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# Is the Endorsement of Depressive Symptoms Influenced by Comorbid Alcohol Problems? A Measurement Invariance Study

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Depression is often assumed to be a heterogeneous condition that varies in symptom presentation. For instance, dual-diagnosed patients are more likely to experience changes in sleep and appetites along with apathy and anxious mood than those without substance use disorder (SUD) symptoms. If a substance worsens or relieves specific symptoms, symptom profiles may differ depending on the alcohol use status. The high prevalence of alcohol use disorders in the Korean population may greatly improve our understanding of its etiology. It is both timely and necessary to evaluate the BDI-II as a severity-rating tool across this population. This study compared the symptomatic presentation between patients with major depressive disorder (MDD) patients and comorbid alcohol abuse, and those without. However, the factor structure in a clinical sample of diagnosed patients has not yet been reported. Clinical interviews were conducted to screen for depression and other comorbid disorders. Measurement invariance was tested in Beck et al. (1996)'s SA-C model and Buckley et al. (2001)'s C-A-S model. Both models indicated a reasonable fit to the data; however, a two-factor model was selected for parsimony. The results indicated strict measurement invariance across groups, implying that the BDI-II could provide a consistent structure across patients with MDD regardless of alcohol use problems.

**Keywords:** BDI-II, depression, alcohol abuse, measurement invariance, comorbidity

The diagnostic criteria for major depressive disorder (MDD) include mood, somatic, and cognitive changes that can significantly affect one's functional level (American Psychiatric Association, 2000). Setting aside common features, comorbid psychiatric disorders (e.g., anxiety disorders and abuse of alcohol) are frequent in people with depression (Hesse, 2004). Some studies on dual-diagnosed patients have compared the severity of depression and factor structure with self-report instruments, such as the Beck Depression Inventory-II (BDI-II) (Davis et al., 2005; Quilty et al., 2010). However, if the BDI-II fails to adequately measure in the same manner across samples, further research may not build upon the previous findings.

Literature on alcohol-induced depression indicates that somatic and affective symptoms are more strongly endorsed than cognitive symptoms of depression. Charney et al. (2001) and Liappas et al. (2002) reported shared symptoms, such as poor sleep, concentration difficulties, and appetite changes related to substance use or withdrawal. Apathy is correlated with the extent of reduction in cortical thickness, and constructive changes in the brain caused by alcohol abuse (Yang et al., 2020). If alcohol acts on specific symptoms, the levels of depressive symptoms may differ depending on the alcohol use profiles of the patients. This is in line with the self-

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medication hypothesis that states that individuals use substances to manage their symptoms (Bolton et al., 2009; Khantzian, 1997). In such cases, the items would not assess the same underlying construct of depression, thus reducing the diagnostic validity of the BDI-II.

To date, several studies have examined the factor structure of the BDI-II across samples with alcohol-related problems. The three-factor model formulated by Buckley et al. (2001) was used in three studies (Dum et al., 2008; Johnson et al., 2006; Seignourel et al., 2008). It consisted of cognitive, affective and somatic constructs. In a recent study by Skule et al. (2014), the SA-C model proposed by Beck et al. (1996) was chosen. This two-factor model consisted of somatic-affective and cognitive constructs. Among these studies, Seignourel et al. (2008) and Skule et al. (2014) also examined measurement invariance and found metric and strict invariance, respectively. However, some studies with clinical samples (Buckley et al., 2001; Johnson et al., 2006; Skule et al., 2014), did not include a clinical interview, which was necessary to screen for comorbid psychiatric diagnoses.

Korea is among the Asian countries with the highest prevalence of alcohol consumption and a permissive drinking culture. In the general population, 15.1% reported a high alcohol consumption rate (Hong et al., 2017). The lifetime and 12-month prevalence rates of alcohol use disorders are estimated to be as 13.4% and 4.4%, respectively (Cho et al., 2015). Although the mood symptoms and alcohol abuse are expected to co-occur, a study examining the factor structure across this population has not yet been conducted. Few studies have examined the factor structure of the Korean version of BDI-II (Lee et al., 2017; Park et al., 2019). Cho & Kim (2002) validated measurement invariance across Korean populations, but used the previous version, the BDI.

Thus, this study aimed to confirm the factor structure of the BDI-II in a clinical sample of patients with depression. The second aim was to examine the invariance of the BDI-II across outpatients with and without alcohol abuse.

## Method

### Participants

Clinical samples were obtained from the psychiatric department of a tertiary-care outpatient clinic in South Korea. Outpatients who met the criteria for MDD as assessed by the Mini-International Neuropsychiatric Interview (M.I.N.I.) for DSM-IV between January 2017 and November 2020 were considered for this study. Participants' ages ranged from 18 to 64 years. Those with evidence of neurological or neurodevelopmental disorders, or general medical conditions related to mental symptoms were excluded from the study. Questionnaires were considered incomplete if any item on either the BDI-II or Alcohol Use Disorders Identification Test (AUDIT) was left unanswered. A total of 1,470 patients who met the above criteria and agreed to participate in this study were enrolled. This study was approved by the Institutional Review Board of the Samsung Medical Center (IRB no. 2020-10-120-001).

### Measures

#### The Beck Depression Inventory – Second Edition (BDI–II)

The BDI-II is a self-report inventory used to estimate depression severity (Beck et al., 1996). It consists of 21 items rated on a 4-point Likert scale (0–3). This study used the Korean version of the scale developed by Lim et al. (2019). This version has adequate internal consistency (.89) and test-retest reliability (.90) (Lim et al., 2019).

#### Alcohol Use Disorders Identification Test (AUDIT)

The AUDIT is used to detect early hazardous or harmful drinking (Saunders et al., 1993). It comprises 10 items rated on a 4-point Likert scale (0–3). This study used the Korean version of the AUDIT, developed by Lee et al. (2000). Cronbach's alpha coefficient for the internal consistency of the Korean version of the AUDIT was .92, with a cut-off point of 12, sensitivity of .84, specificity of .86, and an AUC of .944 (Lee et al., 2000). According to Kwon et al. (2013), the appropriate cutoff value for at-risk drinking was 8 for males and 5 for females. The cutoff applied in this study was 8 or above, to include probable harms caused by alcohol use (Conigrave et al., 1995).

#### Mini–International Neuropsychiatric Interview Plus Version 5.0.0 (M.I.N.I.)

The M.I.N.I. has been used to confirm the diagnosis of mental disorders according to the 10th edition of the International Classification of Diseases (ICD-10) and 4th edition of the Diagnostic


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and Statistical Manual of Mental Disorders (American Psychiatric Association, 2000). The Korean version of the M.I.N.I. has a kappa value of .71 for MDD (Yoo et al., 2018). This study used all the M.I.N.I. modules, including the depression module as a reference standard for the diagnosis of depressive disorders. Master-level clinical psychologists who had received extensive training applied the M.I.N.I. to each participant, and a licensed psychologist supervised the interviews.

### Data Analysis

Between-group comparisons of demographic and clinical characteristics were performed using IBM SPSS 25 and R statistical software (R Core Team, 2021) to conduct *t*-tests, chi-square tests, and Fisher's exact tests. Confirmatory factor analyses (CFA) were applied to test the factorial validity of candidate models to the data of both samples, using the packages "lavaan" (Rosseel, 2012) and "semTools" (Jorgensen et al., 2018) for RStudio. First, Beck et al.'s (1996) SA-C model comprises two latent variables with items assigned as follows: a somatic-affective factor for items 4, 10–13, and 15–21; and a cognitive factor for items 1–3, 5–9, and 14. Buckley et al.'s (2001) C-A-S model included three latent variables with items allocated as follows: a cognitive factor for items 1–3, 5–9, and 14; an affective factor for items 4, 10, and 12–13; and a somatic factor for items 11, and 15–21.

For parameter estimation, we used diagonally weighted least squares (DWLS), which provided a robust variant (weighted least square mean and variance-adjusted chi-square; WLSMV). Estimates can be biased when assuming normality for Likert-scale variables with five or fewer items (Babakus et al., 1987; Green et al., 1997; Muthen & Kaplan, 1992). The WLSMV, which does not assume normally distributed variables, provides the best option for modeling BDI-II data with four response categories (Brown, 2006; Chen et al., 2020). The fit of the model was evaluated using the root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI). Regarding common standards, the following criteria were used to indicate the goodness of fit: RMSEA $\leq .08$, CFI $\geq .95$ and TLI $\geq .95$ (Hu & Bentler, 1999). Fit indices were obtained separately for each group.

To test measurement invariance across groups, we examined changes in model fit measures after increasing the invariance stringency. Configural, metric, scalar and strict models can test invariance in factor patterns, factor loadings, item thresholds, and residuals, respectively (Meredith, 1993). The configural model tests whether the same CFA is valid for each group (Van de Schoot et al., 2012). The next comparison is called metric invariance, which tests whether the factors attribute the same meaning to the latent construct. The scalar model tests whether the meaning of the construct and levels of the underlying items are equal in both groups. This third level was necessary to compare the differences in latent mean scores between groups. Finally, strict invariance implies that all group differences at the level of the items are attributed to group differences at the level of the common factors. Chen (2007) suggests that an increase of $\geq .015$ in RMSEA and a decrease of $\geq .01$ in CFI are evidence of non-invariance.

## Results

### Basic Sociodemographic Characteristics of Participants

Sociodemographic and clinical characteristics of the 1,470 participants included in the analyses are listed in Supplementary Table 1. The sample with comorbid alcohol problems scored higher on the AUDIT scale ($t_{(964.07)} = -4.41$, $p < .001$), but 2.82 points higher on the BDI-II scale ($t_{(487.59)} = -42.48$, $p < .001$). MDD patients with alcohol problems had a similar sex ratio, whereas those without alcohol problems were predominantly females (40.2% vs. 70.6%, $\chi^2 = 61.33$, $p < .001$). There was also a between-group difference in educational levels.

Supplementary Table 1 lists the psychiatric comorbidities, with anxiety disorders showing the highest prevalence (47.1%), followed by somatic symptoms and related disorders (9.3%), attention-deficit/hyperactivity disorder (2.5%), feeding and eating disorders (1.8%), and sleep-wake disorders (0.8%). We compared the psychiatric comorbidity rates between the two groups. The rates of comorbid somatic symptoms and related disorders were higher in patients with MDD without comorbid alcohol problems (11.4% vs. 4.6%, $p < .05$). The group with alcohol problems showed a higher rate of comorbid feeding and eating disorders than the group without concurrent alcohol problems (3.3% vs. 1.1%, $p < .05$).

**Table 1.** *Confirmatory Factor Analyses of the BDI-II across Samples*

| | $\chi^2$ | *df* | RMSEA | CFI | TLI |
|---|---|---|---|---|---|
| Without comorbid alcohol problems (*n* = 1,013) | | | | | |
| SA-C | 969.616 (1,342.985) | 188 | .064 (.078) | .983 (.929) | .981 (.921) |
| C-A-S | 831.161 (1,168.039) | 186 | .059 (.072) | .986 (.940) | .985 (.932) |
| With comorbid alcohol problems (*n* = 457) | | | | | |
| SA-C | 430.138 (557.162) | 188 | .053 (.066) | .984 (.937) | .983 (.930) |
| C-A-S | 376.689 (499.560) | 186 | .047 (.061) | .988 (.947) | .986 (.940) |

*df* = degrees of freedom; RMSEA = root mean square error of approximation; CFI = comparative fit index; TLI = Tucker-Lewis index.
Robust testing in parentheses.

**Table 2.** *Tests for Measurement Invariance of the BDI-II across Samples*

| SA-C model | $\chi^2$ | *df* | RMSEA | ΔRMSEA | CFI | ΔCFI | TLI |
|---|---|---|---|---|---|---|---|
| 1. Configural | 1,531.612 | 376 | .065 | | .896 | | .884 |
| 2. Metric | 1,546.453 | 395 | .063 | \|.002\| | .897 | \|.000\| | .890 |
| 3. Scalar | 1,588.438 | 414 | .062 | \|.001\| | .895 | \|.002\| | .893 |
| 4. Strict | 1,619.048 | 435 | .061 | \|.001\| | .894 | \|.001\| | .897 |

*df* = degrees of freedom; RMSEA = root mean square error of approximation; CFI = comparative fit index; TLI = Tucker-Lewis index.
Robust testing in parentheses.

### Factor Analysis

In this study, Beck et al.'s (1996) two-factor model and Buckley et al.'s (2001) three-factor model were tested. Both models had good RMSEA values ($\leq$ .08) in patients with MDD, with or without concurrent alcohol problems. The CFI and TFI were greater than .90, which was conventionally regarded as a reasonable fit. When the two models are compared, the C-A-S model showed better fit indices but the difference between the two models was small (e.g., $\Delta$CFI $\leq$ .011). Browne & Cudeck (1992) highlighted that proposed fit indices do not guarantee the usefulness of a model; therefore, model selection must be a subjective process. As both models indicated adequacy across each sample, the SA-C model of Beck et al. (1996) was selected because of its more parsimonious nature. These findings are consistent with those of previous studies (Skule et al., 2014). Moreover, the model reflects the characteristics of alcohol-induced depression, which are embedded in both somatic and affective symptoms. Table 1 shows the fit indices for the two models using the robustness criteria. The two-factor model and factor loadings are presented in Supplementary Figure 1.

### Measurement Invariance Across Groups

Table 2 shows the test results of measurement invariance across the two samples. The SA-C model of Beck et al. (1996) was tested. Changes in both the RMSEA and CFI were below the recommended cutoff values ($\geq$ .015 and $\geq$ -.01, respectively). Our results suggested that the factor structure, item loadings, item thresholds, and residuals of the BDI-II were invariant across patients with or without alcohol problems. The strict factorial invariance model did not significantly worsen the model fit, indicating that all model parameters could be equated across patients with depression, regardless of comorbid alcohol problems.

## Discussion

This study aimed to investigate the psychometric properties (e.g., factor structures and measurement invariances) of the BDI-II. Our results indicate that when Beck et al.'s (1996) SA-C model was applied to our clinical data, the factor structure was identical in the two samples, which varied in their level of alcohol problems. We replicated the two-factor structure as a reasonable and parsimonious presentation of BDI-II items in patients diagnosed with MDD, consistent with findings from a community sample (Skule et al., 2014). Given that previous research has reported a three-factor model, our data demonstrated good or acceptable RMSEA, CFI, and TLI values for the C-A-S model for both samples. One possible explanation for this is the similarity between the two models. The


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two candidate models are identical in terms of the cognitive factor. Beck et al.'s (1996) Somatic-affective factor is a combination of two factors in Buckley et al.'s (2001) model: somatic and affective.

Notably, the factor structure, item loadings, and item thresholds of the BDI-II items were invariant across patients with MDD, with or without alcohol problems. To our knowledge, this is the first study to examine the factor structure and measurement invariance of BDI-II in a Korean clinical sample. We hypothesized that alcohol users are more likely to experience somatic and affective symptoms, but less likely to recognize internal signals or cognitive symptoms of depression. However, strict invariance implies that the symptom-specific levels of depression between the two groups were equal. Those with alcohol problems often report a higher severity of depression, as assessed by the total BDI-II score (Ostacher, 2007). Based on these findings, patients with comorbid depression and alcohol abuse should receive appropriate treatment for both conditions.

Our study has strengths, as we screened for diagnoses of depression and comorbid disorders, through clinical interviews. Although the results mirror those of previous research using a community sample (Skule et al., 2014) and sub-clinical substance users (Moore et al., 2016), further research including clinical and sub-clinical samples on a broader continuum is needed. Another limitation is the lack of consensus on the cutoff value for problematic drinking in the Korean population. This study applied a generous standard for alcohol problems (8 or above) for the dichotomous groups. It may not represent heavy drinkers who fulfill formal diagnoses of alcohol use disorders. The third limitation was the lack of accessible information about the patients' ongoing treatment, including their start of treatment. As treatment can improve the fit of the underlying factor structure (Elhai et al., 2013), a sample exposed to different levels of treatment may constrain the extent of generalization.

To our knowledge, this is the first study to consider the characteristics of a clinical sample with various comorbidities. We found that the basic factor structures were identical in patients with depressive symptoms regardless of alcohol problems. Therefore, BDI-II can be used to assess the severity of depressive symptoms. Parallel attention to comorbid pathologies such as substance use is emphasized for treatment.

## Author contributions statement

YL, a clinical psychologist at Samsung Medical Center, wrote the initial manuscript and conducted the statistical analysis. EHL, a clinical psychologist at the Depression Center at Samsung Medical Center, contributed to the data collection for this study. He interpreted the statistical results and critically revised the manuscript accordingly. JHK, a supervisor in the Department of Psychiatry at Samsung Medical Center and a professor at Sungkyunkwan University School of Medicine, supervised the research process. All the authors reviewed the manuscript and participated in the revision process.

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**Supplementary Table 1.** *Sociodemographic and Clinical Characteristics of Participants*

| | Total ($n$ = 1,470) | | Without comorbid alcohol problems ($n$ = 1,013) | | With comorbid alcohol problems ($n$ = 457) | |
|---|---|---|---|---|---|---|
| | N (%) | Mean (*SD*) | N (%) | Mean (*SD*) | N (%) | Mean (*SD*) |
| Gender | | | | | | |
| Male | 530 (36.1) | | 298 (29.4) | | 232 (50.8) | |
| Female | 940 (63.9) | | 715 (70.6) | | 225 (49.2) | |
| Education level | | | | | | |
| Middle school | 119 (8.1) | | 94 (9.3) | | 25 (5.5) | |
| High school | 601 (40.9) | | 378 (37.3) | | 212 (46.4) | |
| Some college | 761 (51.8) | | 541 (53.4) | | 220 (48.1) | |
| Comorbidity | | | | | | |
| ANX | 692 (47.1) | | 500 (49.4) | | 192 (42.0) | |
| SOM | 136 (9.3) | | 115 (11.4) | | 21 (4.6) | |
| ADHD | 37 (2.5) | | 21 (2.1) | | 16 (3.5) | |
| EATING | 26 (1.8) | | 11 (1.1) | | 15 (3.3) | |
| SLEEP | 12 (0.8) | | 6 (0.6) | | 6 (1.3) | |
| Age | | 38.5 (14.4) | | 40.0 (14.6) | | 35.2 (13.2) |
| BDI-II-score | | 32.8 (11.6) | | 31.9 (12.2) | | 34.7 (11.0) |
| AUDIT-score | | 6.5 (8.5) | | 1.7 (2.1) | | 17.2 (7.7) |

ANX = anxiety disorders; SOM = somatic symptom and related disorders; ADHD = Attention-Deficit/Hyperactivity Disorder; EATING = feeding and eating disorders; SLEEP = sleep-wake disorders.


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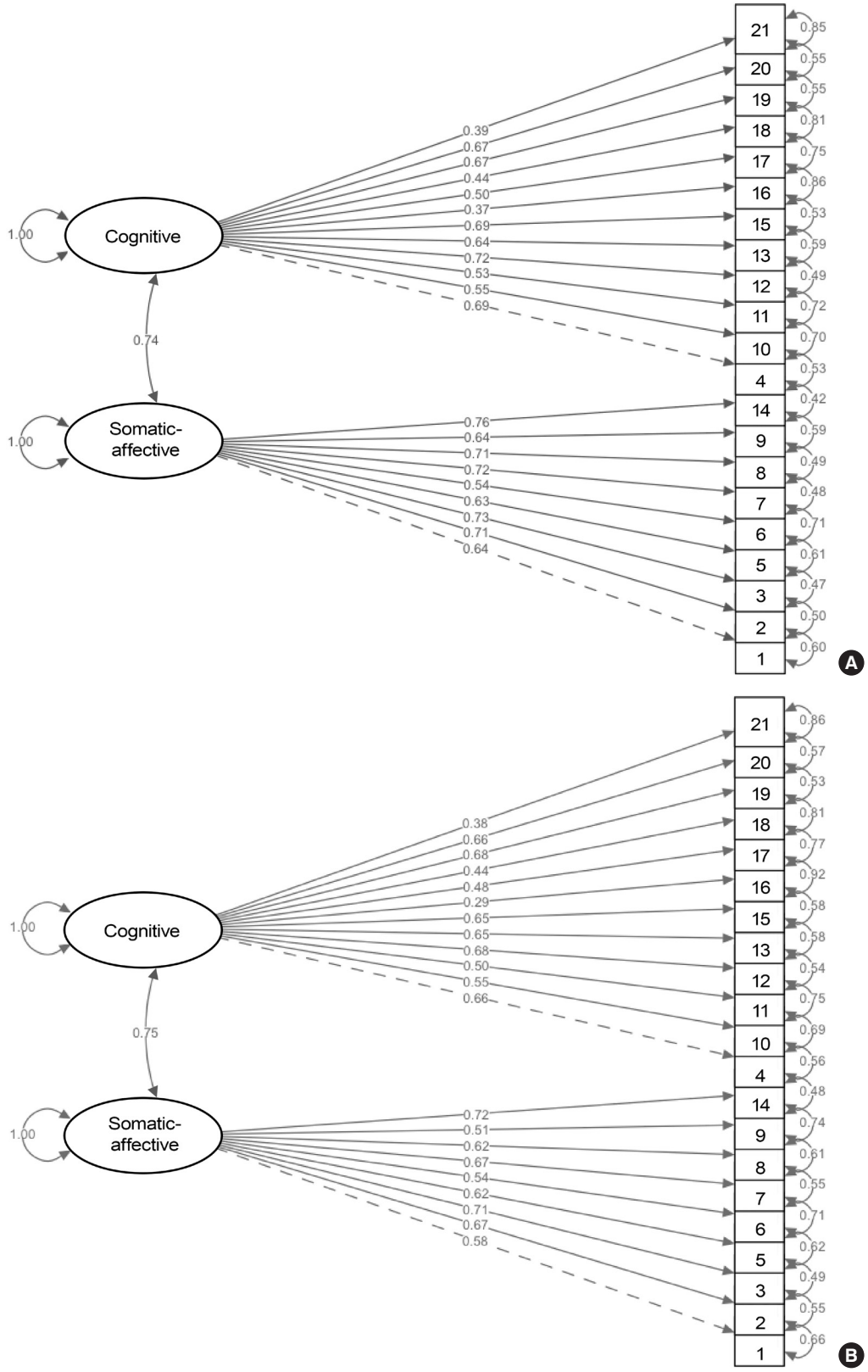


**Supplementary Figure 1.** *Diagram of Confirmatory Factor Analysis for SA-C Model (A) MDD Patients without Alcohol Problems (B) MDD Patients with Alcohol Problems.*