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Evaluation of the psychometric properties of the cardiac distress inventory in Iranian patients with heart disease

Hamid Sharif-Nia[1,2], João Marôco[3], Alun C. Jackson[4], Safoura Salehi[5], Omolhoda Kaveh[6], Fateme Miraghai[7]✉ & Seyed Hamzeh Hosseini[8]

Psychological distress is common among patients with heart disease, necessitating valid and reliable assessment tools for measuring cardiac distress. The Cardiac Distress Inventory (CDI) has been developed for this purpose, but its psychometric properties require validation in different cultural contexts. This study aimed to evaluate the psychometric properties of the Farsi version of the CDI in an Iranian population with heart disease, focusing on its validity, reliability, and factor structure. A cross-sectional study was conducted from October to December 2024 with 400 adult patients diagnosed with heart disease. Participants were recruited from cardiac departments and clinics using convenience sampling. The CDI was translated into Farsi following WHO guidelines and assessed for face and content validity. Exploratory factor analysis using Maximum Likelihood Estimation (MLEFA) with Promax rotation and confirmatory factor analysis were conducted to determine construct validity. Convergent and discriminant validity were examined using average variance extracted (AVE) and heterotrait-monotrait (HTMT) ratio, while reliability was assessed via Cronbach's alpha, McDonald's omega, and composite reliability. Measurement invariance across gender groups was also analyzed. The mean age of participants was 42.95 years (SD = 14.02), and 56.8% were women. EFA identified a two-factor structure—Existential and Emotional Distress and Uncertainty and Maladaptive Coping—explaining 69.15% of the variance, with 10 retained items. CFA confirmed the model fit (χ^2[34] = 45.714, $p = 0.086$, CFI = 0.991, RMSEA = 0.036). The CDI demonstrated strong internal consistency (Cronbach's alpha > 0.8) and good convergent (AVE > 0.5) and discriminant validity (HTMT = 0.374). Measurement invariance across gender was established at the configural, metric, and scalar levels. The Farsi version of the CDI is a valid and reliable tool for assessing cardiac distress in Iranian patients with heart disease. These findings support its use in clinical and research settings to better understand and address the psychosocial challenges faced by this population, ultimately improving psychological assessment and intervention strategies.

Keywords Cardiac distress inventory, Cultural adaptation, Heart disease, Psychometrics, Reliability, Validity

Abbreviations

CDI	Cardiac Distress Inventory
CDI-SF	Cardiac Distress Inventory-Short Form
EFA	Exploratory Factor Analysis
CFA	Confirmatory Factor Analysis
KMO	Kaiser-Meyer-Olkin

[1]Psychosomatic Research Center, Mazandaran University of Medical Sciences, Sari, Iran. [2]Department of Nursing, Amol Faculty of Nursing and Midwifery, Mazandaran University of Medical Sciences, Sari, Iran. [3]Intrepid Lab, ECEO, Universidade Lusófona & CETRAD, Centro de Estudos Transdisciplinares para o Desenvolvimento, Lisbon, Portugal. [4]Centre on Behavioral Health, Hong Kong University, Pokfulam, Hong Kong, People's Republic of China. [5]Imam Khomeini Hospital, Mazandaran University of Medical Sciences, Sari, Iran. [6]Department of Nursing, Sari Faculty of Nursing and Midwifery, Mazandaran University of Medical Sciences, Sari, Iran. [7]Student Research Committee, Mazandaran University of Medical Sciences, Sari, Iran. [8]Department of Psychiatry, Psychosomatic Research Center, Sari Imam Khomeini Hospital, Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Iran. ✉email: fateme.miraghai76@gmail.com

EGA	Exploratory Graph Analysis
CR	Composite Reliability
AVE	Average Variance Extracted

Heart disease is a serious global health problem as identified by the World Health Organization, causing millions of deaths worldwide[1]. It includes conditions such as heart failure, heart attacks, and coronary artery disease, making up one-third of global mortality[2]. Urgent action is needed to tackle this major public health challenge due to its high mortality rate and psychological burden[3]. A recent study conducted in Australia has revealed that being aware of one's heart disease diagnosis can be a source of significant stress for individuals. This is due to the common perception that the threat of a heart attack or other cardiac event is imminent[1]. Receiving a diagnosis of heart disease or having heart surgery can lead to anxiety, stress, and uncertainty about the future and treatment. This can result in increasing rates of mental health disorders among those affected[4]. According to reports, the prevalence of anxiety in this population ranges from 20 to 50%, while depression affects 20–45% of individuals[5].

Cardiac distress is a complicated condition that includes emotional, cognitive, and physical symptoms experienced by individuals after heart events or heart surgery[6]. It goes beyond just anxiety and depression, and involves different aspects of a patient's life that impacts their ability to manage their heart condition on a daily basis[7]. Experiencing cardiac distress can make it hard to manage heart conditions and adapt to lifestyle changes, leading to poor treatment adherence, increased complications, more hospital visits, higher mortality rates, delayed care, faster disease progression, and lasting effects[6]. Individuals with a history of mental health issues are more likely to experience increased distress during and after a cardiac event, while financial struggles can also worsen feelings of distress for patients recovering from heart disease[8]. Cardiac distress encompasses a variety of symptoms across physical, emotional, cognitive, behavioral, and social domains, focusing on heart-related concerns and challenging patients' coping abilities after a cardiac event[9]. Cardiac distress can trigger memories of past trauma or unresolved grief for certain individuals, leading to intrusive and negative thoughts, as well as sleep disturbances and insomnia[10].

Despite the numerous solutions that have been developed over time to address anxiety and depression, clinical intervention in this area has often not been closely aligned with the needs of heart patients due to a lack of interventions that pay attention to the complexity of cardiac emotions experienced by patients[11]. High levels of anxiety and depression are prevalent among these patients, underscoring the importance of interventions that focus on addressing cardiac distress to enhance therapeutic outcomes[12]. Nurses, as key healthcare providers responsible for developing and implementing home care plans for heart patients, very often in the absence of psychological consultation, would benefit from having access to accurate measures to assess cardiac distress. This information is crucial for designing effective care strategies aimed at enhancing patient well-being[12,13].

While there are established criteria for measuring cardiac events and associated emotions such as depression[14] and anxiety[15,16], none of these standards offer a complete and precise assessment to identify cardiac distress[17]. To date there has been no tool available to assist specialists in evaluating cardiac patients' complex emotions as an aid to assist in the effective management of the emotions of these patients, and prioritizing their care[4].

The Cardiac Distress Inventory (CDI) has been developed to assess psychological distress specific to cardiac patients. However, its psychometric properties have not yet been extensively validated in different cultural contexts. It consists of 55 items in eight categories, evaluating aspects such as fear, role changes, and cognitive challenges. The CDI helps healthcare providers understand how heart events affect patients' emotional well-being and coping skills, and guides personalized treatment plans based on identified concerns[4]. The CDI has undergone psychometric evaluations across various cultural contexts, demonstrating its adaptability and reliability. In Australia, the original 55-item CDI was developed to assess multiple dimensions of cardiac distress, including fear and uncertainty, disconnection and hopelessness, and changes to roles and relationships. The CDI exhibited strong psychometric properties, effectively capturing the complex nature of distress experienced by cardiac patients[4]. In Hong Kong, the 12-item Cardiac Distress Inventory – Short Form (CDI-SF) was validated among 227 cardiac patients. The study found a unidimensional factor structure with excellent composite reliability ($\omega = 0.92$). The CDI-SF showed significant correlations with related constructs such as depression and resilience, supporting its convergent validity in the Chinese context[18]. Additionally, the CDI-SF was further examined in an Australian cohort to develop a brief yet comprehensive tool for assessing cardiac distress. The 12-item CDI-SF demonstrated good psychometric properties, with preliminary evidence supporting both its convergent and discriminant validity[19]. Establishing a psychometric CDI tailored to Iranian culture is essential for accurately assessing cardiac distress among patients, as cultural factors significantly influence emotional responses and coping mechanisms. A culturally adapted CDI would enhance the relevance and effectiveness of interventions, ensuring that they align with the specific psychosocial needs and experiences of Iranian patients recovering from heart disease[20].

While various tools have been developed to assess psychological distress in cardiac patients, such as the Cardiac Depression Scale[21] and the Cardiac Anxiety Questionnaire[15], these instruments primarily focus on specific emotional conditions rather than capturing the multidimensional nature of cardiac distress[3]. Existing measures fail to comprehensively evaluate the existential, emotional, and maladaptive coping responses that arise in patients with heart disease, particularly in non-Western populations where cultural factors significantly influence distress experiences[20]. Recent studies validating the CDI in Western and East Asian contexts[4,18] have demonstrated its utility in assessing psychosocial distress in cardiac patients. However, to date, no research has validated this instrument in Middle Eastern populations, despite the region's distinct sociocultural factors that may shape patients' psychological responses to heart disease[19]. Given the lack of culturally adapted and validated tools for assessing cardiac distress among Iranian patients, there is a crucial gap in the literature. Addressing this gap will improve the clinical utility of the CDI in diverse healthcare settings and enhance the psychological assessment of cardiac patients in Iran.

Therefore, the present study was conducted to evaluate the psychometric properties, including validity and reliability, of the CDI within the Iranian population suffering from heart diseases. This assessment aims to ensure that the inventory is culturally relevant and effectively addresses the unique psychosocial challenges faced by these patients.

Methods

Design

This study aims to assess the psychometric properties of the CDI in the Iranian population with heart diseases. In addition to psychometric validation, it employs network analysis to further investigate the structural properties of the CDI. The research was conducted from October to December 2024 through a cross-sectional design.

Study participants and sampling

A total of 400 patients with heart disease participated in this psychometric study, with participants recruited from the heart clinic. The participants were selected using a convenience sampling method, ensuring easy and accessible recruitment. However, to enhance fairness in selection, all eligible individuals who met the inclusion and exclusion criteria were given an equal opportunity to participate in the study.

The sample size was determined based on guidelines for psychometric research, which recommend a minimum of 200 participants for both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA)[22–24]. To ensure robust statistical power, we selected 400 subjects, which allowed for two separate samples of 200 participants for each part of the analysis. This sample size offers adequate statistical power with a significance level (alpha) of less than 0.05, a power of 80%, and a moderate effect size, as recommended for psychometric assessments[22].

Data collection was conducted using a convenience sampling method from November to December 2024. Participants were selected from three healthcare settings: two public hospitals' cardiac clinics and one private cardiology practice in Amol, Iran. A total of 133 cardiac patients were recruited from each hospital's heart clinic, while 134 patients were enrolled from the private practice. All participants were outpatients and were not bedridden during the study period, ensuring that the sample consisted of individuals who were actively managing their heart condition. The study sample included Iranian patients with various heart conditions, such as coronary artery disease, valvular disorders, cardiomyopathy, and heart failure. All participants were in stable condition and did not have acute or critical cardiac events, such as acute myocardial infarction requiring emergency interventions.

Inclusion and exclusion criteria

Participants were selected using convenience sampling from heart departments and clinics. To be eligible for inclusion, individuals had to meet the following criteria:[1] be 18 years of age or older[2], be Iranian citizens or residents[3], have a confirmed diagnosis of heart disease by a healthcare professional[4], be in stable health with no recent hospitalizations or major changes in treatment[5], be capable of providing informed consent, and[6] be willing to complete the CDI and related assessments.

Exclusion criteria were established to minimize potential confounding factors. Participants were excluded if they:[1] had a history of significant psychiatric disorders (e.g., schizophrenia, bipolar disorder) that could interfere with their ability to complete the questionnaire[2], had cognitive impairments or language barriers that would hinder comprehension of the survey[3], were diagnosed with other chronic illnesses that could affect their psychological distress levels independently of heart disease[4], had undergone major cardiac procedures (e.g., coronary artery bypass surgery, valve replacement) within the past three months[5], were receiving treatments that could significantly influence psychological responses (e.g., intensive psychotherapy, major psychiatric medication adjustments), or[6] had previously participated in similar studies within the past year.

The original version of the scale

The CDI is a specialized psychometric scale developed to assess the emotional distress experienced by patients with heart disease. Originally created by a multidisciplinary team of researchers and clinicians, the CDI aims to capture the complex nature of cardiac distress, which encompasses various psychosocial domains related to the experience of living with heart disease. The full version of the CDI consists of 55 items divided into eight subscales, addressing aspects such as fear and uncertainty, disconnection and hopelessness, and health system challenges[4].

To facilitate quicker assessments in clinical settings, a 12-item short form (CDI-SF) was developed. This abbreviated version retains the essential elements necessary for evaluating general cardiac distress while minimizing the burden on respondents. Each item in the CDI-SF is rated using a 4-point Likert scale, where participants indicate their level of distress from 0 (no distress) to 3 (severe distress). This scaling allows for nuanced responses that reflect varying degrees of emotional impact[19].

Translation

Professor Alun C. Jackson, co-author of this article and developer of the CDI scale, has provided written permission for its use in this study. This permission explicitly grants Springer Nature Limited the right to use and publish the instrument in all formats, including print and digital, under a CC BY open access license. The permission statement is in English and has been formally signed by the copyright holder. The copyright holders of the TAS material will be credited in the manuscript. In order to translate the scale, the World Health Organization's recommendation was followed[25], using the forward translation technique to convert the scale from English to Farsi. Two translators, one fluent in English and the other in Persian, were selected to independently translate the CDI. A team of experts, which included some of the authors of this article and two professional translators, meticulously reviewed and combined these two translations to create a cohesive Farsi version of the CDI. Following this, a translator proficient in both Persian and English was tasked with translating the Persian version back into English. The accuracy of the translation and the similarity between the translated English version of the CDI-SF and the original were then verified and confirmed through expert evaluation.

Face validity

The face validity of the scale was assessed through a combination of qualitative and quantitative methodologies.

Qualitative assessment

The scale was administered to a cohort of 11 cardiac patients, who were specifically trained to evaluate the items based on three criteria: difficulty, relevance, and ambiguity. Feedback indicated that all participants found the items to be clear and comprehensible.

Quantitative assessment

Following the qualitative evaluation, the same group of 11 cardiac patients rated each item on a 5-point Likert scale regarding its appropriateness, where 5 indicated "completely appropriate" and 1 indicated "not at all appropriate." Subsequently, an impact score for each item was calculated using the formula.

$$\text{Impact Score} = \text{Frequency} \times \text{Appropriateness}$$

An item was deemed acceptable if it achieved an impact score greater than 1.5. This dual approach ensured a comprehensive evaluation of face validity, integrating both subjective judgments and quantifiable metrics[26].

Content validity

The content validity of the CDI was thoroughly evaluated using both qualitative and quantitative methods. In the qualitative approach, the scale was distributed to 12 experts in the fields of cardiology, nursing, psychology and psychiatry. These experts were tasked with assessing the items for grammar, wording, item allocation, and scaling. Their valuable feedback led to the modification of certain items to enhance the overall quality of the scale. In the quantitative approach, the content validity of the scale was assessed using the content validity ratio (CVR) and modified kappa coefficient (K) to ensure that the scale accurately measures the intended construct. For the CVR evaluation, 12 experts rated the essentiality of CDI on a 3-point Likert scale (1 = not essential, 2 = useful but not essential, 3 = essential). The CVR was calculated using the formula: (ne – (N/2)) / (N/2), where (ne) represents the number of experts who rated the items as "Essential" and (N) is the total number of experts. The interpretation of the results followed the Lawshe rule, with a minimum acceptable CVR score of 0.56[27]. To assess the modified kappa coefficient (K) and control for chance agreement for each item, a panel of 11 experts evaluated the relevance of a 38-item scale. Each expert utilized a 4-point rating system, where 4 indicated "relevant" and 1 indicated "irrelevant." An excellent level of agreement among the experts was defined as a kappa value exceeding 0.75, which signifies a high degree of consensus regarding the relevance of the items[28].

Construct validity

The construct validity of this scale was assessed using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA was conducted using the Maximum Likelihood estimation method with Promax rotation. Since the correlation between the extracted factors was 0.713, an oblique rotation was necessary to account for this interrelationship. Among oblique methods, Promax was selected due to its computational efficiency and ability to simplify factor structures while maintaining interpretability. This approach is particularly useful in psychological research, where factors often exhibit some degree of correlation[29]. Additionally, the Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were utilized to determine sample adequacy and suitability. KMO values exceeding 0.9 were considered excellent indicators of validity[30]. The analysis determined the factor structure by calculating eigenvalues, which represent the variance in each item accounted for by the factor. The percentage of total variance explained by each factor was calculated by dividing the eigenvalue by the total number of items[31]. This study utilized the Horn's parallel analysis and exploratory graph analysis methods to determine the number of extraction factors. Parallel analysis involves generating correlation matrices of random variables and is influenced by both sample size and the number of identical variables in the actual data. The process compares the average eigenvalues from these random correlation matrices to the eigenvalues from the correlation matrix of the real data. By comparing observed eigenvalues to random eigenvalues, factors corresponding to true eigenvalues that exceed the average (95th percentile) of parallel random eigenvalues are extracted. Conversely, true eigenvalues that are equal to or less than the average of parallel random eigenvalues are considered to be measurement errors[26]. Eigenvalues greater than 1, communalities greater than 0.2, and factor loadings greater than 0.3 were taken into consideration to determine the factorability of the data[32].

Exploratory graph analysis (EGA)

Also EGA methods were utilized to determine the factor structure in this study. EGA is a cutting-edge technique in network psychometrics that helps identify the number of factors underlying complex data sets. By generating a network plot, EGA visually showcases how items cluster together, the strength of their relationships, and guides researchers on the optimal number of factors to retain[33].

One of the key advantages of EGA over traditional factor analysis methods is its independence from rotation techniques, which can introduce subjectivity and variability in results. This independence leads to a more robust representation of the underlying structure. Studies have shown that EGA consistently outperforms traditional methods in estimating dimensionality, particularly in scenarios with high item correlations or smaller item sets[34]. The network plots produced by EGA offer a clear and intuitive representation of item interconnections and clustering patterns, aiding in easier interpretation of complex data[34].

The process of EGA involves representing items as nodes, establishing edges as partial correlations between nodes, and identifying communalities as clusters of connected nodes in multivariate data using undirected network models. EGA estimation was carried out using the Graphical Least Absolute Shrinkage Optimization (GLASSO) method, which involved the following steps[35]:

1. Identification of network nodes: Variables of interest were selected as network nodes to be analyzed.
2. Construction of the network: Nodes were connected with links to represent relationships between variables.
3. Descriptive analysis: The topology of the network was analyzed using tools employed in network science, such as node centrality, clustering, and other measures.
4. To gauge the significance of each node within the network, we calculated centrality measures such as strength, closeness, and betweenness.
5. Our analysis also involved clustering to uncover groups of nodes with similar characteristics or relationships.
6. Furthermore, we conducted a comparative analysis of networks from different groups or conditions to pinpoint any notable disparities in structure and relationships between variables[35,36].

In order to strengthen the validity of our results, we utilized bootstrapping techniques throughout the EGA process. This method involved repeatedly resampling our data to evaluate the consistency and dependability of the factor structure we identified. By employing the bootstrapping approach, we were able to more accurately estimate confidence intervals for our centrality measures and gain a deeper insight into the inherent variability within our dataset:

- Betweenness: This measure sheds light on a node's role as a bridge between different parts of the network by identifying how often it lies on the shortest path between other nodes.
- Closeness: This centrality measure gauges a node's ability to swiftly reach other nodes by calculating the average distance between the node and all other nodes in the network.
- Strength: By summing the weights of a node's connections, this centrality measure reveals the node's overall influence within the network.
- Expected Influence: This metric estimates a node's potential impact on the network by considering its strength and the centrality of its neighboring nodes.
- Barabási: Derived from the Barabási-Albert model, this centrality measure focuses on the growth and evolution of networks.
- Onnela: Based on the Onnela-Kim centrality, this measure evaluates a node's significance based on its connectivity and the connectivity of its neighbors.
- WS: Also known as the HITS algorithm, the WS centrality measure identifies nodes that serve as both authorities (highly connected to other nodes with high authority) and hubs (highly connected to other nodes with high hub scores).
- Zhang: This centrality measure is built upon the Zhang-Zhou centrality, which evaluates the importance of a node in terms of its connectivity and the centrality of its neighbors.

Research suggests that in order to obtain accurate estimates of psychological networks, especially when working with binary or ordinal data, it is recommended to have sample sizes of approximately 200 to 300 participants. Studies have demonstrated that these sample sizes consistently produce reliable estimates of network parameters under different circumstances[37,38]. In this study, the EGA was conducted using JASP 0.19.3.0.

Confirmatory factor analysis (CFA)

Subsequent to the EFA results, a CFA was conducted to validate the factor structure identified in the previous step. This analysis was performed using a second random dataset comprising 200 participants and was executed with AMOS version 27. The assessment of model fit was based on several key fit indices: Parsimonious Comparative Fit Index (PCFI > 0.5), Adjusted Goodness of Fit Index (AGFI > 0.8). The Comparative Fit Index (CFI), Normed Fit Index (NFI), Tucker-Lewis Index (TLI), and Incremental Fit Index (IFI), all of which were required to exceed 0.90. Additionally, the Root Mean Square Error of Approximation (RMSEA) was set to be less than 0.05, while a Minimum Discrepancy Function divided by degrees of freedom (CMIN/DF) value of less than 3 was considered indicative of good fit[32].

Effect size calculation

Effect sizes for the exploratory and confirmatory factor analyses were calculated to assess the strength of factor contributions and model fit. For EFA, Epsilon-Squared (ω^2) was computed to determine the proportion of variance explained by each factor. The calculation was based on eigenvalues, using the formula:

$$\omega^2 = \lambda_i / \sum \lambda$$

where $\boldsymbol{\lambda}$ represents the eigenvalues of each extracted factor[39]. For CFA, Cohen's f^2 was derived from the model fit indices to measure effect size, using:

$$f^2 = \chi^2 / N$$

where χ^2 is the model chi-square value and N is the sample size[40].

Convergent and discriminant validity

In order to establish convergent validity, it is crucial that the Composite Reliability (CR) exceeds 0.7, and the Average Variance Extracted (AVE) is greater than 0.5 for each construct. If the AVE falls below 0.5 but the CR is above 0.7, the convergent validity can still be considered acceptable[41]. On the other hand, discriminant validity is achieved by utilizing the Heterotrait-Monotrait ratio (HTMT) of the correlations criterion. This method requires that the HTMT ratio between all constructs is less than 0.85 to ensure discriminant validity[42].

Analysis of invariance

The analysis of invariance by gender was conducted using multigroup confirmatory factor analysis (MGCFA) following the sequence of nested models: configural invariance (unconstrained factor structure), metric invariance (equal factor loadings), scalar invariance (equal factor loadings and intercepts), and means invariance (equal factor loadings, intercepts, and factor means). Invariance was assessed using the criteria of Cheung and Rensvold[43], where a change in absolute Comparative Fit Index ($|\Delta CFI| \leq 0.01$ and Root Mean Square Error of Approximation ($|\Delta RMSEA| \leq 0.015$ between nested models indicated invariance. Additionally, the significance of the chi-square difference test ($\Delta\chi^2$, $p > 0.05$) was examined, though ΔCFI and ΔRMSEA were prioritized due to the sensitivity of χ^2 to sample size. Analyses were performed in R using the `lavaan` package, with robust maximum likelihood estimation (MLR) to address data non-normality and missing categories in some items[44], and fit indices such as CFI, RMSEA, and SRMR were reported for each model.

Reliability

In order to assess the internal consistency and construct reliability of the data, various measures were calculated. These included the Cronbach's alpha (α), McDonald's omega (Ω), average inter-item correlation coefficient (AIC), CR, and Maximal Reliability (MaxR). For a reliable measurement, it was determined that values of α, Ω, CR, and MaxR should exceed 0.7. Additionally, AIC values falling within the range of 0.2 to 0.4 were considered indicative of acceptable internal consistency[26]. Test-retest reliability of the CDI was assessed using the Intraclass Correlation Coefficient (ICC) over a two-week interval. A two-way mixed-effects model was employed to estimate absolute agreement at the individual item level. The ICC values were interpreted based on established guidelines: values between 0.0 and 0.20 indicate low reliability, 0.21 to 0.40 indicate fair reliability, 0.41 to 0.60 indicate moderate reliability, 0.61 to 0.80 indicate substantial reliability, and 0.81 to 1.00 indicate almost perfect reliability[45].

Normal distribution, outliers, and missing data

Skewness (± 3) and kurtosis (± 7) were utilized to individually analyze the univariate distribution of data. Furthermore, multivariate normality was assessed by calculating the Mardia coefficient of multivariate kurtosis (< 8). The Mahalanobis d-squared ($p < 0.001$) was employed to determine if there were any multivariate outliers[46]. EFA was conducted using the pairwise deletion method to handle missing data[47].

All statistical analyses were conducted using appropriate parametric tests to examine the relationships and differences among variables. An independent samples t-test was used to compare the mean total CDI scores between gender groups and between marital status groups. A one-way analysis of variance (ANOVA) was employed to assess differences in total CDI across different education levels. Pearson correlation analysis was performed to evaluate the relationship between age and total CDI. The significance level for all tests was set at $p < 0.05$. Assumptions of normality and homogeneity of variance were assessed before conducting the analyses.

Results

Demographic characteristics

The results of the study revealed that the mean age of the participants was 42.95 years (SD = 14.02). A significant portion of the sample comprised females, accounting for 227 participants (56.8%). The majority of participants were married, with 327 individuals (81.8%) reporting being married. Educationally, a considerable number of participants had less than a high school diploma, totaling 225 individuals (63.8%). The mean Total CDI score was 30.8 (SD = 9.77), with a 95% confidence interval ranging from 29.84 to 31.76.

The independent t-test revealed a statistically significant difference in total CDI scores between gender groups (t = -3.21, $p = 0.001$), with males (M = 29.02, SD = 9.21) scoring lower than females (M = 32.15, SD = 9.99). Similarly, a significant difference was observed between marital status groups (t = -2.31, $p = 0.0214$), where single participants had a lower total CDI score (M = 28.40, SD = 9.46) compared to married participants (M = 31.33, SD = 9.79). A one-way ANOVA indicated a significant effect of education on total CDI scores (F = 5.18, $p < 0.001$). The mean scores for different education levels were as follows: High school (M = 33.88, SD = 10.23), Diploma (M = 29.97, SD = 9.36), Bachelor (M = 28.46, SD = 8.73), and Master and Ph.D (M = 28.98, SD = 9.19), suggesting variations in total CDI based on educational background. Furthermore, Pearson correlation analysis showed a weak but statistically significant positive correlation between Age and total CDI ($r = 0.101$, $p = 0.0465$), indicating that as age increases, total CDI scores tend to slightly increase.

The floor and ceiling effects for HD1 to HD12 variables were analyzed to assess data quality. Floor effects ranged from 0.50 to 3.50%, with HD11 showing the highest floor effect at 3.50%. Ceiling effects varied between 0.25% and 9.50%, with HD10 displaying the highest ceiling effect at 9.50%, followed by HD9 at 9.00%.

The results of maximum likelihood exploratory factor analysis (MLEFA)

The results indicated that all items followed a normal distribution, as skewness (± 3) and kurtosis (± 7) values were within acceptable ranges. Additionally, the Mardia coefficient of multivariate kurtosis (< 8) confirmed multivariate normality, and no significant multivariate outliers were detected based on the Mahalanobis d-squared test ($p < 0.001$).

Factor	Items	Factor loading	h^2	λ	%Variance
Existential and Emotional Distress	Q6. Lacking purpose or meaning in life	0.936	0.745	3.960	%39.60
	Q3. Feeling lonely	0.818	0.517		
	Q8. Being emotionally exhausted	0.806	0.474		
	Q4. Withdrawing from people	0.769	0.341		
	Q5. Having changes in my usual roles	0.695	0.377		
	Q1. Thinking I will never be the same again	0.690	0.539		
Uncertainty and Maladaptive Coping	Q7. Being unable to deal with stress	0.920	0.744	2.955	%29.55
	Q11. Not getting clear directions from my health practitioner on how to manage my heart condition	0.894	0.719		
	Q2. Not knowing what the future holds for me	0.855	0.695		
	Q9. Having difficulty concentrating	0.747	0.580		

Table 1. The result of MLEFA on the five factors the Persian version of CDI ($n = 200$). h^2: Communalities, λ: Eigenvalues.

Network				
Centrality measures **Items**	**Betweenness**	**Closeness**	**Strength**	**Expected influence**
Q1. Thinking I will never be the same again	2.028	1.768	2.048	1.920
Q2. Not knowing what the future holds for me	−0.769	−0.716	−1.342	−1.663
Q3. Feeling lonely	−0.769	−0.379	−0.332	−0.170
Q4. Withdrawing from people	−0.420	−0.381	−0.044	−0.523
Q5. Having changes in my usual roles	−0.769	−0.829	−0.501	−0.319
Q6. Lacking purpose or meaning in life	0.629	1.172	0.467	0.531
Q7. Being unable to deal with stress	−0.420	0.246	−0.048	0.079
Q8. Being emotionally exhausted	1.329	0.602	1.007	1.006
Q9. Having difficulty concentrating	−0.070	0.121	−0.073	0.057
Q11. Not getting clear directions from my health practitioner on how to manage my heart condition	−0.769	−1.605	−1.183	−0.918

Table 2. Centrality measures of CDI in network analysis.

The results of MLEFA with Promax with Kaiser Normalization rotation using the first random dataset ($n = 200$) developed two factors (*Existential and Emotional Distress* and *Uncertainty and Maladaptive Coping*) accounting for 69.15% of the variance comprising 10 items. Item 10 and item 12 were removed from the original version due to communalities of less than 0.2, and factors loading of less than 0.3. Moreover, the results of the KMO (0.936) and Bartlett's test of Sphericity ($p < 0.001$, Chi-square = 6624.330, $df = 66$) showed the sampling is adequate and appropriate for conducting the factor analysis. The detailed results of the MLEFA are shown in Table 1.

The results of EGA

Centrality measures

The results, as displayed in Table 2, encompass centrality measures computed through four distinct methods. Table 2 illustrates how various items in the CDI are grouped together within the network.

Betweenness centrality

Q1 (Thinking I will never be the same again) has the highest betweenness score (2.028), indicating it acts as a significant bridge in the network.

Q2 (Not knowing what the future holds for me), Q3 (Feeling lonely), Q4 (Withdrawing from people), and Q5 (Having changes in my usual roles) show negative scores, suggesting these items do not serve as effective intermediaries.

Q8 (Being emotionally exhausted) also has a notable positive score (1.329), indicating some bridging potential.

Closeness centrality

Q1 again ranks highest (1.768), suggesting it is well-placed to influence the network quickly.

Conversely, Q11 (Not getting clear directions from my health practitioner on how to manage my heart condition) has the lowest score (-1.605), indicating poor proximity to other items in the network.

Strength

Q1 leads with a strength score of 2.048, reinforcing its significance within the network.

Items like Q2, Q3, and Q11 exhibit negative strength scores, highlighting their limited connections or influence.

Expected influence
The highest expected influence is also attributed to Q1 (1.920), further confirming its pivotal role.

In contrast, Q11 has the lowest expected influence (−0.918), suggesting it may detract from overall network connectivity (Fig. 1).

Clustering measures
The results, shown in Table 3, include clustering measures calculated using four different methods. The table and Fig. 2 highlight how different items in the CDI are clustered together in the network.

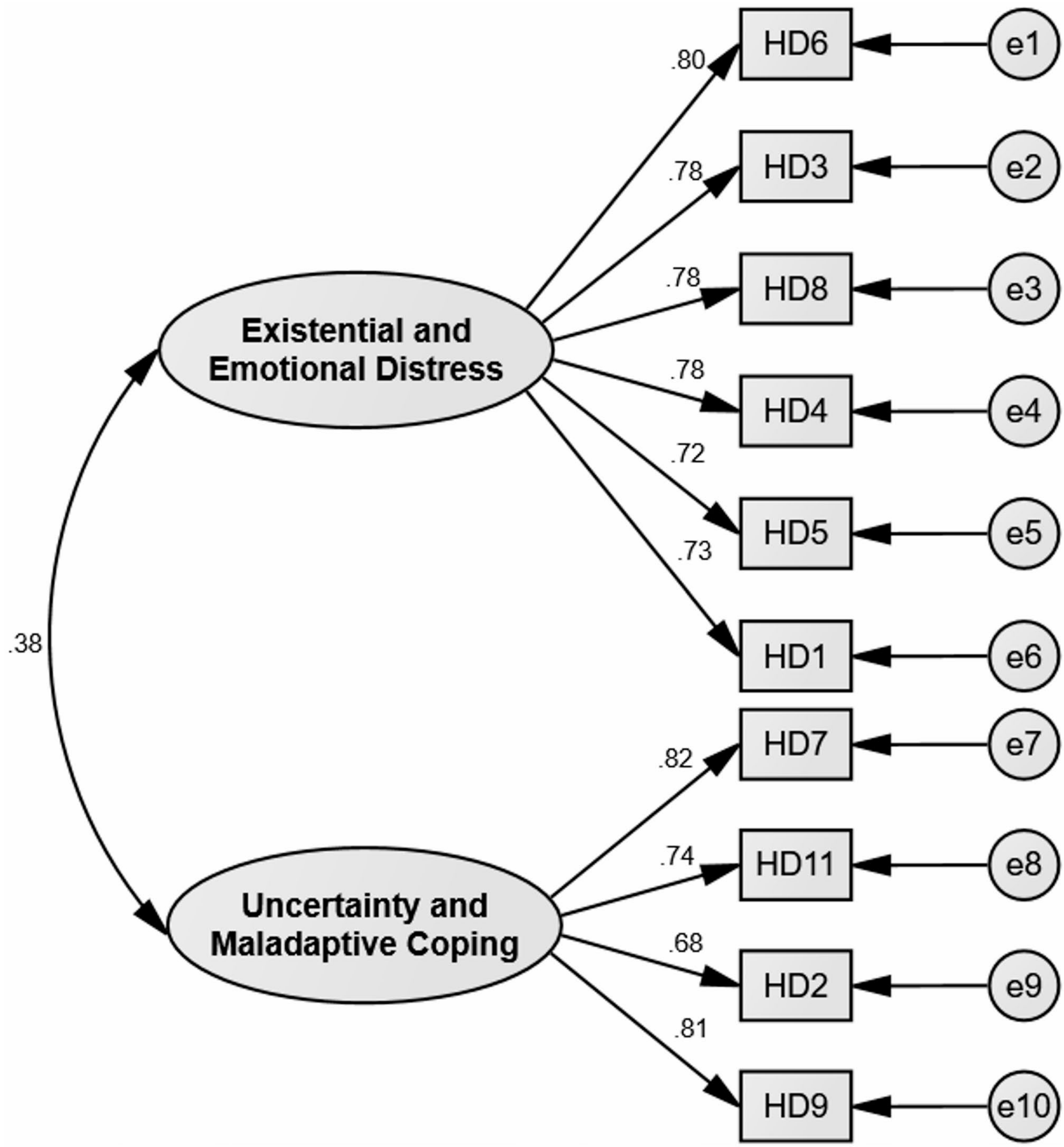

Fig. 1. Confirmatory factor analysis structural model.

Barrat clustering
Q2 (Not knowing what the future holds for me) has the highest Barrat clustering score (1.217), indicating a strong tendency for nodes related to this item to cluster together.

In contrast, Q1 (Thinking I will never be the same again) and Q7 (Being unable to deal with stress) exhibit negative scores (-1.216 and – 1.188, respectively), suggesting weak clustering tendencies.

Onnela clustering
Again, Q2 leads with a score of 1.427, reinforcing its strong clustering characteristics.

Items like Q1 (-2.003) and Q3 (Feeling lonely) (-0.912) show significant negative values, indicating poor clustering behavior.

Watts-Strogatz (WS) clustering
Q5 (Having changes in my usual roles) scores positively at 1.216, suggesting a notable level of clustering.

Conversely, Q3 (-1.472) and Q7 (-0.632) reflect weaker clustering structures.

Zhang clustering
The highest score is found in Q9 (Having difficulty concentrating) at 1.802, indicating strong clustering potential.

In contrast, Q7 shows a substantial negative score (-1.868), highlighting its lack of clustering.

The EGA in Fig. 2 illustrates the network structure of the CDI items, identifying two distinct clusters. Group 1 (orange nodes) and Group 2 (blue nodes) represent separate dimensions of cardiac distress, with stronger connections within each group than between them. The thickness of the edges corresponds to the strength of associations, with the highest observed edge weight being 0.28 between HD1 and HD2, indicating a strong relationship. Other notable connections include 0.24 between HD1 and HD6, and 0.24 between HD8 and HD9, further supporting the internal consistency of each subgroup. The presence of weaker connections (e.g., 0.02 and 0.03) suggests some level of interaction across groups but reinforces the overall distinction between the two factors.

The results of CFA
The CFA was conducted to confirm and validate the factor structure obtained from MLEFA using the second random dataset ($n = 200$). The CFA results showed that the measured items had strong relationships with their underlying constructs, with all coefficients exceeding the threshold of 0.6 and being statistically significant (Fig. 1). The results showed that the data fit the model well as evidenced by (χ^{2}[34] = 45.714, $p = 0.086$, $\chi^2/df = 1.345$, CFI = 0.991, IFI = 0.991, TLI = 0.985, NFI = 0.966, RMSEA = 0.036.

The effect size analysis demonstrated strong psychometric properties for the CDI. In the EFA, the variance explained (Epsilon-Squared, ω^2) for the Existential and Emotional Distress factor was 57.27%, while the Uncertainty and Maladaptive Coping factor accounted for 42.73% of the variance. CFA further supported the model's fit, with a Cohen's f^2 of 110.11, indicating a very strong effect size. Additionally, McDonald's Non-Centrality Index (NCI) was 0.345, reinforcing the robustness of the factor structure. These results highlight the CDI's strong validity and reliability in assessing cardiac distress.

Convergent and discriminant validity and reliability
The results showed that AVE for factors of *existential and emotional distress* and *uncertainty and maladaptive coping* were 0.582 and 0.592 respectively, indicating good convergent validity. The AVE for factors was more than 0.5. factors CR greater than 0.7, it can be concluded that convergent validity for all constructs has been established. As for discriminant validity, the results of the HTMT ratio showed that the correlation between factors of *existential and emotional distress* and *uncertainty and maladaptive coping* (0.374) was lower than 0.85, demonstrating good discriminant validity for all constructs. As for construct reliability, Cronbach's alpha, McDonald's omega, CR, and MaxR for all factors were greater than 0.7, and AIC was more than 0.2, demonstrating good internal consistency and construct reliability (Table 4). To assess test-retest reliability, the

Network				
Clustering measures **Items**	**Barrat**	**Onnela**	**WS**	**Zhang**
Q1. Thinking I will never be the same again	−1.216	−2.003	−0.632	−0.631
Q2. Not knowing what the future holds for me	1.217	1.427	1.216	0.121
Q3. Feeling lonely	−0.687	−0.912	−1.472	0.169
Q4. Withdrawing from people	0.382	0.843	0.544	−0.984
Q5. Having changes in my usual roles	0.942	0.026	1.216	0.142
Q6. Lacking purpose or meaning in life	−0.177	−0.525	0.141	0.013
Q7. Being unable to deal with stress	−1.188	0.730	−0.632	−1.868
Q8. Being emotionally exhausted	0.909	0.694	−0.800	0.806
Q9. Having difficulty concentrating	0.969	0.061	1.216	1.802
Q11. Not getting clear directions from my health practitioner on how to manage my heart condition	−1.151	−0.341	−0.800	0.430

Table 3. Clustering measures of CDI in network analysis.

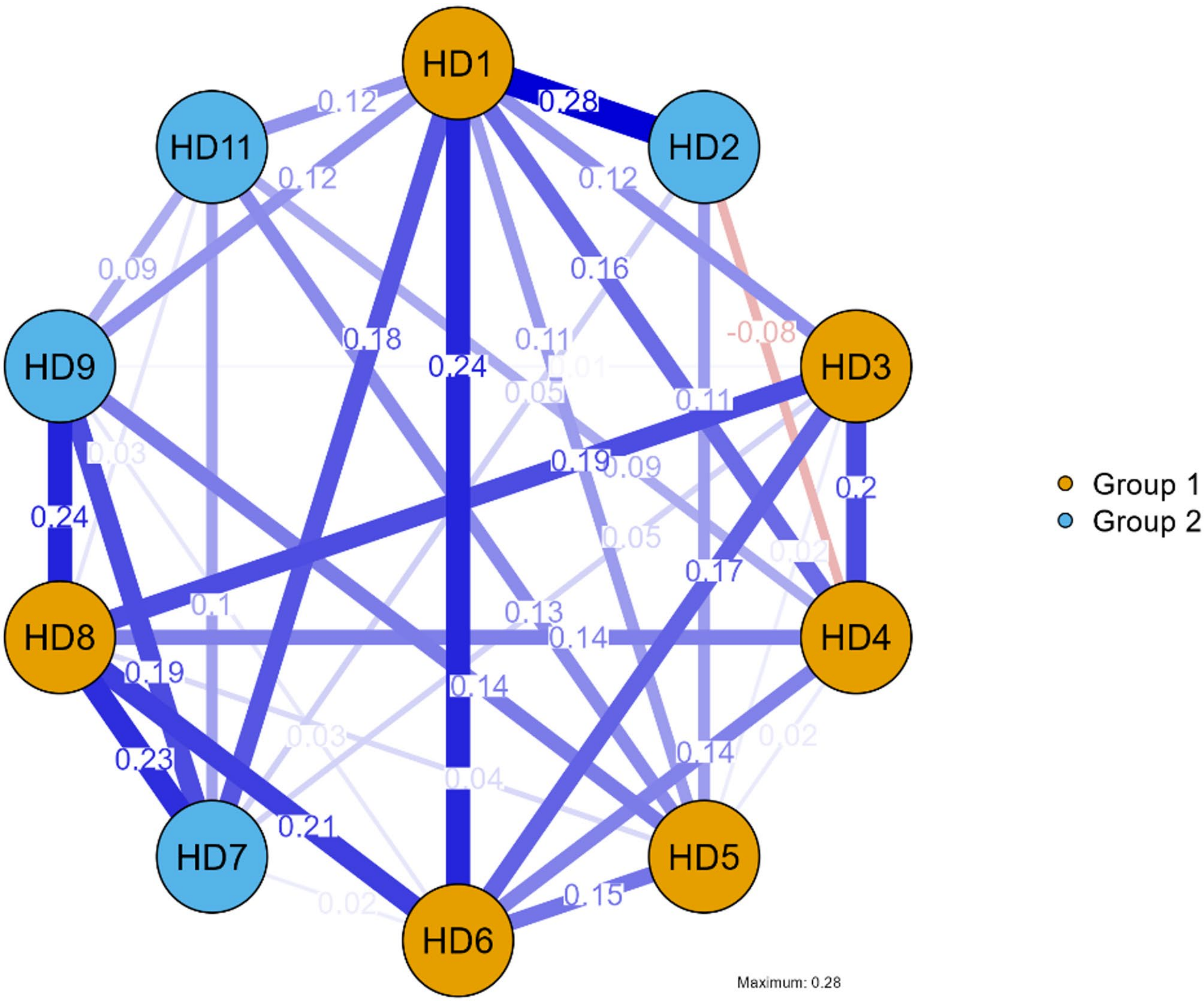

Fig. 2. Exploratory graph analysis by network analysis.

Index Factor	CR	AVE	MaxR (H)	α	Ω	AIC
Existential and Emotional Distress	0.893	0.582	0.897	0.891	0.893	0.580
Uncertainty and Maladaptive Coping	0.850	0.592	0.878	0.847	0.851	0.582

Table 4. The results of convergent validity, discriminant validity, and reliability ($n = 200$).

CDI was administered to a subset of 30 participants twice, with a 10-day interval between the two assessments. The Intraclass Correlation Coefficient (ICC) was calculated to determine the stability of the scores over time. The results indicated excellent test-retest reliability, with an ICC of 0.906 (95% CI: 0.823 to 0.958, F[15] = 12.74, $p < 0.001$).

The results of the analysis of invariance

The analysis of invariance by gender depicted in Table 5 demonstrated configural, metric, and scalar invariance, indicating that the constructs were measured consistently across groups. The configural model showed a good fit (CFI = 0.983, RMSEA = 0.049), and the metric invariance model, constraining factor loadings, had a non-significant chi-square difference ($\Delta\chi$[28] = 6.763, $p = 0.562$), with ΔCFI = 0.002 and ΔRMSEA = -0.005. The scalar model, adding intercept constraints, also showed invariance ($\Delta\chi^2$ = 0.704[8], $p = 1.000$), with ΔCFI = 0.006 and ΔRMSEA = -0.011. However, constraining latent means resulted in a significant chi-square difference ($\Delta\chi$[22] = 11.109, $p = 0.004$), ΔCFI = -0.008, and ΔRMSEA = 0.010, suggesting differences in latent means across genders according to the $\Delta\chi^2$ but not the ΔCFI and ΔRMSEA criteria.

Model	df	AIC	BIC	χ^2	$\Delta\chi^2$	Δdf	*p*	CFI	RMSEA	ΔCFI	ΔRMSEA
Configural	68	7668.263	7891.135	89.834				0.983	0.049		
Metric	76	7657.986	7852.101	95.558	6.763	8	0.562	0.984	0.044	0.002	-0.005
Scalar	84	7642.695	7808.051	96.266	0.704	8	1.000	0.990	0.033	0.006	-0.011
Means	86	7650.167	7808.334	107.739	11.109	2	0.004	0.983	0.043	-0.008	0.010

Table 5. Analysis of invariance by gender.

Discussion

This study aimed to validate the Persian version of the CDI-SF using both exploratory and confirmatory factor analysis on patients with heart disease. Based on the results of factor analysis, two factors comprising 10 items named as "*Existential and Emotional Distress* and *Uncertainty and Maladaptive Coping*" were extracted and CFA confirmed the CDI-SF model fitness. So, the 10-item Persian CDI-SF demonstrates good psychometric properties. The original inventory included 12 items with 8 subscales. In the current study items "*10*" and "*12*" was removed from the model due to low communalities and low factors loading. These items were *"Being physically restricted" and "Thinking about dying"*. Also, total variance of scale obtained 69.15%.

The first extracted factor with six items was "*Existential and Emotional Distress*" with %39.60 variance. The items of this factor were lacking purpose or meaning in life, feeling lonely, being emotionally exhausted, withdrawing from people, having changes in my usual roles and thinking I will never be the same again. This factor encompasses the psychological and emotional challenges faced by patients with heart disease, reflecting a profound sense of loss, isolation, and existential questioning. The items in this factor suggest a common theme of emotional exhaustion, social withdrawal, and a perceived lack of purpose, which are critical aspects of the distress experienced by these patients. Key components of these factors consists of Existential Concerns, Emotional Isolation, Psychological Exhaustion, Psychological Exhaustion and Role Disruption[3,48].

Lacking purpose or meaning in life indicates a fundamental questioning of life's significance post-diagnosis or post-surgery. Barsaei et al. in line with the present study showed that there is a significant relationship between the meaning of life and heart disease[49]. Thinking I will never be the same again reflects fears about identity and future self-concept after experiencing heart disease. Feeling lonely and withdrawing from people highlights social disconnection, a common response to chronic illness that can exacerbate feelings of distress. Being emotionally exhausted suggests a state of burnout resulting from ongoing emotional strain related to health challenges. Having changes in my usual roles points to the impact of heart disease on personal identity and social roles, contributing to overall distress[19]. The concept of cardiac distress as a multifaceted construct is supported by various studies that emphasize its psychosocial dimensions. For instance, the CDI was developed to assess such distress comprehensively, incorporating emotional, cognitive, and social factors relevant to patients' experiences post-cardiac events. Due to the length of CDI items, Grande et al. designed a shorter tool (CDI-SF)[4,19]. The identified factor aligns with existing literature that highlights how cardiac patients often grapple with feelings of hopelessness, isolation, and identity loss, which can hinder their recovery and quality of life[20]. Guan et al. in their study revealed anxiety, distress and depression are prevalent after a cardiac event. Rumination is the unique predictor in the development of these disorders[17]. Another factor represents in our study was "*Uncertainty and Maladaptive Coping* " with %29.55 variance; that refers to the challenges cardiac patients face in managing the uncertainty and stress associated with their condition, exacerbated by perceived inadequate support from healthcare providers[19]. The items suggest a common theme of difficulty coping with stress, lack of clarity about the future, and cognitive challenges, which can hinder patients' ability to effectively manage their heart disease. Maladaptive coping, uncertainty, cognitive challenges and perceived lack of support were key components of this factor[19]. 'Being unable to deal with stress' indicates a lack of effective strategies to cope with the emotional and psychological burden of heart disease. 'Not knowing what the future holds for me' reflects the anxiety and fear associated with the unpredictable nature of cardiac conditions and their long-term prognosis. 'Having difficulty concentrating' suggests that the stress and uncertainty experienced by cardiac patients can negatively impact their cognitive functioning, potentially affecting their ability to engage in self-care and follow treatment recommendations. 'Not getting clear directions from my health practitioner on how to manage my heart condition' highlights the importance of effective communication and guidance from healthcare providers in helping patients coping with their condition[50]. Studies clarify the effect of lifestyle-based stress management program and cognitive behavioral therapy to help with emotional issues related to the disease[51,52]. The concept of cardiac distress as a multifaceted construct that includes uncertainty and maladaptive coping is supported by various studies[6,53]. Also, studies indicate the complexity of cardiac distress and the high level of fear of disease recurrence and distress in patients with coronary artery disease, which may be reduced with effective interventions and strengthening of social support and partner support[6,54–57].

In our study, the finding aligns with previous research validating the CDI and its short form in diverse cultural contexts. For instance, a study conducted in Australia developed the original 55-item CDI, identifying eight subscales that assess various dimensions of cardiac distress. The CDI exhibited robust psychometric properties, providing a comprehensive tool for evaluating psychosocial distress in cardiac patients[4]. Subsequently, a 12-item CDI-SF was developed to facilitate quicker assessments while maintaining the original inventory's integrity. This short form demonstrated good psychometric properties, including satisfactory factorial validity and reliability, making it a practical tool for clinical settings[19]. More recently, the CDI-SF was validated among cardiac patients in Hong Kong. The study supported the unidimensional structure of the CDI-SF, with excellent composite reliability ($\omega = 0.92$) and substantial factor loadings ($\lambda = 0.64–0.94$, $p < 0.001$). The inventory also showed strong convergent validity, correlating positively with measures of depression and burnout, and negatively with resilience and quality of life[18]. These consistent findings across different cultural contexts underscore the CDI-SF's reliability and validity as a measure of cardiac distress. Our study contributes to this body of evidence by confirming the inventory's applicability within the Iranian population, thereby supporting its broader international utility.

Overall, according to the results of the EGA conducted using network analysis, Q1 (Thinking I will never be the same again) stands out as the most central item across all measures, highlighting its critical role in the structure and dynamics of the network. Items with negative scores, such as Q2 (Not knowing what the future holds for me), Q3 (Feeling lonely), and Q11 (Not getting clear directions from my health practitioner on how to manage my heart condition), suggest lower importance or connectivity within the network. Further investigation into these items is necessary to fully understand their impact on the overall behavior of the network. In contrast, Q2 consistently shows strong clustering across multiple measures, indicating its pivotal role in creating cohesive groups within the network. On the other hand, items like Q1, Q3, and Q7 (Being unable to deal with stress) display negative scores across various measures, indicating a lower likelihood of forming clusters and potentially representing isolated or disconnected elements within the network.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, data collection was based on self-report measures, which are commonly used in psychological and clinical research but are inherently susceptible to biases such as social desirability and recall inaccuracies. These biases may influence the precision and objectivity of participant responses. Second, although the sample size was sufficient for psychometric analysis, it may not fully represent the broader population of cardiac patients in Iran. The use of convenience sampling from a limited number of clinical settings further constrains the generalizability of the results. Third, while the study applied comprehensive methods to assess face and content validity—including evaluations by both patients and expert panels—formal cognitive interviews were not conducted. Cognitive interviewing is an important qualitative technique for exploring how individuals understand, interpret, and mentally process questionnaire items, particularly in the context of cross-cultural adaptation. Incorporating this method in future research could enhance the depth and accuracy of content validation. Lastly, although the Cardiac Distress Inventory demonstrated strong psychometric properties, the study did not include an assessment of criterion-related validity. This decision was due to the absence of an established gold standard for measuring cardiac distress in the Iranian context. Future studies should address this gap by evaluating the CDI against appropriate external criteria as they become available.

Practice implications

The present study holds significant clinical implications that can greatly impact patient care:

Enhanced patient assessment

The validation of the CDI equips healthcare professionals with a dependable tool to evaluate cardiac distress in Iranian patients. This enables a more comprehensive understanding of patients' emotional and psychosocial challenges, leading to personalized interventions.

Culturally relevant interventions

By customizing the CDI to the Iranian context, clinicians can effectively address the cultural factors influencing patients' emotional responses and coping mechanisms. This cultural sensitivity is essential for developing treatment plans that resonate with patients' experiences.

Psychological support programs

The CDI can play a crucial role in psychological support programs by enabling healthcare providers to identify specific distress patterns in cardiac patients, facilitating targeted interventions. By incorporating CDI results, personalized counseling, cognitive-behavioral strategies, and stress management programs can be tailored to address emotional and existential concerns. This approach enhances patient-centered care, improving psychological well-being and adherence to treatment plans.

Improved mental health outcomes

Accurate measurement of cardiac distress allows healthcare providers to identify patients at risk for anxiety and depression. Early intervention strategies can then be implemented to alleviate these mental health issues, ultimately enhancing overall health outcomes and quality of life for heart disease patients.

Informed care planning

Insights gained from using the CDI can guide care strategies that incorporate psychological support into cardiac rehabilitation programs. This holistic approach can boost patient adherence to treatment regimens and lifestyle modifications necessary for effectively managing heart disease.

Guidance for future research

The findings from this study contribute to the expanding literature on cardiac distress and its impact on patient care. Subsequent research can build upon this foundation to explore additional psychosocial factors affecting heart disease patients, paving the way for further advancements in psychological assessment tools and interventions.

Conclusion

The study evaluated the psychometric properties of the CDI in Iranian patients with heart disease, confirming its ability to capture two key dimensions of cardiac distress: Existential and Emotional Distress, and Uncertainty and Maladaptive Coping. The findings demonstrated strong validity and reliability through factor analysis, with certain items playing significant roles in the network of cardiac distress. The CDI exhibited good internal consistency and measurement invariance across genders, suggesting its reliability in assessing cardiac distress among Iranian patients. These findings have important clinical implications, as the CDI can serve as a valuable tool for healthcare professionals in identifying psychological distress in cardiac patients and tailoring appropriate interventions. Its application in routine clinical assessments may enhance patient-centered care and improve psychological support strategies.

Future research should focus on evaluating the CDI's predictive validity in clinical outcomes, testing its applicability in diverse cultural and clinical contexts, and examining its responsiveness to changes in distress levels over time. Additionally, longitudinal studies could further clarify its utility in monitoring patient progress and guiding targeted interventions.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Received: 30 November 2024; Accepted: 12 May 2025
Published online: 16 May 2025

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Acknowledgements
Many thanks to the student research committee of Mazandaran University of Medical Sciences for their instrumental support in facilitating this research (proposal code was 20905). We greatly appreciate the resources and guidance provided throughout the process. We would also like to express our gratitude to the patients who voluntarily participated in the study, as their contributions were invaluable. Finally, we extend our sincere thanks to Dr. Michael Le Grande, one of the original developers, for his significant assistance in editing this article.

Author contributions
Performance of data gathering: PN; Planning and supervision of the work: HSH; Performance of the analysis: HSH and JW; Manuscript draft: RF, and AHSH, and All authors; and comment on the final manuscript: ESF and BM and All authors.

Funding
No funds, grants, or other support was received.

Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate
The Ethics Committee of Mazandaran University of Medical Sciences (Sari, Iran) gave its approval to this study (Ethics code: IR.MAZUMS.REC.1403.362). The participants were given a thorough explanation of the study's goals and methods, as well as assurances that their participation was entirely voluntary. Written Informed consent was obtained from all subjects and/or their legal guardian(s). Permissions to use the data collection

instruments were obtained from their developers. All procedures adhered to the appropriate guidelines and regulations.

Consent for publication
The authors and participants have given their consent for the publication of the study.

Additional information
Correspondence and requests for materials should be addressed to F.M.

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