Death Studies

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/udst20

# *Coronavirus Anxiety Scale*: New psychometric evidence for the Spanish version based on CFA and IRT models in a Peruvian sample

**Tomás Caycho-Rodríguez, Lindsey W. Vilca, Carlos Carbajal-León, Michael White, Andrea Vivanco-Vidal, Daniela Saroli-Araníbar, Brian Norman Peña-Calero & Rodrigo Moreta-Herrera**

**To cite this article:** Tomás Caycho-Rodríguez, Lindsey W. Vilca, Carlos Carbajal-León, Michael White, Andrea Vivanco-Vidal, Daniela Saroli-Araníbar, Brian Norman Peña-Calero & Rodrigo Moreta-Herrera (2021): *Coronavirus Anxiety Scale*: New psychometric evidence for the Spanish version based on CFA and IRT models in a Peruvian sample, Death Studies, DOI: 10.1080/07481187.2020.1865480

**To link to this article:** https://doi.org/10.1080/07481187.2020.1865480

DEATH STUDIES
https://doi.org/10.1080/07481187.2020.1865480

Routledge
Taylor & Francis Group



# *Coronavirus Anxiety Scale*: New psychometric evidence for the Spanish version based on CFA and IRT models in a Peruvian sample

Tomás Caycho-Rodríguez[a], Lindsey W. Vilca[b], Carlos Carbajal-León[a], Michael White[c], Andrea Vivanco-Vidal[d], Daniela Saroli-Araníbar[d], Brian Norman Peña-Calero[e], and Rodrigo Moreta-Herrera[f]

[a]Facultad de Ciencias de la Salud, Universidad Privada del Norte, Lima, Peru; [b]Departamento de Psicología, Universidad Peruana Unión, Lima, Peru; [c]Dirección General de Investigación, Universidad Peruana Unión, Peru; [d]Facultad de Psicología, Universidad Peruana de Ciencias Aplicadas, Lima, Perú; [e]Grupo de Estudios Avances en Medición Psicológica, Universidad Nacional Mayor de San Marcos, Lima, Perú; [f]Escuela de Psicología, Pontificia Universidad Católica del Ecuador, Ambato, Ecuador

**ABSTRACT**

The aim of the study was to analyze the psychometric properties of the Spanish version of the *Coronavirus Anxiety Scale* (CAS), using Item Response Theory (IRT) and Confirmatory Factor Analysis (CFA). The participants were 790 Peruvians, selected through a convenience sampling, where the majority were women. The CFA models indicated that the one-dimensional structure better represents the data, is reliable and invariant between men and women. Likewise, IRT findings indicate that CAS is more informative for high levels of COVID-19 anxiety. The CAS in Spanish has adequate psychometric properties to be used as a short measure of COVID-19 anxiety.

The COVID-19 pandemic has caused a set of psychological reactions which are tied to the spread of the disease, such as the appearance of emotional distress during and after the outbreak (Cullen et al., 2020). In this sense, different studies have reported on the impact of COVID-19 on mental health and how it has caused higher levels of stress, depression, anxiety, increased suicide rates, substance abuse and domestic violence (Holmes et al., 2020; Serafini et al., 2020; Thombs et al., 2020; Xiong et al., 2020). This is what some experts have called the "tsunami of psychiatric diseases" (Tandon, 2020).

In the case of anxiety, some review and meta-analysis studies have reported a prevalence ranging from 23.2% to 31.9% (Pappa et al., 2020; Salari et al., 2020), which is higher in women than men (Moghanibashi-Mansourieh, 2020; Pappa et al., 2020). Studies included in previous reviews, however, have used traditional anxiety assessment tools such as the GAD-7 and DASS-21. Using these types of measures can lead to under- or over-estimates since they are not aimed at identifying relevant and specific symptoms of mental health problems associated with COVID-19. To overcome this limitation, instruments have been designed to identify mental health problems specifically related to COVID-19 (Ransing et al., 2020), such as the Coronavirus Anxiety Scale, which aims to measure dysfunctional anxiety related to COVID-19, also known as coronaphobia (CAS, Lee, 2020a). Coronaphobia is an excessive fear response to contracting COVID-19, generated by contact with situations or people that involve an increased likelihood of contracting COVID-19, leaving home, increased exposure to information about the disease, contracting or having contracted COVID-19, uncertainties about the future, the acquisition of new behaviors, loss of confidence in the health care system, and warning statements from international agencies (Arora et al., 2020). Likewise, the presence of coronaphobia generates excessive concern, the presence of physiological symptoms, high levels of stress, increased safety seeking behaviors, deterioration of functioning during daily life due to avoiding public places, high levels of depression, generalized anxiety, and suicidal ideation (Chakraborty & Chatterjee, 2020; Lee, Jobe, & Mathis, 2020; Lee, Mathis, Jobe, et al., 2020; Mora-Magaña et al., 2020).

The CAS was originally developed in English and its psychometric properties were evaluated in that language (Lee, 2020a, 2020b; Lee, Jobe, Mathis, et al., 2020, Lee, Mathis, Jobe, et al., 2020), as well as in Turkish (Evren et al., 2020), Bangla (Ahmed et al., 2020), Korean (Choi et al., 2020) and Spanish (Caycho-Rodríguez, Barboza-Palomino, et al., 2020; Franco-Jimenez, 2020; Mora-Magaña et al., 2020).

**CONTACT** Tomás Caycho-Rodríguez tppcaycho@gmail.com Universidad Privada del Norte, Av. Alfredo Mendiola 6062, Los Olivos, Lima, Peru.

Due to its small number of items, the CAS has been used for the general population (Lee et al., 2020a), as well as nurses (Labrague & De los Santos, 2020), healthcare professionals (Mora-Magaña et al., 2020), and university students (Caycho-Rodríguez, Barboza-Palomino, et al., 2020). All psychometric studies have concluded that the five CAS items have been grouped into a single dimension and are internally consistent, with alpha coefficients varying from 0.80 to 0.93 and omega coefficients with values between 0.80 and 0.88 (Ahmed et al., 2020; Caycho-Rodriguez, Barboza-Palomino, et al., 2020; Evren et al., 2020; Franco-Jimenez, 2020; Lee, 2020a, 2020b; Lee, Jobe, Mathis, et al., 2020; Lee, Mathis, Jobe, et al., 2020) In addition, the CAS has been significantly associated with measures of depression, generalized anxiety, death anxiety, neuroticism, health anxiety, tranquility seeking behaviors, obsession and fear of COVID-19, worry, negativity in regards to mental well-being, as well as other sociodemographic variables, such as age, gender, race, and educational level (Ahmed et al., 2020; Caycho-Rodriguez, Barboza-Palomino, et al., 2020; Evren et al., 2020; Franco-Jimenez, 2020; Lee, 2020a; Lee, Jobe, Mathis, et al., 2020; Lee, Mathis, Jobe, et al., 2020). Finally, a few studies have evaluated the invariance of this scale by age and gender (Ahmed et al., 2020; Franco-Jimenez; 2020; Lee, 2020a).

All previous studies evaluated the psychometric properties of the CAS based on the Classical Test Theory (CTT) which emphasizes the evaluation of internal consistency and construct validity (Hunsley & Mash, 2008). However, the CTT methods do not allow for the precise evaluation of the symptomatology of anxiety caused by COVID-19 throughout the range of anxiety severity. This can be done via Item Response Theory (IRT) models that have an underlying assumption of one-dimensionality (Bjorner et al., 2003; Cook et al., 2007). IRT models are probabilistic and estimate unobservable traits using observed variables and relate item characteristics (difficulty and discrimination) and individuals (in this case COVID-19 anxiety) to the probability of selecting different response options for an item on a measurement instrument (Hambleton et al., 1991). In this sense, in IRT models an individual's responses to items express his or her level of skill in the measured trait (Hambleton & Swaminathan, 1985). As far as the literature is concerned, this is the first study, in any language, to use IRT models to assess the CAS.

Based on previous information and the current increase in the number of studies that have used CTT and IRT models to psychometrically assess measures of self-reported anxiety (Pang et al., 2019), the aim of the present study was to evaluate the psychometric properties of the CAS in Spanish, using CTT and IRT models. The use of both models will provide a more robust psychometric analysis. The CAS is becoming a common instrument to evaluate anxiety from COVID-19. In Scopus, Lee's original article (2020a) has received 46 citations with a weighted citation impact of 62.37, while in the Web of Science it has received 23 citations. The results of this study are expected to guide the best use of the scale in professional practice and research.

## Method

### Participants and procedure

The participants were 790 Peruvians, selected through convenience sampling, between 18 and 65 years old ($M_{age}$ = 25.96, $SD$ = 8.39), where 456 (57.7%) were women and 334 (42.3%) men. The vast majority of participants were single (82.3%) followed by married (8.9%). Fifty-nine percent of the participants were unemployed at the time of the study, 23.5% had a temporary job, and only 17.3% had a permanent job. Likewise, 98.9% were not diagnosed with COVID-19, but all had close (13.2%) or distant (86.8%) family members diagnosed with the disease, and 74.1% also had friends who had been diagnosed. Finally, 45.3% spent between 1 and 3 h listening to or reading information about COVID-19, 22.4% spent more than 7 h, 20.4% spent 3–5 h and 11.9% spent 5–7 h a week.

The study was conducted between May 27 and 8 June 2020. In Peru, the first case of COVID-19 was reported on March 6 and the mandatory quarantine began on March 15, which has been gradually relaxed since 1 July 2020. The online link containing the study's survey was distributed to all participants via email and/or social networks. Before accessing the study questions, participants were informed about the objectives of the study, the voluntary nature of their participation, the benefits and risks, and the confidentiality of the information collected. Then, they were asked for their informed consent by selecting either "I agree to participate" or "I do not agree to participate". Only if the participant chose the "I agree to participate" option could they access the survey questions. Scientific evidence shows that online data collection is appropriate and equivalent to paper and pencil methods (Weigold et al., 2013). The protocol of the research project was approved by the Ethics Committee of the Universidad Privada del Norte and followed the guidelines of the Declaration of Helsinki.

### Instruments

Coronavirus Anxiety Scale (CAS, Lee, 2020a). This is a one-dimensional scale that assesses dysfunctional anxiety related to COVID-19, also known as coronaphobia. The CAS has 5 items with 5 Likert type options (0 = nothing to 4 = almost every day during the last 2 weeks), where a higher score expresses a greater anxiety in front of the COVID-19. The version translated into Spanish and validated in the Peruvian context by Caycho-Rodríguez, Barboza-Palomino, et al. (2020) was used, which has adequate evidence of construct validity, evidence of validity based on the relationship with other variables, and reliability.

### Data analysis

First, descriptive statistics of the items were calculated (mean [*M*], standard deviation [*SD*], asymmetry [*g1*] and kurtosis [*g2*]). Second, Confirmatory Factor Analysis (CFA) was performed using the *Diagonally Weighted Least Squares with Mean and Variance corrected (*WLSMV) estimator due to the ordinal nature of the items (Brown, 2015). The chi-square test ($\chi^2$), the RMSEA index, and the SRMR index were used to evaluate model fit, in which case values less than .05 indicate good fit, and between .05 and .08 are considered an acceptable fit (Kline, 2015). In addition, the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) were used, where values greater than .95 indicate a good fit and greater than .90 an acceptable fit (Schumacker & Lomax, 2015). The internal consistency of the scale was evaluated using the Cronbach's alpha coefficient ($\alpha$; Cronbach, 1951) and omega coefficient ($\omega$; McDonald, 1999), where a value of □ > .80 is appropriate (Raykov & Hancock, 2005). Factorial loads ($\lambda$) above .50 were considered adequate (Dominguez-Lara, 2018).

Third, the invariance of the scale according to the sex of the participants was evaluated from a sequence of hierarchical variance models. First the configural invariance (reference model) was evaluated, followed by the metric invariance (equality of factor loads), the scalar invariance (equality of factor loads and intercepts) and finally the strict invariance (equality of factor loads, intercepts and residuals) was tested. To compare the model sequence, first the chi-square difference ($\Delta\chi^2$) was used, where non-significant values ($p > .05$) suggest invariance between the groups. Second, a modeling strategy was employed, using differences in the CFI (ΔCFI) where values less than < .010 evidence model invariance between groups (Chen, 2007). The RMSEA (ΔRMSEA) was also used, where differences of less than < .015 show the invariance of the model among the groups (Chen, 2007). The difference in latent means of the COVID-19 anxiety construct between men and women was calculated through the Critical Ratio (CR), whose values > 1.96 or < −1.96 reject the equality estimate (Tsaousis & Kazi, 2013). The effect size (ES) was calculated using Cohen's *d,* where values of .20, .50, and .80 indicate a small, medium, and large ES respectively (Fritz et al., 2012).

Fourth, the analysis based on Item Response Theory (IRT), was conducted from a Graduated Response Model (GRM, Samejima, 1997) specifically an extension of the 2-Parameter Logistic Model (2-PLM) for ordered polytomical items (Hambleton et al., 2010). For each item, two types of parameters were estimated, discrimination (a) and difficulty (b). The discrimination parameter (a) determines the slope at which the responses to the items change as a function of the level in the latent trait, and the difficulty parameters of the item (b) determines how much of the latent trait the item requires in order to be answered. Since scales have five response categories, there are four difficulty estimates, one per threshold. The estimates for these four thresholds indicate the level of the latent variable at which an individual has a 50% chance of obtaining a score equal to or greater than a particular response category. The Information Curves for the items and the scale (IIC and TIC respectively) were also calculated.

All analyses were performed in the RStudio environment (RStudio Team, 2018) for R (R Core Team, 2019). For CFA, the "lavaan" package (Rosseel, 2012) was used, for factor invariance the "semTools" package (Jorgensen et al., 2018) and the "ltm" package for GRM (Rizopoulos, 2006).

## Results

### Descriptive analysis

Table 1 shows that item 4 (I lost interest in eating when I thought about or was exposed to information about COVID-19) has the highest mean in the sample ($M = 1.81$); while item 5 (I felt nauseous or had stomach problems when I thought about or was exposed to information about COVID-19) has the lowest mean ($M = .81$). In addition, the poly-correlation matrix shows that all items have a moderate to high correlation coefficient. Furthermore, the indices of asymmetry and kurtosis were within the range ±1.5.

**Table 1.** Descriptive analysis of the items and poly-correlation matrix.

| | Descriptive analysis | | | | Poly-correlation matrix | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ítems | *M* | *SD* | *g1* | *g2* | 1 | 2 | 3 | 4 | 5 |
| 1. Me sentí mareado, aturdido o débil cuando leí o escuché noticias sobre el COVID-19. | 1.01 | .78 | .45 | −.18 | 1 | .64 | .64 | .60 | .63 |
| 2. Tuve problemas para quedarme dormido porque estaba pensando en el COVID-19 | 1.54 | .81 | .09 | −.52 | | 1 | .68 | .69 | .64 |
| 3. Me sentí paralizado o congelado cuando pensaba o estaba expuesto a información sobre el COVID-19. | 1.20 | .83 | .34 | −.39 | | | 1 | .72 | .69 |
| 4. Perdí interés en comer cuando pensaba o estaba expuesto a información sobre el COVID-19 | 1.81 | .74 | −.16 | −.33 | | | | 1 | .79 |
| 5. Sentí náuseas o problemas estomacales cuando pensaba o estaba expuesto a información sobre el COVID-19. | .81 | .85 | .81 | −.08 | | | | | 1 |

*Note.* *M*: Mean; *SD*: Standard Deviation; $g^1$: Skewness; $g^2$: Kurtosis.

**Table 2.** One-dimensional model fit rates and partial invariance models by sex.

| Models | $\chi^2$ | *df* | *p* | SRMR | TLI | CFI | RMSEA | $\Delta\chi^2$ | $\Delta df$ | *p* | ΔCFI | ΔRMSEA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total sample | 33.64 | 5 | <.001 | .023 | .99 | .99 | .085 | – | – | – | – | – |
| Women | 11.04 | 5 | .051 | .017 | .99 | .99 | .052 | | | | | |
| Men | 26.56 | 5 | <.001 | .037 | .98 | .99 | .114 | | | | | |
| Partial invariance by sex | | | | | | | | | | | | |
| Configural | 38.49 | 10 | <.001 | .030 | .99 | .99 | .085 | – | – | – | – | – |
| Metric | 41.81 | 14 | <.001 | .030 | .99 | .99 | .071 | 2.99 | 4 | .559 | < .001 | −.014 |
| Scalar | 58.16 | 28 | .001 | .031 | .99 | .99 | .052 | 19.58 | 14 | .143 | < .001 | −.019 |
| Strict | 241.01 | 29 | <.001 | .032 | .97 | .96 | .132 | 45.26 | 1 | .000 | −.038 | .084 |

*Note.* $\chi^2$: Chi square; *df*: degrees of freedom; SRMR: Standardized Root Mean Square Residual; TLI: Tucker-Lewis Index; CFI: Comparative Fit Index; RMSEA: Root Mean Square Error of Approximation; $\Delta\chi^2$: Change in Chi square; $\Delta df$: Change in degrees of freedom; ΔRMSEA: Change in Root Mean Square Error of Approximation; ΔCFI: Change in Comparative Fix Index.

### *Validity based on internal structure and reliability*

Table 2 shows that the one-dimensional model has adequate adjustment indices in the total sample of participants ($\chi^2 = 33.64$; $df = 5$; $p < .001$; RMSEA = .085 [CI90% .059−.114]; SRMR = .023; CFI=.99; TLI = .99). Once it was proven that the one factor model was adequate, the structure was tested separately in the male and female subgroups. Similarly, the model has adequate adjustment rates in the female group ($\chi^2 = 11.04$; $df = 5$; $p = .051$; RMSEA = .052 [IC90% <.001–.093]; SRMR = .017; CFI = .99; TLI = .99) and males ($\chi^2 = 26.56$; $df = 5$; $p <.001$; RMSEA = .114 [CI90% .074−.158]; SRMR = .037; CFI = .99; TLI = .98).

Table 3 presents the factorial loads of each of the items and the values of the reliability coefficients, which were adequate for the total sample ($\alpha = .91$; $\omega = .88$), as well as for the samples of women ($\alpha = .90$; $\omega = .86$) and men ($\alpha = .92$; $\omega = .89$).

### *Factorial invariance by sex*

To evaluate the degree of invariance, ΔCFI was taken as the main criterion, since ΔRMSEA can be affected by the sample size. Table 2 shows that the configural invariance presents an adequate adjustment to the data, which allows for maintaining it as a reference model. In the configural invariance, the factorial loads, the intersection of the observed variables and the residuals were freely estimated. The equality restriction was then imposed on the factorial loads to test the metric invariance. This model serves to verify if the same item represents the same construct between the groups. The model had an acceptable fit, the chi-square difference ($\Delta\chi^2$) was not statistically significant and the ΔCFI was less than .010 (ΔCFI < .001). Therefore, the presence of metric invariance between the male and female groups is admitted. Later, based on the previous model, equality constraints were imposed on the intercepts to test scalar invariance. This model also had an adequate fit and no difference was reported between the scalar and metric CFIs (ΔCFI < .001). This allows us to

**Table 3.** Standardized factor weights of the items and reliability according to sex and total sample.

| Items | Total sample $\lambda$ (error) | Women $\lambda$ (error) | Men $\lambda$ (error) |
|---|---|---|---|
| Item 1 | .75 (.43) | .71 (.50) | .82 (.34) |
| Item 2 | .80 (.36) | .76 (.42) | .84 (.29) |
| Item 3 | .83 (.31) | .82 (.33) | .83 (.31) |
| Item 4 | .88 (.22) | .87 (.25) | .90 (.19) |
| Item 5 | .86 (.27) | .87 (.24) | .84 (.29) |
| Reliability | | | |
| $\alpha$ | .91 | .90 | .92 |
| $\omega$ | .88 | .86 | .89 |

*Note.* $\lambda$: loadings factor; Factor 1: physiological dimension; Factor 2: emotional dimension.

conclude that scalar invariance exists between the genders. Finally, the structure shows no evidence of strict invariance ($\Delta CFI = -.038$; $\Delta RMSEA = .084$). Despite not complying with strict invariance, overall, the results indicate that anxiety about COVID-19 has the same meaning in men and women.

Having established scalar invariance between men and women, one can compare latent mean differences between these groups. The results showed that women (1.28 ± .80) had greater symptoms of COVID-19 anxiety than men (1.11 ± .75) (CR = 3.15; $p < 0.001$; $d = 0.22$).

**Table 4.** Discrimination and difficulty parameters for scale items.

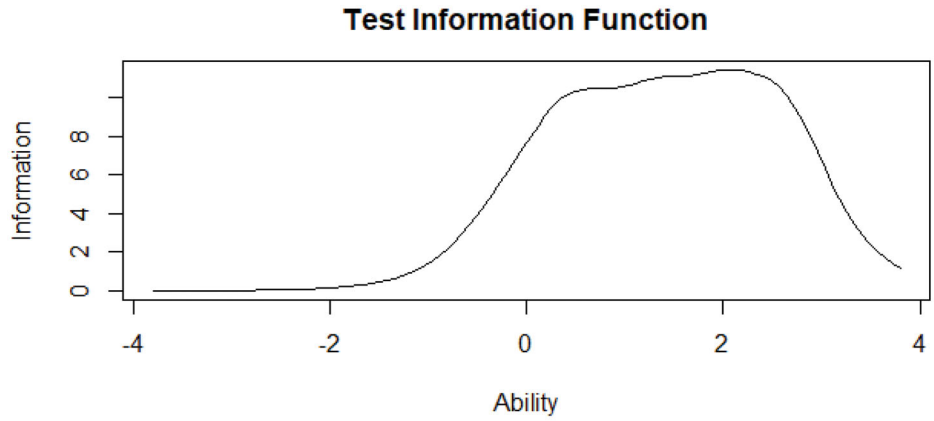
| Model | Item | a | b1 | b2 | b3 | b4 |
|---|---|---|---|---|---|---|
| One-dimensional | Item 1 | 2.20 | .13 | 1.17 | 2.17 | 2.73 |
| | Item 2 | 2.45 | .04 | .99 | 1.74 | 2.24 |
| | Item 3 | 2.82 | −.08 | .94 | 1.85 | 2.62 |
| | Item 4 | 3.43 | .44 | 1.35 | 1.97 | 2.61 |
| | Item 5 | 3.07 | .55 | 1.32 | 2.13 | 2.55 |

*Note.* a: discrimination parameters; b: difficulty parameters.

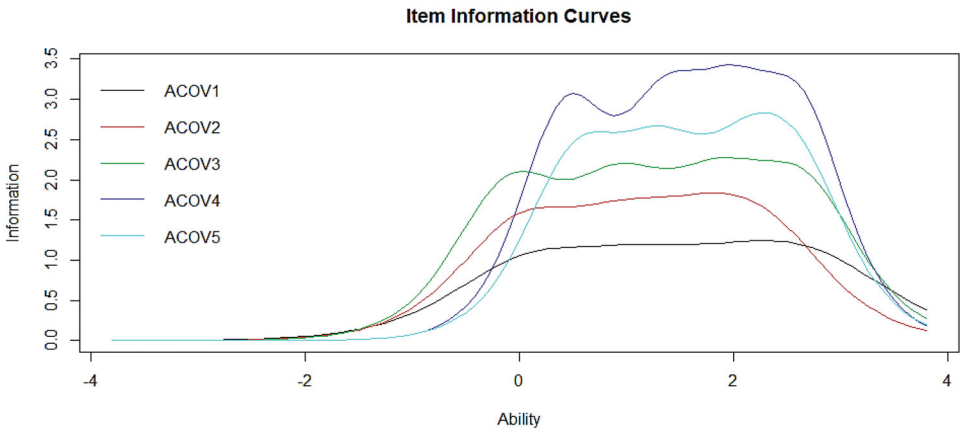
### *Item response theory model: Graduated Response Model (GRM)*

The results found in the Confirmatory Factor Analysis (CFA) support the assumptions of unidimensionality and local independence. Therefore, a Graduated Response Model (GRM) was used, specifically an extension of the 2-Parameter Logistic Model (2-PLM) for ordered polytomical items. Table 4 shows that all item discrimination parameters are above the value of 1, generally considered to be good discrimination (Hambleton et al., 2010). Regarding the parameters of difficulty, all the estimators of the thresholds increased monotonically.

Figure 1 shows the Information Curves for the five items and the scale (IIC and TIC respectively). In the IIC, it can be seen that items 4, 5, and 3 are the most relevant and precise of the scale to evaluate the latent variable. In addition, the TIC shows that the test is more reliable (accurate) in the range of the scale between −0.5 and 3.




Tests Information Curves (TIC)




Item Information Curves (IIC)

**Figure 1.** Item and test information curves for the scale.

## Discussion

In the last few months, different studies have been conducted that translated and validated the CAS (Ahmed et al., 2020; Caycho-Rodriguez, Barboza-Palomino, et al., 2020; Evren et al., 2020; Franco-Jimenez, 2020; Lee, 2020a, 2020b; Lee, Jobe, Mathis, et al., 2020, Lee, Mathis, Jobe, et al., 2020). However, there are few studies in Latin American populations that provide evidence for the validity of the CAS within this cultural setting. In this sense, this study presents new psychometric evidence of the Spanish version of CAS based on SEM and IRT models.

In general, CFA supports the presence of a one-dimensional model, items have high factorial loads and good reliability for internal consistency. These findings are similar to those reported in the original study (Lee, 2020a) and in other previous research (Ahmed et al., 2020; Caycho-Rodriguez, Barboza-Palomino, et al., 2020; Evren et al. 2020; Franco-Jimenez, 2020; Lee, 2020b; Lee, Jobe, Mathis, et al., 2020, Lee, Mathis, Jobe, et al., 2020). Confirming the unidimensionality of the CAS indicates that its five items would express a specific construct (in this case, coronaphobia) and not other related ones, such as stress for COVID-19, which allows for correct interpretations of the CAS score (Ziegler & Hagemann, 2015). Likewise, the one-dimensional structure of the CAS allows for evaluating coronaphobia with few items. This is important since it reduces boredom and fatigue generated by responses to repetitive items; in addition, it is useful in large-scale studies since it provides more space to include other scales or instruments. Finally, due to the current importance of patient-centered care, it is important to have global measures, with a structure that is easy to interpret and that have positive implications for the clinical practice of health professionals (Caycho-Rodríguez, Vilca, et al., 2020).

Additionally, once the dimensionality of the CAS was established, IRT models were estimated. The results show that all items present increasing monotonic values in the difficulty parameter, this means that a person with little or low anxiety about the COVID-19 will tend to choose the first or second response alternative and as he has a higher anxiety level, he will choose a higher response alternative. This is an expected and positive behavior in the instrument since it reflects that the content raised in each of the items allows to take advantage of the answer alternatives shown to the participants and there is no loss of information due to the approach of the measurement instrument. All the items have high discrimination values, which means that, when using the CAS, it will be easy to differentiate between the responses to the items of a person with high anxiety and those of someone with moderate or low anxiety, including the general assessment of the latent variable expressed in total scores. According to the analysis of the information collected by the items, the scale can better and more accurately assess the anxiety about the COVID-19 in individuals who have moderate and high levels of the latent variable in mention, being the items 4, 5, and 3 who better take advantage of this characteristic. In this sense, it is likely that people with low and very low anxiety about the COVID-19 show very similar scores and tend to mark mostly the first alternative of response in all items.

According to the results of the configural and metric invariance, both men and women attribute equal meaning to the coronaphobia construct and interpret the CAS items in the same way. These results would indicate that the CAS items work the same way, regardless of whether they are answered by men or women. Likewise, the demonstration of metric invariance suggests that the predictive relations between coronaphobia and other constructs can be compared in a significant way among the groups evaluated (for example, comparing the strength of the association between coronaphobia and the quality of life in samples of Peruvian men and women). It is also important to consider that, even though a scalar invariance was found, ΔRMSEA was superior to that suggested by Chen (2007) and Cheung and Rensvold (2002). That said, the proposed cutoff values for determining factor invariance are not strict, but rather approximate guidelines (Marsh et al., 2004), thus caution is suggested when comparing the latent means of men and women, as both groups may use the CAS response scale differently. Furthermore, the absence of strict invariance suggests that the five items of the CAS measure coronaphobia with a different measurement error between the groups of men and women. This means that a difference in the CAS score between the groups is not necessarily an expression of the real difference in the coronaphobia construct. However, strict invariance is difficult to encounter in practice because it is considered too restrictive (Little et al., 2007). Furthermore, forcing the assumption of strict invariance may generate biased parameter estimates (Little, 1997). In this sense, the assessment of scalar invariance, rather than strict invariance, is suggested as the last necessary step to test the measurement invariance of a scale and, therefore, to be able to make comparisons of observed and latent means (Gregorich, 2006;

Milfont & Fischer, 2010; Millsap, & Meredith, 2007; Wu et al., 2007). Therefore, in this study, scalar invariance was considered sufficient to compare the latent means of CAS between men and women.

Although CAS worked equally in the male and female groups without the presence of measurement bias, as demonstrated by support for configural, metric and scalar invariance, differences were observed when comparing the latent means of COVID-19 anxiety between the groups. Specifically, the women's group was reported to have higher levels of coronaphobia compared to men. The finding that women reported more COVID-19 anxiety symptoms is not surprising, as other studies have reported similar results (Ahmed et al., 2020¸ Evren et al., 2020) and even three times higher levels of anxiety in women during the COVID-19 pandemic (Wang et al., 2020). Findings suggest that men and women respond differently to different stressors during the pandemic (Nakhostin-Ansari et al., 2020) and may cause women to misinterpret their own feelings, leaving them vulnerable to other negative emotional states such as depression (Özdin, & Bayrak Özdin, 2020). However, another study reported no significant gender differences (Cao et al., 2020).

This study has limitations. First, the participants were selected through convenience sampling; therefore, they do not represent the entire Peruvian general population. Future research should consider working with a more representative sample. Second, the psychometric properties of the CAS were evaluated in a general sample that mostly did not have a diagnosis of COVID-19, so more studies in clinical samples are needed to confirm the findings of the study. Third, the data were collected in a limited period of time, which could have biased the sample studied. Future studies should extend the time period for collecting this type of information. Fourth, invariance was not assessed according to age because each group had a different number of participants. Having groups with similar sample sizes is an important requirement for factor invariance studies (Bollen, 1989). However, future research should test factor invariance of the CAS in Spanish among different age groups, especially since previous literature points to the presence of scalar invariance among people aged 18–29 and 30 or older from different contexts such as Bangladesh (Ahmed et al., 2020).

Despite these limitations, this can be considered a pioneering study within a recent line of research that develops and/or validates instruments that measure mental health symptoms associated with COVID-19. In this sense, this was the first study that rigorously evaluated the psychometric evidence of CAS in Spanish, using SEM and IRT models. Previous studies only used SEM models and, therefore, this study represents a valuable contribution to the scientific literature. Likewise, the diversity of ages and other socio-demographic characteristics constitute strengths for this study, since it allows the CAS to be applied to a greater number of people. Validation of Spanish-language instruments, such as the CAS, is promising and may be useful for mental health professionals to effectively and quickly assess people who may have been psychologically affected by the COVID-19 pandemic. It is anticipated that at the end of the COVID-19 pandemic, different mental health problems will appear in the population, such as symptoms of anxiety, depression and post-traumatic stress (Mora-Magaña et al., 2020). Therefore, identifying and distinguishing the groups of people most vulnerable to experiencing dysfunctional anxiety from an infectious disease is important for providing an effective response to the problem (Taylor, 2019). In addition, this would enable planning and evaluations of the impact of interventions that seek to reduce the symptoms of dysfunctional anxiety related to COVID-19 in Spanish-speaking populations. The latter is important because it would facilitate the generation of evidence so that different public health officials can allocate economic, material and human resources to carry out these scientifically validated interventions (Taylor et al., 2020). Finally, the CAS is freely available for use in professional practice and research.

In conclusion, the Spanish version of the CAS seems to be a self-reporting instrument with sufficient evidence of reliability and validity to measure coronaphobia. Therefore, the CAS may be useful in clinical practice and research involving the general population of Peru. However, it is important that the psychometric properties of CAS continue to be evaluated in socio-cultural contexts that are different from the Peruvian setting. The development of appropriate assessment instruments for use in Spanish, English, Turkish, and Bangla-speaking populations is important for conducting more rigorous studies of mental health symptoms in a time of pandemics. However, the cross-cultural study of the psychometric properties of the CAS should receive greater attention in the future.

## Disclosure statement

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

## Authors contribution

All authors have read, reviewed and approved the final text of the article.

## ORCID

Tomás Caycho-Rodríguez http://orcid.org/0000-0002-5349-7570
Lindsey W. Vilca http://orcid.org/0000-0002-8537-9149
Michael White http://orcid.org/0000-0003-4530-8167

## References

Ahmed, O., Faisal, R. A., Sharker, T., Lee, S. A., & Jobe, M. C. (2020). Adaptation of the Bangla version of the COVID-19 Anxiety Scale. *International Journal of Mental Health and Addiction*, 1–12. https://doi.org/10.1007/s11469-020-00357-2

Arora, A., Jha, A. K., Alat, P., & Das, S. S. (2020). Understanding coronaphobia. *Asian Journal of Psychiatry*, *54*, 102384. https://doi.org/10.1016/j.ajp.2020.102384

Bjorner, J. B., Kosinski, M., & Ware, J. E. Jr., (2003). Calibration of an item pool for assessing the burden of headaches: An application of item response theory to the Headache Impact Test (HIT$^{TM}$). *Quality of Life Research*, *12*(8), 913–933. https://doi.org/10.1023/A:1026163113446

Bollen, K. A. (1989). *Structural equations with latent variables*. John Wiley & Sons.

Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (2nd ed). Guilford Publications. https://books.google.com.pe/books?id=tTL2BQAAQBAJ

Cao, W., Fang, Z., Hou, G., Han, M., Xu, X., Dong, J., & Zheng, J. (2020). The psychological impact of the COVID-19 epidemic on college students in China. *Psychiatry Research*, *287*, 112934. https://doi.org/10.1016/j.psychres.2020.112934

Caycho-Rodríguez, T., Barboza-Palomino, M., Ventura-León, J., Carbajal-León, C., Noé-Grijalva, M., Gallegos, M., Reyes-Bossio, M., & Vivanco-Vidal, A. (2020). Traducción al español y validación de una medida breve de ansiedad por el COVID-19 en estudiantes de ciencias de la salud. *Ansiedad y Estrés*, *26*(2–3), 174–180. https://doi.org/10.1016/j.anyes.2020.08.001

Caycho-Rodríguez, T., Vilca, L. W., Plante, T. G., Carbajal-León, C., Cabrera-Orosco, I., Cadena, C. H. G., & Reyes-Bossio, M. (2020). Spanish version of the Santa Clara Brief Compassion Scale: evidence of validity and factorial invariance in Peru. *Current Psychology*, 1–16. https://doi.org/10.1007/s12144-020-00949-0

Chakraborty, K., & Chatterjee, M. (2020). Psychological impact of COVID-19 pandemic on general population in West Bengal: A cross-sectional study. *Indian Journal of Psychiatry*, *62*(3), 266–272. https://doi.org/10.4103/psychiatry.IndianJPsychiatry_276_20

Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*(3), 464–504. https://doi.org/10.1080/10705510701301834

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *9*(2), 233–255. https://doi.org/10.1207/S15328007SEM0902_5

Choi, E., Lee, J., & Lee, S. A. (2020). Validation of the Korean version of the obsession with COVID-19 scale and the Coronavirus anxiety scale. *Death Studies*, 1–7. https://doi.org/10.1080/07481187.2020.1833383

Cook, K. F., Teal, C. R., Bjorner, J. B., Cella, D., Chang, C.-H., Crane, P. K., Gibbons, L. E., Hays, R. D., McHorney, C. A., Ocepek-Welikson, K., Raczek, A. E., Teresi, J. A., & Reeve, B. B. (2007). IRT health outcomes data analysis project: An overview and summary. *Quality of Life Research*, *16*(S1), 121–132. https://doi.org/10.1007/s11136-007-9177-5

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297–334. https://doi.org/10.1007/BF02310555

Cullen, W., Gulati, G., & Kelly, B. D. (2020). Mental health in the Covid-19 pandemic. *QJM: Monthly Journal of the Association of Physicians*, *113*(5), 311–312. https://doi.org/10.1093/qjmed/hcaa110

Dominguez-Lara, S. (2018). Propuesta de puntos de corte para cargas factoriales: una perspectiva de fiabilidad de constructo. *Enfermería Clínica*, *28*(6), 401–402. https://doi.org/10.1016/j.enfcli.2018.06.002

Evren, C., Evren, B., Dalbudak, E., Topcu, M., & Kutlu, N. (2020). Measuring anxiety related to COVID-19: A Turkish validation study of the Coronavirus Anxiety Scale. *Death Studies*, 1–7. https://doi.org/10.1080/07481187.2020.1774969

Franco-Jimenez, R. A. (2020). Traducción y análisis psicométrico del Coronavirus Anxiety Scale (CAS) en jóvenes y adultos peruanos. *Interacciones*, *6*(2), e159. https://doi.org/10.24016/2020.v6n2.159

Fritz, C. O., Morris, P. E., & Richler, J. J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology. General*, *141*(1), 2–18. https://doi.org/10.1037/a0024338

Gregorich, S. E. (2006). Do self-report instruments allow meaningful comparisons across diverse population groups? Testing measurement invariance using the confirmatory factor analysis framework. *Medical Care*, *44*(11 Suppl 3), S78–S94. https://doi.org/10.1097/01.mlr.0000245454.12228.8f

Hambleton, R. K., & Swaminathan, H. (1985). *Item response theory: Principles and applications*. Kluwer Academic Publishers.

Hambleton, R. K., Swaminathan, H., & Rogers, H. J. (1991). *Fundamentals of item response theory*. Sage.

Hambleton, R. K., van der Linden, W. J., & Wells, C. S. (2010). IRT models for the analysis of polytomously scored data: Brief and selected history of model building advances. In M. L. Nering & R. Ostini (Eds.), *Handbook of polytomous item response models* (pp. 21–42). Routledge.

Holmes, E. A., O'Connor, R. C., Perry, V. H., Tracey, I., Wessely, S., Arseneault, L., Ballard, C., Christensen, H., Cohen Silver, R., Everall, I., Ford, T., John, A., Kabir, T., King, K., Madan, I., Michie, S., Przybylski, A. K., Shafran, R., Sweeney, A., … Bullmore, E. (2020). Multidisciplinary research priorities for the COVID-19 pandemic: A call for action for mental health science.

*The Lancet Psychiatry*, *7*(6), 547–560. https://doi.org/10.1016/S2215-0366(20)30168-1

Hunsley, J., & Mash, E. J. (Eds.). (2008). *A guide to assessments that work*. Oxford University Press.

Jorgensen, T. D., Pornprasertmanit, S., Schoemann, A. M., Rosseel, Y. (2018). *semTools: Useful tools for structural equation modeling. R package version 0.5-1*. https://CRAN.R-project.org/package=semTools

Kline, R. B. (2015). *Principles and practice of structural equation modeling* (4th ed.). The Guilford Press.

Labrague, L. J., & De los Santos, J. A. A. (2020). COVID-19 anxiety among front-line nurses: Predictive role of organisational support, personal resilience and social support. *Journal of Nursing Management*, *28*(7), 1653–1659. https://doi.org/10.1111/jonm.13121

Lee, S. A. (2020a). Coronavirus Anxiety Scale: A brief mental health screener for COVID-19 related anxiety. *Death Studies*, *44*(7), 393–401. https://doi.org/10.1080/07481187.2020.1748481

Lee, S. A. (2020b). Replication analysis of the Coronavirus Anxiety Scale. *Dusunen Adam: The Journal of Psychiatry and Neurological Sciences, 33*(3), 203–205. https://doi.org/10.14744/DAJPNS.2020.00079

Lee, S. A., Jobe, M. C., & Mathis, A. A. (2020a). Mental health characteristics associated with dysfunctional coronavirus anxiety. *Psychological Medicine*, 1–2. https://doi.org/10.1017/S003329172000121X

Lee, S. A., Jobe, M. C., Mathis, A. A., & Gibbons, J. A. (2020b). Incremental validity of coronaphobia: Coronavirus anxiety explains depression, generalized anxiety, and death anxiety. *Journal of Anxiety Disorders*, *74*, 102268. https://doi.org/10.1016/j.janxdis.2020.102268

Lee, S. A., Mathis, A. A., Jobe, M. C., & Pappalardo, E. A. (2020). Clinically significant fear and anxiety of COVID-19: A psychometric examination of the Coronavirus Anxiety Scale. *Psychiatry Research*, *290*, 113112. https://doi.org/10.1016/j.psychres.2020.113112

Little, T. D. (1997). Mean and covariance structures (MACS) analyses of cross-cultural data: Practical and theoretical issues. *Multivariate Behavioral Research*, *32*(1), 53–76. https://doi.org/10.1207/s15327906mbr3201_3

Little, T. D., Card, N. A., Slegers, D. W., & Ledford, E. C. (2007). Representing contextual effects in multiple-group MACS models. In T. D. Little, J. A. Bovaird, & N. A. Card (Eds.), *Modeling contextual effects in longitudinal studies* (pp. 121–148). Erlbaum.

Marsh, H. W., Hau, K. T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. *Structural Equation Modeling: A Multidisciplinary Journal*, *11*(3), 320–341. https://doi.org/10.1207/s15328007sem1103_2

McDonald, R. P. (1999). *Test theory: A unified treatment*. Taylor & Francis.

Milfont, T. L., & Fischer, R. (2010). Testing measurement invariance across groups: Applications in cross-cultural research. *International Journal of Psychological Research*, *3*(1), 111–130. https://doi.org/10.21500/20112084.857

Millsap, R. E., & Meredith, W. (2007). Factorial invariance: Historical perspectives and new problems. In R. Cudeck & R. C. MacCallum (Eds.), *Factor analysis at 100: Historical developments and new directions* (pp. 131–152). Erlbaum.

Moghanibashi-Mansourieh, A. (2020). Assessing the anxiety level of Iranian general population during COVID-19 outbreak. *Asian Journal of Psychiatry*, *51*, 102076. https://doi.org/10.1016/j.ajp.2020.102076

Mora-Magaña, I., Lee, S. A., Maldonado-Castellanos, I., Jiménez-Gutierrez, C., Mendez-Venegas, J., Maya-Del-Moral, A., … Jobe, M. C. (2020). Coronaphobia among healthcare professionals in Mexico: A psychometric analysis. *Death Studies*, 1–10. https://doi.org/10.1080/07481187.2020.1808762

Nakhostin-Ansari, A., Sherafati, A., Aghajani, F., Khonji, M., Aghajani, R., & Shahmansouri, N. (2020). Depression and anxiety among Iranian Medical Students during COVID-19 pandemic. *Iranian Journal of Psychiatry*, *15*(3), 228–235. https://doi.org/10.18502/ijps.v15i3.3815

Özdin, S., & Bayrak Özdin, Ş. (2020). Levels and predictors of anxiety, depression and health anxiety during COVID-19 pandemic in Turkish society: The importance of gender. *The International Journal of Social Psychiatry*, *66*(5), 504–511. https://doi.org/10.1177/0020764020927051

Pang, Z., Tu, D., & Cai, Y. (2019). Psychometric properties of the SAS, BAI, and S-AI in Chinese University Students. *Frontiers in Psychology*, *10*, 93. https://doi.org/10.3389/fpsyg.2019.00093

Pappa, S., Ntella, V., Giannakas, T., Giannakoulis, V. G., Papoutsi, E., & Katsaounou, P. (2020). Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: A systematic review and meta-analysis. *Brain, Behavior, and Immunity*, *88*, 901–907. https://doi.org/10.1016/j.bbi.2020.05.026

R Core Team (2019). *A language and environment for statistical computing (R version 3.6.1)*. R Foundation for Statistical Computing. http://www.r-project.org/

Ransing, R., Ramalho, R., Orsolini, L., Adiukwu, F., Gonzalez-Diaz, J. M., Larnaout, A., Pinto da Costa, M., Grandinetti, P., Bytyçi, D. G., Shalbafan, M., Patil, I., Nofal, M., Pereira-Sanchez, V., & Kilic, O. (2020). Can COVID-19 related mental health issues be measured? Assessment options for mental health professionals. *Brain, Behavior, and Immunity*, *88*, 32–34. https://doi.org/10.1016/j.bbi.2020.05.049

Raykov, T., & Hancock, G. R. (2005). Examining change in maximal reliability for multiple-component measuring instruments. *The British Journal of Mathematical and Statistical Psychology*, *58*(Pt 1), 65–82. https://doi.org/10.1348/000711005X38753

Rizopoulos, D. (2006). ltm: An R package for latent variable modelling and item response theory analyses. *Journal of Statistical Software*, *17*(5), 1–25. https://doi.org/10.18637/jss.v017.i05

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1–36. https://doi.org/10.18637/jss.v048.i02

RStudio Team (2018). *RStudio: Integrated Development Environment for R*. RStudio, Inc. http://www.rstudio.com/

Salari, N., Hosseinian-Far, A., Jalali, R., Vaisi-Raygani, A., Rasoulpoor, S., Mohammadi, M., Rasoulpoor, S., & Khaledi-Paveh, B. (2020). Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: A systematic review and meta-analysis.

*Globalization and Health*, *16*(1), 1–11. https://doi.org/10.1186/s12992-020-00589-w

Samejima, F. (1997). Graded response model. In W. J. Van der Linden & R. K. Hambleton (Eds.), *Handbook of modern item response theory* (pp. 85–100). Springer.

Schumacker, R. E., & Lomax, R. G. (2015). *A beginner's guide to structural equation modeling* (4th ed.). Routledge.

Serafini, G., Parmigiani, B., Amerio, A., Aguglia, A., Sher, L., & Amore, M. (2020). The psychological impact of COVID-19 on the mental health in the general population. *QJM: An International Journal of Medicine*, *113*(8), 531–537. https://doi.org/10.1093/qjmed/hcaa201

Tandon, R. (2020). COVID-19 and mental health: Preserving humanity, maintaining sanity, and promoting health. *Asian Journal of Psychiatry*, *51*, 102256. https://doi.org/10.1016/j.ajp.2020.102256

Taylor, S. (2019). *The psychology of pandemics: Preparing for the next global outbreak of infectious disease*. Cambridge Scholars Publishing.

Taylor, S., Landry, C., Paluszek, M., Fergus, T. A., McKay, D., & Asmundson, G. J. (2020). Development and initial validation of the COVID Stress Scales. *Journal of Anxiety Disorders*, *72*, 102232. https://doi.org/10.1016/j.janxdis.2020.102232

Thombs, B. D., Bonardi, O., Rice, D. B., Boruff, J. T., Azar, M., He, C., Markham, S., Sun, Y., Wu, Y., Krishnan, A., Thombs-Vite, I., & Benedetti, A. (2020). Curating evidence on mental health during COVID-19: A living systematic review. *Journal of Psychosomatic Research*, *133*, 110113. https://doi.org/10.1016/j.jpsychores.2020.110113

Tsaousis, I., & Kazi, S. (2013). Factorial invariance and latent mean differences of scores on trait emotional intelligence across gender and age. *Personality and Individual Differences*, *54*(2), 169–173. https://doi.org/10.1016/j.paid.2012.08.016

Wang, Y., Di, Y., Ye, J., & Wei, W. (2020). Study on the public psychological states and its related factors during the outbreak of coronavirus disease 2019 (COVID-19) in some regions of China. *Psychology, Health & Medicine*. Advance Online Publication. https://doi.org/10.1080/13548506.2020.1746817

Weigold, A., Weigold, I. K., & Russell, E. J. (2013). Examination of the equivalence of self-report survey-based paper-and-pencil and internet data collection methods. *Psychological Methods*, *18*(1), 53–70. https://doi.org/10.1037/a0031607

Wu, A. D., Zhen, L., & Zumbo, B. D. (2007). Decoding the meaning of factorial invariance and updating the practice of multi-group confirmatory factor analysis: A demonstration with TIMSS data. *Practical Assessment, Research, and Evaluation*, *12*(1), 3. https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1170&context=pare

Xiong, J., Lipsitz, O., Nasri, F., Lui, L. M. W., Gill, H., Phan, L., Chen-Li, D., Iacobucci, M., Ho, R., Majeed, A., & McIntyre, R. S. (2020). Impact of COVID-19 pandemic on mental health in the general population: A systematic review. *Journal of Affective Disorders*, *277*, 55–64. https://doi.org/10.1016/j.jad.2020.08.001

Ziegler, M., & Hagemann, D. (2015). Testing the unidimensionality of items: Pitfalls and loopholes. *European Journal of Psychological Assessment*, *31*(4), 231–237. https://doi.org/10.1027/1015-5759/a000309