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HADS dimensionality in IHD patients

**Revisiting the dimensionality of the Hospital Anxiety and Depression Scale in an
international sample of patients with Ischaemic Heart Disease**

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Abstract

Objective: Recently controversy has surrounded the dimensionality of the Hospital Anxiety and Depression Scale (HADS). We assessed the dimensionality of the HADS in a large international sample of patients with ischaemic heart disease (IHD) using confirmatory factor analysis (**CFA**). The analysis of an international sample enabled the current study to **broaden** knowledge gained from existing studies with small, regional samples.

Methods: Data from the HeartQoL study of patients with IHD (n=6,241, 22 countries speaking 15 languages) were analysed using **CFA**.

Results: CFA **indicated** a hierarchical bifactor solution, with mostly strong item loadings on a general factor (**explaining** 73% of the variance), and weak to very weak loadings on orthogonal depression (16%) and anxiety (11%) subscales. The bifactor model fit the data significantly better than both the original bidimensional model and Dunbar's higher-order three-factor model.

Conclusion: These results, from a large international sample of patients with IHD, suggest that the HADS scale is dominated by a single general distress factor. Although the best CFA model fit was a hierarchical bifactor solution, the subscales had weak item loadings, providing little psychometric evidence of the ability of the HADS to differentiate anxiety and depressive symptoms. **It is argued that** clinicians and researchers working with patients with IHD should abandon the HADS and use alternative measures of depression and anxiety.

Keywords: Dimensionality, Hospital Anxiety and Depression Scale, Ischaemic Heart Disease, Confirmatory factor analysis

INTRODUCTION

Studies involving post-myocardial infarction patients have shown that 20% have major depression (1), while Frasure-Smith et al. have established a prevalence of 5.3% for Generalised Anxiety Disorder (GAD) in patients with stable coronary artery disease (2). The relevance of the presence of anxiety and depression in cardiac patients has repeatedly been shown in systematic reviews; both are associated with higher death rates and poorer prognoses in general in cardiovascular disease (3-5).

Zigmond and Snaith originally developed the **Hospital Anxiety and Depression Scale (HADS)** in order to assess anxiety and depression in a medical setting without potential confounding from physical symptoms (6). It has since been used prolifically in clinical and research settings (7). More recently, however, the HADS has been shown to have poor content validity. The exclusion of somatic items, use of colloquial British expressions (**such as “‘butterflies’ in the stomach”**), and emphasis on anhedonia mean **that** the assessed symptoms do not accurately reflect the diagnostic criteria for major depressive disorder or **GAD** (8-10). Doyle et al. **found** that only 4 of 13 diagnostic symptoms for major depression were assessed by the depression subscale (9). Maters et al. further demonstrated that the colloquial British expressions used mean **that** translation of the HADS is problematic, and that several different versions of the HADS can exist in one language leading to interpretation issues (10).

Previous reviews of the literature support the psychometric validity of the HADS as a bidimensional questionnaire for assessing separate factors of anxiety and depression (7, 11), and a recent meta-analysis demonstrated adequate case-finding ability for the depression and anxiety subscales (12). However, controversy has arisen regarding the scale's purported

bidimensional structure and the ability of the HADS to distinguish anxiety and depression in both cardiac and other populations.

Cosco et al. recently reviewed analyses of the structure of the HADS and found that only half of the included studies reported two-factor structures (13). Even among these, the majority featured anomalous factor loadings, **for example**, depression items loading on the anxiety factor. The authors found heterogeneous factor structures within and across a variety of sample populations including cardiac, cancer and non-clinical. **They** concluded that the evidence to support the originally proposed bidimensional anxiety-depression structure is insufficient (13). As a result, Coyne and van Sonderen called for the abandonment of the HADS as a scale for measuring anxiety and depression (14).

However, Norton et al. suggested that the presence of an overarching general distress factor may explain the inconsistent results regarding the latent structure of the HADS, and pointed to two alternative hierarchical models (higher-order and bifactor) which are said to represent hierarchical dimensionality structures (15). **The higher-order model, proposed by Dunbar et al. (16)**, is based on the Tripartite theory of anxiety and depression (17) and is **currently** the most-widely supported three factor structure (13). Tripartite theory **posits** anxiety and depression as lower-level constructs in a tripartite structure (18), **with a higher-order general distress factor termed Negative Affectivity (NA)** (17). Norton et al. **also suggested** bifactor models involving a general factor, such as distress, upon which all items load, and more specific group factors upon which related items load. In contrast to higher-order models, the general factor is at the same level as the group factors, and as a result the variance explained by the general factor can be separated from the other factors (19).

Norton et al. went on to explore 10 alternative models for the HADS, including Dunbar's higher-order model (16) and two bifactor models, using meta-confirmatory factor analysis. This demonstrated that a bifactor structure (one general factor and two group factors) consisting mostly of a general distress factor, which accounted for over 70% of the variance, provided the best solution (19). This was true across community and cardiovascular disease samples and various language groups. The bifactor model provided a more optimal solution than any previously considered structure (19). Norton et al. concluded that these results indicate that the HADS taps into autonomic arousal and anhedonia as originally intended but is saturated by the presence of strong general factor (19).

Anxiety and depression are frequently comorbid conditions (20, 21), and share symptoms (22), making them difficult to distinguish. It may be that the strong general factor found by Norton et al. (19) is a product of the strongly connected symptoms of anxiety and depression in accordance with the network model of psychiatric symptoms (23).

Although Norton et al. used multiple samples and papers from different countries, their study largely used a meta-analysis approach relying on summary statistics (19). Notably, 61% of published studies from the Cosco et al. review (13) were omitted due to inability to obtain summary data, and this may have biased the findings.

The aim of this paper is to assess the dimensionality of the HADS in a large, international sample of patients with ischaemic heart disease (IHD) by employing CFA to test the validity of the originally proposed bidimensional structure as well as two hierarchical models: Dunbar's higher-order model (16) and the bifactor model (19).

METHODS

Participants

Participants for this analysis were drawn from the HeartQoL Project **(24)**. The objective of the HeartQoL Project was the development of a new health-related quality of life scale specific to IHD (24). Patients with IHD (either angina, myocardial infarction or ischaemic heart failure) across 5 regions (Eastern, Southern, and Western European regions, Scandinavia and an English-speaking region including the UK, Ireland, Australia, Canada and the USA) were enrolled in the HeartQoL Project between 2002 and 2010. In the cross-sectional survey phase, data on various patient reported outcome measures (including the HADS) were collected across 54 sites in 22 countries where 15 languages (Norwegian; Swedish; Danish; Dutch; French; Flemish; German; Italian; Portuguese; Spanish; Polish; Russian; Ukrainian; Hungarian; and English) are spoken (24).

For the confirmatory factor analysis **(CFA)** 6,109 of the 6,241 participants were retained following the use of pooled correlation matrices.

Materials

The **HADS** is a 14-item self-report measure with a four-point scale (6). The scale is **comprised of two seven-item subscales designed to assess anxiety and depression** (HADS-A; HADS-D), **and uses a mixture of negative and positive items and varying response options**. Even-numbered items are designed to measure depression while odd-numbered items are said to measure anxiety. **Sample items include "I feel tense or wound up" (HADS-A), with response options ranging from "Not at all" to "Most of the time"; and "I look**

forward with enjoyment to things" (HADS-D), with responses ranging from "As much as I ever did" to "Hardly at all".

Where HeartQoL investigators had access to a HADS translation in their own language, this was used (although it is unclear what version was used if several were available) (10). **If no appropriate translation was available, investigators used** the Outcomes Trust backwards and forwards approach to translations and the HADS was translated into that language from the English version. All participants were given the measure in their language of preference (24). Cronbach's alphas for both the overall scale ($\alpha = .87$) and anxiety and depression subscales ($\alpha = .81$, $\alpha = .79$) were high indicating good internal consistency.

Analysis of scores in the clinical setting **suggest** that a score of 0 to 7 for either subscale could be considered as being in the normal range while scores above this suggest possible or probable 'caseness' (25).

Statistical Analysis

All statistical analyses were carried out using AMOS version 21.0.

Confirmatory factor analysis (CFA)

CFA was employed to confirm the best model of fit. All HADS items were correlated and the resulting pooled matrix was analysed. The three models below were tested (see Figure 1):

- Zigmond and Snaith's originally proposed bidimensional structure (21)
- Dunbar et al.'s (16) higher-order model.

- The hierarchical bifactor structure which emerged from Norton et al.'s recent meta CFA (19)

The maximum likelihood method was used to examine the covariance matrices of the items. Several indices were used to **assess** the model fit of the three models tested. The statistics usually reported in CFA are χ^2 (**with** degrees of freedom **and** p-value), goodness-of-fit index (GFI), comparative fit index (CFI) and root mean square error of approximation (RMSEA) (26). The χ^2 statistic is an overall test of how well the hypothesized model fits the data and a significant χ^2 indicates a model that does not fit the data well. Because the χ^2 statistic assumes multivariate normality and is affected by large sample size (i.e. a model with relatively good fit for a large dataset can still be rejected), additional indices of fit (i.e. TLI, GFI, CFI, SRMR and RMSEA) must be used to make a judgement regarding the fit of the model. The Tucker-Lewis index (TLI) is a relative fit index. It is relatively unaffected by sample size (27) and values over .90 or .95 are considered acceptable (28). The GFI and CFI should have values over 0.95 and the RMSEA value should be below .05 (26). Akaike's information criterion (AIC) is a modification of the standard goodness-of-fit χ^2 statistic that includes a penalty for complexity. This index is useful for making comparisons among two or more models, with lower values indicating better fit. The Bayesian information criterion (BIC) is closely related to AIC and also penalizes model complexity based on the number of parameters. Again lower values are preferred. The SRMR (Standardized Root Mean Residual) is a descriptive fit index, a cutoff value close to .08 is recommended and lower values indicate better fit (28).

Relative fit of the models was assessed by examining change in chi-square values across

the models ($\Delta \chi^2$). However, this test is sensitive to sample size, and is likely to reach the threshold for significance in large samples. Accordingly, Cheung and Rensvold (29) have argued that changes in alternative fit indices should be assessed to compare relative fit of nested models, as these indices are not as sensitive to sample size. Differences in CFI across the three models were therefore assessed, according to a threshold of 0.01 suggested by Cheung & Rensvold (29).

RESULTS

Sample description

Demographics for the total sample are shown in Table 1. The overall sample was composed of 75.1% (4,690) men and 27.7% (1,541) women, typical of the male dominated gender distributions in heart disease populations. The majority of respondents were married with an average age of 62.3 (Median = 62). Regarding regions, 15.9% of the sample was derived from Scandinavia, 23.1% from Western Europe, 18.1% from Southern Europe, 20.9% from Eastern Europe and finally 22.0% from the English-speaking region. There were no significant differences between HADS respondents and non-respondents ($n=143$) in terms of both clinical and sociodemographic data (data not shown). Based on HADS scores, 34.6% of the sample were anxious while 25.1% were depressed (24) (i.e. had a HADS score greater than 7).

The correlation between the anxiety and depression subscales was 0.625.

Confirmatory factor analysis

CFA of the pooled correlation matrix across all samples is shown in Table 2. The bifactor model with two group-factors and a general factor (model 3) provided the best fit. While the other models also fit the data, the bifactor model provided a significantly better fit based on the χ^2 test for differences **and performed best with regard to** TLI, AIC, BIC, SRMR, GFI, CFI and RMSEA. Table 2 shows the CFA results. The bifactor model (.45) was the only solution for which RMSEA was $<.05$, indicating a good fit. Both Dunbar et al.'s (.052) and Zigmond and Snaith's (.058) models exceeded the .05 criterion. AIC and BIC penalize model complexity and according to these measures Dunbar's model fit better than Zigmond and Snaith's while the bifactor provided superior fit to both. Considering TLI, the bifactor model (.96) was the only solution to meet the .95 criterion (Hu and Bentler 1999). **The Δ CFI was $>.01$, indicating that the change in fit between models was meaningful.** Anxiety and Depression factor correlations and factor loading ranges for all three models are presented in Table 3.

The bifactor model consists of a global factor (explaining 73% of the variance) with two separate **orthogonal** factors representing anxiety (11%) and depression (16%) subscales. The anxiety subscale had rather poor loadings while the depression items clustered somewhat more strongly (Table 4). The general factor displayed the highest loadings. All 14 general factor loadings were statistically significant. Two depression factor loadings (items 8 and 14) and four anxiety factor loadings (items 1, 5, 9 and 11) were not statistically significant (30).

The inter-factor correlation for this model was .08 (see model 3 in Figure 1). It is important to point out that the model would not have fit without this correlation.

Discussion

As highlighted in recent reviews, many studies involving **a variety of** populations have revealed factor structures contrary to the two intended HADS subscales (13, 19). This study is the first to assess the dimensionality of the HADS in a large international sample of patients with IHD. While this commonly used scale is thought to differentiate between anxiety and depression, the results of the present analysis and other recent studies (19, 31-36) provide little psychometric evidence in support of its **factorial validity** in this regard.

The bifactor model fit the data better than the original bidimensional structure or Dunbar's model (16), thus supporting the findings of Norton et al. (19). **The ΔCFI indicated that the difference in model fit was meaningful.** Norton et al.'s **bifactor** model did not specify an inter-factor correlation, whereas a bifactor model did not fit our **data** without specifying this inter-factor correlation. However, this very slight correlation (.08), which may merely represent an anomaly from our own data, was deemed inconsequential in terms of overall results and conclusions. **Overall, and supporting** the findings of Norton et al.(19), it seems that while two subscales exist in the HADS items, the scale is dominated by a general distress factor in patients with IHD and thus **may not be sensitive to disorder-specific symptoms in this patient population.**

The bifactor solution helps to explain the conflicting findings of previous studies employing different analytic methods (19). Prior to Norton et al., reviews of CFA studies of the HADS generally pointed to a three factor structure with either a higher-order negative affectivity factor or the anxiety subscale split into two highly correlated factors (7, 13, 19, 37). Norton et al. have suggested these findings may simply represent overextraction following failure to account for a general factor (19). Exploratory factor analyses (**EFA**) of the HADS have

typically produced two factor solutions and as Norton et al. have reasoned this is likely due to rotation motivated by the aim to find a simple structure. The initial unrotated factor found in EFA studies indicates a general factor and it is only when this is rotated that the anxiety-depression factorization emerges (19). Straat et al. have also noted the tendency for EFA to detect heterogeneity in the inter-item correlation matrix, suggesting multidimensionality even when the factor structure is **actually** weak (36). Finally, the fact that IRT studies of the HADS consistently produce unidimensional solutions (13) also accords with the presence of a strong dominant factor (19). Thus all the solutions produced by previous studies of the latent structure of the HADS are understandable in the presence of a strong general factor (19). Unlike these past analyses, the current study, in line with Norton et al.'s meta CFA, allowed for the presence of a general factor by testing two hierarchical models.

Support for the bifactor structure, and the associated claim that the HADS measures general distress or what is common between anxiety and depression, is also found in sensitivity and specificity studies. For instance, the general distress factor which saturates the scale seems to be equally good at identifying depression and anxiety (38, 39). **Also**, evidence suggests the anxiety subscale may be as effective as the depression subscale in screening for depressive disorder (40).

As noted above, the HADS has poor content validity and is often inadequately translated (9, 10). However, even if the HADS were to fully cover the symptoms of these two disorders and avoid colloquial British, most efforts to differentiate anxiety and depression in a single self-report questionnaire will fail. It must be remembered that anxiety and depression are frequently comorbid conditions (20, 21) which also feature shared symptoms (22). **The**

results of the current study suggest that the anxiety and depression factors, as measured by the HADS are best explained by a general factor, perhaps due to the issues around content validity mentioned earlier (i.e. not assessing enough symptoms which are unique to anxiety and depression).

It has recently been suggested that the endemic comorbidity seen in psychopathology research may actually be a result of the misconceptualization of mental disorder. In line with this view, Cramer et al. have developed a network approach to mental disorders and comorbidity where symptoms are viewed not as indicators of latent conditions but as components in a network (41). Employing this network model Borsboom et al. showed that half of the symptoms in the DSM-IV are connected and hypothesized that a significant part of DSM-IV comorbidity is therefore the result of direct relations between symptoms of multiple disorders. Consequently, they suspect that higher-order factors may be similar in form to regions of strongly connected symptoms (42). This network approach to mental disorders, and explanation of comorbidity as a result of the effects of symptoms shared by multiple disorders (41), **is consistent with the model of the HADs identified here, with shared variance between symptoms of anxiety and depression saturated by a general distress factor.** Borsboom et al. have commented on the comorbidity between major depressive episode and GAD in particular and illustrate a causal chain of directly related symptoms (42). Most importantly, this network model of psychiatric symptoms has been shown to fit in with population statistics on prevalence and comorbidity while also accommodating the idiosyncratic unpredictability of the individual person (42).

After highlighting **the difficulty in distinguishing distinct anxiety and depression factors for the HADS scale**, Norton et al. concluded that it would be best computed as a global score

suggesting that this 14-item scale may be an effective clinical tool for identifying unspecified cases of distress (19). This is a solution which was previously put forward by Cosco et al. who uncovered a unidimensional HADS model in a cardiac population in Ireland using IRT methods (43). Naming the factor 'General Psychological Distress', they interpreted this single overarching dimension as a clinically useful measure of general psychological distress, citing the symptomatic overlap demonstrated by the HADS as strong evidence for their 12-item unidimensional psychological distress scale which was interpreted as capturing symptoms of both anxiety and depression. In the current study, all 14 items loaded onto the general factor and yet this model may well be closely related to Cosco et al.'s 12-item solution (43) considering both involved strong general factors revealed in cardiac populations.

Given its wide usage and familiarity in clinic settings retaining the use of the HADS is an attractive option. Although evidence consistently suggests that the HADS does not fulfil the role it was originally intended to – measure depression and anxiety as distinct factors – we argue here that it may be possible to meaningfully use the HADS as a global score. However some caution is required. The HADS as a global score has not yet been fully tested for psychometric and clinical validity. If adequately validated a global score may also prove useful in interpreting already collected data. Where new research is being conducted however, we urge researchers and clinicians to **avoid** the HADS and use **alternative measures of anxiety and depression** with IHD patients.

It has previously been suggested that clinicians and researchers wishing to assess anxiety and depression should abandon the HADS and instead rely upon other established instruments (8) (possibilities include the Patient Health Questionnaire (PHQ-9;(44)), the

Generalised Anxiety Disorder Scale (GAD-7;(45)) and the Inventory of Depression and Anxiety Symptoms (IDAS;(46)) (19)) and this paper provides **further** support for this recommendation in one international population - IHD patients.

This study is somewhat limited by the lack of information on specific language versions used. For instance, there are four available Dutch translations of the HADS (10).

Furthermore, the way in which outcomes were pooled means it is possible that unexplored measurement characteristics across cultural groups or linguistic versions of the HADS may have influenced results. Finally, depression and anxiety were not clinically assessed, and this is a weakness as we could not **assess the clinical validity, especially the sensitivity and specificity of the instrument**. The HADS data in this study was treated as continuous as has frequently been the case throughout the HADS literature as well as in recent studies (47). On reflection however, we have concluded that it may be better to treat the data as quasi-continuous and we recommend future investigations address this. The study was strengthened by its large international sample.

Conclusions

CFA led to the conclusion that the **underlying measurement model of the HADS structure in this large international sample of patients with IHD can be best described as a hierarchical bifactor model**. It seems that the HADS does not **psychometrically** distinguish well between anxiety and depression in this group. While the HADS computed as a global score may be an effective clinical tool for identifying unspecified cases of distress, at this stage we lack sufficient information about its validity in this role to advocate for its widespread use. The bifactor model provides a good fit but a largely impractical solution where clinicians and researchers are concerned. As such clinicians and researchers working

with patients with IHD should avoid the HADS and instead employ alternative measures of depression and anxiety.

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Figure 1. Factor loading patterns for each model

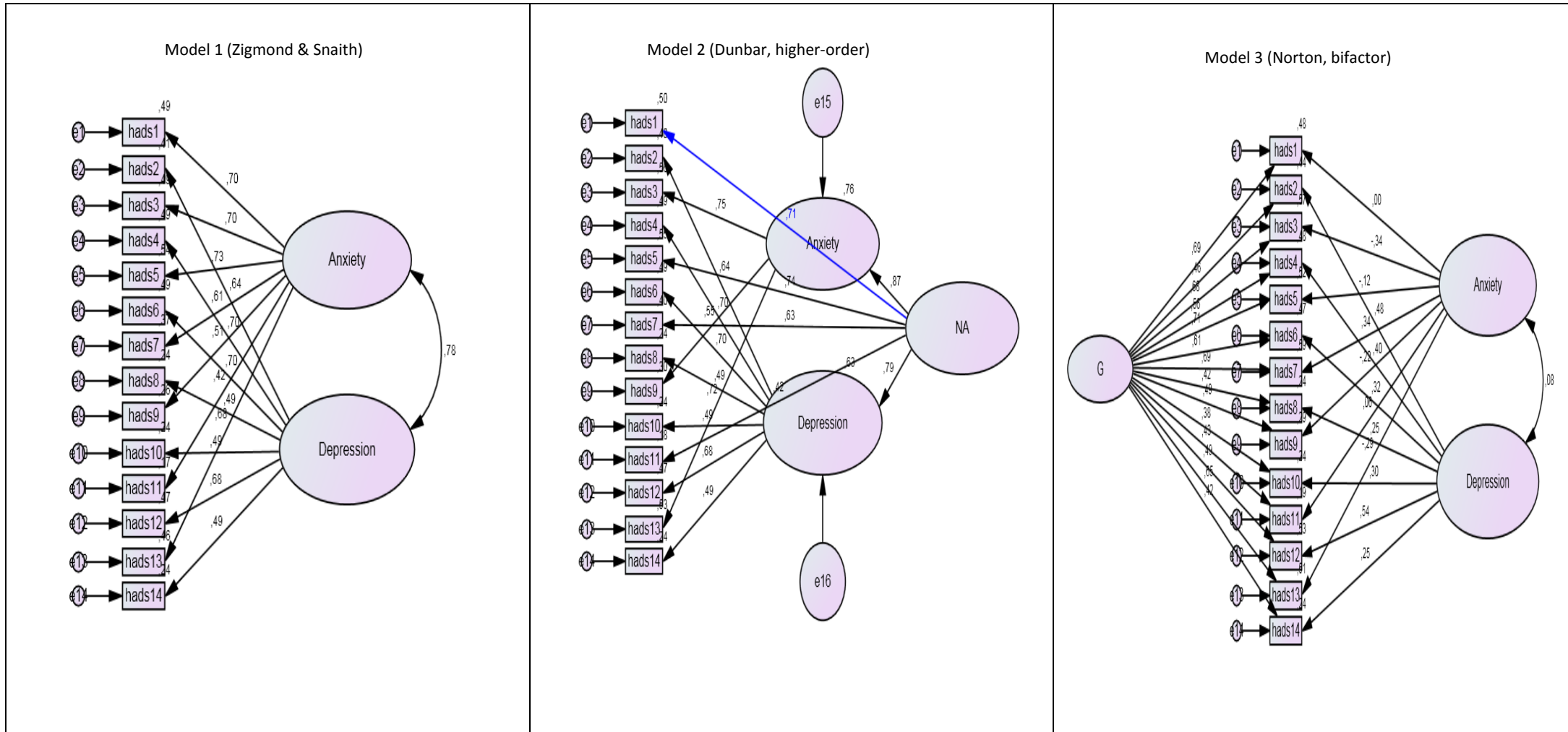


Table 1. Demographic information for total sample (N = 6,241)

<u>Mean</u>	
Age	62.34
(SD)	(11.27)
<u>%</u>	
Primary diagnosis	
Angina	33.2
Myocardial Infarction	37.2
Heart Failure	29.6
Men	75.1
Marital Status	
Single	11.7

Married	74.2
Other	12.6
Education	
High school not completed	36.7
High school completed	30.7
More than high school	28.4
Occupation	
Blue collar	37
White collar	40.8
Managerial responsibilities	37
Pleased with financial situation	54.7

Note. Some percentages do not add up to 100% due to missing data.

Table 2. Results of Confirmatory factor analysis of the HADS in patients with IHD (n=6,109)

Model	χ^2	DF	χ^2 difference (DF)	RMSEA	TLI	CFI	Δ CFI	GFI	AIC	BIC	SRMR
1 Zigmond & Snaith Original bidimensional model[6]	1636.91	76	-	.058	.929	.940	-	.962	1694.91	1889.71	.027
2 Dunbar et al. Higher- order model [25]	1308.59	75	328.33 (1)	.052	.943	.953	.013	.971	1386.59	1570.10	.024
3 Norton et al. Bifactor model [19]	820.98	62	487.60 (13)	.045	.958	.971	.018	.981	906.98	1192.60	.018

Note. DF = degrees of freedom; RMSEA = root mean squared error of approximation; TLI = Tucker-Lewis index; CFI = comparative fit index; Δ CFI = change in comparative fit index; GFI = goodness of fit index; AIC = Akaike information criterion; BIC = Bayesian information criterion; SRMR = standardized root mean residual.

Table 3. Factor Loading Ranges and Correlations

Model		<u>Anxiety</u>		<u>Depression</u>		<u>General/Higher-order</u>		<u>Correlation</u>
		<i>Lowest</i>	<i>Highest</i>	<i>Lowest</i>	<i>Highest</i>	<i>Lowest</i>	<i>Highest</i>	
1	Zigmond & Snaith Original bidimensional model[6]	.00	.73	.00	.70	N/A		.78
2	Dunbar et al. Higher- order model [25]	.00	.75	.00	.70	.39	.74	N/A
3	Norton et al. Bifactor model [19]	-.31	.30	.00	.54	.38	.71	.08

Note. Correlation = correlation between anxiety and depression factors. N/A = not applicable in case of this model.

Table 4. Bifactor model loadings for the sample of 6,109 IHD patients

			General factor	Depression	Anxiety
1	A	I feel tense or wound up	.69	.00	.00
2	D	I still enjoy things I used to enjoy	.46	.48	.00
3	A	I get a sort of frightened feeling as if something awful is about to happen	.66	.00	-.37
4	D	I can laugh and see the funny side of things	.56	.40	.00
5	A	Worrying thoughts go through my mind	.71	.00	-.14
6	D	I feel cheerful	.61	.31	.00
7	A	I can sit at ease and feel relaxed	.70	.00	.30
8	D	I feel as if I am slowed down	.42	.25	.00
9	A	I get a sort of frightened feeling like "butterflies" in the stomach	.48	.00	-.24
10	D	I have lost interest in my appearance	.38	.30	.00
11	A	I feel restless as if I have to be on the move	.43	.00	.05
12	D	I look forward with enjoyment to things	.49	.54	.00
13	A	I get sudden feelings of panic	.64	.00	-.31
14	D	I can enjoy a good book or radio or TV program	.42	.25	.00

Anxiety subscale: Skewness = .62, Kurtosis = -.01; Depression subscale: Skewness = .81, Kurtosis = .02.

Highlights

- We used CFA to test 3 models of the Hospital Anxiety and Depression Scale using data from the HeartQoL study.
- The bifactor model provided the best fit.
- The HADS scale seems to be best explained by a general distress factor in patients with Ischaemic Heart Disease