screening for these disorders is desired, the BSI-18 provides the most economical and accurate alternative. In any screening application, it is important to note that, while the SCL-90-R and its abbreviated forms are useful for screening out depression and anxiety, they are not very useful for screening in these disorders. Nevertheless, they might be useful for prioritising resources in settings where formal neuropsychiatric assessment is of limited availability.

Tables

Table 1. Relationship between SCL-90 and short forms

	M_{diff} *[95% CIs]*	*d [95% CIs]*	*r [95% CIs]*
GSI			
SCL-27	0.02 [0.01, 0.03]	0.12 [0.04, 0.20]	.98 [.97, .98]
SCL-14	0.04 [0.02, 0.06]	0.14 [0.06, 0.22]	.94 [.93, .95]
SCL-K-9	0.09 [0.07, 0.12]	0.27 [0.19, 0.35]	.93 [.92, .94]
BSI	0.01 [0.12, 0.17]	0.10 [0.02, 0.18]	.99 [.99, .99]
BSI-18	0.00 [-0.02, 0.02]	0.00 [-0.08, 0.08]	.96 [.95, .96]
Depression			
SCL-27	0.29 [0.25, 0.33]	0.65 [0.56, 0.73]	.89 [.87, .90]
SCL-14	0.07 [0.04, 0.09]	0.21 [0.13, 0.29]	.95 [.94, .96]
BSI	0.15 [0.12, 0.17]	0.47 [0.39, 0.55]	.95 [.94, .96]
BSI-18	0.15 [0.12, 0.17]	0.47 [0.39, 0.55]	.95 [.94, .96]
Anxiety			
BSI	0.07 [0.05, 0.09]	0.32 [0.24, 0.40]	.97 [.97, .98]
BSI-18	0.05 [0.04, 0.07]	0.27 [0.19, 0.35]	.98 [.97, .98]

Note: M_{diff} is the absolute mean difference between two groups on the relevant measure. *d* = is Cohen's *d*, a standardised measure of effect size. *r* = Pearson's product moment correlation coefficient between the SCL-90-R subscale and the equivalent subscale from the abbreviated form. 95% confidence intervals are shown.

Table 2. Differences between diagnostic groups

	M_{diff} *[95% CIs]*	*d [95% CIs]*
Any diagnosis		
SCL-90-R	0.61 [0.49, 0.73]	0.87 [0.66, 1.02]
SCL-27	0.64 [0.51, 0.77]	0.86 [0.64, 1.00]
SCL-14	0.73 [0.59, 0.87]	0.89 [0.67, 1.03]
SCL-K-9	0.72 [0.57, 0.86]	0.85 [0.64, 1.00]
BSI	0.63 [0.51, 0.76]	0.87 [0.66, 1.02]
BSI-18	0.71 [0.58, 0.85]	0.94 [0.72, 1.08]
Depression		
SCL-90-R	0.85 [0.66, 1.03]	0.96 [0.70, 1.13]
SCL-27	0.88 [0.68, 1.09]	0.91 [0.63, 1.06]
SCL-14	0.92 [0.72, 1.12]	0.94 [0.69, 1.13]
BSI	0.93 [0.73, 1.13]	0.95 [0.69, 1.13]
BSI-18	0.93 [0.73, 1.13]	0.95 [0.69, 1.13]
Anxiety		
SCL-90-R	0.79 [0.61, 0.97]	0.94 [0.66, 1.10]
BSI	0.88 [0.69, 1.07]	0.98 [0.70, 1.14]
BSI-18	0.85 [0.67, 1.04]	0.98 [0.70, 1.15]

Note: M_{diff} is the mean difference between two groups on the relevant measure. *d* = is Cohen's *d*, a standardised measure of effect size. 95% confidence intervals are shown.

Table 3. Classification performance

	AUC [95% CI]	*Cut-off*	*Sensitivity*	*Specificity*	*NPV*	*PPV*
Any diagnosis						
SCL-90-R	.75 [.71, .79]	0.81	.72	.67	.82	.53
SCL-27	.74 [.70, .78]	0.83	.67	.69	.80	.53
SCL-14	.75 [.71, .79]	0.94	.65	.74	.80	.56
SCL-K-9	.73 [.70, .78]	1.06	.67	.73	.81	.57
BSI	.75 [.71, .79]	0.86	.69	.71	.82	.56
BSI-18	.76 [.72, .80]	0.92	.65	.76	.81	.58
Depression						
SCL-90-R	.76 [.71, .81]	1.04	.79	.64	.92	.36
SCL-27	.76 [.71, .81]	0.71	.76	.75	.91	.36
SCL-14	.76 [.71, .81]	1.08	.72	.68	.90	.37
BSI	.76 [.71, .81]	0.92	.76	.68	.92	.38
BSI-18	.76 [.71, .81]	0.92	.76	.68	.92	.38
Anxiety						
SCL-90-R	.77 [.72, .81]	0.68	.84	.60	.94	.34
BSI	.77 [.73, .81]	0.92	.75	.67	.91	.36
BSI-18	.77 [.71, .81]	0.92	.75	.67	.91	.36

Note: AUC = area under the curve with 95% confidence intervals computed using DeLong's method (1988) with the approach described by Sun and Xu (2014).

Table 4. Confirmatory factor analysis model fit indices

	χ^2	*DF*	*CFI*	*TLI*	*SRMR*	*RMSEA*
SCL-90-R	7104.824	3284	.835	.829	**.055**	**.050**
SCL-27	561.217	309	**.957**	**.952**	**.038**	**.043**
SCL-14	153.279	74	**.971**	**.964**	**.039**	**.048**
SCL-K-9	54.238	27	**.978**	**.959**	**.027**	**.051**
BSI	2161.789	1091	.914	.908	**.046**	**.048**
BSI-18	380.174	132	.936	.926	**.040**	.066

Note: χ^2 = robust test statistic. *DF* = degrees of freedom. *Sig* = significance test for model fit. *TLI* = robust Tucker-Lewis index. *CLI* = robust comparative fit index. *RMSEA* = robust root mean square error of approximation. SRMR = standardised root mean square residual. All models estimated using full-information maximum likelihood with robust (Huber-White) standard errors and a scaled test statistic. **Bold** = indices suggesting good fit (RMSEA < .06, SRMR < .08, TLI > .95, and CFI > .95).

Figures

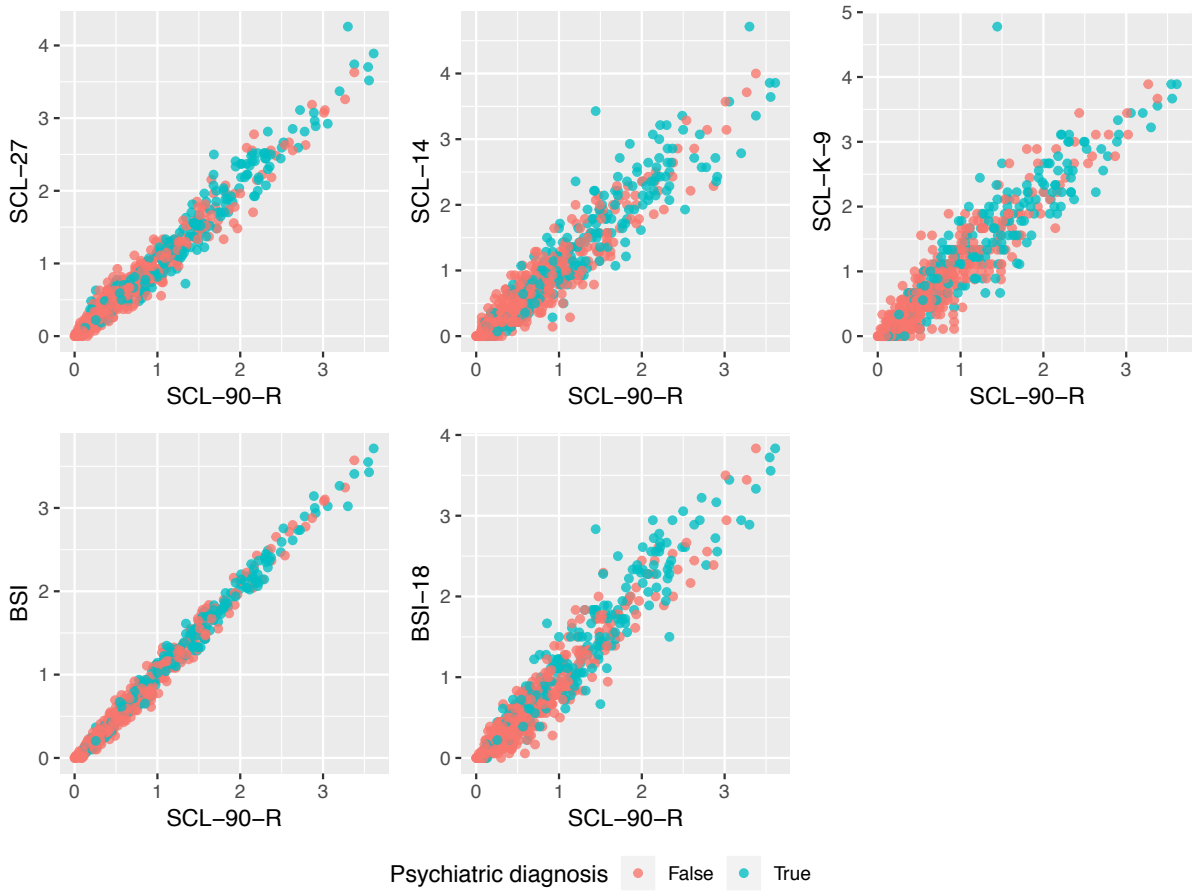

Figure 1. Correlations between the Global Severity Index (GSI) of the long form SCL-90-R and abbreviated forms. As shown, the correlations between the measures was high (r = .93 - .99). Patients with any major psychiatric diagnosis are shown in green, while those without any diagnosis are shown in red.

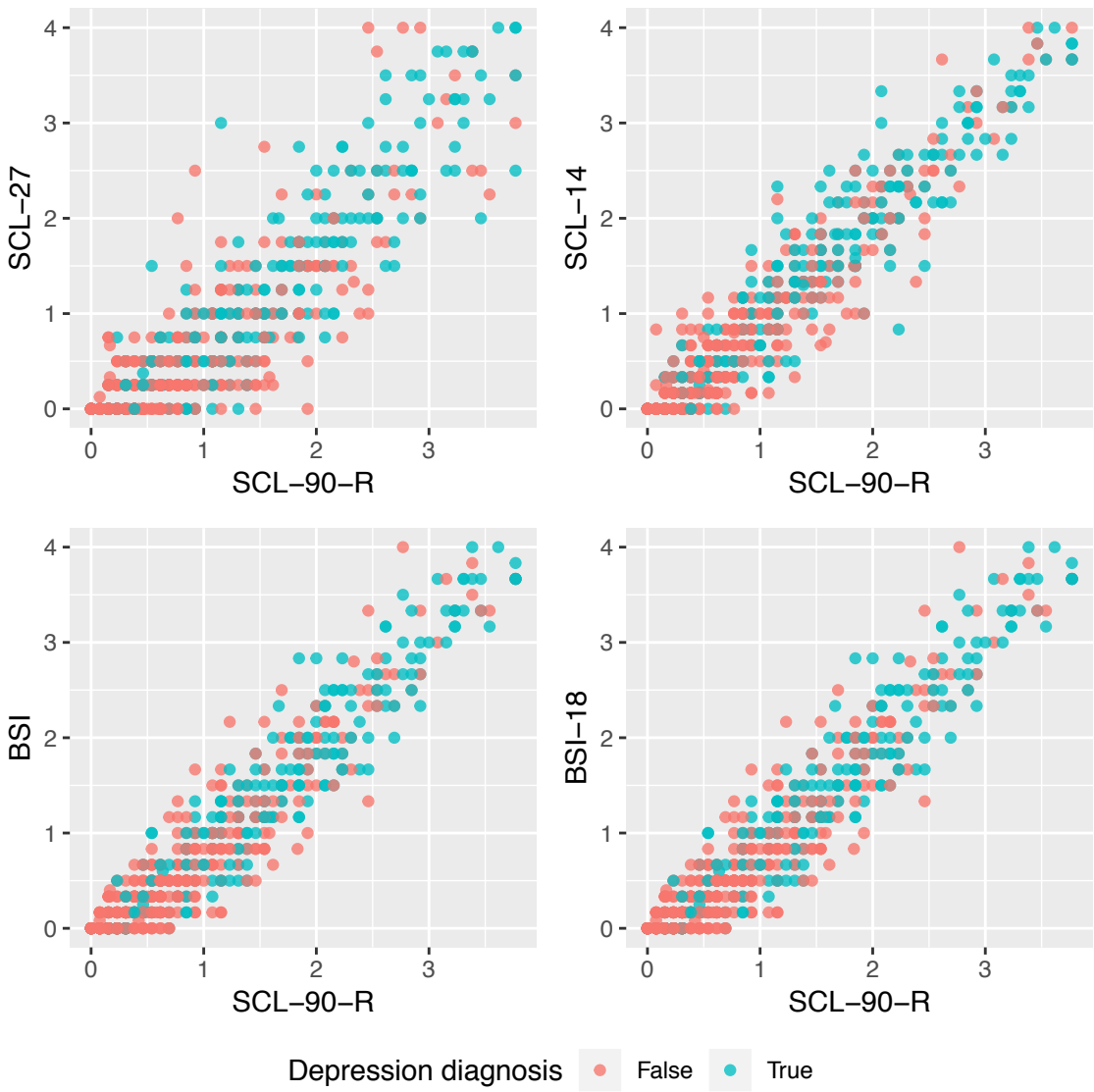

Figure 2. Relationships are shown between the long form SCL-90-R depression score and the depression scores from the SCL-27, SCL-14, BSI, and BSI-18 short forms. The correlations were high across all instruments (r = .89 - .95).

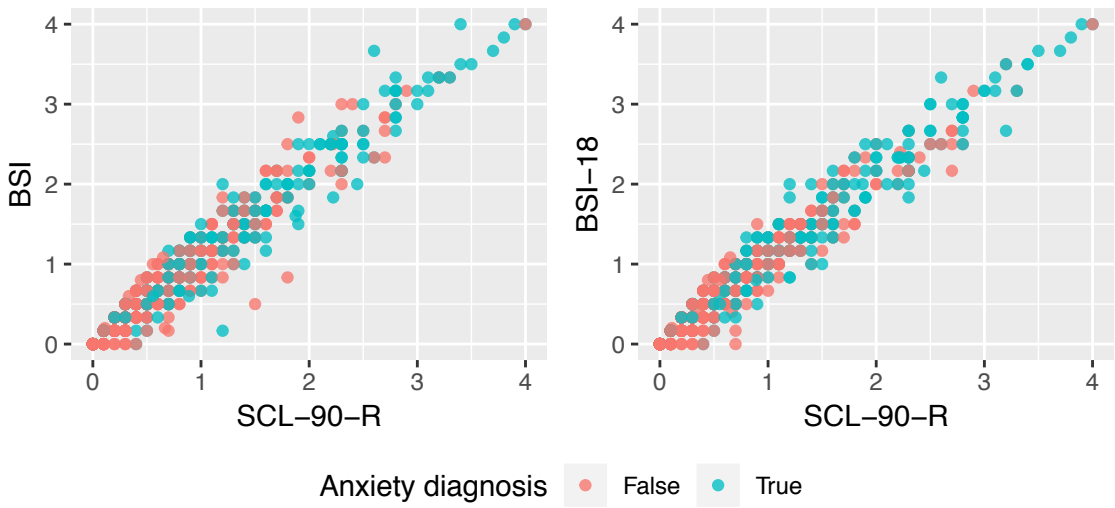

Figure 3. The relationship is shown between the long form SCL-90-R anxiety scores and the anxiety scores from the BSI and BSI-19. These correlations were high for the BSI (r = .97) and BSI-18 (r = .98).

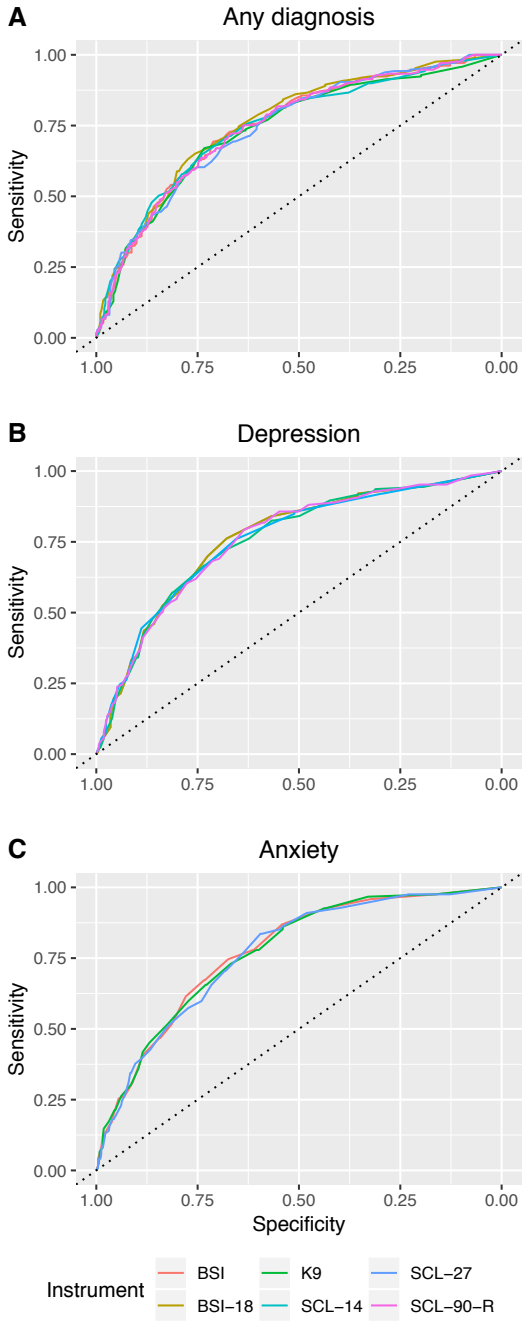

Figure 4. Receiver operating characteristic (ROC) curves for the SCL-90-R and its abbreviated forms. **A** shows the ability of the global severity indices (GSI) from the various measures to identify patients meeting criteria for any major psychiatric diagnosis. **B** shows the performance of the various depression scores to identify patients meeting criteria for a depressive disorder, while **C** shows the performance of the various anxiety scales to detect patients with an anxiety disorder. Overall, there was little difference in classification performance across measures.

References

Aben, I., Verhey, F., Lousberg, R., Lodder, J., & Honig, A. (2002). Validity of the beck depression inventory, hospital anxiety and depression scale, SCL-90, and hamilton depression rating scale as screening instruments for depression in stroke patients. *Psychosomatics, 43*(5), 386-393.

Agrawal, S., Turco, L., Goswami, S., Faulkner, M., & Singh, S. (2015). Yield of monitoring in an adult epilepsy monitoring unit (P2. 097). In: AAN Enterprises.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders : DSM-IV-TR*: American Psychiatric Pub.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5®)*: American Psychiatric Pub.

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological bulletin, 107*(2), 238.

Bentler, P. M. (1995). *EQS structural equations program manual* (Vol. 6): Multivariate software Encino, CA.

Blumer, D., Montouris, G., & Hermann, B. (1995). Psychiatric morbidity in seizure patients on a neurodiagnostic monitoring unit. *The Journal of neuropsychiatry and clinical neurosciences, 7*(4), 445-456.

Brophy, C. J., Norvell, N. K., & Kiluk, D. J. (1988). An examination of the factor structure and convergent and discriminant validity of the SCL-90R in an outpatient clinic population. *Journal of Personality Assessment, 52*(2), 334-340.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). United States of America: Lawrence Erlbaum Associates.

Cyr, J., McKenna-Foley, J., & Peacock, E. (1985). Factor structure of the SCL-90-R: is there one? *Journal of Personality Assessment, 49*(6), 571-578.

de Oliveira, G. N., Lessa, J. M. K., Gonçalves, A. P., Portela, E. J., Sander, J. W., & Teixeira, A. L. (2014). Screening for depression in people with epilepsy: comparative study among neurological disorders depression inventory for epilepsy (NDDI-E), hospital anxiety and depression scale depression subscale (HADS-D), and Beck depression inventory (BDI). *Epilepsy & Behavior, 34*, 50-54.

Derogatis, L. (1992). *SCL-90-R, administration, scoring and procedures manual-II for the R(evised) version and other instruments of the Psychopathology Rating Scale Series*. Townson: Clinical Psychometric Research.

Derogatis, L. (1993). *The Brief Symptom Inventory (BSI): administration, scoring, and procedures manual*. Minneapolis: National Computer Services.

Derogatis, L. (2000). *The Brief-Symptom-Inventory-18 (BSI-18): administration, scoring and procedures manual*. Minneapolis: National Computer Services.

Derogatis, L., & Savitz, K. The SCL-90-R and the Brief Symptom Inventory (BSI) in Primary Care. Maruish, ME. *Handbook of psychological assessment in primary care settings*, 297-334.

Diprose, W., Sundram, F., & Menkes, D. B. (2016). Psychiatric comorbidity in psychogenic nonepileptic seizures compared with epilepsy. *Epilepsy & Behavior, 56*, 123-130.

Fisher, R. S., Acevedo, C., Arzimanoglou, A., Bogacz, A., Cross, J. H., Elger, C. E., . . . Glynn, M. (2014). ILAE official report: a practical clinical definition of epilepsy. *Epilepsia, 55*(4), 475-482.

Green, S. B., & Yang, Y. (2009). Reliability of summed item scores using structural equation modeling: An alternative to coefficient alpha. *Psychometrika, 74*(1), 155-167.

Hardt, J., & Gerbershagen, H. U. (2001). Cross-validation of the SCL-27: A short psychometric screening instrument for chronic pain patients. *European Journal of Pain, 5*(2), 187-197.

Harfst, T., Koch, U., Kurtz von Aschoff, C., Nutzinger, D., Rüddel, H., & Schulz, H. (2002). Entwicklung und Validierung einer Kurzform der Symptom Checklist-90-R. *DRV-Schriften, 33*, 71-73.

Jones, J. E., Hermann, B. P., Woodard, J. L., Barry, J. J., Gilliam, F., Kanner, A. M., & Meador, K. J. (2005). Screening for major depression in epilepsy with common self-report depression inventories. *Epilepsia, 46*(5), 731-735.

Jöreskog, K. G. (1969). A general approach to confirmatory maximum likelihood factor analysis. *Psychometrika, 34*(2), 183-202.

Karouni, M., Arulthas, S., Larsson, P. G., Rytter, E., Johannessen, S. I., & Landmark, C. J. (2010). Psychiatric comorbidity in patients with epilepsy: a population-based study. *European journal of clinical pharmacology, 66*(11), 1151-1160.

Klaghofer, R., & Brähler, E. (2001). Konstruktion und Teststatistische Prüfung einer Kurzform der SCL-90–R. *Zeitschrift für Klinische Psychologie, Psychiatrie und Psychotherapie*.

Leathem, J. M., & Babbage, D. R. (2000). Affective disorders after traumatic brain injury: cautions in the use of the Symptom Checklist-90-R. *The Journal of head trauma rehabilitation, 15*(6), 1246-1255.

Lesser, R. P. (1996). Psychogenic seizures. *Neurology, 46*(6), 1499-1507.

Meredith, W. (1993). Measurement invariance, factor analysis and factorial invariance. *Psychometrika, 58*(4), 525-543.

Müller, J. M., Postert, C., Beyer, T., Furniss, T., & Achtergarde, S. (2010). Comparison of eleven short versions of the Symptom Checklist 90-Revised (SCL-90-R) for use in the assessment of general psychopathology. *Journal of Psychopathology and Behavioral Assessment, 32*(2), 246-254.

Pearson, K. (1895). Notes on Regression and Inheritance in the Case of Two Parents. *Proceedings of the Royal Society of London, 58*, 240-242.

Prinz, U., Nutzinger, D. O., Schulz, H., Petermann, F., Braukhaus, C., & Andreas, S. (2013). Comparative psychometric analyses of the SCL-90-R and its short versions in patients with affective disorders. *BMC psychiatry, 13*(1), 104.

R Core Team. (2019). *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing.

Rai, D., Kerr, M. P., McManus, S., Jordanova, V., Lewis, G., & Brugha, T. S. (2012). Epilepsy and psychiatric comorbidity: a nationally representative population-based study. *Epilepsia, 53*(6), 1095-1103.

Rauter, U. K., Leonard, C. E., & Swett, C. P. (1996). SCL-90-R factor structure in an acute, involuntary, adult psychiatric inpatient sample. *Journal of Clinical Psychology, 52*(6), 625-629.

Rayner, G. (2017). The contribution of cognitive networks to depression in epilepsy. *Epilepsy currents, 17*(2), 78-83.

Robin, X., Turck, N., Hainard, A., Tiberti, N., Lisacek, F., Sanchez, J.-C., & Müller, M. (2011). pROC: an open-source package for R and S+ to analyze and compare ROC curves. *BMC bioinformatics, 12*(1), 77.

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling and more. Version 0.5–12 (BETA). *Journal of Statistical Software, 48*(2), 1-36.

Ruis, C., van den Berg, E., van Stralen, H. E., Huenges Wajer, I. M., Biessels, G. J., Kappelle, L. J., . . . van Zandvoort, M. J. (2014). Symptom Checklist 90–Revised in neurological outpatients. *Journal of clinical and experimental neuropsychology, 36*(2), 170-177.

Schmitz, N., Hartkamp, N., Kiuse, J., Franke, G., Reister, G., & Tress, W. (2000). The symptom check-list-90-R (SCL-90-R): a German validation study. *Quality of Life Research, 9*(2), 185-193.

Sereda, Y., & Dembitskyi, S. (2016). Validity assessment of the symptom checklist SCL-90-R and shortened versions for the general population in Ukraine. *BMC psychiatry, 16*(1), 300.

Steiger, J., & Lind, J. (1980). *Statistically-based tests for the number of common factors*. Paper presented at the Annual Spring Meeting of the Psychometric Society, Iowa City.

Tellez-Zenteno, J. F., Patten, S. B., Jetté, N., Williams, J., & Wiebe, S. (2007). Psychiatric comorbidity in epilepsy: a population-based analysis. *Epilepsia, 48*(12), 2336-2344.

Tucker, L. R., & Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika, 38*(1), 1-10.

Urbán, R., Kun, B., Farkas, J., Paksi, B., Kökönyei, G., Unoka, Z., . . . Demetrovics, Z. (2014). Bifactor structural model of symptom checklists: SCL-90-R and Brief Symptom Inventory (BSI) in a non-clinical community sample. *Psychiatry research, 216*(1), 146-154.

Vassend, O., & Skrondal, A. (1999). The problem of structural indeterminacy in multidimensional symptom report instruments. The case of SCL-90-R. *Behaviour Research and Therapy, 37*(7), 685-701.

Weatherburn, C. J., Heath, C. A., Mercer, S. W., & Guthrie, B. (2017). Physical and mental health comorbidities of epilepsy: population-based cross-sectional analysis of 1.5 million people in Scotland. *Seizure, 45*, 125-131.

West, S. G., Taylor, A. B., & Wu, W. (2012). Model fit and model selection in structural equation modeling. In R. Hoyle (Ed.), *Handbook of structural equation modeling* (pp. 209-231). New York: Guilford Press.

Wiebe, S., Rose, K., Derry, P., & McLachlan, R. (1997). Outcome assessment in epilepsy: comparative responsiveness of quality of life and psychosocial instruments. *Epilepsia, 38*(4), 430-438.

Youden, W. J. (1950). Index for rating diagnostic tests. *Cancer, 3*(1), 32-35.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta psychiatrica scandinavica, 67*(6), 361-370.