ORIGINAL RESEARCH

Factor Structure and Measurement Invariance of the Hospital Anxiety and Depression Scale Across the Peripartum Period Among Pregnant Japanese Women

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Purpose: The Hospital Anxiety and Depression Scale (HADS) is a self-report questionnaire widely used to assess anxiety and depression. To the best of our knowledge, only four studies have examined the factor structure of the HADS for assessing pregnant women, with conflicting results. This study aimed to assess the factor structure and measurement invariance of the HADS for use with pregnant Japanese women.

Participants and Methods: A total of 936 pregnant Japanese women completed the HADS questionnaire at three time points: the first and third trimester of pregnancy, and postpartum. We examined the factor structure of the HADS in Group 1 (n = 466) using exploratory factor analysis (EFA). We then compared the models identified in Group 1 with those from previous studies using confirmatory factor analysis (CFA) in Group 2 (n = 470). We performed multiple-group CFA for Group 2 to test the measurement invariance of the best-fit model across the three time points.

Results: The EFA for the Group 1 data at the three time points revealed a two-factor model. In the CFA, the two-factor model from Group 1 showed the best fit with the data at the three time points. In the multiple-group CFA for Group 2, we confirmed the configural and metric invariance of the two-factor model across the three time points.

Conclusion: Our findings provide evidence for a two-factor structure and weak measurement invariance of the HADS in pregnant Japanese women during the peripartum period.

Keywords: confirmatory factor analysis, exploratory factor analysis, Hospital Anxiety and Depression Scale

Introduction

The Hospital Anxiety and Depression Scale (HADS) is a 14-item self-report questionnaire that was designed to assess anxiety and depression at non-psychiatric hospital clinics.[1] The HADS contains anxiety and depression subscales, each consisting of seven items. This scale is used worldwide in several clinical and research settings.[2] Numerous studies have examined the factor structure of the HADS in various ethnic populations such as Chinese,[3] Dutch,[4] and German[2] participants with several thousand samples. However, these studies have produced conflicting results.[2–7] Inconsistencies among studies may stem from differences in the study population (eg non-clinical individuals and cancer patients), ethnicity (eg Chinese, Dutch, and German) and method (eg exploratory factor analysis [EFA]

and confirmatory factor analysis [CFA]). Therefore, the factor structure of the HADS should be identified individually for each population and ethnicity using both EFA and CFA with independent datasets.

The HADS has been widely used in pregnant women to identify peripartum anxiety and depression.[8–20] To the best of our knowledge, four studies have examined the factor structure of the HADS for pregnant women.[11,12,16,20] Karimova and Martin[12] conducted an EFA in British and Uzbek women (n = each 50) when they were 12- and 34-weeks pregnant. They found that the factor structures varied between British and Uzbek women as well as between the two time points. Jomeen and Martin[11] performed both EFA and CFA with the same dataset of 101 pregnant British women. However, no models showed a good fit with the data in the CFA. Waqas et al[20] found a one-factor structure using both EFA and CFA with the same dataset of 500 pregnant Pakistani women. Lodhi et al[16] reported that EFA of 200 pregnant Pakistani women resulted in an ambiguous two-factor structure. These inconsistencies indicate that further studies are required to determine the factor structure of the HADS in pregnant women. Further, while some studies conducted HADS twice during the peripartum period,[12,13,15,18] no studies have tested the measurement invariance of the HADS across the peripartum period.

The factor structure of the HADS has been examined in Japanese populations of cancer patients, psychiatric outpatients, and undergraduate students. Kugaya et al[21] supported the original two-factor structure (anxiety and depression subscales)[1] using CFA in 128 cancer patients. Matsudaira et al[22] identified a two-factor structure where two items had dual loadings using both EFA and CFA in the combined data from 408 psychiatric outpatients and 1069 undergraduate students. However, the factor structure of the HADS in pregnant Japanese women has not been determined.

To identify the factor structure of the HADS, it is necessary to use both EFA and CFA with independent datasets. Further, to validate the measurement invariance of the HADS across the peripartum period, a multiple-group CFA is required. Here, we performed EFA, CFA, and multiple-group CFA among 936 pregnant Japanese women at three time points: the first and third trimester of pregnancy, and postpartum.

Paticipants and Methods
Ethics Statement
This study followed the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Niigata University (approval number: 2016–0019) and the ethics committees of the participating obstetric institutions. Written informed consent was obtained from all participants.

Participants
This study is part of the Perinatal Mental Health Research Project[23,24] and comprises a sub-analysis of data collected between March 2017 and March 2020. Participants were 936 pregnant Japanese women, recruited from 34 obstetric institutions in Niigata Prefecture.[23,24] Each participant was randomly assigned to Group 1 (n = 466) or 2 (n = 470) for EFA and CFA, respectively.

Measurements
The HADS is a 14-item self-report questionnaire.[1] Each item is graded on a 4-point Likert scale (0–3 points) and items 1, 3, 5, 6, 8, 10, 11, and 13 are reverse-scored. Anxiety and depression subscales consist of odd and even numbered items, respectively. Higher HADS scores indicate more severe symptoms. The Japanese version of the HADS[25] was validated in a previous study.[21] Participants in the present study completed the HADS questionnaire at three time points: the first trimester (approximately 12–15 weeks) and third trimester (approximately 30–34 weeks) of pregnancy and postpartum (4 weeks after childbirth).

Statistical Analysis
We examined the factor structure of the HADS in Group 1 using an EFA within Statistical Package for the Social Sciences (SPSS) v25.0 (IBM Japan, Tokyo, Japan). We determined the number of factors from a scree plot. We used the maximum likelihood method and the promax rotation for the EFA. We considered items with factor loadings greater than 0.35 in a particular factor to belong to that factor. Cronbach's α was employed to evaluate internal consistency. Cronbach's α ≥0.80 and ≥0.70 showed good and acceptable internal consistency, respectively.

We compared four models in Group 2 using a CFA within Analysis of Moments Structures (AMOS) v25.0.0 (IBM Japan, Tokyo, Japan). The four models were: the two-factor model from Zigmond and Snaith,[1] the two-factor model from Matsudaira et al[22], the one-factor model from Waqas et al[20], and the two-factor model identified by the EFA of data from Group 1. We assessed the fit of each model to the data using the comparative fit index

(CFI) and the root mean square error of approximation (RMSEA). A good fit was indicated by CFI ≥ 0.95 and RMSEA ≤ 0.05, whereas an acceptable fit was indicated by CFI ≥ 0.90 and RMSEA ≤ 0.10. Akaike's Information Criterion (AIC) and a chi-square, normalized by degrees of freedom (chi-squared/*df*), were also used to measure the goodness of fit. Lower AIC and chi-squared/*df* values indicate a better fit.

We performed a multiple-group CFA on the data from Group 2 to test the measurement invariance of the best-fit model across the three time points. We subsequently tested the configural, metric, and scalar invariance. A change in CFI (ΔCFI) ≤0.01 for two nested models was considered to confirm measurement invariance.

Results

Groups 1 and 2 were age-matched (mean age ± SD: 31.1 ± 4.7 and 31.2 ± 5.1 years, respectively). There were no significant differences in the mean total, anxiety, and depression HADS scores between Groups 1 and 2 at the three time points (Table 1).

First, we performed an EFA for the 466 participants in Group 1 (Table 2). Cronbach's α for the 14-item HADS was 0.786, 0.809, and 0.833 in the first trimester, third trimester, and postpartum, respectively. A scree plot suggested two

Table 1 HADS Total, Anxiety, and Depression Scores in Groups 1 and 2

HADS	**Group 1** (n = 466)	**Group 2** (n = 470)	*p*
First trimester			
Total	12.6 ± 5.8	12.3 ± 5.6	0.416
Anxiety	6.5 ± 3.6	6.1 ± 3.4	0.097
Depression	6.2 ± 3.2	6.2 ± 3.2	0.791
Third trimester			
Total	11.6 ± 5.7	11.5 ± 5.6	0.681
Anxiety	5.8 ± 3.5	5.7 ± 3.4	0.684
Depression	5.8 ± 3.0	5.8 ± 3.1	0.882
Postpartum			
Total	11.7 ± 6.8	11.4 ± 6.2	0.489
Anxiety	5.4 ± 4.0	5.3 ± 3.8	0.592
Depression	6.3 ± 3.6	6.2 ± 3.3	0.567

Note: Data are shown as the mean ± SD.
Abbreviation: HADS, Hospital Anxiety and Depression Scale.

factors, with an eigenvalue greater than 1. Factor 1 included seven items (1, 3, 5, 8, 9, 11, and 13), with the exception of item 8 in the first trimester. This factor explained 0.182, 0.196, and 0.233 of the total variance in the first trimester, third trimester, and postpartum, respectively. Cronbach's α for the seven items of Factor 1 was 0.778, 0.774, and 0.830 at the three time points, respectively. Factor 2 included seven

Table 2 Exploratory Factor Analysis of HADS in Group 1

Item	First Trimester (Approximately 12–15 Weeks)		Third Trimester (Approximately 30–34 Weeks)		Postpartum (4 Weeks After Childbirth)	
	Factor 1	**Factor 2**	**Factor 1**	**Factor 2**	**Factor 1**	**Factor 2**
1	**0.638**	0.050	**0.636**	0.040	**0.674**	0.095
2	−0.253	**0.465**	−0.226	**0.543**	−0.071	**0.474**
3	**0.767**	−0.159	**0.625**	−0.069	**0.769**	−0.077
4	0.218	**0.498**	0.174	**0.449**	0.205	**0.539**
5	**0.658**	0.037	**0.666**	0.040	**0.689**	0.032
6	0.142	**0.402**	0.174	**0.368**	0.111	**0.500**
7	−0.003	**0.478**	0.015	**0.565**	0.027	**0.563**
8	0.288	0.193	**0.366**	0.041	**0.457**	0.029
9	**0.458**	−0.094	**0.515**	−0.099	**0.471**	0.021
10	0.052	**0.454**	0.158	0.290	0.096	**0.370**
11	**0.485**	0.130	**0.523**	0.130	**0.573**	0.069
12	0.010	**0.627**	0.021	**0.568**	0.032	**0.586**
13	**0.742**	−0.011	**0.755**	−0.069	**0.867**	−0.076
14	−0.070	**0.700**	−0.037	**0.738**	−0.120	**0.811**
Explained variance	0.182	0.151	0.196	0.162	0.233	0.191
Cronbach's α	0.778	0.724	0.774	0.719	0.830	0.769

Note: Boldface indicates loadings with absolute value of 0.35 or more.
Abbreviation: HADS, Hospital Anxiety and Depression Scale.

Table 3 Confirmatory Factor Analysis of HADS in Group 2

Indicator	Model			
	Zigmond and Snaith[1]	**Matsudaira et al[22]**	**Waqas et al[20]**	**Current Study**
Factor structure				
Factor 1	1, 3, 5, 7, 9, 11 and 13	1, 3, 5, 6, 7, 9, 11 and 13	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12 and 13	1, 3, 5, 8, 9, 11 and 13
Factor 2	2, 4, 6, 8, 10, 12 and 14	2, 4, 6, 7, 8, 10, 12 and 14	–	2, 4, 6, 7, 10, 12 and 14
First trimester				
Chi-squared/*df*	441.049/76	292.903/74	512.4 83/54	165.635/76
CFI	0.853	0.919	0.774	0.935
RMSEA	0.075	0.056	0.095	0.050
AIC	335.739	246.744	560.483	223.635
Third trimester				
Chi-squared/*df*	443.868/76	274.806/74	470.933/54	170.186/76
CFI	0.865	0.926	0.804	0.940
RMSEA	0.077	0.058	0.091	0.051
AIC	346.281	252.202	518.933	228.186
Postpartum				
Chi-squared/*df*	362.644/76	256.445/74	451.199/54	115.135/76
CFI	0.931	0.963	0.862	0.976
RMSEA	0.056	0.042	0.088	0.033
AIC	247.632	196.97	491.821	173.135

Abbreviations: AIC, Akaike's information criterion; CFI, comparative fit index; HADS, Hospital Anxiety and Depression Scale; RMSEA, root mean square error of approximation.

items (2, 4, 6, 7, 10, 12, and 14), with the exception of item 10 in the third trimester. This factor explained 0.151, 0.162, and 0.191 of the total variance in the first trimester, third trimester, and postpartum, respectively. Cronbach's α for the seven items of Factor 2 was 0.724, 0.719, and 0.769 at the three time points, respectively.

Second, we performed a CFA to compare the four models in Group 2 (Table 3). The two-factor model identified in Group 1 showed the best fit with the data. In the first trimester, CFI (0.935) showed an acceptable fit, whereas RMSEA (0.050) showed a good fit. In the third trimester, CFI (0.940) and RMSEA (0.051) showed acceptable fits. In the postpartum period, CFI (0.976) and RMSEA (0.033) showed good fits.

Third, we performed a multiple-group CFA in Group 2 to assess the measurement invariance of our two-factor model across the peripartum period (Table 4). In the configural invariance model, CFI (0.952) and RMSEA (0.026) showed good fits. In the metric invariance model, CFI (0.943) showed an acceptable fit, whereas RMSEA (0.027) showed a good fit. Metric invariance was confirmed (ΔCFI = 0.009). In the scalar invariance model, CFI (0.903) showed an acceptable fit, whereas RMSEA (0.034) showed a good fit. However, scalar invariance was not confirmed (ΔCFI = 0.040). In the metric

invariance model, all items had loadings $\geq$0.35 on a latent factor, with the exception of item 8 (Figure 1). The latent factors were correlated (r = 0.43).

Discussion

In the present study, EFA and CFA confirmed the two-factor structure of the HADS in 936 pregnant Japanese women at three time points: first trimester (approximately 12–15 weeks), third trimester (approximately 30–34 weeks), and postpartum (4 weeks after childbirth). Multiple-group CFA confirmed the configural and metric invariance of the two-factor model across the three time points, indicating weak measurement invariance. Factors 1 and 2 are regarded as anxiety and depression, respectively,

Table 4 Multiple-Group Confirmatory Factor Analysis of HADS in Group 2

Model	Chi-Squared/*df*	CFI	RMSEA	AIC
Configural invariance	450.956/228	0.952	0.026	708.956
Metric invariance	513.204/252	0.943	0.027	723.204
Scalar invariance	726.552/280	0.903	0.034	880.552

Abbreviations: AIC, Akaike's information criterion; CFI, comparative fit index; HADS, Hospital Anxiety and Depression Scale; RMSEA, root mean square error of approximation.
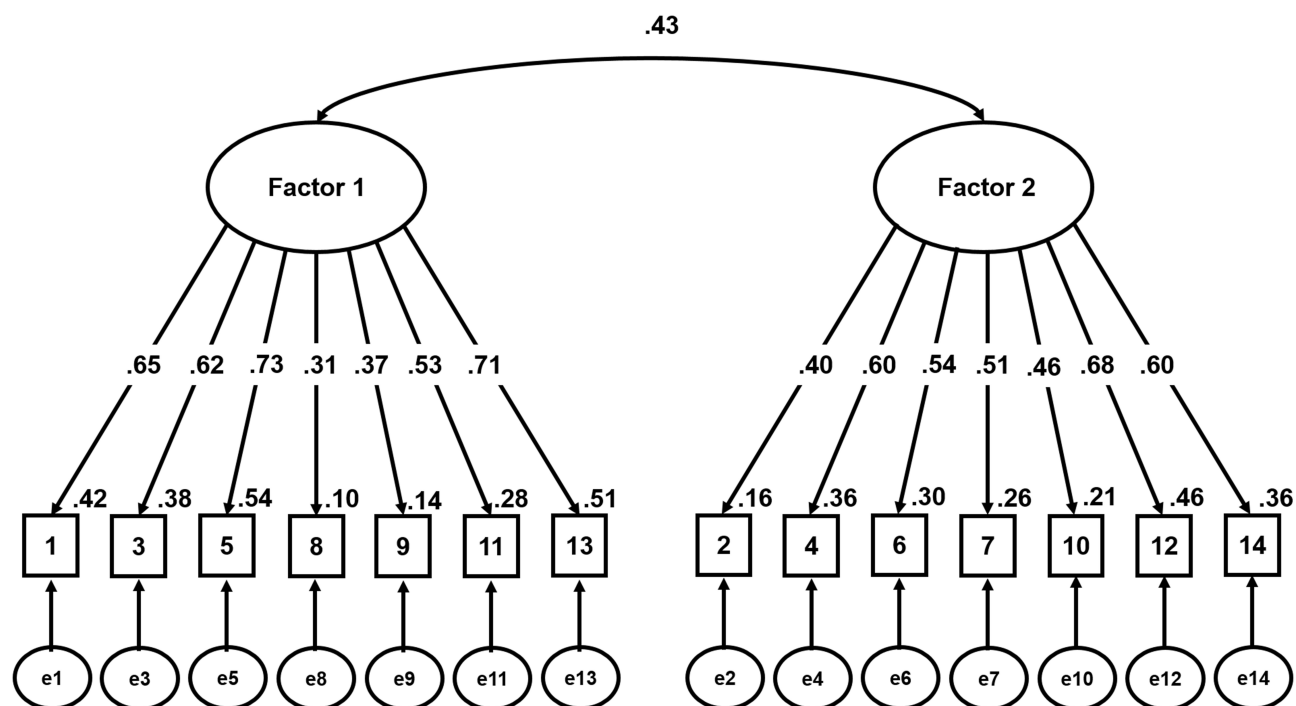
Figure 1 Path diagram of the Hospital Anxiety and Depression Scale. A multiple-group confirmatory factor analysis confirmed metric invariance of the two-factor model across the first trimester, third trimester, and postpartum period in 470 participants in Group 2. The values shown are standardized coefficients.

with a moderate correlation. We observed good or acceptable internal consistency of the 14 HADS items: seven for Factor 1 and seven for Factor 2.

We used EFA and CFA to identify the two-factor structure of the HADS in 936 pregnant Japanese women across the peripartum period. Karimova and Martin[12] performed an EFA of British and Uzbek women (n = each 50) when they were 12- and 34-weeks pregnant. In the British women, five- and two-factor structures were identified at the two time points, whereas two- and three-factor structures were found in the Uzbek women. Karimova and Martin claimed that the HADS was inappropriate for assessing pregnant women; however, their sample size was insufficient to conduct an EFA. Therefore, no definitive conclusion can be drawn from their study. Jomeen and Martin[11] performed both EFA and CFA with the same dataset of 101 pregnant British women. While EFA revealed a three-factor structure, none of eight models tested using CFA exhibited a good fit with the data. Waqas et al[20] performed both EFA and CFA with the same dataset of 500 pregnant Pakistani women. EFA showed a one-factor structure to be more interpretable than a two-factor structure, while CFA showed a one-factor structure, excluding items 11 and 14, to have a good fit (CFI = 0.95 and RMSEA =

0.05). Lodhi et al[16] performed an EFA of 200 pregnant Pakistani women. They identified a two-factor structure where items 3, 6, 7, and 13 had dual loadings while item 14 did not belong to either factor with a low factor loading. Therefore, the two-factor model seems to be inappropriate. Differences in ethnicity are likely to explain the inconsistent findings among studies. Further studies should be carried out in various ethnic populations.

To the best of our knowledge, this is the first study to confirm the factor structure of the HADS in pregnant Japanese women. In our two-factor structure, items 7 (an anxiety item) and 8 (a depression item) loaded on Factor 2 (depression) and Factor 1 (anxiety), respectively. Kugaya et al[21] supported the original two-factor structure (ie anxiety and depression subscales consisting of odd and even number items, respectively) using CFA in 128 cancer patients. Matsudaira et al[22] performed EFA and CFA in 739 and 738 datasets, respectively, from the combined data of 408 psychiatric outpatients and 1069 undergraduate students. They identified the two-factor structure where items 6 and 7 had dual loadings. Taken together, these findings indicate that the HADS has a two-factor structure of anxiety and depression in the Japanese population, although the items constituting the two factors are not

necessarily the same among studies. Of note, item 7 ("I can sit at ease and feel relaxed") loaded as a depression factor in 20 of 36 studies using EFA.[6] This anomalous factor loading may stem from the ambiguous wording of item 7.[22]

A major strength of this study is that the factor structure of the HADS was identified by EFA in a randomly selected group comprising half of the participants (Group 1; n = 466) and cross-validated using CFA in the other half (Group 2; n = 470). We also recognize the limitations of this study. First, the multiple-group CFA confirmed the configural and metric invariance of the HADS across the peripartum period, indicating weak but not strong measurement invariance. Second, participants were recruited from 34 obstetric institutions in Niigata Prefecture, Japan. However, the study population may not be representative of the general population of pregnant Japanese women. Further studies should be performed in a larger sample of pregnant Japanese women to confirm our findings.

Conclusion

Our findings provide evidence for a two-factor structure and weak measurement invariance of the HADS in pregnant Japanese women across the peripartum period.

Abbreviations

AIC, Akaike's information criterion; CFA, confirmatory factor analysis; CFI, comparative fit index; EFA, exploratory factor analysis; HADS, Hospital Anxiety and Depression Scale; RMSEA, root mean square error of approximation.

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Disclosure

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