Published in final edited form as:

Eur J Psychol Assess. 2020 March ; 36(2): 229–236. doi:10.1027/1015-5759/a000510.

Confirmatory Factor Analysis of the Center for Epidemiologic Studies Depression Scale in Oncology With Examination of Invariance Between Younger and Older Patients

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Abstract

Accurate measurement of depressive symptoms in the cancer setting is critical for ensuring optimal quality of life and patient outcomes. The present study compared the one-factor, correlated two-factor, correlated four-factor, and second-order factor models of the Center for Epidemiologic Studies Depression Scale (CES-D), a commonly used measure in oncology settings. Given the importance of adequate psychometric performance of the CES-D across age groups, a second aim was to examine measurement invariance between younger and older adults with cancer. Participants ($N = 663$) were recruited from outpatient clinics at a large cancer center. Over one-fourth of the sample endorsed clinically significant depressive symptoms (25.9%, $n = 165$). Confirmatory factor analysis of the CES-D supported the hypothesized correlated four-factor model as the best fit. The second-order factor also demonstrated good fit, but interpretations of the factors were more complex. Factors were highly correlated (range = .38–.91). There was also support for full scalar invariance between age groups, suggesting that regardless of age, respondents endorse the same response category for the same level of the latent trait (i.e., depression) on the CES-D. Taken together, the results suggest that the CES-D is a viable depression screening option for oncology settings and does not require scoring adjustments for respondent age.

Keywords

aging; cancer; CFA; depression; screening

Across oncology practice, there is a push to focus on the development, implementation, and dissemination of psychological and distress screening programs (Andersen et al., 2014; Pirl et al., 2014). Psychological symptoms are common in the cancer setting, with estimates ranging from 3% to 58% of patients reporting clinically significant depressive symptoms

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Electronic Supplementary Material

The electronic supplementary material is available with the online version of the article at <https://doi.org/10.1027/1015-5759/a000510>

during the cancer trajectory (Krebber et al., 2014; Massie, 2004). Despite the widely recognized need to assess patients' psychological well-being in oncology, there is no universal agreement on "best practice" methods for screening and assessment. Moreover, there is debate as to whether or not depression screening initiatives can actually improve patient outcomes (Meijer et al., 2011; Thombs & Ziegelstein, 2017). However, in order for this debate to be resolved, we must first ensure that the construct of depression is being adequately assessed by existing measures with acceptable psychometric properties. Additionally, the aging of the US population will include a 67% increase in cancer incidence among older adults by the year 2030 compared to only an 11% increase for younger adults (Smith, Smith, Hurria, Hortobagyi, & Buchholz, 2009). As such, policymakers are calling for research that focuses on tailoring existing oncology practice to the unique developmental needs of the older cancer patient, with a major focus on assessment (Hurria et al., 2015). Included in this agenda is the psychometric analysis of patient-reported outcomes to determine their potentially changing characteristics in older cancer patients (Nelson, Cho, Berk, Holland, & Roth, 2009; Saracino, Weinberger, Roth, Hurria, & Nelson, 2017). Overall, geriatric depression is a widely studied construct, and late-onset depression (i.e., appearing after age 60) tends to differ phenomenologically from depression emerging in adulthood (e.g., characterized by anhedonia, not depressed mood; Alexopoulos et al., 2002; Blazer, 2003; Covinsky, Cenzer, Yaffe, O'Brien, & Blazer, 2014; Fiske, Wetherell, & Gatz, 2009). Thus, one cannot assume that existing depression measures developed in younger, generally healthier populations, will necessarily adequately capture the symptoms experienced by older patients.

The Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) is a 20-item self-report measure of depressive symptom severity that is commonly used in oncology practice and research (Andersen et al., 2014; Hann, Winter, & Jacobsen, 1999; Vodermaier, Linden, & Siu, 2009). It is well suited for use among medical patients as it does not rely heavily on the presence of somatic items that might be confounded with symptoms of cancer and its treatment. Instead, it includes additional affective and cognitive symptoms beyond those that comprise the *Diagnostic and Statistical Manual (DSM)* criteria for a major depressive episode (American Psychiatric Association, 2013) such as loneliness, fearfulness, crying, and interpersonal perceptions. Its development, however, occurred outside of oncology, and whether or not it maintains its factor structure in the cancer setting is relatively understudied.

The initially proposed factor structure of the CES-D included four factors: depressed affect (DA), positive affect (PA), somatic complaints (SC), and interpersonal problems (IP) (Radloff, 1977). Several confirmatory factor analyses (CFAs) have supported this correlated four-factor model (Gomez & McLaren, 2017; Hertzog, Van Alstine, Usala, Hultsch, & Dixon, 1990; Williams et al., 2007), but only one examined medically ill patients (Adams et al., 2017). There is little evidence for a one-factor model in which all items load on this factor (Adams et al., 2017; Gomez & McLaren, 2017). This is controversial, however, given that most settings utilize a single CES-D summary score as an indicator of depressive symptoms. Reliance on a single score rather than examining each factor could be problematic for score interpretation, as it may obscure subtypes of depression or the identification of specific symptom clusters. Some evidence exists for a correlated two-factor

model that consists of the original PA factor and a general DA factor (Edwards, Cheavens, Heiy, & Cukrowicz, 2010). However, the utility of the PA factor has been questioned as an element of depression, as it appears to be a distinct construct (Edwards et al., 2010). Additionally, given that these four items are reverse-coded, it may result in increased measurement error due to respondents potentially overlooking response option changes (Edwards et al., 2010; Hertzog et al., 1990; Saracino, Cham, Rosenfeld, & Nelson, 2018). Several studies have also found evidence of a second-order factor model, in which the four factors (DA, PA, SC, and IP) load on a general depression second-order factor (Hertzog et al., 1990; Knight, Williams, McGee, & Olan, 1997). In this model, the four factors are interpreted as the residual (leftover) factors over and above the second-order factor.¹

Although the CES-D is widely used in oncology research and clinical settings, its factor structure has not been examined in this setting generally, nor have potential age-related differences in the optimal structure been examined. Only one study has examined the factor structure of the CES-D in cancer using exploratory factor analysis (EFA), and they concluded that a one-factor model that eliminated the four positively worded items was the most suitable for this population (Schroevers, Sanderman, Van Sonderen, & Ranchor, 2000). In examining age-related differences only, Hertzog et al. (1990) found that among community-dwelling adults ($N = 447$), the correlated four-factor and second-order factor models fit the CES-D data well. They also found that there was age-related invariance in the unstandardized factor loadings across age groups. Older adults, however, had lower total, DA, PA, and IP scores than younger participants, with no differences on SC scores. They concluded that the CES-D was overall a valid measure for use with older adults. It is particularly important to understand whether or not the unique interaction of cancer and aging impacts the psychometric properties of the CES-D, as the potential for symptom confounding due to overlap between somatic symptoms of depression, cancer, and normal age-related physical symptoms is great. Moreover, in oncology, older age tends to be the norm (Bluthmann, Mariotto, & Rowland, 2016), and thus, there is a pressing need to identify measures that are appropriate for use with older adults. Such analyses will ensure accurate interpretation of CES-D data and will inform psychosocial screening programs in oncology.

The current study sought to first determine the optimal factor structure of the CES-D among patients with cancer by comparing the one-, correlated two-, correlated four-, and second-order factor models. Following identification of the optimal factor structure, the second aim was to examine measurement invariance between the younger and older adult groups. We hypothesized that based on the literature:

Hypothesis 1 (H1): The correlated four-factor model would be the best fit.

Hypothesis 2 (H2): Invariance of this factor model between younger and older adults would be supported.

¹The literature has also considered a bifactor model that the four factors (DA, PA, SC, and IP) are uncorrelated and all the items also load on a general factor. This is a more general form of the second-order factor model (Yung, Thissen, & McLeod, 1999). In the CES-D, this model does not converge properly because IP has only two items. Convergence can only be achieved when the factor loadings of two items are set to be identical. Given the lack of rationale and guidelines about which two items should be used, we did not further consider this model.

Hypothesis 3 (H3): Older adults would score lower than younger adults across CES-D factors.

Method

The total sample was comprised of 636 adult outpatients receiving outpatient care from Memorial Sloan Kettering Cancer Center (MSK) between January 2016 and May 2016. To be eligible for participation, patients had to be fluent in English, at least 40 years old, and have a cancer diagnosis. Patients were approached by trained research personnel and offered participation in the study while awaiting routine outpatient appointments. The sample was recruited to fill two groups: younger (i.e., 40–64 years) and older (i.e., 65 years or older). Age 40 was selected as the inclusion criteria cutoff in order to differentiate the sample from what the National Comprehensive Cancer Network (Coccia et al., 2018) operationalized as “Adolescent and Young Adult,” which refers to patients from 15 to 39 years of age. Age 65 was selected as the cutoff in order to be consistent with existing literature and public policy (Bluethmann et al., 2016; Centers for Medicare and Medicaid Services, 2018; Gilbody et al., 2017).

All participants completed a brief packet of questionnaires in a fixed order. Sociodemographic and medical data were collected using a self-report questionnaire. Depressive symptoms were assessed with the CES-D, a 20-item self-report measure that asks participants to rate how they have felt during the past week on a four-point Likert scale, with 0 = *Rarely* or *none of the time (less than one day)* and 3 = *Most or all of the time (5–7 days)*. Four “positive affect” items (i.e., 4, 8, 12, and 16) are reverse-scored. Higher scores are indicative of more severe depressive symptoms (range = 0–60). The CES-D is widely used both in research and clinical settings with older adults and in a range of medical settings. Past research has demonstrated acceptable psychometric properties (Hann et al., 1999; Lewinsohn, Seeley, Roberts, & Allen, 1997; Nelson et al., 2009; Saracino et al., 2017; Vodermaier et al., 2009).

The study was approved by the Fordham University and Memorial Sloan Kettering Cancer Center Institutional Review Boards. Trained research personnel approached patients who were waiting for routine clinic appointments and offered them participation in this study. Eligible patients were then informed of the study procedures, risks, and benefits and asked if they wanted to participate.

Statistical Analyses

In the total sample of 663 patients, there were 27 patients (4.1%) who did not respond to any of the CES-D items. These patients were not significantly different on any demographic or illness-related variables, $ps > .05$. Patients who did not report on all the items were less likely to be currently receiving depression treatment ($p = .04$) and more likely to have comorbidity ($p = .006$). For the remaining 636 patients, missing data rates of CES-D items ($Mdn = 3.9\%$, range = 1.9–5.4%) and patients’ demographic and illness-related variables ($Mdn = 0.0\%$, range = 0.0–3.6%) were not high. We concluded that pairwise deletion, which was used in the selected estimation procedure, sufficed to handle these missing values.

All analyses were conducted using *Mplus* 7.2 (Muthén & Muthén, 1998–2015). First, the one-factor, correlated two-factor, correlated four-factor, and second-order factor models were compared using the total sample. The weighted least squares mean and variance adjusted (WLSMV) estimation was used, which treats the CES-D items as ordered-categorical variables (Rhemtulla, Brosseau-Liard, & Savalei, 2012). The likelihood ratio test was used to compare the model fit between nesting models. In addition, the root mean square error of approximation (RMSEA; lower values indicate better model fit) and comparative fit index (CFI; higher values indicate better model fit) were used to compare these models. Suggested cutoffs for satisfactory model fit were used to evaluate the models (RMSEA < .06; CFI > .95; Hu & Bentler, 1999). Factor loadings and factor correlations of the tested models were also interpreted for model selection.

Second, the measurement invariance of the selected factor model between the younger and older adults was tested. We tested three invariance models in sequence: configural invariance (same factor model in two groups), metric invariance (configural invariance plus the same factor loadings between two groups), and scalar invariance (metric invariance plus the same item thresholds between two groups). We evaluated the three models by the likelihood ratio test between the consecutive nesting models that nonsignificant results support the more stringent models. We also followed the guidelines by Chen (2007) and Cheung and Rensvold (2002) that a small worsening of RMSEA and CFI between consecutive nesting models supports the more stringent model. The WLSMV estimation with delta parameterization was used in the invariance test, while theta parameterization produced identical likelihood ratio tests (Millsap & Tein, 2004). WLSMV estimation uses pairwise deletion to handle the missing values.

Results

The sample consisted of 339 participants in the younger adult group (53.3%) and 297 in the older adult group (46.7%) with mean ages of 56.2 ($SD = 5.9$) and 72.2 ($SD = 5.8$), respectively. The sample was comprised of 47.8% and 43.9% female participants in the younger and older adult groups, respectively. Most participants were white (87.1%; $n = 554$); 5.5% were black ($n = 35$) and 8.2% ($n = 52$) identified as Hispanic. Most participants were married or living with a partner (71.5%; $n = 455$) and had a college and/or graduate education (68.9%; $n = 438$). The most common cancer diagnoses were gynecological (16.0%; $n = 102$), prostate (14.3%; $n = 91$), lung (14.3%; $n = 91$), and colorectal (8.2%; $n = 52$).

Applying the recommended cutoff score of 16 for identifying adults with clinically significant depressive symptoms (Lewinsohn et al., 1997), 25.9% ($n = 165$) of the sample was categorized as having significant depressive symptoms (total scores were not computed for 110 participants due to one or more omitted items). There was a significant relationship between age and severity of depressive symptoms, with 27.1% ($n = 92$) of the younger group endorsing clinically significant depressive symptoms compared to 24.6% ($n = 73$) in the older group, $\chi^2(526) = 5.10$, $p = .03$.

Table 1 presents the fit indices for all tested models using the total sample (see Electronic Supplementary Material, ESM 1 for complete analyses input and output). The fit of the one-factor model, $\chi^2(170) = 2,128.35$, RMSEA = .135 [90% CI: .130, .140], CFI = .844, was significantly worse than the correlated two-factor model, $\chi^2(169) = 477.834$, RMSEA = .054 [90% CI: .048, .059], CFI = .984, likelihood ratio test $\chi^2(1) = 264.03$, $p < .001$. In turn, the two-factor model generated a significantly worse fit than the correlated four-factor model, $\chi^2(164) = 369.00$, RMSEA = .044 [90% CI: .038, .050], CFI = .984, likelihood ratio test $\chi^2(5) = 72.97$, $p < .001$. The second-order factor model, which is nested within the correlated four-factor model, fit the data as well as the four-factor model, $\chi^2(166) = 367.42$, RMSEA = .044 [90% CI: .038, .050], CFI = .984, likelihood ratio test, $\chi^2(2) = 3.36$, $p = .19$.

We next examined invariance between the two age groups for the four-factor and second-order models. Table 2 shows the fit indices and likelihood ratio test results of the measurement invariance between the two age groups for the four-factor model. The configural invariance model had satisfactory model fit, $\chi^2(328) = 515.66$, RMSEA = .042 [90% CI: .035, .049], CFI = .985. The metric invariance model fit the data as well as the configural invariance model, $\chi^2(344) = 534.19$, RMSEA = .042 [90% CI: .035, .048], CFI = .985, likelihood ratio test, $\chi^2(16) = 21.43$, $p = .16$. The scalar invariance model fit the data as well as the metric invariance model, $\chi^2(380) = 546.08$, RMSEA = .037 [90% CI: .030, .044], CFI = .987, likelihood ratio test, $\chi^2(36) = 35.58$, $p = .49$. Thus, scalar invariance was established between the two age groups. In this model, the older adults' mean DA ($M_{\text{difference}} = -0.33$, $p < .01$) and SC ($M_{\text{difference}} = -0.34$, $p < .01$) were significantly lower than the younger adults', while their mean PA ($M_{\text{difference}} = -0.14$, $p = .12$) and IP ($M_{\text{difference}} = 0.30$, $p = .35$) were not significantly different than the younger adults.

We also tested the invariance of the CES-D second-order factor model between age groups; results supported scalar invariance of the second-order factor model. For the second-order factor model, the configural invariance model had satisfactory model fit, $\chi^2(333) = 515.17$, RMSEA = .041 [90% CI: .034, .048], CFI = .986. In this configural model, the residual variance of the first-order DA factor needs to be constrained to zero to avoid model estimated negative variance. The metric invariance model fit the data as well as the configural invariance model, $\chi^2(352) = 472.70$, RMSEA = .033 [90% CI: .025, .040], CFI = .991, likelihood ratio test, $\chi^2(19) = 20.61$, $p = .36$. The scalar invariance model fit the data as well as the metric invariance model, $\chi^2(412) = 645.58$, RMSEA = .042 [90% CI: .036, .048], CFI = .982, likelihood ratio test, $\chi^2(60) = 156.70$, $p < .001$. Thus, scalar invariance was established between the two age groups.

In choosing between the correlated four-factor model and the second-order factor model, which both had similar and satisfactory model fit, we considered the clinical utility of each approach. For the correlated four-factor model, the composite scores of items can be used to represent the four factors. For the second-order factor model, the composite scores of items cannot represent the four factors, because they fail to capture the idea that the four factors are the residual (leftover) factors over and above the second-order factor. Also, the composite scores of all items do not represent the second-order factor because no items load on the second-order factor directly. Therefore, we concluded that the correlated four-factor model is the best fitting model and also has the most clinical utility and interpretability.

Table 3 shows the standardized factor loadings and factor correlations of the correlated four-factor model in the whole sample. All items had standardized factor loadings above .55 on their corresponding factors. All factors were significantly correlated with each other (r 's > .38). This model also fit well in the younger adult group, $\chi^2(164) = 281.88$, RMSEA = .049 [90% CI: .039, .059], CFI = .981, and older adult group, $\chi^2(164) = 234.96$, RMSEA = .036 [90% CI: .025, .046], CFI = .990.

Additional analyses were conducted to examine the robustness of the results. First, measurement invariance testing between (40–64) and (age ≥ 70) was conducted (eliminating participants between 65 and 70). The results were consistent, such that scalar invariance was established. Second, all of the analyses were replicated using robust maximum likelihood (MLR) estimation which treats all items as continuous. The results also supported the correlated four-factor model and scalar invariance between the two age groups (these results are available upon request).

Discussion

This study examined the psychometric properties of the CES-D in a large sample of patients with cancer. The one-factor model demonstrated significantly worse fit than the correlated two-factor model, and the correlated two-factor model fit significantly worse than the correlated four-factor model. The second-order factor model fit the data as well as the correlated four-factor model, but was rejected because the model is more limited in applied settings. Thus, consistent with our hypothesis and prior research in other populations (Adams et al., 2017; Gomez & McLaren, 2017; Hertzog et al., 1990; etc.), this study supported the correlated four-factor model of the CES-D for patients with cancer.

The four factors were also highly correlated with one another. The strongest correlations were between DA and SC, $r = .91$. While causal relationships cannot be determined, this correlation reiterates the strong relationship between affective and somatic symptoms in patients with cancer. While physical symptom burden and coping with cancer and its treatment can contribute to the development of depressive symptoms, depressive symptoms can also augment one's experience of their somatic complaints (Goesling, Clauw, & Hassett, 2013). Understanding the etiology of depressive symptoms among patients with cancer is beyond the scope of the current investigation; however, we see that by dividing the CES-D into its four component factors, we can appreciate the relationships between symptom subtypes that are otherwise obscured when interpreting only a total score. This is particularly important in cancer, where depression scores could be inflated by the physical symptom burden of cancer and its treatment. For example, if a patient scores a 16 on the CES-D but primarily endorses items on the SC subscale, the score might be interpreted as a potential artifact of cancer or its treatment itself rather than depression. Additionally, despite previous concerns about PA items (Edwards et al., 2010; Hertzog et al., 1990; Saracino et al., 2018), our analyses supported the presence of a PA factor. These findings depart from Schroevers and colleagues (2000), who suggested removing the PA items in the cancer setting. The current study results may be more reliable given the use of CFA, which has several strengths over EFA in this context, as there is a theoretical basis and previously identified factor structure to guide hypotheses (Hurley et al., 1997). The second aim of the

study was to examine measurement invariance of the CES-D between younger and older adult participants. Measurement invariance across the two age groups was tested for the selected four-factor model. The findings supported scalar invariance between the two age groups. This means that it is generally safe to assume that regardless of age, respondents endorse the same response category for the same level of the latent trait (i.e., depression) on the CES-D. However, older participants did have lower total and DA and SC factor scores compared to younger participants. This is consistent with ample past research documenting lower endorsement of depressive symptoms among older adults relative to younger adults in oncology settings (Nelson et al., 2009; Saracino et al., 2017). These findings are also consistent with research by Hertzog et al. (1990), who also found CES-D scores to be invariant across age groups in community-dwelling adults, despite lower CES-D total and factor scores among older adults. Therefore, researchers and clinicians can safely interpret CES-D factor scores without having to adjust for age-related differences, and thus, comparisons between younger and older adults can generally be considered reliable and meaningful.

Several study limitations are worth noting. First, we do not have information regarding the participants who did not complete the CES-D and how they might differ from those who did provide complete data. Therefore, whether or not this subgroup is unique in ways that might influence the factor structure of the CES-D cannot be determined. Our sample was also largely non-Hispanic white and highly educated; thus, the generalizability of the findings to other racial, ethnic, and educational groups is limited. Additionally, we adopted the widely accepted cutoff of age 65 to separate younger and older adults. This may obscure more subtle age differences in response style and depressive symptom clusters. Future research with larger samples should examine the potential differences in symptom endorsement and factor structure in a range of age cohorts (e.g., 65–75, 75–85, and 85 years).

The need to accurately measure depression in the cancer setting is undeniable. In the present study, over one-fourth of the sample endorsed clinically significant depressive symptoms. The CFA analyses supported the use of the correlated four-factor model of the CES-D in oncology settings and this model generalized across age groups, suggesting that it can be used regardless of respondent age. Taken together, the results suggest that the CES-D is a viable option for depression screening in the oncology setting.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding

This research was supported by funding from the National Cancer Institute: T32CA009461 and P30CA008748

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Table 1.

Model fit indices of tested factor models

Model	χ^2	df	RMSEA [90% CI]	CFI
One-factor	2,128.35	170	.135 [.130,.140]	.844
Correlated two-factor	477.83	169	.054 [.048,.059]	.975
Correlated four-factor	369.00	164	.044 [.038,.050]	.984
Second-order factor	367.42	166	.044 [.038,.050]	.984

Model fit indices and likelihood ratio tests of measurement invariance between age groups for four-factor model (40–64 and 65)

Table 2.

Model	χ^2	df	RMSEA [90% CI]	CFI	Likelihood ratio test		
					Comparison	χ^2	p
Configural	515.66	328	.042 [.035,.049]	.985	Configural	21.43	.163
Metric	534.19	344	.042 [.035,.048]	.985	Metric	35.58	.488
Scalar	546.08	380	.037 [.030,.044]	.987			

Table 3.
Standardized factor loadings and factor correlations of the correlated four-factor model

(A) Standardized factor loading				
	DA	PA	SC	IP
CES-D items				
1. Bothered by things			.82	
2. Appetite was poor			.62	
3. Could not shake off the blues	.92			
4. Just as good as other people		.55		
5. Trouble concentrating			.79	
6. Felt depressed	.92			
7. Everything was an effort			.84	
8. Hopeful about the future		.75		
9. Life had been a failure	.75			
10. Felt fearful	.77			
11. Sleep was restless			.55	
12. I was happy		.98		
13. Talked less than usual			.76	
14. Felt lonely	.73			
15. People were unfriendly			.76	
16. Enjoyed life		.82		
17. Had crying spells	.81			
18. Felt sad	.85			
19. Felt that people disliked me			.84	
20. Could not get "going"			.82	
(B) Factor correlation				
Factor	DA	PA	SC	IP
DA	1.00			

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(A) Standardized factor loading				
	DA	PA	SC	IP
PA	.45	1.00		
SC	.91	.45	1.00	
IP	.72	.38	.63	1.00

Note. DA = depressed affect; PA = positive affect (reversed scored); SC = somatic complaints; IP = interpersonal problems.