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An assessment of the CES-D scale factor structure in black women: The Black Women's Health Study

Kepher H. Makambi[a,*], **Carla D. Williams**[a], **Teletia R. Taylor**[a], **Lynn Rosenberg**[b], and **Lucile L. Adams-Campbell**[a]

[a]Howard University Cancer Center, 2041 Georgia Avenue, NW, 20060 Washington, DC, USA

[b]Slone Epidemiology Center, Boston University, Boston, MA, USA

Abstract

This study investigates the dimensional structure of the Center for Epidemiologic Studies Depression (CES-D) scale in U.S. Black women with and without history of cancer via single-group and multi-group analyses. The CES-D questionnaire was administered in 1999 to 50,774 black women who are participants in the Black Women's Health Study (BWHS). For our analysis, we utilized a group of 690 women with a history of at least one of the three types of cancer (breast cancer, colon cancer or lung cancer) and an age-matched group of 1,380 healthy women with no history of any cancer or other chronic conditions including myocardial infarctions, stroke, angina, diabetes, lupus, and sarcoidosis. Three a priori hypothesized models were tested via confirmatory factor analysis: single-, three- and four-factor structures. The four-factor model provided the best fit and remained largely invariant across the groups when tested via multi-group comparisons. Two internal consistency measures of the scale (Cronbach's α coefficient and split-half coefficient) were also shown to be satisfactory. We concluded that the CES-D scale is appropriate for use in black women regardless of their cancer status.

Keywords

Depression; confirmatory factor analysis; single- and multi-group analyses

1. Introduction

Clinical depression is a serious medical problem affecting more than 19 million American adults each year, but one that can effectively be treated. Epidemiological studies report that women are at a higher risk of depression compared to men (Rhee et al., 1999; Nguyen et al., 2004). Minority groups have also been reported to have high levels of depressive symptoms, with no consensus on the ethnic differences in depression due to lack of depressive surveys among the different subgroups (Nguyen et al., 2004). Despite the debate on the relative prevalence rates of depression in African Americans compared to whites, there is evidence that there is inadequate and insufficient research data on depression in African Americans, especially women (Carrington, 2006). Apart from the high risk of depression in this group of women, research has also shown that there is a tendency for these women to either delay or not seek medication for depression (Barbee, 1992; Jackson, 2006). Some studies have also reported a high prevalence of depression among the medically ill (Katon and Sullivan, 1990),

* Corresponding Author: Tel.: +1 202 806 5295; Fax: +1 202 667 1686. E-mail address: E-mail: makambi1@hotmail.com (K.H. Makambi).

with between 1.5−50% of all cancer patients experiencing depression in the initial period after diagnosis (McDaniel et al., 1995).

The Center for Epidemiologic Studies Depression (CES-D) scale is a self-report instrument used to measure several functional domains commonly linked to depression (e.g., affective and somatic symptomatology), and is geared toward assessing depressive symptoms in large-scale epidemiological studies. This instrument is frequently used to measure current depressive symptoms and identify possible cases of depressive disorders in the general population (Hertzog et al., 1990; Kessler et al., 1992; Vera et al., 1991), and in cancer patients (Given et al., 1994; Kurtz et al., 1994; Pasacreta, 1997). The CES-D scale has also been shown to be suitable for administration to different ethnic and age groups (Noh et al., 1992; Matschinger et al., 2000), as well as in the medically ill elderly inpatients (Schein and Koenig, 1997). To be useful for research and clinical application, the CES-D must adequately capture the construct of depression in diverse populations. Moreover, it is important to understand how the inter-relationships among the latent factors underlying depression may differ across populations.

A number of studies conducted so far have identified and/or replicated varied CES-D scale factor structures in different populations and subpopulations. For instance, a two-factor structure (depressed affect and positive affect) was identified by Edman et al. (1999), Manson et al. (1990), and Schroevers et al. (2000); a three-factor structure (depressive affect and somatic, positive/well-being and interpersonal) by Beals et al. (1991), Guarnaccia et al. (1989); a four-factor structure (depressive affect, somatic-retarded activity, positive affect/well-being, and interpersonal) by Boisvert et al. (2003), Herzog et al. (1990), Knight et al. (1997), Williams et al. (2007) and Shafer (2006); a five-factor structure by Thorson and Powell (1993); a seven-factor structure (depressive affect, somatic-retarded activity, positive affect/well-being, interpersonal, anxiety, introspection and crying) by Callahan and Wolinsky (1994).

Through confirmatory factor analysis, Herzog et al. (1990) found out that a four-factor structure fitted their data of young and older adults, and noted that the factors were highly interrelated (see also Sheehan et al., 1995). Results from studies by Beals et al. (1991) and Somervell et al. (1993) among American Indians indicate that a four-factor and a three-factor model yielded satisfactory fit indices. However, the three-factor model was preferred because of the high-correlation between the depressed affect and somatic activity of the four-factor model. For African American women, Callahan and Wolinsky (1994), Nguyen et al. (2004) and Williams et al. (2007) identified a four-factor solution. However, in Callahan and Wolinsky (1994) study, the CES-D scale items ‘mind’ and ‘failure’ did not load onto any factor for African American women. In a study on older African American women, Foley et al. (2002) revealed a new factor ‘social well-being’ in addition to the three factors depressive/somatic, positive and interpersonal. Other studies focusing on ethnic minorities have recommended a three-factor structure (Guarmacia et al., 1989; Iwata and Roberts, 1996).

Working on a sample of 475 patients with cancer and a group of 255 matched reference subjects from the general population, Schroevers et al. (2000) could not replicate the four-factor structure of the CES-D. Further, studies using CES-D by Beeber et al. (1998) on newly diagnosed patients, and Barlow and Wright (1998) on people with arthritis that the original four-factor model could not always be replicated. These studies cast doubt on the generalizability of the four-factor structure in all populations and necessitate investigation into the factorial structure of CES-D scale, especially in minority groups.

The current study investigates the dimensional structure of the CES-D scale (Radloff, 1977) across two groups: Group 1 consisted of women with a history of any one of the three types of cancer: breast cancer, lung cancer, or colon cancer; and Group 2 comprised healthy women

with no history of either cancer or other chronic conditions including myocardial infarctions, stroke, angina, diabetes, lupus, and sarcoidosis. The first goal of the present study was to test the validity of the single-, three- and four-factor structures in the two groups of women (Group 1 and Group 2) using single-group confirmatory factor analysis (CFA). A single-factor model is based on the assumption that a global construct is responsible for the high internal consistency of the CES-D and for the moderate to high correlations found between items. Next, a three-factor model is hypothesized in which the items from depressed affect and somatic-retarded activity are combined into a single factor. Lastly, we test a four-factor model that has been shown by several authors to provide reasonable fit (Hertzog et al., 1990; Radloff, 1977). This is essentially examining the validity of the models in each group separately. This is followed by an investigation into the factorial invariance of the best model across the groups. Even though the CES-D has been widely used to assess depressive symptoms in populations with varied age, sex, language, ethnicity; there is limited investigation of the same instrument comparing factor structures among black women with cancer and with no cancer or other chronic conditions. This investigation will supplement and strengthen the extant literature of CES-D scale application among black women.

2. Methods

2.1. Participants

In 1995, 64,500 black women aged 21 to 69 years were enrolled in the Black Women's Health Study (BWHS) through postal questionnaires. The questionnaires were mailed to subscribers of ‘Essence’ magazine (whose readership is predominantly black women), members of selected black women's professional organizations and friends and relatives of the respondents (Rosenberg et al., 1995). The respondents were from across mainland USA. Follow-up questionnaires were sent out every two years to update risk factors of interest and to ascertain newly diagnosed diseases. The cohort being followed comprises 59,000 women whose addresses were judged to be valid one year after commencement of the study in 1995. The 1999 questionnaire, which included the CES-D scale, was completed by 50,774 (86%) of the participants in the BWHS (mean age 43.7 years, standard deviation, SD = 10.8). Out of the 40403 who completed all the 20 CES-D items, 690 (1.7%) reported history of at least one of the following: Breast cancer, lung cancer, or colon cancer; 39,713 (98.3%) did not report history of such conditions. For our analysis, we utilized 690 women in Group 1 and an age-matched group of 1,380 in Group 2.

2.2. Measures

Symptoms of depression were measured by the CES-D scale (Radloff, 1977). Participants indicated how often, over the past week, they experienced each of the 20 symptoms described in the CES-D scale. Responses were made on a 4-point scale ranging from 0 (rarely or none of the time) to 3 (most of or all the time). Scores on the scale can range from 0 to 60. Those with scores 16 or higher are generally considered to be at increased risk of experiencing clinical depression (Fuhrer et al., 1993)

2.3. Statistical analysis

Two measures of internal consistency were computed: Cronbach's α coefficient and split-half coefficient. Confirmatory factor analysis was used to assess the dimensionality of the CES-D scale. We first fit separate first-order models (single-, three- and four-factor models) for each group without any constraints. For invariance of factor structure across the two groups, we investigated whether (i) the number of underlying factors is equivalent, (ii) the pattern of factor loadings is equivalent, and (iii) the structural relations among the four factors are equivalent. While it is possible to test for equality of error variances across groups, we considered such constraint to be excessively stringent and therefore opted not to proceed with it.

Because the CES-D items have a 4-point response scale that represent ordinal measurement, PRELIS program was used to adjust the analysis for multivariate non-normality. That is, we analyzed matrices of polychoric correlations that are based on weighted least squares estimation and assume asymptotic covariance matrices. As a prerequisite to testing factorial invariance across the groups, we considered a baseline model that is estimated separately for each group. This is to ascertain that the underlying factor structure (four factor structure) fits the data in the two groups.

Assessment of model fit was based on the chi-square test corrected for nonnormality, χ^2. For single-group analyzes, however, we simply reported the χ^2 and did not use it for goodness-of-fit assessment because it is considered as an over-stringent criterion due to its sensitivity to sample size. As a result, other indices, namely, the Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI) and Comparative Fit Index (CFI), were used to evaluate the adequacy of the models. The RMSEA (Browne and Cudeck, 1993; Dolan, 2000) is a measure of the error of approximation of the model covariance structure to the covariance structure in the populations. As a rule of thumb, an RMSEA of < 0.05 indicates good fit.

The GFI values range between 0 and 1.00, with values near 1.00 indicating good fit. The CFI has an upper ceiling of 1.00 and values > 0.90 indicate good fit. For comparison of competing models, differences between chi-square ($\Delta\chi^2$) associated with two alternative models, which is also distributed as chi-square, was calculated as an index for model change improvements (Hoyle and Panter, 1995). The indices given above were also used (the RMSEA, GFI and CFI) with same cutoffs indicating adequacy of models. We also used the Critical N (CN) of Hoelter (1983) to assess the adequacy of our sample size. This index estimates the sample size that would be enough to give adequate fit for chi-square test, Hu and Bentler (1995).

3. Results

The combined sample of 2,070 women (690 in Group 1 and 1,380 in Group 2) had a median age of 54.0 years (mean age of 53.8 years, standard deviation, SD = 9.7). Out of the 690 with cancer, the distribution of those with at least one of the cancer types was as follows: breast cancer (81.6%), colon cancer (13.6%) and lung cancer (7.4%). Further more, 97.8%, 1.7% and 0.4% of the women reported one type, two types and three types of cancer, respectively. Among the women with cancer, 23.3% had a history of other comorbidities including myocardial infarctions, stroke, angina, diabetes, lupus, and sarcoidosis.

The composite CES-D score was positively skewed (skewness = 1.4), suggesting a moderate proportion of high scores in the data. Using the conventional cutoff score of 16 (< 16, ≥ 16) recommended by Radloff (1977), the percentage of women with elevated depression was 25.5% in Group 1 and 21.2% in Group 2 (chi-square, $\chi^2 = 0.03$). The mean total CES-D score for those with a history of cancer was higher (mean ± SD = 11.5 ± 9.6) than the healthy group (10.1 ± 8.5), with a significant difference between the two means (t-test, $p = 0.002$).

The Cronbach's α coefficient for the overall sample was 0.89. However, this index was 0.90 for the cancer group and 0.89 for the healthy group. For the Guttman split-half coefficient, the scale was split into two halves such that the two halves would be as equivalent as possible. In splitting the items we took into consideration whether the items assessed depressed affect, somatic and retarded activity, positive affect, or interpersonal symptoms. The first half included items sad, depressed, crying, sleep, talk, going, effort, enjoy, good, and unfriendly, while the second half included items bothered, appetite, blues, mind, hopeful, failure, fearful, happy, lonely and dislike. The value for the Guttman split-half coefficient was 0.89 for the overall sample. This index was 0.89 for the cancer group and 0.88 for the health group. The two indices indicate satisfactory reliability for the overall sample and for the two groups, separately.

Table 1 presents fit indices for each of the hypothesized models. The three-factor model provides a better fit compared to the single-factor model. The single-factor model provides an inadequate fit as the RMSEA is above the cutoff of 0.05 for the two groups, and the GFI is also below 0.90 for the two groups. All the models provided adequate CFI, that is, above 0.90 (Bentler and Bonett, 1980). The fit for the four-factor model was best and an improvement over the three-factor model. Notice that for the two groups, the chi-square difference test indicated that the four-factor model provided a statistically better fit than the three-factor model, $\Delta\chi^2 = 33.14$ and 47.56 for the cancer group and the healthy group, respectively ($\Delta df = 3$, $p < 0.0001$ for the two groups). The index Critical N, CN, ranges between 172 and 486; the smaller sample size for our two groups was 690. This indicates that our sample sizes were sufficient to allow for adequate fit for the models, assuming the models were correctly specified. We also notice that for each group, CN is a function of the model parameters and increases with increasing number of parameters estimated, Table 1.

The four-factor model yielded the best fit indices and henceforth we investigate the factorial invariance of this model across the two groups. First, we assess whether the four-factor model was invariant across the groups using multi-group comparisons. To do this, a two-group model was estimated that specified the same four-factor model in each of the two groups without imposing any between-group equality constraints on the loadings. The magnitudes of the fit indices were $\chi^2 = 897.17$, $df = 328$, RMSEA = 0.045, GFI = 0.86, and CFI = 0.99. Apart from the chi-square statistic, which usually depends on sample size, the other indices indicate that the overall model is consistent with one that is well fitting. We conclude that a four-factor model can describe depression in the two groups. Table 2 shows the standardized factor loadings, and the pooled and within group interfactor correlations. All the factor loadings were significant with magnitudes of above 0.43. The pooled interfactor correlations ranged between 0.43 for interpersonal and positive, to 0.90 for depressed affect and somatic affect. A similar trend is exhibited in the factor correlations within the two groups: ranging between 0.31 for interpersonal and positive in both Group 1 to 0.90 between depressed affect and somatic affect in Group 2.

Next, we tested whether the magnitudes of the factor loadings are equal across the two groups by specifying the four-factor structure with equality restrictions on the factor loadings. For the validity of these constraints we compared the χ^2 value for this model ($\chi^2 = 907.79$, df = 344) with the unconstrained model ($\chi^2 = 897.17$, $df = 328$). This yielded a significant decrease in model fit as indicated by an increase in the chi-square value ($\Delta\chi^2 = 10.62$, $\Delta df = 16$, $p = 0.83$). The conclusion is that the hypothesized equality of factor loadings across the two groups does hold. The other fit indices derived from this model indicate satisfactory fit: RMSEA= 0.045, GFI = 0.86 and CFI = 0.99. The Critical N, CN = 802 while our total sample size was 2,070, showing adequate sample size to perform these analyses.

Further, we tested the hypothesis of invariance of factor variance-covariance matrix across the groups. The fit indices from this model were $\chi^2 = 919.25$, $df = 354$, RMSEA = 0.044, GFI = 0.85 and CFI = 0.99. We compared the chi-square value in this model with the model immediately above ($\chi^2 = 907.79$, $df = 344$) yielding $\Delta\chi^2 = 11.46$, $\Delta df = 10$, p = 0.32. Therefore, the hypothesis of equality of factor variance-covariance matrix is not rejected, implying that the factor variance/covariance matrix can be assumed to invariant across the two groups. We stop here because we consider testing the invariance of error variance-covariance matrix to be too restrictive.

After establishing invariance across the two groups, we examined the individual CES-D items and presented the means (standard deviations, SD) in Table 3. The item means for Group 1 (Group 2) ranged between 0.30 (0.27) to 1.04 (0.94). On average, positive affect items were more dispersed about the mean compared to the other three factors. In Group 1, the mean (SD)

item score for depressed affect, somatic affect, positive affect and interpersonal were 0.49 (0.14), 0.67 (0.20), 0.69 (0.15), 0.32 (0.03), respectively; compared to 0.46 (0.15), 0.63 (0.17), 0.67 (0.11), 0.33 (0.03), respectively, for Group 2 (not in table). Notice that the mean item scores for positive affect is the highest both groups. Cronbach's α for both groups were 0.86, 0.77 and 0.71 for depressed affect, somatic affect, and positive affect, respectively. However, for interpersonal affect, Cronbach's α for Group 1 was 0.60 compared to 0.64 for Group 2. The lower values for individual factors Cronbach's α may be explained by the fact that this index is a function of the number of items – the smaller the number of items the lower the Cronbach's α and vice-versa.

4. Discussion

The present study evaluated the factor structure of the CES-D scale in two groups of US black women, those with cancer and those with no cancer or other comorbidities. Single- and multi-group confirmatory factor analysis was used to assess the validity and reliability of the single-, three- and four-factor structures that are hypothesized in the extant literature. Prior to testing the measurement structure of the CES-D scale, we assessed internal consistency of our data by Cronbach's α coefficient and split-half coefficient, yielding magnitude of over 0.85 for both indices for the overall sample. Therefore, this scale can be considered reliable with our data. In general, our results indicated that the models investigated were similar in the two groups of women. However, the single-factor structure did not fit the data adequately in any of the groups based on the assessment indices it yielded. The original four-factor model proposed by Radloff (1977) fitted our data well and was found to be better than the single- and three-factor models. In their study, Nguyen et al. (2004) demonstrated that a four-factor structure was valid for low socioeconomic status African Americans. Their results indicated a poorer fit for a three-factor structure. A four-factor structure has also been supported by a number of other studies on African American women. For instance, Callahan and Wolinsky (1994) in a study of older African American women demonstrated the validity of a four-factor structure using exploratory factor analysis. Our study also supported the invariance of a four-factor structure across the two groups, the cancer group and the healthy group.

The BWHS is the largest and the most geographically dispersed study of the health of black women in the US. Our results are based on a subset of these women and can therefore be claimed to be representative of black women in the whole country. However, like many other observational studies, the CES-D scale is self-reported and information bias may influence the results. For instance, participants may not give responses that are a true representation of their status. A question of great interest is that of the relationship between clinically diagnosed depression and the CES-D scale score. An answer to this question will enhance our understanding of the experience of depression in, for instance, cancer survivors (see, for instance, Hann et al., 1999). Future studies could focus on the stability of CES-D over time and making comparisons with other racial groups. Given the high interfactor correlations, another future direction of research could be to test a second-order hierarchical factor model consisting of the four factor structure with an additional single higher order general depression factor. The advantage of the second-order model is that it will account for the high degree of covariation observed between the four first-order factors. A two-factor model along the lines of Schroevers et al. (2000) could also be informative and worth investigating to see whether results in this study could be replicated.

In conclusion, this study suggests that a four-factor CES-D scale structure is an adequate measure of depressive symptomatology in black women with or with no history of cancer. Because depression may have adverse impacts on medical illness (Katon, 2003), it is valuable to know that the CES-D scale can be satisfactorily used in a diverse subject pool which may include those with and without chronic health problems.

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Table 1

Comparisons of competing models

Model	*df*	χ^2	CFI[a]	RMSEA[b]	GFI[c]	CN[d]
Group1						
Single-factor model	170	658.50	0.97	0.077	0.76	172
Three-factor model	167	440.00	0.98	0.053	0.84	302
Four-factor model	164	406.86	0.99	0.047	0.86	338
Group 2						
Single-factor model	170	900.14	0.97	0.072	0.78	216
Three-factor model	167	537.87	0.99	0.049	0.87	412
Four-factor model	164	490.31	0.99	0.044	0.90	486

[a] CFI= Comparative Fit Index

[b] RMSEA=Root Mean Square Error of Approximation

[c] GFI=Goodness of Fit Index

[d] CN=Critical N

Table 2

Four-factor structure: Standardized solutions for CES-D items in the BWHS

Item	Depressed Group 1 (Group 2)	Somatic Group 1 (Group 2)	Positive Group 1 (Group 2)	Interpersonal Group 1 (Group 2)
Blues	0.82 (0.81)			
Depressed	0.88 (0.89)			
Failure	0.71 (0.73)			
Fearful	0.68 (0.69)			
Lonely	0.73 (0.73)			
Crying	0.75 (0.77)			
Sad	0.86 (0.87)			
Bothered		0.59 (0.61)		
Appetite		0.46 (0.47)		
Mind		0.61 (0.64)		
Effort		0.76 (0.75)		
Sleep		0.50 (0.56)		
Talk		0.54 (0.55)		
Going		0.75 (0.75)		
Good			0.43 (0.45)	
Hopeful			0.61 (0.61)	
Happy			0.83 (0.86)	
Enjoy			0.90 (0.88)	
Unfriendly				0.69 (0.73)
Dislike				1.01 (0.94)
Interfactor Correlation				
Depressed	1.0 (1.00) [1.00]			
Somatic	0.88 (0.90) [0.90]	1.00 (1.00) [1.00]		
Positive	0.69 (0.75) [0.69]	0.56 (0.62) [0.63]	1.00 (1.00) [1.00]	
Interpersonal	0.58 (0.61) [0.65]	0.54 (0.59) [0.65]	0.31 (0.40) [0.43]	1.00(1.00) [1.00]

[.] pooled interfactor correlation

Table 3

CES-D item means (standard deviations, SD) for Group 1 and Group 2 subjects

Item	Group 1 Mean (SD)	Group 2 Mean (SD)
Depressed		
Blues	0.49 (0.81)	0.44 (0.74)
Depressed	0.60 (0.86)	0.57 (0.79)
Failure	0.31 (0.67)	0.27 (0.62)
Fearful	0.41 (0.72)	0.40 (0.70)
Lonely	0.70 (0.91)	0.68 (0.86)
Crying	0.34 (0.68)	0.28 (0.61)
Sad	0.58 (0.79)	0.56 (0.74)
Somatic		
Bothered	0.57 (0.81)	0.55 (0.76)
Appetite	0.41 (0.68)	0.39 (0.66)
Mind	0.75 (0.82)	0.69 (0.79)
Effort	0.67 (0.91)	0.62 (0.84)
Sleep	1.04 (0.96)	0.94 (0.94)
Talk	0.73 (0.82)	0.67 (0.80)
Going	0.54 (0.73)	0.52 (0.74)
Positive		
Good	0.53 (0.94)	0.57 (0.96)
Hopeful	0.86 (1.04)	0.80 (0.99)
Happy	0.76 (0.88)	0.72 (0.84)
Enjoy	0.62 (0.90)	0.59 (0.84)
Interpersonal		
Unfriendly	0.33 (0.63)	0.35 (0.64)
Dislike	0.30 (0.67)	0.30 (063)