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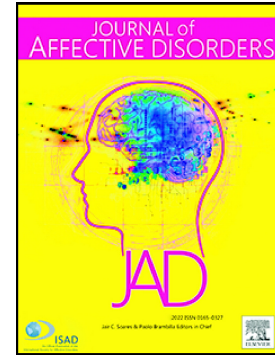
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Title: Measurement Invariance of the Multidimensional Depression Assessment Scale (MDAS) across gender and ethnic groups of Asian, Caucasian, Black, and Hispanic.

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Abstract

Background: Major Depressive Disorder is a severe and highly disabling mental illness. Almost all self-reported questionnaires have overlooked the interpersonal symptoms of depression which are important across gender and culture. The Multidimensional Depression Assessment Scale (MDAS) developed by Cheung and Power (2012) entails comprehensive emotional, cognitive, somatic, and interpersonal subscales. It addresses the criticism that existing self-report depression scales might not cover sufficient phenomenological heterogeneity of depression. The current study aimed to evaluate the psychometric properties of the MDAS across gender and four major ethnic groups of Caucasian, Black, Asian and Hispanic, including reliability and concurrent validity against the Centre for Epidemiological Studies Depression Scale (CES-D) and Patients Health Questionnaire (PHQ-9). It also aimed to establish a stable factor structure across gender and ethnic groups and test the measurement invariance to enhance its potential for clinical use. **Methods:** A community sample of 3499 participants from four ethnic groups were recruited via online crowdsourcing sites of Qualtrics and Amazon M Turk. Each individual completed a demographic questionnaire, the MDAS, CESD and PHQ-9. **Results:** There was good internal consistency (Cronbach's alpha >0.90) and concurrent reliability across gender and ethnic groups. Strict measurement invariance was established for MDAS over a four-factor factor structure corresponding to the four subscales. **Conclusions:** The MDAS showed good psychometric properties and measurement invariance of a four-factor structure, suggesting its potential to be used in clinical settings across gender and ethnic groups. **Limitations:** Participants all answered the questionnaires in English, which could hinder cultural variations in their expression of symptoms.

Keywords: Depression; Psychometrics; Culture; Validation; Measurement Invariance

Measurement invariance of the Multidimensional Depression Assessment Scale (MDAS) across gender and ethnic groups of Asian, Caucasian, Black, and Hispanic.

Introduction

Major depressive disorder (MDD) has been recognised as a serious threat to mental well-being and the leading cause of disability, affecting 300 million people worldwide (World Health Organization (WHO), 2017). MDD is heterogeneous in phenotypic expression and aetiology (Monroe and Anderson, 2015). The core symptoms lie in the affective, cognitive, and somatic domains, according to the well-adopted diagnostic criteria for depression, the *Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5)* (American Psychiatric Association, 2013; Friedman, 2014). The DSM is culturally bound with the implicit assumption that Western-based diagnostic criteria transcend culture and that the underlying pathology of mental disorders is universal (Chentsova-Dutton et al., 2014). The Western conception of depression has been widely implemented in assessing depression across populations, thus obstructing further exploration of the cultural expression of depression and the development of culturally sensitive assessment methods (Wong, 2009). Summerfield (2012) believed that “Western psychiatric templates [of disorders] cannot generate a universally valid knowledge base” because they may not represent the “nature of reality for the individuals under study” (p. 5). Scales developed in Western populations may be biased, as many crucial symptoms in other parts of the world are overlooked in the Western model, and vice versa. Hence, more work is needed in the current diagnosis and screening to systematically identify “missing symptoms” (Summerfield, 2012, p.5). Cultural differences in depression have been reflected in epidemiological studies in which African Americans and Hispanics show elevated rates of major depression compared to Whites (Dunlop et al., 2003). Nevertheless, African Americans with socioeconomic stress and Asians are less likely to seek help (Bailey et al., 2019) or meet with counsellors of their culture (Eken et al., 2021). The expression of distress in each culture also varies (Baas et al., 2011) and could result in underdiagnoses of depression in some ethnic groups (Bailey et al., 2019).

The DSM-5 has long been criticised for overlooking the interdependence of the self in collectivist cultures (Fabrega, 1996). The intrapersonal characteristics of DSM result in the absence of interpersonal symptoms (Chentsova-Dutton et al., 2014), which are particularly important for collectivistic cultures and have been heavily reviewed in the literature (Kupferberg et al., 2016). Interpersonal impairments have an important relationship with depression. In empirical studies, Barrett and Barber (2007), for example, reported greater interpersonal distress in patients with MDD than in patients with other mental health problems. In particular, depressed patients encounter more problems with social isolation, avoidance of social situations, lack of assertiveness, and emotional detachment. Renner et al. (2012) documented that the predominant interpersonal styles fall between social avoidance and non-assertiveness in patients with MDD. Other symptoms, such as feelings of worthlessness or guilt and seeking reassurance, could create a negative social environment and social interaction that maintain and prolong the current episode and may trigger future episodes that support the chronicity of depression (Hames et al., 2013). The connection between impaired interpersonal functioning and depression is consistent and coherent across studies (Joiner and Coyne, 1999). However, the nature of the association remains in contention. By observing depressed individuals in experimental settings, researchers have been able to study the impact of depression on basic behavioural features and communication. Patients in psychotherapy often experience and report persistent difficulties in social relationships besides their primary symptoms of the mental disorder (Horowitz and Vitkus, 1986).

Recent evidence has also highlighted the narrative of interpersonal features of distress in depression across cultures. A systematic review of 170 study populations from 76 nationalities examined the most prevalent depressive symptoms/features reported across cultures and identified *social isolation/loneliness* among the features of depression with the highest relative frequencies besides the report of DSM diagnostic symptoms (Haroz et al., 2017). In trauma-affected populations, interpersonal tendencies, such as *reluctance to talk to others* and *feeling suspicious*, are more commonly reported than in other populations. The results suggest that interpersonal symptoms are crucial features in the cluster of depression, although overlooked by the diagnostic criteria of MDD (Haroz et al., 2017). In particular, the study found that four of the most frequently mentioned ubiquitous features across cultures did not belong to the DSM-5 diagnostic criteria: *social isolation/loneliness*, *crying*, *anger*, and *general pain* (Haroz et al., 2017). Similarly, most Nepalian adolescents attribute interpersonal explanations primarily to depression rather than cognitive factors (Rose-Clarke et al., 2021). The heart-mind ethnopsychology that Nepalese adopt for emotions, experiences, and memories (Rose-Clarke et al., 2021) is very familiar in many Asian countries. Interpersonal symptoms could also be important in university students, who are prone to social stressors, low self-esteem and assertiveness, which could be manifested into depressive symptoms (Coiro et al., 2017; Ira and Suman, 2010; Khawaja et al., 2013; Vredenburg et al., 1988).

Beyond cultural variations in depression, most of the current literature in gender difference of MDD supports a higher prevalence of depression in women than in men in various age groups (de Graaf et al., 2013; Eid et al., 2019; Khawaja et al., 2013). This gender ratio of depression of female against male almost double, according to a meta-analysis by Salk et al. (2017). Gender differences in major depression were observed and onset early in the developmental stage (adolescents), particularly in countries with greater gender equity (Salk et al., 2017). In undergraduate students, however, the reverse pattern was observed, that male Iranian students were found to be more depressed than female ones (Habibi et al., 2014). Women are more likely to present with atypical depression, in which a long-standing pattern of interpersonal rejection is a salient symptom that impedes social functioning (Bogren et al., 2018). This observation might be largely attributed to the greater tendency to generate interpersonal stress in women, which intertwines with depression, especially in the early development of depressive symptoms (Meiser and Esser, 2017). Social isolation/loneliness are also important in males (Haroz et al., 2017), although men's experience of depression is associated with many features outside of the diagnostic criteria, such as aggression and impulsivity (Martin et al., 2013), which are overlooked in DSM. The gender difference has also been found to be embedded across cultures. For instance, younger Iranian males demonstrated more lethargy symptoms than females. For more senior students, the pattern was reversed that Iranian and Portuguese male students were more likely to manifest depression in losing interest in studies than female students (Khawaja et al., 2013).

Unlike other symptoms, interpersonal symptoms are almost missing in self-reported depression scales. The DSM-5 and all the commonly used self-report depression inventories, such as the Beck Depressive Inventory (BDI) and Hospital Anxiety and Depression Scale (Depression subscale) (HADS-D). Centre for Epidemiologic Studies Depression Scale (CES-D) contains two interpersonal items and could be insufficient in capturing detailed cultural variations. The well-validated University Student Depression Inventory (USDI) by Khawaja and Bryden (2006) also contained only two interpersonal symptoms. However, the Multidimensional Depression Assessment Scale (MDAS) fills the gap by entailing a

comprehensive spectrum of interpersonal dysfunctional manifestations and motivations to measure depression of different severity.

The MDAS, a 52-item measure, was the first culturally sensitive self-report depression assessment scale that included a 12-item comprehensive subscale of interpersonal symptoms, alongside with comprehensive symptoms of emotion, cognition and physical. The comprehensive symptom spectrum in MDAS captures variations in depression manifestations and severity that could change across gender, age and cultures. For example, MDAS items are also consistent with most of the symptoms in USDI (lethargy and physical exhaustion, cognitive and emotional difficulties and low motivation for study) (Habibi et al., 2014; Khawaja and Bryden, 2006) and symptoms of life satisfaction, depression affect and withdrawal in the Geriatric Depression Scale (GDS) (Zhao et al., 2019), making it a potentially useful scale across a wide age range of populations. The scale has been tested in Chinese clinical (Cheung, Williams, and Chan, 2020) and pregnant samples (Cheung et al., 2020a) with good psychometric characteristics, including high reliability and validity. It has also been validated in clinical and community samples in Iran (Darharaj et al., 2016; Darharaj et al., 2018)(Table 1). A four-factor structure is generally supported across culture (Table 1). The stability of the factor structure has yet to be examined using measurement invariance across populations (Van De Schoot et al., 2015) to determine whether MDAS measures the same underlying factor. As demonstrated in previous studies, interpersonal symptoms could be particularly important in measuring depression in certain cultural contexts, especially among Asian populations (Wong et al., 2012). Across cultures, interpersonal dysfunction is also a common precipitating and maintenance factor of depression (Cheung and Power, 2012). Interpersonal stress is a more serious problem among girls during puberty (Meiser and Esser, 2019). In light of the review of depression across gender in general and culture, this study tested MDAS across gender and major ethnic groups globally to further investigate the gender and cultural manifestations of depression and clinical applications of the tool. We validated MDAS for future measure of cultural and gender manifestations of depression.

Table 1 to be inserted here-

The current study tested the hypothesised four-factor models corresponding to the four subscales (emotional, cognitive, somatic, and interpersonal) and the hierarchical five-factor structure, with depression as a secondary unidimensional factor across gender and the major ethnic groups of Caucasians, Asian, Black, and Hispanic. Arguably, a unidimensional structure is more in favour of adopting the total score of MDAS in measuring depression severity. In light of the previous literature of gender difference in depression transcending cultures, and the cultural difference in depression, the latent factors and test scores of MDAS across gender and ethnic groups were compared by exploring measurement invariance, which has significant implications for research and practice. Developing a measurement-invariant MDAS could offer a stable factor structure unaffected by group membership and occasion of measurement (e.g. location and time). Thus, it would allow meaningful comparisons of latent factor means across populations (Mellenbergh, 1989). The difference in test scores across populations can then be attributed to the group differences in the underlying variables. In other words, a measurement-invariant MDAS would enable researchers and clinicians to fairly compare depression scores between gender and ethnic groups. The scoring of MDAS across gender and ethnic groups could allow us to attribute the difference in scores to depression rather than ethnicity for meaningful comparisons of depression severity.

Taken together, the primary aims of the current paper were: 1) to examine the factor structure of MDAS across gender in general and in four ethnic groups (Asian, Caucasian, Black, and Hispanic), and 2) to test the measurement invariance of MDAS across gender and these ethnic groups. This paper is the first to compare gender and ethnic groups using MDAS. Rather than focusing on the ethnic groups in a particular nation, its sample was drawn from four major ethnic groups in the world to maximise the representativeness and diversity of the populations involved.

Methods

Participants

A community sample of 3499 individuals was recruited through Amazon M Turk (AMT) and Qualtrics. Both are among the largest online crowdsourcing platforms for users across the globe. AMT and Qualtrics have gained increasing popularity in providing feasible and effective solutions for collecting psychological data. Samples drawn from their diverse pools across nations can capture the diversity of humanity (Pauszel et al., 2017). The study sample included four ethnic groups of participants: White ($n = 795$, 22.7%), Asian ($n = 1316$, 37.6%), Hispanic ($n = 660$, 18.9%), and Black ($n = 707$, 20.2%). The inclusion criteria were being over 18 years old with self-identified proficiency in written English. There were no other exclusion criteria. The sample size was determined based on the rule of thumb of the item-person ratio between 10 and 20 per item for confirmatory factor analysis. The initial sample was screened before data analysis based on several criteria: 1) participants who completed the questionnaire under 1 minute were screened out (as the questionnaire was unlikely to be completed within 1 minute); 2) participants who provided improbable demographic information (e.g. living on the 6000th floor) were also screened out. The final sample size ($N = 3499$) contained 87.4% of the collected data for better data quality.

Measures

The Multidimensional Depression Assessment Scale (MDAS)

MDAS has demonstrated a high Cronbach's alpha = .87 in the overall scale and also in each subscale (emotional = .87; cognitive = .88; somatic = .83; interpersonal = .89). The significant correlation ($r = .77$) between MDAS and Beck Depression Inventory II (Cheung and Power, 2012) suggested good concurrent validity. MDAS is also available in Chinese. The Chinese MDAS version has also demonstrated high internal consistency overall (Cronbach's alpha = .96) as well as within each subscale (emotional = .93; cognitive = .91; somatic = .85; interpersonal = .84). The correlation between the Chinese MDAS and the Chinese version of the Beck Depression Inventory (BDI) was also high ($r = .72$; Cheung et al., 2020). The Cronbach's alphas of MDAS for the four ethnic groups on MDAS are shown in Table 2.

Centre for Epidemiological Studies Depression Scale (CES-D)

The CES-D (Radloff, 1977) is a 20-item self-report questionnaire in which participants rate the frequency of occurrence of each item on a 4-point Likert scale. Upon its development, the CES-D has been proposed to entail four dimensions: *Positive Affect* (four items), *Negative Affect* (seven items), *Somatic Symptoms* (seven items), and *Interpersonal Difficulties* (two items). However, a general score for severity was in favour of evaluating depression severity using its total score due to the high consistency of the four dimensions.

The CES-D has been shown to have sound reliability and validity (>0.9) across populations and has acceptable screening accuracy of general populations with a cut-off value of 16 that yields a sensitivity over 0.8 and a specificity over 0.7 (Vilagut et al., 2016). The Cronbach's alphas for the four ethnic groups on CES-D are shown in Table 2.

Patients Health Questionnaire-9 (PHQ-9)

The patient health question-9 (PHQ-9) is a nine-item self-report questionnaire for the screening of depression in primary care settings (Gilbody et al., 2007). Previous validation in clinical samples (in primary care and psychiatric settings) of the PHQ-9 yielded both unidimensional structure and bifactor structure (somatic and cognitive affective) (Beard et al., 2016; Hansson et al., 2009). Besides its acceptable reliability (Cronbach's alpha <0.9) and validity, a cut-off value of 10 has been shown to yield a sensitivity of 0.88 and a specificity of 0.85 in identifying cases of depression (Levis et al., 2019). The Cronbach's alphas for the four ethnic groups on PHQ-9 are shown in Table 2.

Table 2 to be inserted here.

Procedure

The study was advertised on Amazon M Turk and Qualtrics for potential participants who matched the inclusion criteria to sign up freely. Amazon M Turk is the largest English-based platform with users across 49 countries. Samples of White, Asian, Black, and Hispanic were collected by AMT and Qualtrics across the world. Participants were given an information sheet regarding the study and we obtained their informed consent before they completed the questionnaire anonymously. On the AMT platform, the study was publicised for the access of all workers. Once participants submitted a completed questionnaire, they were reimbursed with USD 2.5 in cash or Amazon credits. On Qualtrics, potential participants who met the inclusion criteria were sent an email invitation. They completed a questionnaire containing demographic information, including age, gender, education, occupation, ethnicity, marital status, presence of current status and history of mental illness. After that, they were asked to complete the MDAS, CES-D, and PHQ-9 questionnaires. They were compensated through Qualtrics, supported by a research grant for the current study. Ethics approval from Hong Kong Metropolitan University was obtained prior to the launch of the project. *Written informed consent was obtained from all participants.*

Data analysis plan

The psychometric properties (reliability and validity) of MDAS were measured. A Cronbach's alpha of >0.9 would indicate excellent internal consistency (Nunnally and Bernstein, 1994). A significant Spearman correlation between the MDAS, PHQ, and CES-D questionnaires would indicate good concurrent validity. Confirmation factor analysis (CFA) was conducted on two hypothesised models (a four-factor model corresponding to the four subscales of MDAS, and a five-factor model of the four first-order factors with a single second-order factor). A most robust estimator of the maximum likelihood ratio (MLR) was adopted for Likert scale items. Model fit indices were compared using the comparative fit index (CFI) and the Tucker-Lewis index (TLI) (Kline, 2010). A model fit of $CFI \geq .95$, $TLI > .95$, and a $RMSEA \leq .05$ would indicate excellent fit, whereas good fit would be indicated by a $CFI > .90$, $TLI > .90$, and a $RMSEA < .08$ (Browne and Cudeck, 1993). Chi-square difference tests were also conducted among nested models. However, the X^2 and $\Delta \chi^2$

values did not serve as primary indicators of model fit because a large sample size would generally give rise to a significant difference in the chi-square test (Cheung and Rensvold, 2002), which was expected in the current study given its large sample size. Thus, we used indicators with less sample-size sensitivity (Chen, 2007).

To test the measurement invariance, we implemented the procedure by Widaman and Reise (1997) using a multigroup CFA approach. The first step was testing for configural invariance by carrying out CFAs on each ethnic group of the sample to examine the structure of the latent variables of each group of data. The second step involved examining metric invariance (weak invariance) using restrictive multiple-group CFAs of equal factor loadings across groups. The third step of scalar invariance (strong invariance) was built based on metric invariance with equal variable intercepts. The final step of residual error invariance (strict invariance) containing equal error variance was established. Changes in RMSEA <0.015 and changes in CFI <0.01 were recommended to indicate satisfactory measurement invariance from the baseline model to the resulting model (Chen, 2007).

The criteria indicated a non-significant increment in model fit from each step of the configural invariance test to the next (e.g. from configural to strict invariance) (Rutkowski and Svetina, 2017). A p value of 0.05 was selected *a priori* to limit the measurement error. For each model, modification indices (MI) were inspected to determine whether covarying constrained parameters would improve the extent of chi-square. Despite arguments against covarying subfactor item errors, the covariance of subfactor item errors was justified in this study due to the similarity in item content (Abd-El Fattah, 2010). Measurement invariance was performed using the Lavaan package of R statistical software (Rosseel, 2012). The remaining analyses were conducted using IBM SPSS 26.

Results

Descriptive statistics

A total of 3499 participants were recruited. The majority of participants were Asian, whereas a similar number of participants were from Caucasian, Black, and Hispanic ethnic groups. The majority were females (except for Hispanic participants), in their 30s with a bachelor's degree, employed full time, married (except for Black participants), and did not have a history of mental disorders. See Table 3 for details.

Table 3 to be inserted here.

Concurrent validity of MDAS

A high and significant correlation ($p < 0.001$) was found for Spearman correlation between MDAS, CES-D, and PHQ-9 across the four ethnic groups (Table 3).

Table 4 to be inserted here.

Confirmatory factor analysis across ethnic groups and genders

Using CFA to examine the dimensionality of MDAS, two models were fitted, and the model fit was compared. The hypothetical model fit for the four-factor corresponding to the four subscales and a hierarchical 5-factor model with four first-order factors of the subscales and a

second-order depression factor across ethnic groups and gender (Table 4 and Table 5). Both models were fitted to two genders regardless of culture and each ethnic group (Caucasian, Black, Hispanic, and Asian).

Similar model fit indices were found for both models for each group of the sample. A good model fit (CFI >0.9, TFI >0.9, RMSEA <0.07) was achieved for both the hypothetical four-factor model and the hierarchical model. The model fit indices showed a slightly better fit across genders than among ethnic groups. Both models were thus tested for measurement invariance across gender and ethnic groups.

Table 5 to be inserted here.

Measurement invariance

To test factor invariance across gender and the four ethnic groups the same two models were applied to all four subgroups and across the gender and ethnic groups in the sample. As shown in Table 5, for the four-factor model, we observed a change in the model fit of CFI < -0.01 (0.919–0.914) in the sequence of gradually more restrictive models, from the configural invariance (constrained for equal factor structure across ethnic groups) to the metric invariance (constrained for equal factor loadings), the scalar invariance (constrained for equal intercepts), and finally, the strict invariance (residual variance). We also found a change in the model fit of RMSEA <0.015 (0.057–0.058). Based on the results of MI, items within the same subfactor were covaried for error term (Item 6 and Item 11; Item 50 and Item 51; Item 38 and Item 41; Item 2 and Item 5). The same trend was observed across genders for the four-factor model. However, to test the scalar invariance across both ethnic groups and genders, the model would not converge. Hence, the scalar invariance of MDAS across both gender and ethnic groups for the hierarchical model was not supported (Table 5).

Table 6 to be inserted in here.

Discussion

The current study aimed to validate MDAS in four ethnic groups (Caucasian, Asian, Black/African, and Hispanic) and across genders in terms of its reliability, validity, factor structure, and measurement invariance. The rationale for the study stems from the noticeable difference in the prevalence of depression across ethnicities and genders and the cultural and gender differences in depression narratives from qualitative studies (Haroz et al., 2017). Developing a measurement-invariant scale with a comprehensive depressive symptom profile, especially an interpersonal subscale, has important clinical and research implications across ethnic and gender groups. In comparison to studies of ethnic groups recruited from a single country, the current study also has the advantage of focusing on ethnicity over the country effect by self-identification of ethnicity. The self-identification of ethnicity is coherent with the cultural heritage, language, social practice, traditions, and geopolitical factors with which individuals perceive themselves to be affiliated. A measure with self-identified ethnicity might be more accurate in comparing cultural groups, as self-identified ethnicity creates ethnic groups that are more homogeneous than country-level comparisons. Studies have found that self-report population descriptors (such as Caucasian, African American, Hispanic, and Asian) are usually correct in capturing their population origin (Mersha and Abebe, 2015).

Tang et al. (2005) also reported a high level of consistency between self-reported ethnicity and genetic cluster membership.

Consistent with previous studies on the psychometric properties of MDAS (Cheung et al., 2020a; Cheung et al., 2020b), a high Cronbach's alpha (>0.9) was replicated in the current multi-ethnic sample for the total MDAS and each subscale, with a high Spearman correlation observed with PHQ-9 and CES-D, pointing to good concurrent validity of the same clinical factors (Fava et al., 2012). This observation is likely because MDAS encompasses a more comprehensive list of symptoms that covers the items in PHQ-9 and CES-D (e.g. The 2-item social functioning subscale), thus resulting in a high correlation. The evidence supports the feasibility of MDAS as a measure to reflect depression severity based on its total score, with the added advantage of providing a more comprehensive assessment of depressive symptoms for further study of symptom patterns.

The resulting four-factor structure of the invariant scale addresses the debate on the dimensionality of depression, which has been increasingly recognised as multidimensional (Vares et al., 2015), originating from various aetiologies. In support of the multidimensionality structure, the present study validates MDAS, addressing the criticism of insufficient coverage of symptoms to measure the dimensionality of depression (Vares et al., 2015). This support for the interpersonal subscale is consistent with Horowitz et al. (1986) who highlighted the importance of assessing interpersonal difficulties in measuring depression by postulating the relationship between interpersonal processes and interpersonal symptoms in depression. In particular, depressive symptomatology is a complex cluster of subjective experiences with interrelated cognitive, affective, and interpersonal components. Interpersonal symptoms are therefore important for the cultural adaptation of depression measurements as cultural manifestations and expressions of depression in collectivistic populations (Baas et al., 2011).

The study is novel in that all configural, metric, scalar and strict invariances were found in a best-fit four-factor model, as shown in previous studies (Cheung et al., 2020; Darharaj et al., 2016, 2018), rather than a hypothetical five-factor hierarchical model for unidimensionality. The established strict invariance of the four-factor structure further addresses the prerequisite for the comparison of depression severity across groups by establishing an equivalent general four-factor structure, factor loadings, and intercepts. It provides evidence in support of measuring cultural-related depression using MDAS across genders and major ethnic groups worldwide. The results may suggest that for a large community sample with various degrees of depression severity across ethnic groups, MDAS could be a useful measure with subscales to indicate the symptom picture of each domain of depression. It also highlights the utility of assessing depression in all four domains, regardless of culture and gender. However, a unidimensional model is often advantageous, especially in the single diagnostic process that the total score of MDAS with a cut-off value (Alexandrowicz et al., 2018). Nevertheless, scholars such as Marsh et al. (2018), argued against always achieving scalar invariance by CFA, believing that it is an unachievable ideal and that meaningful mean-level comparison may still be possible with scalar non-invariance (McCrae, 2015). In fact, the scalar non-invariance could also indicate the actual group differences that we desire to see across cultures.

Nonetheless, this study has certain limitations that should be noted. First, the MDAS was validated on general adults over 18. While there is an age effect of depression (Habibi et al., 2014), future studies should compare MDAS with USDI and GDS to validate existing

symptoms while adding more age specific list of symptoms. This would help create a scale free of age and population bias. In addition, the factor structure could emerge differently across cultures. For example, Cheung et al. (2020) yielded a three-factor structure (affective, interpersonal, and somatic) rather than the hypothesized four-factor structure in a more collectivistic population of Inner Mongolia clinical patients. Further studies should explore the possible factor structures indicating various symptom pattern manifestation across cultures, gender and age groups for an extensive investigation into cultural, age and gender effects of depression.

In addition, the measurement invariance was established across gender regardless of cultures, rather than gender groups within each culture. This is in response to the general literature on gender differences of depression transcending culture. Future studies should consider how gender difference impacts measurement, and invariance could be established across gender within individual cultures and across different ages. Second, the study involved examining modification indices, and the correlated errors of the observed variables were added to yield a better model fit. While this is generally accepted in practice, there have also been counter-arguments against this approach (e.g. Hermida, 2015). However, in the current study, the correlated errors should arguably be allowed among items close in wording and meaning (Bollen and Lennox, 1991) and should fit into the framework of the theoretical model (Worrall, 2003) (e.g. decrease in social activity and social withdrawal). The findings also open up further investigation into reducing the number of items in the measure to create a more succinct scale for more efficient clinical use. Finally, completing the questionnaires in English might have led to a unified conceptualisation of depression. Acculturation and intercultural marriages could also impose challenges in identifying with a single ethnicity and cultural heritage. Future studies in the cultural effect of depression should include a more direct measure of cultural values. The current sample was also biased towards a higher socioeconomic status as a larger percentage of participants received university degrees and were currently employed. Subsequent studies should introduce greater sample variability to generate a more valid results that could be generalized to a wider population.

Conclusion

Based on a large sample, the current study validated MDAS across gender and four ethnic groups—Caucasian, Black, Asian, and Hispanic—by establishing its psychometric properties and measurement invariance. The key findings suggest that MDAS has good internal consistency and concurrent validity across gender and these ethnic groups, indicating its potential use in clinical settings.

References

- Abd-El-Fattah, S.M., 2010. Structural Equation Modeling with AMOS: Basic Concepts, Applications and Programming. *Journal of applied quantitative methods* 5, 365.
- Alexandrowicz, R.W., Jahn, R., Wancata, J., 2018. Assessing the dimensionality of the CES-D using multi-dimensional multi-level Rasch models. *PloS one* 13, e0197908-e0197908, 10.1371/journal.pone.0197908.
- American Psychiatric Association, 2013. *Diagnostic and statistical manual of mental disorders : DSM-5*, 5th ed. American Psychiatric Association, Arlington, VA.
- Baas, K.D., Cramer, A.O.J., Koeter, M.W.J., van de Lisdonk, E.H., van Weert, H.C., Schene, A.H., 2011. Measurement invariance with respect to ethnicity of the Patient Health

- Questionnaire-9 (PHQ-9). *Journal of Affective Disorders* 129, 229-235, <https://doi.org/10.1016/j.jad.2010.08.026>.
- Bailey, R.K., Mokonogho, J., Kumar, A., 2019. Racial and ethnic differences in depression: current perspectives. *Neuropsychiatr Dis Treat* 15, 603-609, 10.2147/NDT.S128584.
- Barrett, M.S., Barber, J.P., 2007. Interpersonal profiles in major depressive disorder. *Journal of Clinical Psychology* 63, 247-266, 10.1002/jclp.20346.
- Beard, C., Hsu, K.J., Rifkin, L.S., Busch, A.B., Björgvinsson, T., 2016. Validation of the PHQ-9 in a psychiatric sample. *Journal of Affective Disorders* 193, 267-273, <https://doi.org/10.1016/j.jad.2015.12.075>.
- Bogren, M., Brådvik, L., Holmstrand, C., Nöbbelin, L., Mattisson, C., 2018. Gender differences in subtypes of depression by first incidence and age of onset: a follow-up of the Lundby population. *European Archives of Psychiatry and Clinical Neuroscience* 268, 179-189, 10.1007/s00406-017-0778-x.
- Bollen, K., Lennox, R., 1991. Conventional Wisdom on Measurement: A Structural Equation Perspective. *Psychological bulletin* 110, 305-314, 10.1037/0033-2909.110.2.305.
- Browne, M.W., Cudeck, R., 1993. Alternative ways of assessing model fit. In: Bollen, K.A., Long, J.S. (Eds.), *Testing Structural Equation Models*. Sage, Newbury Park, CA, pp. 136-162.
- Chen, F.F., 2007. Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modelling* 14, 464-504.
- Chentsova-Dutton, Y.E., Ryder, A.G., Tsai, J., 2014. Understanding depression across cultural contexts, *Handbook of depression*, 3rd ed. Guilford Press, New York, NY, US, pp. 337-354.
- Cheung, G.W., Rensvold, R.B., 2002. Testing factorial invariance across groups: A reconceptualization and proposed new method. *J. Manage* 25, 1-27, 10.1016/S0149-2063(99)80001-4.
- Cheung, H.N., Chan, S.W.Y., Williams, J.M., 2020a. Validation of Chinese Multidimensional Depression Assessment Scale (MDAS) in Inner Mongolia pregnant women and risk factors of antenatal depression in Inner Mongolia in the era of one-child policy. *PLoS One* 15, e0227944, 10.1371/journal.pone.0227944.
- Cheung, H.N., Williams, J.M., Chan, S.W.Y., 2020b. A cultural validation of the Chinese version of multidimensional depression assessment scale (MDAS) in clinically depressed patients in Inner Mongolia. *CURR PSYCHOL*, 10.1007/s12144-020-01107-2.
- Coiro, M.J., Bettis, A.H., Compas, B.E., 2017. College students coping with interpersonal stress: Examining a control-based model of coping. *J Am Coll Health* 65, 177-186, 10.1080/07448481.2016.1266641.
- Darharaj, M., Habibi, M., Power, M.J., Farzadian, F., Rahimi, M., Kholghi, H., Kazemitabar, M., 2016. Inpatients with major depressive disorder: Psychometric properties of the new Multidimensional Depression Scale. *Asian journal of psychiatry* 24, 103-109, 10.1016/j.ajp.2016.08.018.
- Darharaj, M., Habibi, M., Power, M.J., Pirirani, S., Tehrani, F., 2018. Factor structure and psychometric properties of the new multidimensional depression scale in a non-clinical sample. *Clinical psychologist (Australian Psychological Society)* 22, 63-71, 10.1111/cp.12106.
- de Graaf, R., ten Have, M., Tuithof, M., van Dorsselaer, S., 2013. First-incidence of DSM-IV mood, anxiety and substance use disorders and its determinants: results from the Netherlands Mental Health Survey and Incidence Study-2. *J Affect Disord* 149, 100-107, 10.1016/j.jad.2013.01.009.

- Dunlop, D.D., Song, J., Lyons, J.S., Manheim, L.M., Chang, R.W., 2003. Racial/ethnic differences in rates of depression among preretirement adults. *American journal of public health* 93, 1945-1952, 10.2105/ajph.93.11.1945.
- Eid, R.S., Gobinath, A.R., Galea, L.A.M., 2019. Sex differences in depression: Insights from clinical and preclinical studies. *Progress in Neurobiology* 176, 86-102, <https://doi.org/10.1016/j.pneurobio.2019.01.006>.
- Eken, H.N., Dee, E.C., Powers, A.R., Jordan, A., 2021. Racial and ethnic differences in perception of provider cultural competence among patients with depression and anxiety symptoms: a retrospective, population-based, cross-sectional analysis. *Lancet Psychiatry* 8, 957-968, 10.1016/S2215-0366(21)00285-6. .
- Fabrega, H., 1996. Cultural and historical foundations of psychiatric diagnosis., In: Mezzich, J.E., Kleinman, A., Fabrega, H., Parron, D.L. (Eds.), *Culture and psychiatric diagnosis: A DSM-IV perspective* American Psychiatric Press, Inc., Washington, DC, pp. 3-14.
- Fava, G.A., Tomba, E., Sonino, N., 2012. Clinimetrics: the science of clinical measurements. *Int J Clin Pract* 66, 11-15, 10.1111/j.1742-1241.2011.02825.x
- Friedman, E.S., 2014. *Handbook of depression*, 3rd ed. London : Springer Healthcare.
- Gilbody, S., Richards, D., Brealey, S., Hewitt, C., 2007. Screening for Depression in Medical Settings with the Patient Health Questionnaire (PHQ): A Diagnostic Meta-Analysis. *Journal of General Internal Medicine* 22, 1596-1602, 10.1007/s11366-007-0333-y.
- Habibi, M., Khawaja, N.G., Moradi, S., Dehghani, M., Fadaei, Z., 2014. University Student Depression Inventory: Measurement model and psychometric properties. *Australian Journal of Psychology* 66, 149-157, 10.1111/ajpy.12037.
- Hames, J.L., Hagan, C.R., Joiner, T.E., 2013. Interpersonal Processes in Depression. *Annual Review of Clinical Psychology* 9, 355-377, doi:10.1146/annurev-clinpsy-050212-185553.
- Hansson, M., Chotai, J., Nordstöm, A., Lundlund, O., 2009. Comparison of two self-rating scales to detect depression: HADS and PHQ-9. *British Journal of General Practice* 59, e283, 10.3399/bjgp09X454070.
- Haroz, E.E., Ritchey, M., Bass, J.K., Kuehrt, B.A., Augustinavicius, J., Michalopoulos, L., Burkey, M.D., Bolton, P., 2017. How is depression experienced around the world? A systematic review of qualitative literature. *Social Science & Medicine* 183, 151-162, 10.1016/j.socscimed.2016.12.030.
- Horowitz, L.M., Vitkus, J., 1985. The interpersonal basis of psychiatric symptoms. *Clinical Psychology Review* 6, 443-469, 10.1016/0272-7358(86)90031-0.
- Ira, D., Suman, M., 2010. Effect of Depression upon Time Management of Undergraduate Students. *Journal of psychosocial research* 5, 291,
- Joiner, T.E., Coyne, J.C., 1999. The interactional nature of depression: advances in interpersonal approaches. American Psychological Association, Washington, DC.
- Khawaja, N.G., Bryden, K.J., 2006. The development and psychometric investigation of the university student depression inventory. *Journal of affective disorders* 96, 21-29, 10.1016/j.jad.2006.05.007.
- Khawaja, N.G., Santos, M.L.R., Habibi, M., Smith, R., 2013. University students' depression: a cross-cultural investigation. *Higher education research and development* 32, 392-406, 10.1080/07294360.2012.697129.
- Kline, R.B., 2010. *Principles and Practice of Structural Equation Modeling* (3rd ed.). Guilford Press, New York, NY.
- Kupferberg, A., Bicks, L., Hasler, G., 2016. Social functioning in major depressive disorder. *Neuroscience & Biobehavioral Reviews* 69, 313-332, 10.1016/j.neubiorev.2016.07.002.
- Levis, B., Benedetti, A., Thombs, B.D., 2019. Accuracy of Patient Health Questionnaire-9 (PHQ-9) for screening to detect major depression: individual participant data meta-analysis. *BMJ* 365, 11476, 10.1136/bmj.11476.

- Marsh, H.W., Guo, J., Parker, P.D., Nagengast, B., Asparouhov, T., Muthén, B., Dicke, T., 2018. What to do When Scalar Invariance Fails: The Extended Alignment Method for Multi-Group Factor Analysis Comparison of Latent Means Across Many Groups. *Psychological methods* 23, 524-545, 10.1037/met0000113.
- McCrae, R.R., 2015. A more nuanced view of reliability: specificity in the trait hierarchy. *Pers Soc Psychol Rev* 19, 97-112, 10.1177/1088868314541857.
- Meiser, S., Esser, G., 2017. Interpersonal Stress Generation—A Girl Problem? The Role of Depressive Symptoms, Dysfunctional Attitudes, and Gender in Early Adolescent Stress Generation. *The Journal of Early Adolescence* 39, 41-66, 10.1177/0272431617725197.
- Meiser, S., Esser, G., 2019. Interpersonal Stress Generation—A Girl Problem? The Role of Depressive Symptoms, Dysfunctional Attitudes, and Gender in Early Adolescent Stress Generation. *The Journal of early adolescence* 39, 41-66, 10.1177/0272431617725197.
- Mellenbergh, G.J., 1989. Item bias and item response theory. *International Journal of Educational Research* 13, 127-143, 10.1016/0883-0355(89)90002-5.
- Mersha, T.B., Abebe, T., 2015. Self-reported race/ethnicity in the age of genomic research: its potential impact on understanding health disparities. *Human Genomics* 9, 1, 10.1186/s40246-014-0023-x.
- Monroe, S.M., Anderson, S., 2015. Depression: The Shroud of Heterogeneity. *Current Directions In Psychological Science* 24, 227-231, 10.1177/0963721414568342.
- Nunnally, J.C., Bernstein, I.H., 1994. *Psychometric theory* (3rd ed.). McGraw-Hill, Inc, New York, NY.
- Pauszek, J.R., Szybel, P., Gibson, B.S., 2017. Evaluating Amazon's Mechanical Turk for psychological research on the symbolic control of attention. *Behavior Research Methods* 49, 1969-1983, 10.3758/s13428-016-0847-5.
- Radloff, L.S., 1977. The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement* 1, 385-401, 10.1177/014662167700100306.
- Renner, F., Jarrett, R.B., Vittengl, J.R., Parrett, M.S., Clark, L.A., Thase, M.E., 2012. Interpersonal problems as predictors of therapeutic alliance and symptom improvement in cognitive therapy for depression. *Journal of affective disorders* 138, 458-467, 10.1016/j.jad.2011.12.044.
- Rose-Clarke, K., Hassan, E., Bhattarai, P., Magar, J., Devakumar, D., Luitel, N.P., Verdeli, H., Kohrt, B.A., 2021. A cross-cultural interpersonal model of adolescent depression: A qualitative study in rural Nepal. *Social Science & Medicine* 270, 113623, 10.1016/j.socscimed.2020.113623.
- Rutkowski, L., Svetina, D., 2017. Measurement Invariance in International Surveys: Categorical Indicators and Fit Measure Performance. *Applied measurement in education* 30, 39-51, 10.1080/08957347.2016.1243540.
- Salk, R.H., Hyde, J.S., Abramson, L.Y., 2017. Gender Differences in Depression in Representative National Samples: Meta-Analyses of Diagnoses and Symptoms. *Psychological bulletin* 143, 783-822, 10.1037/bul0000102.
- Summerfield, D., 2012. Afterword: Against "global mental health". *Transcultural Psychiatry* 49, 519-530, 10.1177/1363461512454701.
- Van De Schoot, R., Schmidt, P., De Beuckelaer, A., Lek, K., Zondervan-Zwijnenburg, M., 2015. Editorial: Measurement Invariance. *Frontiers in Psychology* 6, 10.3389/fpsyg.2015.01064.
- Vares, E.A., Salum, G.A., Spanemberg, L., Caldieraro, M.A., Fleck, M.P., 2015. Depression Dimensions: Integrating Clinical Signs and Symptoms from the Perspectives of Clinicians and Patients. *PLoS One* 10, e0136037-e0136037, 10.1371/journal.pone.0136037.

- Vilagut, G., Forero, C.G., Barbaglia, G., Alonso, J., 2016. Screening for Depression in the General Population with the Center for Epidemiologic Studies Depression (CES-D): A Systematic Review with Meta-Analysis. *PLoS One* 11, e0155431, 10.1371/journal.pone.0155431.
- Vredenburg, K., O'Brien, E., Krames, L., 1988. Depression in College Students: Personality and Experiential Factors. *Journal of counseling psychology* 35, 419-425, 10.1037/0022-0167.35.4.419.
- Widaman, K.F., Reise, S.P., 1997. Exploring the measurement invariance of psychological instruments: Applications in the substance use domain, In: Bryant, K.J., Windle, M., West, S.G. (Eds.), *The science of prevention: Methodological advances from alcohol and substance abuse research*. American Psychological Association., pp. 281–324.
- Wong, R., 2009. *Depression in Chinese American Immigrant Adults: An Exploration of Culturally Based Manifestations, Structure, and Measurement*, Department of Social Welfare. UC Berkeley, U.S.A, p. 173.
- Wong, R., Wu, R., Guo, C., Lam, J.K., Snowden, L.R., 2012. Culturally sensitive depression assessment for Chinese American Immigrants: Development of a comprehensive measure and a screening scale using an item response approach. *Asian American Journal of Psychology* 3, 230-253, 10.1037/a0025628.
- World Health Organization (WHO), 2017. *Depression fact sheet*.
- Worrall, J., 2003. Normal science and dogmatism, paradigms and progress: Kuhn 'versus' Popper and Lakatos, In: Nickles, T. (Ed.), *Thomas Kuhn*. Cambridge, New York, NY.
- Zhao, H., He, J., Yi, J., Yao, S., 2019. Factor Structure and Measurement Invariance Across Gender Groups of the 15-Item Geriatric Depression Scale Among Chinese Elders. *Frontiers in Psychology* 10, 10.3389/fpsyg.2019.01260.

Table 1. Validation of MDAS across countries.

Studies	Sample size	Sample	Country	Factor structure
Cheung et al. (2020a)	N= 234	Community pregnant	China	4
Cheung and Power (2012)	N= 87	Community	UK	4
Cheung et al. (2020c)	N= 171	Clinical	China	3-factor model-affective, interpersonal, and somatic
Darharaj et al. (2016)	N= 271	Clinical, Iran	Iran	4
Darharaj et al. (2018)	N= 559	Community, Iran	Iran	4

Table 2. Cronbach's alpha of MDAS, CESD, and PHQ across ethnic groups.

Cronbach's alpha	Caucasian (n = 795)	Asian (n = 1316)	Black/African (n=707)	Hispanic (n=660)
Total score MDAS	.989	.986	.936	.987
Emotional subscale MDAS	0.959	0.952	0.952	0.951
Cognitive subscale MDAS	0.970	0.964	0.962	0.965
Somatic subscale MDAS	0.951	0.935	0.943	0.942
Interpersonal subscale MDAS	0.960	0.958	0.955	0.956
CESD	.916	.892	.909	.906
PHQ	.926	.925	.922	.927

Table 3. Descriptive statistics of four ethnic groups.

Variables	Caucasian (n=795)	Asian (n =1316) n (%)	Black/African (n=707) n (%)	Hispanic (n=660) n (%)
Age				
15-19	2 (0.3)	94 (7.1)	75 (10.6)	69 (10.5)
20-29	214 (26.9)	363 (27.6)	260 (36.8)	239 (36.2)
30-39	268 (33.7)	416 (31.6)	153 (21.6)	174 (26.4)
40-49	154 (19.3)	212 (16.1)	100 (14.1)	95 (14.4)
50-59	103 (13.0)	118 (9.0)	74 (10.5)	60 (9.1)
60-69	49 (6.2)	84 (6.4)	39 (5.5)	19 (2.9)
70-79	5 (0.6)	21 (1.6)	5 (0.7)	4 (0.6)
80-85	0 (0.0)	5 (0.4)	1 (0.0)	0 (0.0)
Over 85	0 (0.0)	3 (0.2)	0 (0.0)	0 (0.0)
Gender				
Female	444 (55.8)	862 (65.5)	468 (66.2)	438 (66.4)
Male	351 (44.2)	454(34.5)	239 (33.8)	222 (33.6)
Highest education attainment				
Primary School	20 (2.5)	42 (3.2)	79 (11.2)	51 (7.7)
Secondary Education	83 (10.4)	143 (10.9)	181 (25.6)	182 (27.6)
Post-secondary non-tertiary education	106 (13.3)	171 (13.0)	135 (19.1)	134 (20.3)

Bachelor or equivalent	438 (55.1)	662 (50.3)	198 (28.0)	210 (31.8)
Master or equivalent	131(16.5)	224 (17.0)	78 (11.0)	51 (7.7)
Doctoral or Equivalent	17 (2.1)	63 (4.8)	12 (1.7)	14 (2.1)
Have not attained any formal education	0 (0.0)	11 (0.8)	24 (3.4)	18 (2.7)
Employment status				
Full-time employment	624 (78.5)	679 (51.6)	305 (43.1)	297 (45)
Part-time employment	81 (10.2)	169 (12.8)	116 (16.4)	105 (15.9)
Unemployed	39 (4.9)	177 (13.4)	130 (18.4)	136 (20.6)
Student	9 (1.1)	177 (13.4)	78 (11.0)	87 (13.2)
Retired	19 (2.4)	70 (5.3)	48 (6.8)	18 (2.7)
Others	23 (2.9)	44 (3.3)	30 (4.2)	17 (2.6)
Marital Status				
Single	256 (32.2)	587 (44.6)	443 (62.7)	360(54.5)
Married	476 (59.9)	661 (50.2)	191 (27.0)	246 (37.3)
Divorced	50 (6.3)	44 (3.3)	37 (5.2)	13 (4.4)
Widowed	9 (1.1)	15 (1.1)	26 (3.7)	12 (2.0)
Separated	4 (0.5)	9 (0.7)	10 (1.4)	0 (0.0)
History of mental disorders				
Yes	196 (24.7)	183 (13.9)	99 (12.7)	140 (21.2)
No	599 (75.3)	1133 (86.1)	617 (87.3)	520 (78.8)

Table 4. Spearman correlation of MDAS and CES-D, PHQ across ethnic groups.

Scale	Ethnic Groups			
	Caucasian	Asian	Black/African	Hispanic
MDAS vs CESD	.918**	.809**	.785**	.814**
MDAS vs PHQ	.934**	.845**	.838**	.867**

** Correlation significance at $p < 0.001$

Table 5. CFA across ethnic groups and genders

	CFI	TLI	RMSEA (90% CI)	χ^2	df	P_{χ^2}
CFA across ethnic groups						
Four-factor model						
White	0.911	0.907	0.063 (0.060-0.065)	4052.478	1264	0.000
Black	0.929	0.926	0.051 (0.049-0.054)	2741.093	1264	0.000
Hispanic	0.921	0.917	0.055 (0.053-0.058)	3074.512	1264	0.000
Asian	0.918	0.914	0.056 (0.054-0.058)	4631.196	1264	0.000
Hierarchical five-factor model						
White	0.911	0.907	0.063 (0.061-0.065)	4074.271	1266	0.000
Black	0.929	0.926	0.051 (0.049-0.054)	2751.436	1266	0.000

Hispanic	0.919	0.915	0.056 (0.053-0.058)	3104.320	1266	0.000
Asian	0.918	0.914	0.056 (0.055-0.058)	4641.091	1266	0.000
CFA across gender						
Four Factor Model						
Female	0.927	0.924	0.053 (0.052-0.054)	6357.519	1264	0.000
Male	0.923	0.919	0.056 (0.055-0.058)	4513.682	1264	0.000
Hierarchical five-factor model						
Female	0.927	0.923	0.053 (0.052-0.054)	6393.080	1266	0.000
Male	0.922	0.918	0.057 (0.055-0.059)	4551.685	1266	0.000

Error covariance freed in the model: Item 6 and Item 11; Item 50 and Item 51; Item 38 and Item 41; Item 2 and Item 5.

Table 6. Measurement invariance of MDAS by multi-group CFA across ethnic groups and gender.

	CFI	TFI	RMSEA (90% CI)	χ^2	df	P_{χ^2}	Δ CFI	Δ RMSEA
Measurement invariance across ethnic groups								
Four-factor model								
Configural	0.919	0.915	0.057 (0.055-0.058)	14500.198	5056	0.000	-	-
Metric	0.917	0.916	0.055 (0.055-0.057)	14931.350	5200	0.000	-0.001	-0.001
Scalar	0.914	0.915	0.057 (0.056-0.058)	15512.634	5344	0.000	-0.003	0.001
Strict	0.908	0.911	0.058 (0.057-0.059)	16425.312	5500	0.000	-0.006	0.001
Hierarchical five-factor model								
Configural	0.918	0.915	0.057 (0.056-0.058)	14570.679	5064	0.000	-	-
Metric	0.917	0.915	0.055 (0.055-0.058)	15031.054	5217	0.000	-0.001	-0.002
Scalar	-	-	-	-	-	-	-	-
Measurement invariance across gender								
Four-factor model								
Configural	0.926	0.922	0.054 (0.053-0.055)	10847.483	2528	0.000	-	-

Metric	0.925	0.923	0.054 (0.053- 0.055)	10969.540	2576	0.000	-0.001	0
Scalar	0.925	0.924	0.053 (0.052- 0.054)	11105.442	2624	0.000	0	-0.001
Strict	0.924	0.925	0.053 (0.052- 0.054)	11257.636	2676	0.000	-0.001	0
Hierarchical five-factor model								
Configural	0.925	0.921	0.054 (0.053- 0.055)	10921.120	2532	0.000	-	-
Metric	0.925	0.923	0.054 (0.053- 0.055)	11053.903	2583	0.000	-0.001	-0.002
Scalar	-	-	-	-	-	-	-	-

Error covariance freed in the model: Item 6 and Item 11; Item 50 and item 51; Item 38 and Item 41; Item 2 and Item 5.

Author statement

Contributions

Dr H N Cheung-lead author, PI of the project for current study, design the project, data collection, data analysis, first draft, revision.

Dr. Jo. Williams-coauthor, Co-I of the project for current study, revision.

Dr. Stella Chan- coauthor, Co-I of the project for current study, revision

Ms. S.S Chan-coauthor, data collection, references.

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Data and Code Availability

The data and code is available upon request. Please contact the corresponding author at cheunghn@ouhk.edu.hk.

Compliance with Ethical Standards

Ethics approval from the Hong Kong Metropolitan University was granted prior to the launch of the project.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the study and publication of this paper.

Consent to participants

Written informed consent was obtained from all participants.

Consent for publication

Participants' identity remains anonymous for publication and the consent was sought when participants provided consent to the study.

Statement of conflict of interest

The current study has no conflict of interest with any parties.

Journal Pre-proof

Highlights:

- Good Psychometric properties of Multidimensional depression assessment scale (MDAS)
- Strict measurement invariance of a four-factor structure
- Measurement invariant across gender and four ethnic groups in the world
- Support cross-cultural comparison of depression severity using MDAS.

Journal Pre-proof