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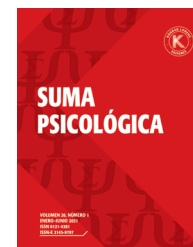
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Factor Structure and Invariance Analysis of the Center for Epidemiologic Studies Depression Scale - Revised (CESD-R) in a Brazilian Population

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KEYWORDS

Depression,
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Abstract Introduction: The Center for Epidemiologic Studies Depression Scale - Revised (CESD-R) was developed to provide an efficient screening scale for depression syndrome, mimicking the original CESD, one of the most widely used screening tools to measure depressive symptoms globally. This investigation examined the factor structure of the CESD-R with a non-clinical Brazilian population. **Method:** We performed exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) of two adult samples, and also conducted invariance analysis by sex and place of residence of the participants. The full sample consisted of 1,427 adults, divided into two groups. The first sample ($n = 400$) was used for the EFA and the second sample ($n = 1027$) for the CFA. **Results:** The EFA indicated an internal structure composed of a single factor, which explained 53.2% of the variance. The CFA attested to the unidimensionality of the measure. Fit indices and reliability indicators showed values higher than expected, without modifications in the initial structure. The model was invariant in relation to the variables investigated at four different levels (configural, metric, scalar, and strict). **Conclusions:** Our findings support the utility of the CESD-R and suggest its validity for application to the Brazilian population in general.

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Estrutura Fatorial e Análise de Invariância da Center for Epidemiologic Studies Depression Scale - Revised (CESD-R) em uma População Brasileira

PALAVRAS-CHAVE:

Depressão,
CESD-R,
análise fatorial
exploratória, análise
fatorial confirmatória,
análise de invariância

Resumo Introdução: A Center for Epidemiologic Studies Depression Scale - Revised (CESD-R) foi elaborada para fornecer um eficiente diagnóstico de sintomas de depressão, seguindo a proposta original da CESD, que é uma das escalas para rastreamento da depressão mais utilizadas mundialmente. Esta pesquisa avaliou a estrutura fatorial da CESD-R em uma população não-clínica no Brasil. **Método:** Realizaram-se análises fatoriais exploratória (AFE) e confirmatória (AFC) com duas amostras compostas por adultos. Também foi verificada a invariância do modelo por sexo e local de residência do participante. A amostra total foi composta por

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1427 adultos, tendo sido dividida em duas subamostras. A primeira subamostra ($n = 400$) foi utilizada para a AFE e a segunda ($n = 1027$) para a AFC. **Resultados:** A AFE indicou uma estrutura interna composta por um único fator, que explicou 53.2% de variância. A AFC atestou unidimensionalidade da medida. Os índices de ajuste e indicadores de confiabilidade apresentaram valores acima do esperado, sem modificações na estrutura inicial. O modelo foi invariante em relação às variáveis investigadas em quatro diferentes níveis (configural, métrico, escalar e estrito). **Conclusões:** Os presentes achados suportam a utilidade da CESD-R e sugerem sua validade para aplicação na população brasileira.

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The Center for Epidemiologic Studies - Depression Scale (CESD, Radloff, 1977) is one of the three most widely used screening tools for measuring depressive symptoms worldwide (Mohebbi et al., 2018; Van Dam & Earleywine, 2011; Vilagut et al., 2016). The CESD contains 20 questions oriented toward the general syndrome of depression with a 4-point Likert scale range denoting the weekly frequency of symptoms related to depression (from less than 1 day to 5-7 days per week), which include somatic complaints, interpersonal relationships, motor activity, and mood changes (Eaton et al., 2004). Since it was developed before the third edition of the Diagnostic and Statistical Manual, it lacks several of the symptom criterion groups oriented toward diagnosis. But the CESD is still widely employed to screen for depressive symptomatology in the general population.

Recently, the revised version of the CESD (CESD-R) was published to meet the DSM-IV parameters for major depressive disorder (Eaton et al., 2012a, 2012b). The main changes were: the inclusion of an additional category involving the frequency of the symptoms (nearly every day for two weeks), and the addition of items related to suicidal ideation, psychomotor changes, and anhedonia, whereas other items were removed because they were not related to the most recent definitions of depression (Eaton et al., 2004). The CESD-R has been adapted to the DSM-IV criterion and is also compatible with the DSM-5 guidelines (Van Dam & Earleywine, 2011). Although the revised version is still not as widely used as its predecessor, it has been applied in studies on depression and posttraumatic stress (Beagley et al., 2018), religiosity in elders (Stearns et al., 2018), barriers to mental health care (Hayward & Honegger, 2018), expressive writing and trauma (Glass et al., 2019), and geriatric cancer (Sarcino et al., 2016).

Depressive disorders are the leading mental health cause of the global burden of disease, the main cause of years lived with disability (YLD) across the lifespan, and are ranked as one of the most important contributors to the disability-adjusted life years (DALY) globally (Hay et al., 2017). Depression is one of the most disabling disorders and improving that situation will require earlier diagnosis and intervention, because treatment rates remain low in most countries (Eaton et al., 2012c; World Health Organization [WHO], 2017). Nevertheless, even places that have expanded the coverage of mental health care have not decreased the prevalence of depression as much as hoped (Hay et al., 2017). Thus, more effective strategies for screening significant depression symptomatology in primary care

and among the general population remains essential (Siu & US Preventive Services Task Force, 2016).

An important obstacle to timely treatment, optimized recovery and reduced burden of depression is the low detection rate at the basic health care level. Consequently, it is important to take advantage of inexpensive valid tools to improve early diagnosis and referral of individuals who screen positive for appropriate assistance (Eaton et al., 2012a; Siu & US Preventive Services Task Force, 2016). The CESD-R has several positive characteristics for large-scale use given that, it is available on the web for free (www.cesd-r.com), it is suitable for time-constrained situations, and it is accessible to non-mental health professionals (Eaton et al., 2004; Eaton et al., 2012b).

The original CESD, besides being adapted and used in many languages and countries (Carleton et al., 2013), including Brazilian Portuguese (Batistoni et al., 2007), was subjected to several investigations of its factor structure through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) (Carleton et al., 2013). On the other hand, apart from the initial validation (Eaton et al., 2004), we have only found four other research papers on the factor analysis of the CESD-R. The first one used a specific version of the CESD-R with 35 items and performed EFA on a sample of elderly Mexicans (Sánchez-García et al., 2008). In the second one, Van Dam and Earleywine (2011) performed EFA and CFA on US adults. The third was the analysis of Haroz et al. (2014), applying a 10-item version on a sample of American adolescents using both analyses. The most recent study (Rababah et al., 2020) found a four-factor structure, which was not supported by CFA in the same study. Additionally, we found two recent specific studies: one involving criterion validation among Indonesian adolescents (Tran et al., 2019), and the other, a development of an app for smartphones in South Korea (Chung et al., 2018).

Exploratory and confirmatory factor analysis are pivotal steps in examining psychometric features of a measurement instrument, particularly when it is used in international scenarios, because social and cultural elements affect how a scale performs when analysing a new population (Flora & Flake, 2017; Milfont & Fisher, 2010). Thus, analysing CESD-R's psychometric properties with a Brazilian sample is a relevant contribution to the field of studies on depression in Brazil, as well as elsewhere. This study aimed to examine the factor structure of the CESD-R with a non-clinical Brazilian population. We performed EFA and CFA with two subsamples, and conducted invariance analysis by sex and place of residence.

Method

Participants

The study had a cross-sectional design considering households. The target population was adults of both sexes between 18 and 70 years old who lived in Aracaju (capital) or 15 other municipalities of the state of Sergipe, Brazil. The full sample was composed of 1,427 participants, which was divided into two samples for each step of the analysis. Subjects were invited to take part in the study in their homes and only one resident per household was asked to participate. Domestic servants and visitors were not included in the sample. This study was approved by the Ethics Committee of Federal University of Sergipe and all participants signed an informed consent form.

The first sample contained 400 participants, 259 (64.8%) living in the capital (Aracaju) and 141 (35.3%) in other municipalities. Most were females (60.8%; $n = 243$) and the mean age was 36.8 years old [$DP = 14.5$; *Minimum (Min)* = 18; *Maximum (Max)* = 78]. The age was also categorized into groups, with 43.8% ($n = 175$) between 18 and 30, 33.8% ($n = 135$) between 31 and 50, and 22.5% ($n = 90$) over 51 years old. The second sample had 1,027 participants, 655 (63.8%) from the capital and the remaining 372 (36.2%) from other municipalities. Females were predominant (63.8%; $n = 655$) and the mean of age was 36.7 years old [$SD = 14.1$; *Min* = 18; *Max* = 77]. The age category breakdown was 42.5% ($n = 436$) between 18 and 30, 35.7% ($n = 367$) between 31 and 50, and 21.8% ($n = 224$) over 51 years old.

Instruments

Center for Epidemiologic Studies Depression Scale - Revised (CESD-R) (Eaton et al., 2004; Portuguese version). The CESD-R contains 20 items for the evaluation of the presence and frequency of depression-related symptoms, based on the DSM-IV. It is a self-administrated scale and answers are given on a 5-point Likert scale. To assess the presence of depressive syndrome in parallel with the original CESD, the final CESD-R score is calculated as a simple sum of all 20 questions, but with the two last categories receiving the same value to keep the same range as the CESD ([0] not at all or less than 1 day, [1] 1-2 days, [2] 3-4 days, [3] 5-7 days, and [3] nearly every day for 2 weeks). Previous research found good to excellent psychometric properties in different populations (Eaton et al., 2004; Haroz et al., 2014; Rababah et al., 2020; Sánchez-García, et al., 2008; Van Dam & Earleywine, 2011).

Data Analysis

The exploratory factor analysis (EFA) was performed with the *Factor software* (v. 10.8, Lorenzo-Seva & Ferrando, 2006) and the robust diagonally weighted least squares (DWLS) estimation method was applied. Parallel analysis was used to identify the number of factors. The closeness to unidimensionality assessment parameter was employed to verify the plausibility of the scale's unidimensionality according to the indicators: UniCO > .95, ECV > .85,

and MIREAL < .30. The fit indices of the model's estimates applied were the comparative fit index (CFI), the goodness of fit index (GFI), the non-normed fit index (NNFI) (expected > .95), and the root mean square error of approximation (RMSEA) (expected < .08). Cronbach's Alpha (α ; expected > .60) and McDonald's Omega (Ω ; expected > .70) were assessed to analyse the reliability (Hair et al., 2014). The H-latent was calculated as the index of replicability (expected > .80; Hancock & Mueller, 2001).

The confirmatory factor analysis (CFA) and the measurement invariance (MI) were conducted with the JASP software (v. 0.12.2). The estimation method was robust DWLS and the model's fit indices were the Chi-square ratio (χ^2/df ; expected < 3), TLI (expected > .95), SRMR (expected < .08), and the CFI, GFI, and RMSEA with the same cut-offs applied in the EFA. The testing for MI was executed at four levels: configural, metric, scalar, and strict invariances (Byrne, 2010; Milfont & Fisher, 2010). Parameters for invariance rejection were Delta CFI ($\Delta CFI \leq .01$) and Delta RMSEA ($\Delta RMSEA \leq .015$) for sequential models from the configural analysis (Chen, 2007; Hair et al., 2014).

Results

Exploratory Factor Analysis

The Kaiser-Meyer-Olkin (KMO = .90) index and the Bartlett's sphericity test ($\chi^2[df] = 3225.8[190]$; $p < .001$) indicated the feasibility of the EFA. The parallel analysis presented internal structure of one factor (53.2% of explained variance), which was reinforced by the unidimensionality parameters (UniCO = .96, IC95% .95 - .98; ECV = .85, IC95% = .83 - .90, and MIREAL = .22, IC95% = .18 - .24). Factor loadings (lambdas) varied between .40 (Item 11) and .83 (Item 4), keeping the same structure as the original scale with 20 items. All fit indices were above the expected values (CFI = .97, GFI = 1.000, NNFI = .96, and RMSEA = .055). Cronbach's Alpha ($\alpha = .93$) and McDonald's Omega ($\Omega = .93$) indicated high reliability. The H-latent (.95) showed high replicability of the measure (Table 1).

Confirmatory Factor Analysis

The CFA attested to the unidimensional structure of the CESD-R, with fit indices higher than the satisfactory values [$\chi^2/df = 2.5$; TLI = .97; CFI = .98; GFI = .98; RMSEA = .03 (IC90% = .03 - .04); SRMR = .06]. In this one-factor model, all factor loadings were higher than .30, with an average of .52 ($SD = .11$). The highest factor loading was that of item 4 (.71) and the lowest was that of item 1 (.33) (Table 1). Finally, we evaluated the model's invariance by sex (male and female) and place of residence (capital or other municipality). There was invariance in the configural, metric, scalar, and strict levels for all variables investigated (ΔCFI and $\Delta RMSEA$ comparison) (Table 2).

Discussion

The main purpose of this study was to explore and test the factor structure and invariance of the CESD-R in a Bra-

Table 1 Psychometric properties of the Exploratory and Confirmatory Factor Analysis of the Center for Epidemiological Scale Depression - Revised (CESD-R) in a Brazilian Population

Items	λ^1	λ^2	%	M (SD)	Skewness	Kurtosis (Zero centred)
1. My appetite was poor.	.42	.33	40.5	.8 (1.26)	1.37	.61
2. I could not shake off the blues.	.76	.60	39.0	.8 (1.25)	1.50	1.05
3. I had trouble keeping my mind on what I was doing.	.66	.60	58.2	1.2 (1.38)	.75	-.74
4. I felt depressed.	.83	.71	40.5	.8 (1.29)	1.46	.80
5. My sleep was restless.	.58	.51	61.2	1.3 (1.40)	.78	-.70
6. I felt sad.	.82	.70	64.2	1.1 (1.23)	1.05	.15
7. I could not get going.	.71	.55	47.2	1.0 (1.26)	1.22	.31
8. Nothing made me happy.	.80	.53	22.5	.4 (1.05)	2.21	3.83
9. I felt like a bad person.	.60	.44	20.7	.3 (.77)	2.75	7.77
10. I lost interest in my usual activities.	.68	.61	34.2	.7 (1.15)	1.57	1.32
11. I slept much more than usual.	.40	.38	38.2	.8 (1.31)	1.36	.48
12. I felt like I was moving too slowly.	.63	.56	41.5	.8 (1.21)	1.32	.61
13. I felt fidgety.	.60	.46	54.0	1.1 (1.38)	0.86	-.60
14. I wished I were dead.	.76	.50	19.0	.3 (.90)	2.76	7.08
15. I wanted to hurt myself.	.66	.35	10.0	.2 (.66)	3.98	16.34
16. I was tired all the time.	.65	.64	50.5	1.2 (1.46)	0.91	-.64
17. I did not like myself.	.74	.53	30.0	.6 (1.11)	1.85	2.38
18. I lost a lot of weight without trying to.	.50	.40	17.7	.4 (1.06)	2.55	5.24
19. I had a lot of trouble getting to sleep.	.60	.46	48.5	1.0 (1.36)	1.08	-.14
20. I could not focus on the important things.	.71	.67	50.0	1.0 (1.28)	1.06	-.04

Notes. ¹ Exploratory Factor Analysis; ² Confirmatory Factor Analysis.

λ = factor loadings; M = mean; SD = standard deviation; Range: 0 to 4; % = percentage of subjects who endorse options 1, 2, 3 or 4 (presence of the symptom).

zilian sample. To the best of our knowledge, there are only four previous studies that have analysed the internal structure of the CESD-R. Three of these papers tested an internal structure of just one factor/dimension (Haroz et al., 2014; Rababah et al., 2020; Van Dam & Earleywine, 2011).

Haroz et al. (2014) evaluated the 10-item version of the CESD-R through CFA in a sample of adolescents. The authors found that the unidimensional model showed the best fit. Rababah et al. (2020) analysed the CESD-R's psychometric properties with undergraduate students and found, through PCA, a four-factor solution, which was not supported by CFA procedures in the same sample. The correlation between factors varied from .70 to .96, suggesting an overlap of the factors. The authors proposed a one-factor model with 12 items, which presented a satisfactory fit in that sample and was invariant by sex at three levels (configural, metric and scalar).

Lastly, the Van Dam and Earleywine (2011) aimed to determine the factor structure and psychometric properties of the CESD-R in two samples: community dwelling adults and undergraduate psychology students. The EFA was applied with half of the first sample and the CFA with the other half plus the undergraduates. The EFA pointed to a

two-factor solution (negative mood and functional impairment) that was theoretically and psychometrically consistent. The CFA with the two-factor model, in both samples (community dwellers and undergraduates), showed that this solution was superior to the unidimensional model. However, the authors highlighted that the factor correlation was .94 in the first sample and .97 in the second, which indicated the unidimensional model was more parsimonious; that is, it led to a better solution.

Alternatively, Sánchez-García et al. (2008) analysed the internal structure of a longer version of the CESD-R (35 items) among elderly Mexicans. They detected a nine-factor structure (hopelessness, life satisfaction, fatigue, pessimism, sleep disturbance, poor concentration, drastic weight change, apprehension, and well-being), which was the only investigation with the aim of finding a structure with more than one factor. However, this solution was found through PCA, a technique considered inappropriate to determine the number of factors (Damásio, 2012). Thus, these findings remain somewhat uncertain regarding validity, which is aggravated due to the disparity in relation to the conclusions of the other studies on the CESD-R's validity, including our study. Therefore,

Table 2 Measurement Invariance Analysis of the Unidimensional Model of the CESD-R by Sex and Place of Residence in a Brazilian Population

Parameters	Sex	Place of Residence
$\chi^2(df)$	-	-
Configural	589.549 (359)	587.531 (359)
Metric	589.549 (359)	587.531 (359)
Scalar	627.051 (378)	608.437 (378)
Strict	674.985 (398)	632.309 (398)
CFI	-	-
Configural	.98	.98
Metric	.98	.98
Scalar	.97	.98
Strict	.97	.98
ΔCFI	-	-
Configural	-	-
Metric	0	0
Scalar	.01	0
Strict	0	0
RMSEA	-	-
Configural	.031	.035
Metric	.035	.035
Scalar	.036	.034
Strict	.037	.034
$\Delta RMSEA$	-	-
Configural	-	-
Metric	.004	.000
Scalar	.001	.001
Strict	.001	.000

Notes. 1. Sex: Male or female; Place of Residence: Capital or municipality.

from the four studies found in the literature, three found a one-factor solution as satisfactory or the best-fitting model - like we have found here - suggesting that the CESD-R is better represented with a unidimensional structure.

Further regarding unidimensionality, the majority of the studies that have evaluated the internal structure of different instruments for measuring depression summarize the items in a single total score, which is interpreted as the severity of depressive symptoms (Fried et al., 2016). Our findings indicate a single total score as the most appropriate choice to score the CESD-R in order to classify the severity of the depressive symptomatology. Thus, although few investigations were found to have the aim of verifying the factor structure of the CESD-R, our findings support the plausibility of using this scale as a unidimensional metric.

Another objective of this study was to analyse the invariance of the best structure of the CESD-R across some independent variables. We found that the one-factor model demonstrated evidence of invariance at four different levels for sex and residence. For all groups, fit indices were equal to or greater than the parameter values and their delta values were below the respective cut-offs. Configural invariance means that the CESD-R structure is valid for all tested groups and the constructs in question have the same configuration. Metric invariance indicates that factor loadings are comparable to groups under contrast and that subjects in different groups answer the questionnaire in a similar way. Scalar invariance allows comparing CESD-R scores across groups properly. Finally, strict invariance attests whether the residuals from the group comparisons are equivalent

(Byrne, 2010; Milfont & Fisher, 2010). Therefore, the utilization of the unidimensional model across those groups seems plausible, because the configuration, measurement, intercept, and residual parameters were equivalent.

The difference in depression by sex is well documented in terms of prevalence and onset, and in some studies, the course of the disorder (Salk et al., 2017). Similarly, the place of residence is an interesting aspect to analyse the invariance of a depression scale, even though it is not yet very usual in group comparisons. Urban versus rural life tends to reveal peculiar health-disease situations, which influence the prevalence and course of depressive disorders; for example, due to distinct community stressful experiences or lifestyles (Kringlen et al., 2006; Romans et al., 2011).

Limitations

Due to time and context constraints, some important limitations were the absence of data regarding previous or current depressive disorder, whether the participants were or had been using psychotropic drugs, or if they were being treated by mental health professionals (e.g., psychologist or psychiatrist). Besides, it is important to mention that our sample has a higher proportion of females, probably due to the social characteristics of housework, which is commonly performed by women in Brazil. We think that all those aspects might be important when analysing their impacts on the model's invariance and also in the CFA. Thus, we hope future research will attempt to control for these matters

related to the diagnosis of depression because such aspects are often related to the mental status of patients who suffer from depressive disorders.

Conclusions

This is the first investigation into the structure of the CESD-R in Brazil, and we found that the 20-item version is adequate. We believe the CESD-R should be considered in research on depression with Brazilian adults, mainly due to its efficiency in terms of administration. The unidimensional model and the invariance patterns were interesting findings of this study. In sum, we conclude that the CESD-R can be useful for screening depression-related symptoms in the Brazilian population.

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