Original Article

Effect of Brain Behavioral System on Psychological Vulnerability of Diabetic Female Patients with a Mediating Role of Positive and Negative Emotions: A Structural Equation Modeling Design

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Abstract

Background and Objective: In 2021, chronic diseases were responsible for two-thirds of all diseases and considered the primary cause of mortality and general disability. Therefore, this research was carried out to examine how the brain-behavioral system affected the psychological susceptibility of diabetic women, with positive and negative emotions playing a mediating role.

Materials and Methods: This descriptive study was conducted using a structural equation modeling design. The study included all women with diabetes who referred to the specialized diabetes clinic in Karaj during the first six months of 2011. The samples (n=380) were selected using a purposive sampling method. The research instruments were Watson et al.'s (1988) Positive and Negative Affect Scale, Mental Health Questionnaire (SCL-25), and Carver and White's Brain-Behavioral Systems Questionnaire. The collected data were analyzed using structural equation modeling and Pearson's correlation coefficient in SPSS 23 and Amos 18 software.

Results: The findings showed that there was a positive indirect path coefficient between psychological vulnerability and the behavioral inhibition system (β=0.188; P=0.001). It was also found that there was a negative and significant indirect path coefficient between psychological vulnerability and the behavioral activation system (β=0.147; P<0.01). Nevertheless, the indirect path coefficient between the behavioral inhibition system and psychological vulnerability was positive via positive effect (β=0.066; P=0.003), while it was negative and significant between the behavioral activation system and psychological vulnerability via positive effect (β=-0.070: P=0.001). Nonetheless, the indirect path coefficient was positive between psychological vulnerability and the behavioral inhibition system via negative emotion (β=0.126; P=0.001), whereas it was negative and significant between psychological vulnerability and the behavioral activation system via negative emotion (β=0.081; P=0.007).

Conclusions: In female diabetic patients, positive and negative emotions had a positive mediating role in the effect of the behavioral inhibition system on psychological vulnerability, while they played a negative mediating role in the effect of the behavioral activation system on psychological vulnerability.

Keywords: Brain behavioral system, Modeling, Patients with diabetes, Positive and negative emotions, Psychological vulnerability, Structural equations

Background

According to the estimate of the World Health Organization, chronic diseases, making up two-thirds of all diseases, constituted the leading cause of mortality and public disability in 2021 [1], and they contribute greatly to the continuation of pain and the resulting disability [2]. One of the largest groups of chronic patients are patients with diabetes, in four groups: type 1 diabetes (as a result of the destruction of beta cells, which usually causes an absolute lack of insulin), type 2 diabetes mellitus in pregnancy (diagnosed during pregnancy), and other specific types of diabetes classified for other causes [3].

In Iran, 36% of all Women with diabetes are placed in the type 1 diabetes group [4]; nonetheless, attributing a specific type of diabetes to a person often depends on the conditions present at the time of diagnosis. Many diabetic people cannot be easily classified into only one class and group of the disease. For example, a person suffering from gestational diabetes may still have high blood sugar even after giving birth. In this case, a diagnosis of

type 2 diabetes will be made [5].

Diabetes exerts marked effects on individual and social functioning [6]. This chronic disease has fatal complications and is known as the main cause of limb amputation, chronic kidney failure, blindness, and heart disease [7]. Diets, medication, and nutritional regimens increase the risk of psychiatric diseases, such as low self-esteem, depression, anxiety, and eating disorders, in these patients [8]. Consequences associated with diabetes include coronary and peripheral vascular disease, stroke, diabetic nephropathy, limb amputation, kidney failure, and blindness [9]. This disease has numerous psychological and behavioral complications greatly affecting the mental health and quality of life of these patients. In most primary studies, diabetes has been introduced as a disease with psychological causes [10]. It seems that such an attitude is reasonable since, for many years, those who deal with diabetic patients have reported that these people suffer from psychological damage and emotional disorders [11].

Psychological vulnerability is recognized as a congenital or acquired predisposition to conflicts and mental disorders, encompassing cognitive, emotional, biological, and social elements [12]. The pattern is based on deficiency or problem in one or more areas of mental function, including general function or specific functions; nonetheless, it is not limited to these areas [13]. These symptoms should not be an expected response to a general stressor or a lack of a culturally approved response to a specific event. They are not primarily caused by social deviance or a person's conflict with society; rather, they are affected by cognitive, behavioral, and personality contexts, such as the neurobehavioral system [14]. Based on individual differences in response to punishing and rewarding stimuli, it has two systems of inhibition and behavioral activation [15]. One of these systems operates at three behavioral, neurological, and cognitive levels [16]. The activation system is the neurophysiological basis of impulsivity associated with positive emotions and activated by positive stimuli [17]. The high activity of this system leads to behavioral and bipolar disorders, while the behavioral inhibition system is the neurophysiological basis of anxiety related to negative emotions and stimuli [18]. Excessive activity of this system causes anxiety disorders in childhood, and any defect in its activity plays a role in hyperactivity disorder [14]. It is assumed that positive emotions, such as happiness and peace, are related to orientational motivation, and negative emotions, such as sadness and fear, are related to avoidance motivation [19]. The most important trait reflecting these two systems is

anxiety and impulsivity. This theory refers to three basic emotional systems in the central nervous system of mammals, which are the basis of personality differences [20]. Each of these systems responds to different reinforcing events with different behaviors. Secondly, they are controlled by a separate set of interconnected brain structures that process sensitive information from the environment, affecting behavioral and cognitive sensitivity [21].

Every person's emotions, as an essential part of the dynamic system of human personality, are affected by high-risk behaviors, such as addiction [22]. Negative effect is a general dimension of inner despair and lack of engagement in enjoyable work [23], which is followed by avoidant emotional states, such as anger, sadness, hatred, humiliation, guilt, fear, and anger [24]. Positive emotion is also a state of active energy, high concentration, and engagement in enjoyable activities, including a wide range of positive moods, such as happiness, feelings of empowerment, enthusiasm, desire, interest, and self-confidence [25]. In general, people with diabetes are potentially threatened by other factors, such as negative emotions and nervous system defects, which affect whether or not they are influenced by diabetes-related wounds. It is thought that these series of factors play the role of the initiating or stimulating mechanism in the severity and initiation of diabetes and other mental disorders.

Objectives

Therefore, the main question is whether the model of the impact of the brain-behavioral system on female diabetic patients experiencing psychological vulnerability, with positive and negative emotions playing a mediating role, has the necessary fit.

Materials and Methods

This applied research was carried out based on structural equation modeling design. The research study's population consisted of all female diabetes patients who visited the specialized diabetes clinic in Karaj during the first six months of 2021. The sample size was calculated based on the number of observed variables, with a factor of 10 allocated for each observed variable, while also considering the potential for incomplete questionnaires. As a result, 380 cases were chosen as the samples via the purposive sampling method according to the inclusion and exclusion criteria.

The study included patients meeting the following criteria: having type 1 diabetes, being aged between 18 and 44 years, having an average severity level of

disease progression as determined by the attending physician, failing to effective psychological and physical treatments in the process of cooperation in the meetings as diagnosed by the psychiatrist of the medical centers, residing in Karaj, and expressing a willingness to take part in the study. On the other hand, incomplete completion of questionnaires was considered the exclusion criterion.

Study tools

1. **Brain-Behavioral Systems Scale (BAS/BIS):** The Brain-Behavioral Systems Scale, which was developed by Carver and White in 1994, contains 24 self-report questions, as well as two BIS and BAS subscales. The items are rated on a four-point Likert scale (from 1=completely disagree to 4=completely agree). The subscale of the behavioral restraint system in this questionnaire includes seven items (2, 8, 13, 16, 19, 22, 24). The behavioral activation system subscale, which measures the sensitivity of the brain behavioral activation system, contains three other subscales: drive (3, 9, 12, 21), response to reward (4, 7, 14, 18, 23), and looking for fun (5, 10, 15, 20). Items 1, 6, 11, and 17 have no effect on scoring. A high score in the behavioral activation system is considered good, and a high score in the behavioral inhibition system is bad. Content and construct validity were confirmed by the designer, and Cronbach's alpha reliability was estimated at 0.91 for the behavioral activation system scale and 0.93 for the behavioral inhibition system subscale. It was reported as 0.78 for the behavioral activation system scale and 0.81 for the behavioral inhibition system subscale [26].

2. **Psychological injury questionnaire (SCL-25):** The 25-item psychological injury questionnaire (SCL-25), designed by Najarian and Davoudi (2010), is considered a mental health questionnaire; nonetheless, it assesses one's psychological pathology, which includes eight main factors: intellectual and practical obsession, anxiety, interpersonal sensitivity, paranoid thoughts, depression, morbid phobic anxiety, and psychotic thoughts in the past week; however, question 18 is not calculated. The replies are scored on a 5-point Likert scale (from 0=none to 4=severe), with higher scores indicating poorer mental health and lower scores suggesting higher mental health. An average of two or higher in the raw scores of the whole questionnaire is considered a sign of serious symptoms. The reliability of this tool was obtained by calculating the internal consistency of 0.98 in a male sample and 0.97 in a female sample. The test-retest reliability coefficient of this instrument was estimated at 0.78 in a sample of 312 students at Shahid Chamran University at an interval of five weeks [27].

3. **Measurement of positive and negative emotions by Watson, Clark, and Tellegen (1988):** Watson, Clark, and Tellegen (1988) developed and validated this instrument to assess positive and negative emotions. This scale consists of two sets of 10 questions to measure positive (1 to 10) and negative (11 to 20) emotions, which are answered on a 5-point Likert scale (from 1=completely disagree to 5=completely agree). From the total points divided by the number of questions, the respondent's status in positive and negative emotions is determined separately. It does not have a total score. In Iran, according to the research by Bakhshipurpour and Dejkam, this instrument has acceptable construct validity and audit validity, and its internal consistency coefficients were obtained at 0.81 for the positive effect and 0.80 for the negative effect using Cronbach's alpha coefficient method [28]. The reliability of this scale was confirmed in the current study, rendering a Cronbach's alpha coefficient of 0.77 for positive emotions and 0.80 for negative emotions. The gathered data were analyzed using Pearson's correlation coefficient and structural equation modeling in SPSS 23 and Amos 18 software packages.

Results

In the present study, there were 380 women with diabetes, of whom 112 (29.5%) were less than 25 years old, 96 (25.3%) cases were 26-30 years old, and 54 (14.2%) subjects were 31-35 years old, 68 (17.9%) people were 36-40 years old, and 50 (13.2%) cases were more than 40 years old. Regarding marital status, 84 (22.1%) subjects were single, 266 (70%) cases were married, and 30 (7.9%) subjects were separated from their spouses. In terms of education, out of the participants, 78 (20.5%) had a diploma, 118 (31.1%) an associate's degree, 65 (17.1%) a bachelor's degree, 93 (24.5%) a master's degree, and 26 (6.8%) a PhD. Table 1 presents the mean, standard deviation, and correlation coefficients between the research variables.

Table 1 presents data on the correlation coefficients between the variables, demonstrating that the correlation direction between the variables was consistent with the expectations and theories of the research field.

According to the findings of the above table, the skewness and kurtosis values of all components fell within the range of ±2. As a result, the assumption

Table 1. Correlation matrix between research variables

Research variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. BIS	-														
2. DBIS	-0.21	-													
3. BAS-RR	-0.23	0.53	-												
3. BAS-ES	-0.24	0.58	0.60	-											
5. PE	-0.39	0.30	0.27	0.33	-										
6. NE	0.42	-0.23	-0.23	-0.25	-0.51	-									
7. MV-PC	0.34	-0.15	-0.20	-0.16	-0.38	0.44	-								
8. PV-OC	0.21	-0.13	-0.17	-0.19	-0.30	0.27	0.39	-							
9. PV-IS	0.25	-0.19	-0.15	-0.16	-0.25	0.35	0.62	0.41	-						
10. PV-D	0.26	-0.23	-0.17	-0.21	-0.27	0.37	0.52	0.38	0.41	-					
11. PV-A	0.28	-0.20	-0.29	-0.29	-0.44	0.45	0.57	0.52	0.38	0.51	-				
12. PV.MF	0.32	-0.16	-0.21	-0.18	-0.36	0.42	0.61	0.4	0.61	0.45	0.60	-			
13. PV-PT	0.20	-0.05	-0.10	-0.09	-0.27	0.29	0.40	0.26	0.42	0.38	0.45	0.47	-		
14. PV-P	0.03	-0.13	-0.14	-0.16	-0.08	0.18	0.26	0.22	0.30	0.26	0.36	0.24	0.39	-	
15. MV-D	0.17	-0.02	-0.13	-0.12	-0.24	0.26	0.44	0.17	0.43	0.18	0.39	0.40	0.27	0.21	-
Mean	15.27	8.52	9.58	8.87	24.17	23.23	18.56	8.40	8.49	5.74	8.70	8.16	2.74	7.37	2.25
SD	3.92	2.80	3.22	3.09	5.50	5.84	4.42	3.07	3.28	2.37	3.18	3.06	1.47	2.13	1.09

of normality regarding the distribution of single variable data among the data was upheld. The findings from Table 2 indicate that predictor variables have tolerance coefficient values greater than 0.1, with each of them having variance inflation factor values smaller than 10. Therefore, the assumption of collinearity was also maintained among the data of this research. In this study, the "Mahlnobais interval" was employed to analyze information to establish whether the assumption of normality of the distribution of multivariate data was established. The skewness and kurtosis values for the Mehlen-Bais distance data were determined to be 1.06 and 1.13, respectively, falling within the range of ±2. This finding validated the assumption of the normal distribution of multivariate data. Finally, to assess the assumption of variance homogeneity, the scatter plot of the standardized error variances was examined, confirming that the assumption held true for the data.

Once the assumptions were evaluated and confirmed, the data were analyzed using the structural equation modeling method. As displayed in Figure 1, in the current research model, it was assumed that the brain behavioral system has an effect on psychological vulnerability in female patients with diabetes both directly and through the mediation of positive and negative emotions. The model presented in Figure 1 demonstrates that the two variables of the behavioral activation system and psychological vulnerability are latent and form the measurement model of the research. In the driver measurement model, responding to reward and entertainment seeking are latent variable indicators of the behavioral activation system, while obsessive-compulsive disorder, physical complaints, anxiety, depression, interpersonal sensitivity, paranoid thoughts, morbid fear, psychosis, and dementia are latent variable indicators of vulnerability. The AMOS software (version 24.0) was utilized to assess the fit of the measurement model through confirmatory factor analysis and maximum likelihood estimation.

Table 2. Examining the assumptions of normality and collinearity

Variable	Assumption of normality		Collinearity assumption	
	Skewness	Kurtosis	Tolerance coefficient	Variance inflation
Behavioral inhibition system	0.42	-0.50	0.59	1.71
Behavioral activator-driver system	0.51	-0.46	0.57	1.76
Behavioral activation system - response to reward	0.40	-0.82	0.51	1.96
Behavioral activation system - entertainment seeking	-0.05	-0.69	0.77	1.30
Positive emotions	-0.24	-0.51	0.66	1.51
Negative emotions	0.12	-0.61	0.61	1.63
Psychological vulnerability - physical complaints	0.04	-0.29	-	-
Psychological vulnerability - obsessive-compulsive disorder	-0.21	-0.17	-	-
Psychological vulnerability - interpersonal sensitivity	-0.06	-1.12	-	-
Psychological vulnerability - depression	-0.19	-0.47	-	-
Psychological vulnerability - anxiety	-0.20	-1.04	-	-
Psychological vulnerability - morbid fear	0.08	-0.93	-	-
Psychological vulnerability - paranoid thoughts	-0.16	-1.50	-	-
Psychological vulnerability - psychosis	0.32	-1.04	-	-
Mental vulnerability - dementia	0.09	-1.47	-	-

Table 3. Fit indices of the measurement model and structural model

Fitness indicators	Measurement model	Structural model	cut point
chi square	110.63	207.43	-
model/df	53	84	-
df²χ	2.09	2.48	3 >
GFI	0.952	0.934	0.90 >
AGFI	0.930	0.905	0.850 >
CFI	0.964	0.939	0.90 >
RMSEA	0.054	0.062	0.08 <

df: normed chi-square

Information regarding the fit indices of both the measurement model and the structural model is provided in Table 3.

According to Table 3, all fit indices derived from the confirmatory factor analysis were indicative of the acceptable fit of the measurement model with the gathered data (df=2.09, CFI=0.964, GFI=0.952, AGFI=0.930, and RMSEA=0.054). The largest factor load in the measurement model was related to the fun-seeking indicator (β=0.825), whereas the smallest one belonged to the psychotic indicator (β=0.361). As a result of the factor loadings for all indicators being greater than 0.32, it can be concluded that each of them possessed the necessary power to gauge the variables under study. The fit of the structural model with the data was examined to ensure that the measurement model had an acceptable fit with the data. The fit indices in Table 3 demonstrate that the structural model has an acceptable fit with the data (df/2=2.47, CFI=0.939, GFI=0.934, AGFI=0.905, and RMSEA=0.062). Table 4 illustrates the path coefficients in the structural model.

Based on Table 4, the total path coefficient between the behavioral inhibition system and psychological vulnerability (β=0.313, P=0.001) is positive, while the total path coefficient between the behavioral activation system and psychological vulnerability (β=-0.253, P=0.001) is negative and significant. The path coefficient between negative emotion and psychological vulnerability (β=0.348, P=0.001) is positive, while the path coefficient between positive emotion and psychological vulnerability (β=0.215, P=0.001) is negative and significant.

According to Table 4, the indirect path coefficient was positive between psychological vulnerability and the behavioral inhibition system (β=0.188, P=0.001), while it was negative and significant between psychological vulnerability and the behavioral activation system (β=0.147, P<0.01). Nonetheless, as depicted in Figure 1, there were two mediators (positive emotion and negative emotion) in the research model. Consequently, to establish whether each of the two mediator variables played a significant or non-significant role, the formula by Baron and Kenny (1986, cited in Malenkrot et al., 2006) was employed. Accordingly, the results showed that the indirect path coefficient between the behavioral inhibition system and psychological vulnerability via positive effect (β=0.066, P=0.003) and the indirect coefficient between the behavioral activation system and psychological vulnerability through positive effect (β=0.070, P=0.001) was negative and significant.

Furthermore, the coefficient of the indirect path was positive between psychological vulnerability and the behavioral inhibition system via negative emotions (β=0.126, P=0.001), while it was negative and significant between the behavioral activation system and psychological vulnerability via negative emotions (β=0.081, P=0.081). Therefore, it was concluded that among female diabetic patients, positive and negative emotions played a positive mediating role in the effect of the behavioral inhibition system on psychological vulnerability, while it had a negative and significant mediating role in the effect of the behavioral activation system on psychological vulnerability. Figure 1 presents the

Table 4. Total and direct path coefficients between the research variables in the structural model

Effect		b	S.E	β	p
Direct	Behavioral inhibition system- negative emotion	0.529	0.076	0.356	0.001
	Behavioral activation system-negative affect	-0.650	0.176	-0.227	0.001
	Behavioral inhibition system- positive affect	-0.418	0.073	-0.296	0.001
	Behavioral activation system- positive affect	0.851	0.165	0.315	0.001
	Behavioral inhibition system - Psychological vulnerability	0.087	0.034	0.125	0.024
	Behavioral activation system - Psychological vulnerability	-0.144	0.084	-0.107	0.085
	Negative emotion- Psychological vulnerability	0.163	0.029	0.348	0.001
	Positive affect- psychological vulnerability	-0.107	0.032	-0.215	0.001
indirect	Behavioral inhibition system -Psychological vulnerability	0.131	0.026	0.188	0.001
	Behavioral activation system - Psychological vulnerability	-0.198	0.053	-0.147	0.001
Total	Behavioral inhibition system -Psychological vulnerability	0.218	0.041	0.313	0.001
	Behavioral activation system - Psychological vulnerability	-0.342	0.081	-0.253	0.001

structural model used in the study to demonstrate how the brain-behavioral system influences psychological vulnerability in female diabetes patients, taking into account the mediating role of positive and negative emotions.

Discussion

The present study aimed to determine the effect of the brain-behavioral system on psychological vulnerability through the mediation of positive and negative emotions in patients with diabetes. The obtained results pointed out that in female patients with diabetes, the brain behavioral system and positive and negative emotions explain 37% of the variance of psychological vulnerability. The results of the current research are consistent with those reported by Dixon, Wheatcroft, and Perry [23], Farrell et al. [24], Jackson, Miklash, Al-Siyahabiba, Shiar and Privitra [25], and Rosenkranz et al. [26]. Behavioral activation has an inverse relationship with the psychological trauma of social interaction. In addition, this research demonstrated that participants with generalized social fears showed a low level of behavioral activation sensitivity compared to those with specific social fears [27]. Moreover, behavioral activation has a negative relationship with psychological damage and fear of negative evaluation, social avoidance, and psychological damage. Behavioral inhibition and behavioral activation work interactively to influence behavior [28].

The high level of sensitivity of the behavioral inhibition system through cognitive biases has a direct effect on psychological damage in different occupational, educational, and even social dimensions, and the brain-behavioral systems for threatening and negative social information is a mechanism through which the behavioral inhibition system shows its effects on psychological damage [29]. Individual differences in the sensitivity of brain behavioral systems in the behavioral inhibition system to social cues are an important determinant of how a person responds to specific social situations, such as education and work. In an inhibitory activity, a person perceives behavioral sensitivity in social situations. The result of this perception is fear and avoidance of threatening social situations, such as psychological trauma, which ultimately leads to psychological trauma disorder. Individuals with stronger behavioral inhibition show more signs of psychological damage [30].

There is a positive relationship between behavioral inhibition and state negative emotion, which is a predictor of psychological harm. These findings indicate that having high behavioral inhibition is a risk factor for having a high level of psychological harm. Considering high behavioral inhibition, it is not surprising that psychological damage and avoidance are high [31]. The relationship between behavioral inhibition and psychological damage can indicate the biological basis of this disorder. It can be suggested that a person's inherent vulnerability to psychological trauma is the result of genetic effects on the behavioral inhibition function and the behavioral inhibition system. It is considered that individuals with a genetic history of anxiety or other neurotic disorders are more susceptible to psychological disorders [32]. People who are genetically capable of showing a high level of behavioral inhibition display a higher level of behavioral inhibition and shyness in the educational and educational environment, while adults demonstrate a higher level of neuroticism, trait psychological damage, and shyness.

Furthermore, behavioral inhibition is a pattern of withdrawal and avoidance, which leads to social problems, reduced relationships with friends, and avoidance of social interactions, ultimately leading to psychological damage. Emotional damage, restraint behavior, active avoidance, and silence are receiving more attention, the neuroanatomical foundations of this system are being established, and its high activity is related to the experience of psychological trauma [33]. The occurrence of inhibition behaviors, sensitivity to signs of punishment, and lack of reward in the environment are more observed in people with social psychological harm disorder. In this regard, another finding of his research indicated that the behavioral activation system has a negative effect on the occurrence and persistence of psychological damage symptoms. This finding means that individuals with weaker behavioral activation demonstrate more signs of psychological damage.

In the process of trying to avoid arousal through anxiety sensitivity, people's anxiety may persist or even become more intense. Accordingly, people may become increasingly disgusted with their emotional experiences, deny them, or attribute them to confusion, leading to an increase in anxiety sensitivity as an automatic and evasive strategy, and as a result, this cycle becomes permanent [34]. The roots of this defective cycle can be found in anxiety sensitivity, which is exclusively related to an individual with avoidant behavior. On the other hand, it is considered to be one of the first-order vulnerability factors in relation to avoidant disorders [35]. The fear of physical signs causes excessive ringing and internal self-monitoring of signs and feelings. Therefore, fear of anxiety stimuli and

symptoms of the sympathetic system, such as sweating, shortness of breath, and increased heart rate, are characteristic of people with high anxiety sensitivity [36].

The model indicates that people's belief in their ability to control anxiety during stress is influenced by their perception of control over anxiety. Individuals suffering from anxiety disorder encounter unforeseen experiences and a sequence of emotions. These consecutive warnings lead people with anxiety and vulnerability to perceive their physical and emotional responses as unmanageable. Therefore, individuals with anxiety disorders tend to avoid social situations and employ less cognitive reappraisal in such situations due to their perceived lack of internal control over their emotional responses when interacting with others [37]. Among the limitations of this study, we can mention the limited number of patients with type 1 diabetes, an age range of 18-44 years, and people living in Karaj that were under the supervision of diabetes clinics. Therefore, it is suggested that future studies consider other diseases and different age groups.

Conclusion

According to the findings of our study, among female diabetic patients, positive and negative emotions played a mediating role in the impact of the behavioral inhibition system on psychological vulnerability in a positive way, and the impact of the behavioral activation system on psychological vulnerability in a negative and significant way.

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