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BDI-II in Acute Myocardial Infarction 1 A General Factor Model for the Beck Depression Inventory – II: Validation in a Sample of Patients Hospitalized with Acute Myocardial Infarction

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Abstract

Many studies have linked symptoms of depression after an acute myocardial infarction (AMI) to negative health outcomes, including subsequent mortality. It has been suggested, however, that this link may be due to biased measurement of depressive symptoms in post-AMI patients related to confounding with somatic symptoms related to the AMI. The BDI and BDI-II are the most common self-report measures used in research with post-AMI patients. Ward (2006) demonstrated that a factor model for the BDI-II with orthogonal General Depression, Somatic, and Cognitive factors (G-S-C) fit the data better than correlated two-factor models in five nonmedical samples. The objective of this study was to test the validity of Ward's model in a sample of 477 hospitalized post-AMI patients. We found that, similar to Ward's results, the G-S-C model fit as well or slightly better than two previously published correlated two-factor models, Thus, the G-S-C model presents a viable mechanism to test links between symptoms of depression, as measured by the General Depression factor, and health outcomes among patients with AMI after explicitly removing variance due to somatic symptoms that is unrelated to the General Depression factor.

Introduction

Major depression is diagnosed in approximately 20% of patients hospitalized with acute myocardial infarction (AMI) (1). Following AMI, symptoms of depression predict ongoing functional impairment (2), less favorable self-care behaviors (3), substantially higher health-care costs (4), and increased cardiac morbidity and mortality (5). The high rate of depression among medically ill patients, including patients with AMI, however, has raised questions about the validity of existing methods of symptom assessment because there is substantial overlap in somatic symptoms of depression and symptoms common in medical illness, including fatigue or loss of energy, anhedonia, changes in sleep patterns, and changes in appetite (6).

The Beck Depression Inventory (BDI) (7) and its revised version, the Beck Depression Inventory-II (BDI-II) (8), are the most commonly used assessment tools in research of post-AMI patients (1). Specific concerns have been raised, however, about the performance characteristics of the Beck depression scales in patients with medical illness since approximately half of the items on the BDI and BDI-II assess somatic or performance related symptoms (9, 10). Consistent with this, several authors have argued that studies linking depression to cardiac and all-cause mortality post-AMI have not adequately controlled for potential bias in the measurement of depressive symptoms related to confounding of somatic symptoms of depression and symptoms of the AMI (11-13).

Existing studies that have assessed the relationship between depressive symptoms measured during hospitalization for AMI and subsequent outcomes have used linear regression, logistic regression, and survival models, which treat total scores on instruments like the BDI or BDI-II are treated as error-free measures of depressive symptoms. Structural equation modeling techniques, on the other hand, present an alternative paradigm that allows for the possibility of explicitly separating variance related to depression per se and variance related to extraneous somatic factors. Indeed, a confirmatory factor analysis (CFA) model of the BDI-II developed by Ward (14) explicitly separates variance from a General Depression factor from variance from unrelated somatic symptoms. Ward demonstrated in five different samples that a BDI-II model with orthogonal General Depression, Somatic, and Cognitive factors (G–S–C) fit as well or better than previously published two-factor BDI-II models, representing either Somatic-Affective and Cognitive factors (SA–C) (8) or Cognitive-Affective and Somatic factors (CA–S) (15). In Ward's model, all BDI-II item scores are indicators of the General Depression factor, and some items also load on Somatic or Cognitive factors that are orthogonal to the General factor and each other.

Demonstration that Ward's (2006) G-S-C model is valid with medically ill post-AMI patients would provide a mechanism for using latent variable models to explicitly model longitudinal outcomes following AMI on the General depression factor independent of variance from the orthogonal Somatic factor. Thus, the objective of this report was to replicate Ward's (2006) G-S-C model in a sample of patients hospitalized with AMI.

Methods

Patients and Procedure

Participants in the study included patients who were treated for AMI at any of 10 hospitals in Québec, Canada between December 28, 1996 and November 1, 1998. Patients with AMI were eligible for enrollment in the study if they survived at least 24 hours after admission and had been admitted through the emergency department rather than as transfers from another

hospital. Patients were excluded if they did not read and understand French or English or if they were medically incapable of giving informed consent or responding to a questionnaire. Research nurses approached eligible patients for informed consent and enrollment within 2-3 days after the date of admission. Study participants completed a self-administered questionnaire in the hospital at the time of enrollment that included the BDI-II. The BDI-II (8) is a 21-item self-report inventory of symptoms of depression that has been used with both psychiatric and non-psychiatric samples. Each item consists of four statements, scored 0-3, indicating increasing symptom severity; total scores range from 0-63. This study was an ancillary study to a prospective cohort study of quality of life after AMI (16) that received ethical approval from the Montreal General Hospital Ethics Review Board.

Data Analysis

All CFA models were conducted with Mplus (version 3.11) (17), explicitly modeling the BDI-II items as ordinal data. To do this, Mplus initially estimates item thresholds for ordinal outcome variables using maximum likelihood methods. These estimates are then used to estimate a polychoric correlation matrix. Model parameters are subsequently estimated with weighted least squares using the inverse of the asymptotic covariance matrix as the weight matrix (18). A chi-square goodness-of-fit test and four fit indices were used to assess model fit, including the Tucker-Lewis Index (TLI) (19), the comparative fit index (CFI) (20), the root mean square error of approximation (RMSEA) (21), and the standardized root-mean-square residual (SRMR) (22). Since the chi-square test is highly sensitive to sample size and can lead to the rejection of well-fitting models, practical fit indices were emphasized (23). Guidelines proposed by Hu and Bentler (24) suggest that models with TLI and CFI close to .95 or higher, RMSEA close to .06 or

lower and SRMR close to .08 or lower are representative of good fitting models. A CFI of .90 or above (25) and a RMSEA of .08 or less (26), however, are also considered to represent reasonably acceptable model fit.

Three factor models were fit to the BDI-II data following Ward's (2006) procedure. The SA-C two-factor model originally reported by Beck et al. (8) was fit with 12 items loading on the Somatic-Affective factor and 9 items on the Cognitive factor. For each model, modification indices were used to identify pairs of items within factors for which model fit would improve if error estimates were freed to correlate, and for which there appeared to be theoretically justifiable shared method effects. For the SA-C model, correlated errors were permitted between two pairs of items: loss of energy with fatigue and agitation with irritability. A second correlated two-factor model (S-CA) was also specified with 5 items loaded on a Somatic factor and 16 items on a Cognitive-Affective factor. In this model, four pairs of error terms were freed to correlate: loss of energy with fatigue, agitation with irritability, self-dislike with self-criticalness, and loss of pleasure with loss of interest. Ward's (2006) orthogonal G-S-C model was the third model fit to the data. Per Ward's procedure, all 21 items loaded on the General factor. In addition, 5 items loaded on a Somatic factor (loss of energy, sleep problems, appetite, concentration, fatigue), 8 items loaded on a Cognitive factor (pessimism, past failure, guilty feelings, punishment feelings, self-dislike, self-criticalness, suicidal thoughts, worthlessness), 2 items loaded on a Self-Criticalness factor (self-dislike, self-criticalness), and 2 items loaded on an Anhedonia factor (loss of pleasure, loss of interest). The pairs of items that loaded on each of the latter two factors were constrained to equality for model identification purposes. For the G-S-C model, item communalities (h²s) that represent the percent of variance in each item predicted

by the factors were calculated from standardized factor loadings.

Results

Sample Characteristics

The study sample consistent of 477 AMI patients who completed the BDI-II in the hospital, including 83 women (17.4%) and 454 patients who self-identified as White (95.2%). The mean age of the sample was 60.1 years (SD = 12.2 years, range = 29 to 90), the mean level of education completed was 11.2 years (SD = 4.6 years, range = 1 to 21), and 71.1% of patients (n = 339) were married or living as married. A total of 96 patients (20.1%) had a prior AMI and 25.2% (n = 120) had a history of angina. Approximately half (51.2%, n = 244) were hospitalized with a Q-wave AMI (abnormally deep Q waves on electrocardiogram, generally involving death of muscle cells throughout the entire thickness of the heart muscle wall), and 17.4% (n = 83) had Killip class > 1 (clinical signs of heart failure). Among cardiac risk factors, 15.5% (n = 74) were diagnosed with diabetes mellitus, 35.8% (n = 171) with hypertension, and 38.2% (n = 182) with hypercholesterolemia. A history of smoking was present in 75.9% (n = 362) of patients, and 41.9% (n = 200) were current smokers. The mean BDI score was 9.2 (SD = 7.9).

Confirmatory Factor Analysis

Model fit statistics for each of the three models tested are shown in Table 1. In addition to chi-square test results and fit indices, factor correlations are shown for the SA-C and CA-S two-factor models. Both the SA-C and CA-S fit reasonably well based on fit indices. All factor loadings for both models were statistically significant with standardized loadings of .46 or higher for all items in the SA-C model and .44 or higher for all items in the CA-S model. The fit of the G-S-C model (Figure 1) was as good or slightly better than each of the other two models. All

factor loadings were significant with the exception of *pessimism* on the Cognitive factor (z = 1.65, p = .10). Removing this factor loading from the model did not meaningfully change the chisquare test ($\chi^2_{76} = 255.3$), any fit indices (CFI = .92, TLI = .96, RMSEA = .07, SRMR = .07), or any model parameters. The Somatic factor of the G-S-C model reflected a sense of fatigue and low energy. The loadings of these two items were .82 and .62, respectively, compared to .19 to .25 for the other three items that loaded on the factor. The Cognitive factor was largely driven by a sense of self-blame, and the loadings from three items related to failure, guilt, and punishment were between .51 and .56, compared to loadings of .29 to .43 for the items *self-dislike, selfcriticalness, suicidal thoughts*, and *worthlessness*, and .11 (non-significant) on the item *pessimism*. As in Ward's results, the General factor explained the highest proportion of total covariance (communality = 73%) with the Somatic and Cognitive factors contributing modest amounts (11% and 13%, respectively), and the two minor Self-Criticalness and Anhedonia factors < 1% each. Item endorsement rates, means, and communalities are shown in Table 2.

A simplified version of the G-S-C model that did not include the minor Self-Criticalness and Anhedonia factors was also tested. As shown in Table 1, simplifying the G-S-C to facilitate practical use in model building and to provide a conceptually more coherent model did not meaningfully affect its overall fit to the data. Item-factor loadings and other model data for the three models are available upon request from the corresponding author.

Discussion

The main finding of this study was that, consistent with results reported by Ward (14) in three clinical and two college student samples, the G-S-C model fit as well as or slightly better than the correlated two-factor SA-C and CA-S models in a sample of patients hospitalized with AMI. The General factor of the G-S-C model explained 73% of total communality, which is within the range of 71% to 82% reported by Ward. The Somatic and Cognitive factors accounted for 11% and 13%, respectively, of total communality, also similar to the ranges of 6% to 11% (Somatic) and 8% to 14% (Cognitive) reported by Ward (14) in non-medical samples. As in Ward's study, all items on the General factor had reasonably strong loadings. The items *loss of interest, indecisiveness,* and *loss of pleasure* had the highest loadings. The three most salient items on the Cognitive factor were *past failure, punishment feelings,* and *guilty feelings,* representing a strong theme related to self-blame. The Somatic factor was largely defined by the items *loss of energy* and *fatigue,* each of which loaded much more robustly than any other items.

As reviewed by Ward (14), the G-S-C model has interpretive advantages over the SA-C and CA-S two-factor models. In each of the two-factor models, the factors are highly correlated (.80 and .72, respectively) and would be expected to provide only limited discriminant validity. In addition, they do not tend to be highly stable across samples. Steer et al. (27), for instance, warned that certain items in the SA-C model tend to shift dimensions across samples. In addition, the two-factor model implications can be misleading since many items, including *sadness, irritability, agitation,* and *loss of pleasure,* are not easily described as either purely somatic or cognitive items. The G-S-C model, on the other hand, has been shown to provide a stable fit that is as good or better than the two-factor models across several different samples, including the sample of AMI patients in this study. Furthermore, interpretation of the G-S-C is consistent with the use a single summary score to estimate the severity of depressive symptoms as described by Beck et al. (8).

Among medically ill patients, including patients hospitalized with AMI, the G-S-C model

has additional conceptual and pragmatic advantages. The Somatic factor was dominated by items related to fatigue and loss of energy, both of which are commonly experienced during hospitalization for AMI and which may or may not be related to depression. Variance from items on the Cognitive factor is similarly allocated, which takes on special meaning in the context of an AMI given the predominance of self-blame on the Cognitive factor. Cognitive theories of depression (28) associate self-blame with poor adjustment. On the other hand, studies of the consequences of illness attributions among patients with medical illness (29), suggest that selfblame or attribution of consequences to one's own behavior may be related to more positive coping and better subsequent outcomes (30). These two theoretical models, however, may be addressing two distinct constructs, characterological and behavioral self-blame. Whereas characterological or personality-related self-blame would be expected to be maladaptive, behavioral self-blame may be a useful coping strategy after an acute medical event that provides a sense of controllability of the future and over one's own health (30). Thus, separating variance from cognitive items that is orthogonal to the General Depression factor may have important implications among medically ill patients. Pragmatically, the G-S-C model also provides a framework for testing models of relationships between symptoms of depression and long-term health outcomes post-AMI. By regressing outcomes on the General Depression factor within a structural equation modeling approach, possible pathways from symptoms of depression to outcomes can be modeled after explicitly removing variance from somatic factors that is unrelated to the General Depression factor.

In summary, the G-S-C model provides a reasonably good-fitting explanation of BDI-II data from patients hospitalized with AMI that is as good as or better than model fit from

alternative two-factor models. The G-S-C model has important theoretical and practical advantages, including the ability to model the relationship of a General Depression factor with important health outcomes after explicitly removing variance from somatic factors unrelated to the General Depression factor.

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	Factor							
Model	Correlation	χ^2	df	р	CFI	TLI	RMSEA	SRMR
SA-C	.80	258.6	77	< .01	.92	.96	.07	.08
CA-S	.72	296.1	76	< .01	.90	.96	.08	.08
G-S-C		256.1	76	<.01	.92	.96	.07	.07
G-S-C Simplified		260.4	77	<.01	.92	.96	.07	.07

Table 1.	Summary	of Results fron	n Confirmatory	/ Factor Analyses
	2		2	2

CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean

Square Error of Approximation; SRMR = Standardized Root Mean Square

Residual; SA-C = Somatic/Affective - Cognitive; CA-S = Cognitive/Affective -

Somatic; G-S-C = General – Somatic – Cognitive;

BDI Item		G S	C	SC	An	h ^{2a}
1	Sadness	.69				.51
2	Pessimism	.74	.11 ^b			.60
3	Past Failure	.60	.55			.60
4	Loss of Pleasure	.75			.29	.60
5	Guilty Feelings	.55	.51			.54
6	Punishment Feelings	.53	.56			.57
7	Self-Dislike	.71	.42	.30		.73
8	Self-Criticalness	.61	.39	.30		.55
9	Suicidal Ideation	.59	.43			.51
10	Crying	.71				.49
11	Agitation	.62				.40
12	Loss of Interest	.79			.29	.64
13	Indecisiveness	.77				.56
14	Worthlessness	.71	.29			.61

Table 2. Standardized Factor Loadings and Communalities from the G-S-C Model.

	Communality †	.73	.11	.13	.01	.01	
21	Sexual Disinterest	.45					.30
20	Fatigue	.51	.82				.78
19	Concentration	.65	.24				.47
18	Appetite	.54	.25				.35
17	Irritability	.57					.38
16	Sleep Problems	.53	.19				.34
15	Loss of Energy	.51	.62				.73

G = General; S = Somatic; C = Cognitive; SC = Self-Criticism; An = Anhedonia; h² = item communality. All factor loadings are significant at p < .05 except where noted.

^aCommunality (h^2) for each factor is the proportion of total communality that is attributable to the factor.

^bFactor loading not significant (p = 10).

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