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REVIEW ARTICLE

A systematic review and meta-analytic confirmatory factor analysis of the perceived stress scale (PSS-10 and PSS-14)

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Abstract

Stress is defined as a person's interaction with their environment that is thought to threaten or affect an individual's potential, resources, and well-being. The most popular instrument to assess perceived stress is the Perceived Stress Scale (PSS). Therefore, making a systematic review of studies testing the internal structure of PSS and conducting a Meta-Analytic Confirmatory Factor Analysis (MACFA) on the database created with the information obtained from these studies are the aims of this research. A total of 76 samples from 57 unique studies were included in this database using various inclusion criteria (total N for PSS-14 = 28,632, for PSS-10 = 46,053). The correlated two-factor model for PSS was confirmed by MACFA performed on the pooled correlation matrix generated by the random effects meta-analysis. Findings of dimensionality analyses, factor loadings, omega values, and measurement invariance showed that the model that best explained the factor structure of PSS was the correlated two-factor model. The strict measurement invariance of the PSS was achieved across age and clinical status, and the internal consistency was high according to the omega values. Several recommendations moving forward are discussed.

KEYWORDS
factor structure, measurement invariance, meta-analytic confirmatory factor analysis, systematic review, the perceived stress scale

1 | INTRODUCTION

Stress, which is frequently used in multidisciplinary studies due to its biological, sociological, and psychological content, has a prominent role in overall mortality but it is also associated with the most common public health diseases (e.g., cardiometabolic and mental diseases) (Cohen et al., 2007; Sapolsky, 2004). On the other hand, perceived stress (PS), which is defined as the feelings or thoughts that an individual has about how stressed he/she is (Phillips, 2013), is a mediator between depression and anxiety (Li & Lyu, 2021). PS is also associated with perceived health status (Leung et al., 2010) and symptoms of post-traumatic stress (Mitchell et al., 2008).

As a transactional model, stress is the interaction between the person (coping) and the environment (stressors), and this association is evaluated as the person's overcoming their coping resources and endangering their well-being (Lazarus & Folkman, 1984). Based on Lazarus and Folkman's transactional model of stress and coping with it, The Perceived Stress Scale (PSS) was developed by Cohen et al. (1983). The PSS, a self-report measure, was designed to address "the degree to which respondents felt their lives were unpredictable, uncontrollable,

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and overloaded" rather than focussing on a specific event (Cohen & Williamson, 1988). Although PSS is the most frequently used measurement tool to measure perceived stress, there are also many studies in the literature in which criticisms are made about the internal structure, scoring, wording, validity, and reliability of the scale (Barbosa-Leiker et al., 2013; Golden-Kreutz et al., 2004; Taylor, 2015; Tomas & Oliver, 1999). In line with these criticisms, issues such as the internal structure, psychometric quality, and dimensionality of the scale have also become questionable. Given these findings, it would be enlightening and informative to examine the factor structure of the PSS, which is widely used to measure perceived stress.

1.1 | The perceived stress scale

PSS was first developed by Cohen et al. (1983) as 14 items. Later, Cohen and Williamson (1988) reduced the number of items in this scale to 10, and this 10-item version was widely used in subsequent studies. However, since the 14-item version of the scale is still used in current studies (Dominguez-Lara et al., 2022; She et al., 2021), both PSS-10 and PSS-14 versions were evaluated in our study. The 4-item version is another short form of the PSS available in the literature. However, due to the low model-data fit values (Ingram et al., 2016) and low reliability coefficients (Kim, 2016) related to the factor structure of this version, PSS-4 was not evaluated in our study.

The factor structure of the PSS was not presented in the first study in which the scale was developed (Cohen et al., 1983). In a later study (Cohen & Williamson, 1988), although a 2-factor structure was put forward, the second factor was deemed theoretically and statistically inadequate by the authors, so it was accepted that the scale was unidimensional and a total score could be obtained from this scale. However, the view that this decision is problematic both theoretically and psychometrically (Reis et al., 2019) is common. Considering the PSS as a uni-dimensional measure (Cohen et al., 1983; Cohen & Williamson, 1988) the existence of well-being-related items that needed to be reversed in order to get a total score created a problem. For this reason, in factor-analysis-based studies, it was determined that items containing expressions of well-being constituted a specific factor (positive stress, perceived efficacy, or perceived control), while items containing discomfort constituted another specific factor (negative stress, perceived helplessness, or perceived stress) (Lee, 2012). Since the first studies of the scale were concerned with a uni-dimensional structure, it was included among the models (Model 1) tested in our research. It has been determined that the correlated 2-factor structure of the scale has been confirmed in dozens of subsequent studies (Almadi et al., 2012; Lee & Jeong, 2019; Michaelides et al., 2016). Therefore, the correlated 2-factor model (Model 2) was included in our study. In the literature, there are also studies that include only one of the positive and negative factors in the model besides the general factor (Dominguez-Lara et al., 2022; Juárez-García et al., 2021; Park & Colvin, 2019; Tikka et al., 2022). With these studies, two incomplete bifactor models were identified. The first one is Model 3 with a general factor and a positive subscale, and the other is Model 4 with a general factor and a negative subscale.

After the discussions about the existence of two distinct factors of the PSS consisting of negative and positive items and the artificial derivation of these factors, the factor structure of the PSS was started to be tested with the bifactor model (Jovanović & Gavrilov-Jerković, 2015; Perera et al., 2017; Reis et al., 2019; Wu & Amtmann, 2013). In a bifactor model, the PSS-10 includes two separate factors, such as perceived distress and perceived coping, as well as a general factor underlying perceived stress (Denovan et al., 2019; Lee & Jeong, 2019). In most studies where PSS was tested with the bifactor model, it was determined that the model-data fit values of the bifactor model were better when compared to other competitive models (e.g. Michaelides et al., 2016; Park & Colvin, 2019; Perera et al., 2017). In addition, essentially uni-dimensionality has been determined. This reinforces the idea that PSS has a strong general factor. Therefore, another model of our research (Model 5) is the bifactor model, which consists of a general factor and two specific factors.

Some studies in the literature have found that PSS has a 3-factor structure. In one of these studies, a 3-factor structure was identified as a result of the factor analysis applied to the data set obtained from 480 Indian adults. The factors were named “perceived helplessness”, “perceived distress”, and “self-efficacy for coping” (Pangtey et al., 2020). In the other study, a 3-factor structure was confirmed in the factor analysis performed on healthy Australians. In this study, the factors were named “distress”, “coping”, and “emotional reactivity” (Bradbury, 2013). However, as far as we know, there is no study that obtained a three-factor structure for PSS apart from these two studies. Besides, the distribution of the items to the factors in these two studies is not consistent. Moreover, since it does not represent Lazarus and Folkman's (1984) model, the three-factor structure was not discussed in the present study.

All models discussed for the PSS are presented in Figure 1.

1.2 | The current study

This study has two main aims. The first of these is to make a systematic review with cross-sectional psychometric studies using PSS-14 and PSS-10. This systematic review, it is aimed to examine the factor structure of PSS. The second aim is to perform our own meta-analytic confirmatory factor analysis (MACFA) on the data set obtained from the reviewed studies. In order to determine the most appropriate factor structure, five different competitive models were defined and compared through model-data fit. With this finding, it was aimed to synthesise previous research findings. In addition, it aimed to contribute to the literature by determining the most suitable factor structure of PSS, whose factor structure is controversial. In our systematic review, we found that most of the studies we examined did not test the measurement invariance of the PSS for variables such as age. However, it is important to collect evidence of measurement invariance so that responses to PSS items and subscales can be validly compared across specific groups. Finally, we

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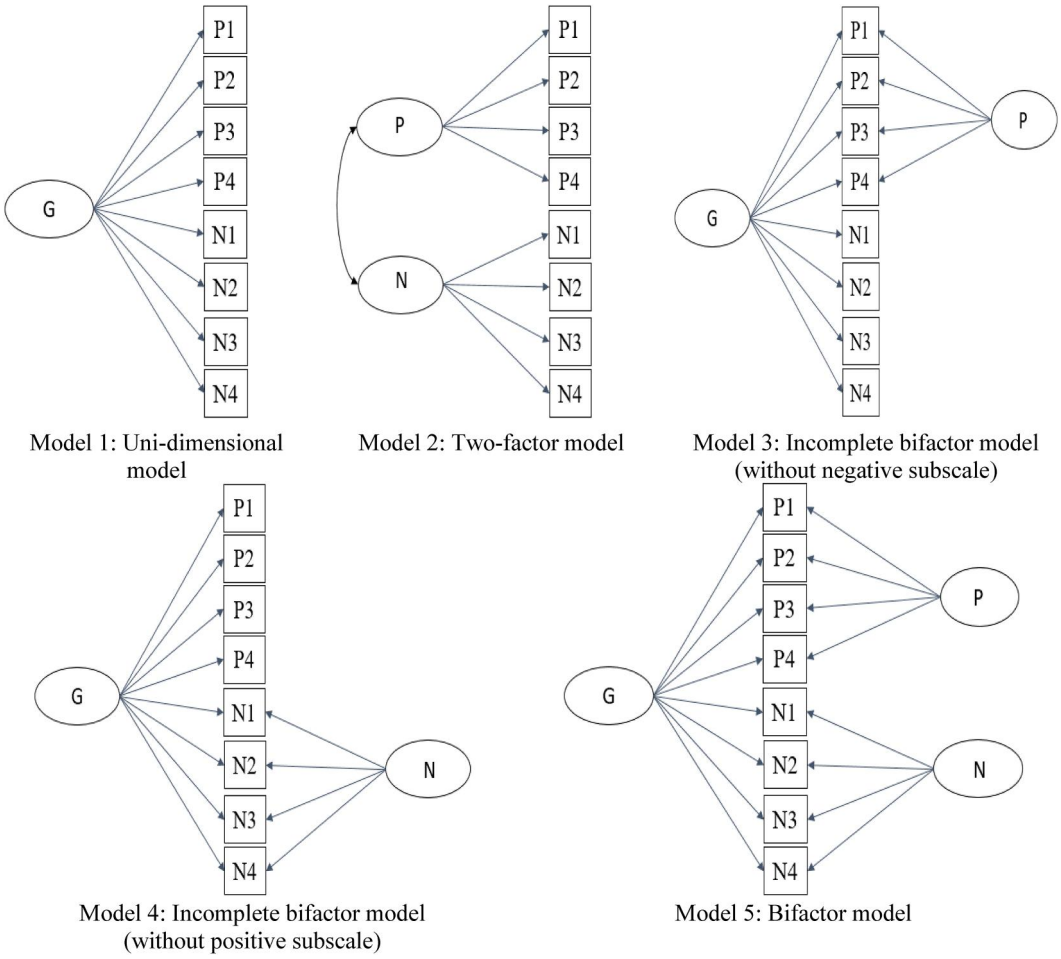


FIGURE 1 Conceptual Representation of All Models Tested for PSS. G, general factor; P, factor for positive items; N, factor for negative items; S, stress factor; the number of items shown is only informative.

examined measurement invariance among potential sources of heterogeneity in the meta-analytic results. Although the PSS is a scale used in both clinical and non-clinical settings, we think that the factor structure may vary depending on the setting in which it is used. Therefore, clinical and non-clinical status was the first variable selected. There are also studies indicating that young adults are more stressed than older adults (Neubauer et al., 2019). Therefore, it was thought that age may also affect the factor structure of PSS.

2 | METHOD

In this study, systematic review methods and MACFA were used to determine the characteristic features, methodological procedures, and outcome models of the studies dealing with the internal structure of the PSS-14 and PSS-10. In this process, the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Page et al., 2021) were followed and reporting was made according to this guideline. The PRISMA checklist is shown in Supplementary Table S1 and also pre-registration of the study was made at: https://osf.io/ctvxf/?view_only=99eff3b469fb4dfca0dd47fdc3de9e5e.

2.1 | Data sources and searches strategies

In November 2022, studies were searched by Google Scholar and with PsychINFO and PsycArticles databases. Search terms for PSS-10: ("PSS-10" OR "Perceived Stress Scale - 10" OR "Perceived Stress Scale-10") AND ("valid*" OR "factor analysis" OR "factor structure" OR "psychometric" OR "assess*" OR "eval*") and PSS-14: (PSS-14 OR "Perceived Stress Scale – 14" OR "Perceived Stress Scale-14") AND ("valid*" OR "factor analysis" OR "factor structure" OR "psychometric" OR "assess*" OR "eval*"). We identified 12,552 potentially relevant papers in total.

2.2 | Study selection and eligibility for full-text review

By examining the search results, the presence of duplicate studies was determined and irrelevant studies were eliminated. Then, using the defined inclusion criteria, the scientific studies to be included in the database were selected. These inclusion criteria were: (a) the paper must have been published in English, (b) the paper must have

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been published in a peer-reviewed outlet, (c) factor loadings or inter-item correlation matrix must be given in the paper, (d) paper with full text available. We also ensured that the journals and/or publishers where these full-text studies were published were not predatory journals.

2.3 | Data Extraction

After all the identified papers were downloaded, the studies were evaluated by both authors. Evidence of validity and reliability was reviewed for each study. In this way, it was tried to prevent the risk of bias in the publications. Studies that confirmed the relevant factor structure but did not specify any reliability coefficient for the factors and studies that calculated reliability lower than 0.70 for the factors were excluded from the database. Because, as recommended by Nunnally and Bernstein (1994) and Cortina (1993), the internal consistency coefficient should be 0.70 or greater. This condition was not taken into account for studies using the raw data inter-item correlation matrix. Besides, if both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were applied to the same sample, only EFA findings were used. If there were EFA and CFA findings from different samples, both EFA and CFA findings were used. The final factor loadings after rotation were selected in the EFA findings. If more than one different CFA model was applied to the same sample, the findings of the model with the highest model-data fit were selected. Multigroup CFA findings were not used. Studies that did not report the factor analysis method and model-data fit were not extracted. Since factor loadings of both general and specific factors are reported in bifactor models, variance is distracted between general and specific factors. Therefore, factor loadings obtained from bifactor models were not used in this study. For this reason, in studies examining the factor structure of PSS using a bifactor model, an e-mail was sent to the corresponding author and inter-item correlation matrices were requested. E-mails were sent to 7 authors in total, but only 2 authors replied to the e-mail. The inter-item correlation matrices sent by these authors were used in our study.

Separate databases for PSS-14 and PSS-10 were created by using much information about the selected studies. Descriptive information was extracted about the sample (i.e., such as sample size, country of origin of participants, and average age) and reported factor analysis (i.e., number of response options, rotation method). The excel file with such information can be accessed from the supplementary files.

2.4 | Meta-analytic confirmatory factor analysis procedure

MACFA was conducted using the two-stage structural equation modelling (TSSEM) approach proposed by Cheung and Chan (2005, 2009). In the first stage of TSSEM, a pooled correlation matrix was obtained by using factor loadings, an inter-item correlation matrix, and inter-factor correlation values of cross-cultural studies conducted for the PSS-14 and PSS-10. At this stage, as stated in the "Data Extraction" title of our study, both EFA and CFA findings were used. Rasch and IRT findings were excluded from the study. At this stage, a pooled correlation matrix was obtained by performing random effects meta-analysis. Random effects meta-analysis was chosen because it produces more accurate parameter estimates than fixed effects approaches (Field, 2005; Hunter & Schmidt, 2004). In the second stage, 5 different competitive models (Models 1–5) that were previously described in the literature were tested using the pooled correlation matrix. Before the evaluation with CFA, dimensionality analyzes were applied via the pooled correlation matrix. For this purpose, EFA was applied and the optimum factor number was determined by applying the minimum average partial (MAP) test and Horn's (1965) parallel analysis tests. Afterwards, CFA was applied to all measurement models and the maximum likelihood (ML) was preferred as the factor extraction technique because the sample size was sufficient. Model-data fits were evaluated in order to compare all competitive models. Overall model fit for each tested model was assessed using suggested cutoff points (Hu & Bentler, 1999): Comparative fit index (CFI $\geq$0.90, acceptable, and $\geq$0.95, desirable), Tucker-Lewis Index (TLI $\geq$0.90, acceptable, and $\geq$0.95, desirable), Root Mean Square Error of Approximation (RMSEA $\leq$0.05, good fit; $\leq$0.08, acceptable fit; $\geq$0.10, poor fit), and Standardized Root Mean Square Residual (SRMR $\leq$0.08, good fit; = 0, perfect fit). Considering that the chi-square test is highly sensitive to sample size, CFI, TLI, RMSEA, and SRMR values were taken into account when deciding on model fit. All competitive models were evaluated based on the expectation that factor loadings (>0.40) and omega values should be high (>0.70) as well as model-data fit. According to all these evaluations, the best model was defined as the "actual" factor structure.

After the most appropriate factor structure of the scale was selected, follow-up analyzes were started. For this purpose, measurement invariance (MI) was tested according to clinical and non-clinical samples and to age samples of PSS. In this way, it is aimed to detect a structural deterioration caused by the age and the data set obtained from the clinical environment. Age definitions of American Psychological Association (APA) were used to separate the age group (VandenBos, 2007). Accordingly, the group aged 35 and under, which includes adolescents and young adults, constituted the youth group. People aged 36 and over, including middle adults and the elderly, constituted the elderly group. The MI procedure is based on testing a set of hierarchically nested models with various constraints on the measurement parameters tested in each model. Metric and scalar invariance models are tested simultaneously in ordered categorical data (see Ebesutani et al., 2014). Configural invariance model (the same number of factors and the item-factor loading patterns – Model 1), metric/scalar invariance

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model (equal factor loadings and thresholds—Model 2), and strict invariance model (equal factor loadings, thresholds, and residual variances – Model 3) have been tested for MI. Then, the CFI differences ($\Delta CFI = CFI_{constrained\ model} - CFI_{unconstrained\ model}$) and RMSEA differences ($\Delta RMSEA = RMSEA_{constrained\ model} - RMSEA_{unconstrained\ model}$) obtained from the more constrained model and the less constrained model were examined. An absolute difference in CFI that is less than or equal to 0.01 and RMSEA difference of under 0.015 would indicate measurement invariance (Cheung & Rensvold, 2002). When two of these three conditions are met, measurement invariance is achieved.

All the R codes of this study were written by reconsidering the R codes in Schroders et al.'s (2022) study. Analysis of EFA and pooled correlation matrix were performed with psych package 2.2.9 (Revelle, 2022) and metaSEM package 1.2.5.1 (Cheung, 2022). Mplus 8.3 (Muthén & Muthén, 2017) was used to test all competitive CFA models. The omega coefficients were calculated with the help of The Bifactor Indices Calculator excel file (Dueber, 2017).

3 | RESULTS

3.1 | Study characteristics

As shown in the PRISMA flow chart (Figure 2), a total of 57 unique studies and 76 different samples (total N for PSS-14 = 28,632, for PSS-10 = 46,053) were obtained as a result of the research process.

While the mean sample size is 1506.95 (range: 80–9507) in studies using PSS-14 (n = 17), the mean age is 36.94 (range: 20.48–58.56), although the mean age is not reported in every study. Compared to the male and female ratios in the studies, the female ratio in the samples is higher (57.77% female). The ranking obtained by examining the studies by continent is Europe (n = 6), Asia (n = 6), South America (n = 4), and North America (n = 1).

While the mean sample size is 807.95 (range: 67–9507) in studies using PSS-10 (n = 50), the mean age is 35.24 (range: 15.26–80.0), although the mean age is not reported in every study. Compared to the male and female ratios in the studies, the female

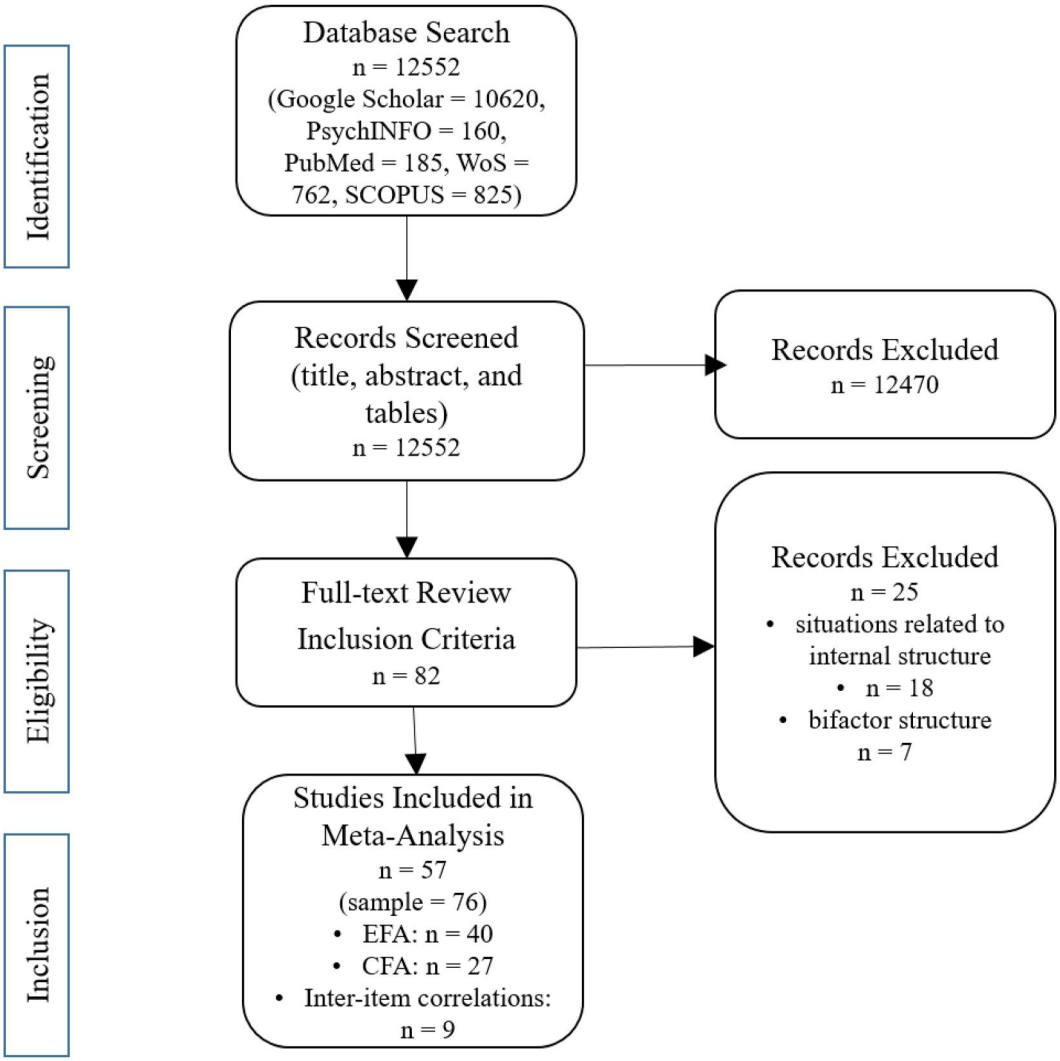


FIGURE 2 Literature search summary.

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ratio in the samples is higher (64.09% female). The ranking obtained by examining the studies by continent is Asia (n = 29), South America (n = 10), Europe (n = 10), North America (n = 7), and Africa (n = 1).

Two separate tables were created for the PSS-14 and PSS-10 studies included in the research (see supplementary files Table S2–S3). First, the characteristics of each study such as author, year, country, sample, and language of the scale were determined. Then, the studies were evaluated in terms of their methodological features. In the studies, factor analysis design (e.g. EFA, CFA) used to examine the psychometric properties of the scales; estimation method (e.g. principal component analysis—PCA, principal axis factoring—PAF) and rotation method (e.g. varimax, oblimin) used for EFA studies; estimation methods and tested models for CFA studies were determined. In addition, studies were also examined in terms of reliability analyzes and measurement invariance.

3.1.1 | Systematic review of the internal structure of the PSS-14

In this study, EFA was used in 12 studies for PSS-14. Clinical samples were used in 3 of these studies. When the studies reporting the mean age were examined, it was determined that adult participants were generally included in all of the EFA studies. 1 of the studies were carried out for the original language of the scale, English. PCA (n = 10) was mostly used as factor extraction method. The most commonly used method for rotation is varimax (n = 7). It was determined that eigenvalues (n = 11), factor loadings (n = 7), and scree plot (n = 4) were used as factor determination methods. In studies conducted on different countries and samples, all researchers, except Figalová and Charvát (2021), determined that EFA results revealed a two-factor structure. However, in some studies, the two-factor structure of PSS-14 was not achieved over 14 items. For example, Hewitt et al. (1992) found the factor loadings of 7 items in the first factor and 4 items in the second factor to be higher than 0.40 and items 10, 12, and 13 were removed from the scale. Huang et al. (2020) also improved the model-data fit by removing item 12 for the two-factor structure of PSS-14.

Although different names are used for factors in EFA studies, the most common usage is to call factor 1 "Negative" and factor 2 "Positive". It is seen that the correlations between the factors of PSS are generally at a moderate level. Correlations between the factors of PSS-14 ranged from 0.27 to 0.71. In the 6 EFA studies, there was no reporting on correlations. The Cronbach alpha coefficient for reliability was reported in all EFA studies, and the test-retest reliability coefficient was also calculated in 3 studies. MI testing was not performed in any of the studies that performed EFA.

In 13 studies using CFA, it was determined that the most used estimation method was ML (n = 9). In 10 of these studies, different models were tested in addition to the original two-factor structure of the scale (e.g. 1-factor model, modified two-factor model). 3 of the studies were conducted on clinical samples. When the studies reporting the mean age were examined, it was determined that adult participants were generally included in the CFA studies. None of the studies were carried out on the English version of the scale, which is the original language. According to the CFA result, the structure confirmed for PSS-14 in different countries and samples is the original two-factor structure (n = 12). However, in 2 of these studies, the model was validated using modification indices. In one study, the bifactor structure of the scale was confirmed (Figalová & Charvát, 2021). Although different names are used for factors in CFA studies, the most common usage is to call factor 1 "Negative" and factor 2 "Positive". Correlations between the factors of PSS-14 ranged from 0.12 to 0.74. In the 3 CFA studies, there was no reporting on correlations. The Cronbach alpha coefficient for reliability was reported in all CFA studies, and the test-retest reliability coefficient was also calculated in 2 studies. 2 studies reported the omega coefficient and 2 other studies reported composite reliability. MI testing was not performed in studies that performed CFA.

In 8 studies, both EFA and CFA were performed. Only 4 of them were carried out on two different groups, and the remaining 4 were carried out on the same group. In 7 of these studies, a two-factor structure was obtained with both EFA and CFA.

3.1.2 | Systematic review of the internal structure of the PSS-10

EFA was used in 28 studies in this study. Clinical samples were used in 8 of these studies. When the studies reporting the mean age were examined, it was determined that adult participants were generally included in all of the EFA studies. 3 of the studies were carried out for the original language of the scale, English. As factor extraction method, PCA (n = 17) was used the most, followed by ML (n = 5). As the rotation method, varimax (n = 16) was used the most. It was determined that eigenvalues (n = 22), factor loadings (n = 12), and scree plot (n = 11) were used as factor determination methods. A two-factor structure emerged in most of the EFA results (n = 27) conducted over different countries and samples. Although different names are used for factors in EFA studies, the most common usage is to call factor 1 "Perceived Helplessness" and factor 2 "Perceived Self-efficacy". Correlations between the factors of PSS ranged from 0.12 to 0.72. In 13 EFA studies, there was no reporting on correlations for factors. The Cronbach alpha coefficient for reliability was reported in all EFA studies and the test-retest reliability coefficient was also calculated in 10 studies. MI test was performed in only 1 of the studies that performed EFA (see. Ali et al., 2021).

In 38 studies using CFA, it was determined that the most used estimation method was ML (n = 27). In 28 of these studies, different models were tested in addition to the original two-factor structure of the scale (e.g. 1-factor model, bifactor model). 12 of the studies were conducted on a clinical sample. When the studies reporting the mean age were examined, it was determined that adult participants were generally included in all of the CFA studies. 7 of the studies were

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carried out on the English version of the scale, which is the original language. According to the CFA result, the most confirmed construct for PSS-10 in different countries and samples was the correlated two-factor construct (n = 32). However, in 5 of these studies, the model was validated using modification indices. The number of studies in which the bifactor model was tested is 7, and it was determined that the bifactor model was the best model in 3 of them. Although different names are used for factors in CFA studies, the most common usage is to call factor 1 "Perceived Helplessness" and factor 2 "Perceived Self-efficacy". Correlations between the factors of PSS ranged from 0.003 to 0.85. Most of the CFA studies (except 2 studies) reported the Cronbach alpha coefficient for reliability, and the test-retest reliability coefficient was also calculated in 7 studies. In 5 studies, omega coefficients were included. Measurement invariance was tested in a total of 7 studies, and in the most of these studies (n = 4) comparisons were made across gender group.

In 17 studies, both EFA and CFA were performed. Only 9 of them were carried out on two different groups, and the remaining 8 were carried out on the same group. Only Figalová and Charvát (2021) advocated the bifactor structure as the best structure, and in all the other 16 studies, the EFA and CFA results supported each other and provided evidence for the two-factor structure.

In 9 of these studies examining the factor structure of PSS-10, the factor structure of PSS-14 was also examined (Huang et al., 2020; Lee et al., 2015; Lesage et al., 2012; Leung et al., 2010; Mitchell et al., 2008; Mondo et al., 2021; Ruisoto et al., 2020; She et al., 2021; Yokokura et al., 2017) generally supported 2-factor structures for PSS-14 and PSS-10 in these studies. However, for PSS-10, more robust evidence was found to support the original structure (Huang et al., 2020; Lee et al., 2015; Mondo et al., 2021). In addition, the use of PSS-10 is recommended because PSS-10 provides shorter and more robust evidences of validity and reliability (Leung et al., 2010; Mondo et al., 2021).

3.2 | Dimensionality analysis

A pooled correlation matrix was obtained by using factor loadings, factor correlations, and inter-item correlation values obtained from different samples in the database. The correlation coefficients in the pooled correlation matrix range from −0.105 to 0.500 for the PSS-14 and −0.091 to 0.548 for the PSS-10. The average value of the correlation coefficients is 0.261 for the PSS-14 and 0.271 for the PSS-10. In our study, after obtaining a pooled correlation matrix with random-effects meta-analysis on cross-cultural studies of the PSS-14 and PSS-10, the dimensionality of this summary data was examined first. The reason for applying dimensionality analysis is that although a 2-factor structure was explained in the majority of cross-cultural studies, various structures, such as uni-dimensional and 3-factor, were also used to explain the factor structure of PSS in the literature.

Optimum factor number and dimensionality status were determined by applying the minimum average partial (MAP) test and Horn's (1965) parallel analysis tests. Since it is known that there is a correlation between the factors, the optimum number of factors is 2 according to the findings of the parallel analysis test applied using the oblique rotation technique. The optimum factor number is 2 according to the findings of the MAP test applied using oblimin rotation. In this case, according to the dimensionality analysis applied for preliminary evaluation, the pooled correlation matrix shows a multidimensional structure and factorises best when there are two factors.

3.3 | Meta-analytic confirmatory factor analysis

MACFA was applied to test 5 different competitive models previously described in Figure 1. Model-data fit values obtained in 5 different competitive models are given in Table 1. It was determined

TABLE 1 Fit indices of the all competitive models.

	Models	χ^2	df	CFI	TLI	RMSEA	90% CI for RMSEA	SRMR
PSS-14	Model 1	46,784.35	77	0.555	0.474	0.146	[0.144, 0.147]	0.159
	Model 2	351.26	76	0.997	0.997	0.011	[0.010, 0.012]	0.011
	Model 3	220.22	70	0.999	0.998	0.009	[0.007, 0.010]	0.007
	Model 4	322.71	70	0.998	0.997	0.011	[0.010, 0.012]	0.010
	Model 5	105.40	63	1.000	0.999	0.005	[0.003, 0.006]	0.005
PSS-10	Model 1	48,005.94	35	0.670	0.575	0.173	[0.171, 0.174]	0.154
	Model 2	307.59	34	0.998	0.998	0.013	[0.012, 0.015]	0.011
	Model 3	189.94	31	0.999	0.998	0.011	[0.009, 0.012]	0.006
	Model 4	267.69	29	0.998	0.997	0.013	[0.012, 0.015]	0.010
	Model 5	68.17	25	1.000	0.999	0.006	[0.004, 0.008]	0.003

Abbreviations: CFI, comparative fit index; CI, confidence interval; df, degrees of freedom; Model 1, uni-dimensional Model; Model 2, 2-factor correlated model; Model 3, incomplete bifactor model (without negative subscale); Model 4, incomplete bifactor model (without positive subscale); Model 5, bifactor model; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; TLI, Tucker–Lewis index.

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that the model-data fit of the uni-dimensional model, which was the first model to be examined, was not sufficient. However, it is possible to say that the model-data fit of the other 4 competitive models is close to perfect. There is no difference in terms of the model-data fit between Model 2 to Model 5. However, in the light of all the information discussed, since the most recommended model for the factor structure of PSS in the literature is the two-factor correlation (Model 2) model, subsequent analyzes for this model were continued. In addition, the bifactor model (the model that includes one general and two specific factors for PSS) (Model 5), which has been used in studies examining the internal structure of PSS in recent years, was also examined in the next stages.

The factor loadings of general and specific factors obtained from the bifactor model and the correlated two-factor model of PSS-14 and PSS-10 and the I-ECV values are given in Table 2. For PSS-14, the general factor loadings of the negatively worded factor are quite low (<0.30), while the factor loadings of the specific factor are quite high (>0.40), in the bifactor model. In this case, the specific factor is stronger than the general factor. However, the factor loadings of both the general and the specific factors of the positively worded factor are high. In PSS-10, it is possible to present a clearer frame. The general factor loadings of the negatively worded factor and the specific factor loadings of the positively worded factor were quite high (>0.40) for the PSS-10. In order to make more detailed explanations on this subject, Item Explained Common Variance (I-ECV) values were also examined. The I-ECV provides an individual assessment of the uni-dimensionality of each item. High values (>0.80; Stucky & Edelen, 2015) indicate that the factor loading of the general factor is high and uni-dimensionality is possible. All I-ECV values of PSS-14 are lower than 0.80. In this case, it is seen that there is no essential uni-dimensionality. However, in PSS-10, the I-ECV value of I1 is greater than 0.80. In this case, an essential uni-dimensionality may have been observed in PSS-10 due to the negatively worded factor. Although the specific factors were more dominant than the general factor in the individual evaluations of the items.

The factor loadings of the correlated two-factor model for PSS-14 varied between 0.486 and 0.709; for PSS-10, factor loadings were determined to vary between 0.585 and 0.746. These very high factor loadings show once again how strong the specific factors of PSS are. So, it was decided that the most appropriate factor structure of the PSS was the correlated two-factor model (PSS-14: CFI = 0.997; TLI = 0.997; RMSEA = 0.011, 90% CI [0.010, 0.012]; SRMR = 0.011; PSS-10: CFI = 0.998; TLI = 0.998; RMSEA = 0.013, 90% CI [0.012, 0.015]; SRMR = 0.011), depending on the reasons for obtaining the findings emphasising a multidimensional structure in the dimensionality analysis, suggesting a 2-factor solution on dimensionality analysis, obtaining I-ECV values as generally low values, and generally low factor loadings of the general factor.

Omega values of NEG and POS specific factors were calculated as 0.808 and 0.828 for PSS-14 and 0.846 and 0.785 for PSS-10, respectively. Therefore, the internal consistency obtained for both scales is high.

TABLE 2 Standardized factor loadings (λ) and I-ECVs for PSS-14 and PSS-10.

	PSS-14				PSS-10			
	Model 5			Model 2	Model 5			Model 2
Items	λ_G	λ_S	I-ECV	λ_S	λ_G	λ_S	I-ECV	λ_S
NEG								
I1	−0.178	0.642	0.071	0.666	0.687	0.270	0.866	0.709
I2	−0.147	0.656	0.048	0.672	0.607	0.429	0.667	0.746
I3	−0.160	0.684	0.052	0.702	0.617	0.398	0.706	0.736
I8	−0.120	0.515	0.051	0.529	0.428	0.411	0.520	0.585
I11	−0.155	0.575	0.068	0.596	0.516	0.393	0.633	0.649
I12	−0.127	0.469	0.068	0.486	-	-	-	-
I14	−0.134	0.614	0.045	0.628	0.532	0.502	0.529	0.720
POS								
I4	0.532	0.406	0.632	0.651	-	-	-	-
I5	0.520	0.474	0.546	0.698	-	-	-	-
I6	0.466	0.531	0.435	0.709	−0.122	0.681	0.031	0.692
I7	0.285	0.561	0.205	0.606	−0.078	0.680	0.013	0.682
I9	0.438	0.456	0.480	0.633	−0.134	0.642	0.042	0.656
I10	0.322	0.566	0.245	0.636	−0.099	0.726	0.018	0.732
I13	0.297	0.442	0.311	0.529	-	-	-	-

Abbreviations: I-ECV, item-level expected common variance; NEG, negatively worded subscale; POS, positively worded subscale.

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3.4 | Measurement invariance testing

The measurement invariance (MI) findings of the correlated two-factor model of PSS tested according to age and clinical status are given in Table 3. In the first stage, at configural MI, the same number and pattern of factors are reached between age and clinical status groups. Findings from the metric invariance stage indicate a very good model-data fit. In addition, when the model comparison findings are examined, the model-data fit difference between the two models is below the criterion value, that is, metric invariance is confirmed. In this case, it can be stated that factor loadings are equal. Findings from the scalar invariance stage indicate also a very good model-data fit. When the model comparison findings are examined, the model-data fit difference between the two models is below the criterion value, that is, scalar invariance is achieved. In this case, it can be specified that the item threshold parameters are equal together with the factor loadings equality. Findings from the strict invariance stage indicate also a very good model-data fit. Only for PSS14, the ΔCFI value was found to be above the criterion value. However, since TLI and RMSEA values met the criterion, strict measurement invariance was achieved. In this case, it can be specified that the residual variance values are equal as well as the equality of factor loadings and item threshold parameters.

4 | DISCUSSION

One of the two main purposes of this study is to conduct a systematic review of studies examining the factor structure of PSS, which is a frequently used measurement tool in the literature to measure perceived stress. In this study, a systematic review was conducted on 17 studies for PSS-14 and 49 studies for PSS-10. However, factor structure of both PSS-10 and PSS-14 was tested in 9 studies. Therefore, the number of unique studies is 57 in total. Since PSS has a factor structure that has been determined before, it is seen that more CFA was performed in these studies (13 studies for PSS-14, 39 studies for PSS-10). However, there are also studies that perform EFA (12 studies for PSS-14, 28 studies for PSS-10). PCA was mostly used as an estimator in these EFA studies. However, although EFA and PCA are similar to each other, there are differences in the logical framework of their applications (for details, see Alavi et al., 2020). In addition, the use of more orthogonal rotation in studies creates a controversial situation. Because orthogonal rotation techniques are recommended to be used in cases where there is no correlation between the factors (Kline, 1994). However, in most of the studies examined, significant correlations were found between the factors. The most commonly used estimation method for CFA is ML. However, this estimation method cannot make robust estimations for data that do not show normal distribution (Chou et al., 1991). However, there is no explanation for the normality assumption in general in the studies.

Although it is important to have the replicability of the results in quantitative studies, very few of the studies examined involve retesting the structure on different samples and examining measurement invariance. Performing both EFA and CFA analyses sequentially on the same sample in a study is not considered as a replicability test due to the methodological differences between these two analyses (Merino-Soto et al., 2022). For internal consistency or reliability analyses, the alpha coefficient was mainly used in the studies. However, the alpha coefficient should be used if various assumptions are met (Green & Yang, 2015). Studies have shown that reliabilities with alpha estimate less accurately than with omega when baseline tau-equivalence is violated (Raykov, 1998).

TABLE 3 Fit indices of measurement invariance models.

		Model	χ^2	df	CFI	TLI	RMSEA	ΔCFI	ΔTLI	ΔRMSEA
PSS-14	Clinical	Configural	1772.89	152	0.989	0.982	0.029			
		Metric/Scalar	2387.36	164	0.984	0.981	0.031	0.005	0.001	0.002
		Strict	3999.38	180	0.973	0.973	0.037	0.011	0.008	0.006
	Age	Configural	2045.25	152	0.987	0.984	0.029			
		Metric/Scalar	2224.42	164	0.986	0.984	0.029	0.001	0.000	0.000
		Strict	3133.84	180	0.980	0.979	0.033	0.006	0.005	0.004
PSS-10	Clinical	Configural	394.74	68	0.998	0.997	0.014			
		Metric/Scalar	657.90	76	0.996	0.995	0.018	0.002	0.002	0.004
		Strict	893.33	88	0.994	0.994	0.020	0.002	0.001	0.002
	Age	Configural	513.52	68	0.996	0.995	0.018			
		Metric/Scalar	682.50	76	0.995	0.994	0.020	0.001	0.001	0.002
		Strict	1077.45	88	0.991	0.991	0.024	0.004	0.003	0.004

Abbreviations: CFI, comparative fit index; RMSEA, root mean square error of approximation; TLI, Tucker–Lewis index; ΔCFI, CFI values difference; ΔRMSEA, RMSEA values difference; ΔTLI, TLI values difference.

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The fact that very few studies estimate reliability using the omega coefficient makes the internal consistency of the PSS questionable.

The other main purpose of our research aimed to evaluate the factor structure of PSS more accurately by eliminating the possible effect of sample size and subgroups of the sample on the factor structure of PSS by using a MACFA. For this purpose, a random-effect meta-analysis was applied using factor loadings, inter-factor correlation coefficients, and inter-item correlation coefficients in 76 samples. In this way, a pooled correlation matrix was obtained at the item level. MAP test and Horn's (1965) parallel analysis tests were applied, primarily by applying meta-analytic EFA to the pooled correlation matrix. Both dimensionality tests indicate that the PSS can be represented by the most appropriate 2 factors. Then, 5 different competitive models (see Figure 1) determined in the literature were tested, including uni-dimensionality, the first-factor structure of the PSS designed. The correlational two-factor model, which is the most frequently defined model as the factor structure of PSS, and the bifactor models, which are frequently used to explain PSS, come to the fore. The fact that the model-data fit of these factor structures is close to perfect shows that both have the potential to explain the factor structure of PSS. The fact that the bifactor model is superior to the correlated two-factor correlated model in only 3 of 7 different studies conducted with the expectation that PSS may have a general dominant factor makes it questionable whether the bifactor model is the most appropriate model. However, in our study, when the additional information (dimensionality findings, factor loadings, omega values, and I-ECV values) of these two models were also examined, it was decided that the model that best explained the factor structure of PSS was the correlated two-factor model.

The strict measurement invariance of the structure of the correlated two-factor model of PSS was achieved according to age and clinical status, and the internal consistency was high according to the omega values. In a study confirming the factor structure of PSS with a correlated two-factor model, strict measurement invariance was achieved by age (Ali et al., 2021). In addition, in another study confirming the factor structure of PSS with a correlated two-factor model, strict measurement invariance was provided according to clinical status (Schneider et al., 2020).

4.1 | Limitations, future directions, and conclusion

The limitation of our study regarding the systematic review is our choice of the study included in the review. All the studies we reviewed are the studies that we included in the database we prepared in order to apply MACFA. A total of 76 samples from 57 unique studies were included in this database using various inclusion criteria. The exclusion of large numbers of studies from the database may cause bias.

The original language of the PSS is English. In our study, data sets of PSS forms adapted to a total of 18 different languages other than English were also used. This may call into question the equivalence of PSS forms in different languages due to translation and other factors related to adaptation. However, due to the lack of detailed information about the adaptation process in the studies and the lack of statistical evidence on this issue, the possibility that different language forms of the PSS may not be equivalent was ignored in our study. This is the first limitation of our study.

The second limitation of our study is that we could not perform Exploratory Structural Equation Modelling (ESEM) and bifactor-ESEM analyses. Although we cannot test these models, it is recommended that these factor structures be used to examine the internal structure of PSS in future studies. In addition, although we selected the correlated two-factor model as the model that best represents the internal structure of PSS compared to the bifactor model in our study, the bifactor model may have significant potential in explaining the factor structure of PSS. Because the data of a small number of studies that test bifactor models in our analyses may have caused a bias. Therefore, it is clear that many more cross-cultural studies are needed in which the factor structure of PSS is tested with the bifactor model.

Another limitation of our meta-analysis study is that only 9 of 76 samples included an inter-item correlation matrix. In this case, factor loadings and inter-factor correlations were obtained from 67 other studies. Cross-cultural studies are required to report inter-item correlation values. Therefore, there may be bias in our decision to obtain the most appropriate factor structure. The fact that the cross-cultural studies used in creating the database mostly used PCA, did not explain the demographic characteristics in detail, frequently used ML as a factor extraction method in CFA studies, and dozens of studies used sample sizes less than 500, the findings obtained from these studies may also biased.

In conclusion, given the findings from both our systematic review and meta-analytical factor analysis, it is clear that more research is needed to explain the factor structure of PSS. In addition, providing the strict measurement invariance of the factor structure of the PSS according to age and clinical status is an important finding, but it is considered important to examine the factor structure of the PSS according to other moderators such as gender. As a result of our meta-analysis study, the PSS-14 and PSS-10 are valid measurement tools to measure perceived helplessness and self-efficacy. These two factors are known as distinguishing features of subjectively perceived stress in the light of the transactional stress model. Our study yielded highly satisfactory psychometric results with very high model-data fit over a very large sample.

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CONFLICT OF INTEREST STATEMENT

No potential conflict of interest was reported by the author(s).

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DATA AVAILABILITY STATEMENT

The databases, R codes, and supplementary materials for the study are available at this OSF link: https://osf.io/ctvxf/?view_only=99eff3b469fb4dfca0dd47fdc3de9e5e.

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