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Adverse childhood experiences and suicidal ideation in patients with major depressive disorder: investigating the mediating role of emotional reactivity and probabilistic and reinforcement learning

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Abstract

Objectives Major Depressive Disorder (MDD) is a severe and widespread psychiatric condition that affects individuals globally. Suicidal ideation is one of the key symptoms associated with this disorder. Numerous studies have explored the impact of adverse childhood experiences on the development of suicidal thoughts in adulthood. However, limited research focuses on the underlying mechanisms that mediate this relationship. Therefore, the present study aimed to investigate whether emotional reactivity, along with probabilistic and reinforcement learning (PRL), serves as a mediator in the relationship between adverse childhood experiences and suicidal ideation in Iranian patients with MDD.

Method The study included 201 inpatients diagnosed with MDD hospitalized in various psychiatric wards across Shiraz, Iran. Participants were selected using a convenient sampling method. Data were collected through the Probabilistic Reward Task, the Emotional Reactivity Scale, the Beck Scale of Suicidal Ideation, and the Modified Adverse Childhood Experiences – International Questionnaire. The collected data were analyzed using Pearson's correlation test and structural equation modeling with SPSS and AMOS 26.

Results Adverse childhood experiences were found to have a direct and significant relationship with suicidal ideation ($p < .001$). Additionally, emotional reactivity and PRL served as significant mediators in the relationship between adverse childhood experiences and suicidal ideation.

Conclusion Our findings indicate that various factors—including adverse childhood experiences, emotional reactivity, and PRL—contribute to the development of suicidal ideation in patients with major depressive disorder (MDD). Therefore, it is essential to consider these factors when developing therapeutic plans.

Keywords Adverse childhood experiences, Suicidal ideation, Probabilistic and reinforcement learning, Emotional reactivity, Major Depressive Disorder

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Introduction

Major Depressive Disorder (MDD) is one of the most severe and prevalent psychiatric disorders globally, affecting over 300 million people each year. According to the World Health Organization [1], MDD is currently the third most significant global economic burden and is projected to become the foremost by 2030. It presents with symptoms such as deep sadness, loss of pleasure, suicidal thoughts and actions, and cognitive and emotional difficulties, significantly impacting individuals and the healthcare system [2]. Individuals with MDD are five times more likely to experience suicidal thoughts and behaviors [3], as well as complete suicide [4]. Despite significant advancements in effective psychotherapeutic and pharmacological treatments for psychiatric disorders associated with a high risk of suicidality, the rates of suicidal thoughts, attempts, and completed suicides have not decreased substantially over the past few years [5]. On the other hand, research has shown that experiences of Adverse Childhood Experiences (ACEs) are common among patients with major depressive disorder. These childhood adversities are linked to an earlier age at which individuals are first diagnosed with major depression, as well as an increased likelihood of experiencing lifetime suicidal thoughts, and severe depression [6]. Research indicates that adults who have experienced four or more ACEs are 4.6 times more likely to report depression in the past year compared to those without a history of ACEs (95% CI: 3.8–5.6). Additionally, the presence of just one ACE increases the odds of experiencing depression by 50% (OR: 1.5, 95% CI: 1.3–1.7) [7]. This dose–response relationship between the number of ACEs and the likelihood of depression in adulthood is consistently supported by various studies [7–9]. Furthermore, evidence suggests that addressing ACEs could potentially reduce the risk of depression in the general population by as much as 44.1% [9].

Adverse childhood experiences and suicidal ideation

Every year, approximately 800,000 people worldwide die by suicide. Suicidal ideation, which refers to thoughts about taking one's own life, is considered a critical indicator of suicidal behavior [10]. This term encompasses a broad range of thoughts, wishes, and mental concerns related to death and suicide [11]. It is specifically defined as "thoughts about hurting oneself, including a voluntary concern or planning regarding ways to bring about one's death" [12]. Numerous studies have explored the factors that increase the risk of suicide, identifying a variety of individual, familial, and social elements that contribute to suicidal behavior [13, 14]. Many of these studies focus on events that occur close to the onset of suicidal

thoughts and actions. However, it is also important to acknowledge that early life experiences can significantly influence suicide risk. Individuals may encounter various traumatic events during their development, such as issues with parental mental and physical health, sexual abuse, maltreatment, unstable living conditions, and financial loss [15]. ACEs are traumatic events [15] that can lead to significant functional and structural changes in the brain. These experiences are linked to a variety of psychiatric issues, including anxiety disorders, MDD, and suicidal thoughts [15]. Many studies have demonstrated that specific ACEs, such as child abuse and neglect, significantly increase the risk of suicidal behaviors in adulthood [16]. Recent research [17, 18] has established a connection between suicidal ideation and exposure to negative experiences in early life. A study conducted by Miche et al. involved a 10-year longitudinal examination of a community sample, focusing on suicidal behaviors and ACEs in adolescents and young adults aged 14 to 24 years. The findings indicated that the risk of suicide attempts increased with exposure to various traumatic events, with rape and sexual abuse presenting the highest hazard ratios [19]. Similarly, a school-based health survey conducted across four regions in China revealed that children and young people aged 10 to 20 years who experienced a greater number of ACEs were more likely to report suicidal behaviors compared to those who encountered fewer ACEs [20]. Additionally, a systematic review provides strong evidence that childhood maltreatment is associated with a higher risk of suicidal behaviors later in life [21]. According to Harkness et al. [22], individuals who face abuse or neglect during childhood tend to be more affected by subsequent adverse events in their lives. They found that these individuals reported fewer stressful life events before experiencing a depressive episode compared to those without such backgrounds. Although suicide has long been recognized as a multifactorial issue, there is limited understanding of the complexities of ACEs and their relation to suicidal crises [7].

Probabilistic and reinforcement learning as a mediator

Anhedonia is a key symptom used to diagnose MDD and affects between 37 and 72% of individuals with this condition [23, 24]. This multifaceted construct is strongly associated with prolonged disorder duration and more serious outcomes [25], poor response to psychological [26], pharmacological [27], and neuro-modulatory interventions [28], as well as heightened suicide risk [29]. Originally defined as the "loss of interest and pleasure" [30], our understanding of anhedonia has grown to encompass various deficits in reward processing [31, 32]. The National Institute of Mental Health (NIMH) has

recently introduced the term "positive valence systems" to explore reward processing in the context of mental health issues [33]. Positive valence systems are responsible for how we respond to positive motivational situations, including seeking rewards, engaging in approach behaviors, and learning through rewards and habits [34]. According to the revised framework for positive valence systems proposed by the NIMH in 2018, this system consists of three distinct dimensions related to rewards: reward responsiveness, reward learning, and reward valuation. Reward learning is the process by which organisms acquire knowledge about stimuli, actions, and contexts that are associated with positive outcomes. Behavior can be adjusted based on new rewards received or when outcomes surpass expectations. This reward learning process includes three key components: predictive reward learning (PRL), reward prediction error, and habit formation [34]. PRL involves the ability to identify which actions or stimuli are linked to obtaining a relevant reinforcer, even if a specific action or stimulus is not consistently associated with that reinforcer [35]. Preclinical studies suggest that these components utilize relatively distinct neural systems [35]. Generally, anhedonia, the diminished ability to experience pleasure, arises from dysfunction in one or more parts of the reward processing system [36].

Anhedonia is generally associated with suicidal thoughts and behaviors in patients with MDD [37]. Research by Dombrovsky and Hallquist [38] has shown that various aspects of anhedonia involve impairments in reward processing, such as disruptions in reward learning and valuation. These deficits can lead to poor decision-making and an increased risk of suicidality. Most studies to date have concentrated on the correlations and predictors of suicidal ideation within the context of negative valence systems. However, there have been few attempts to explore other areas, such as positive valence systems. Focusing solely on one research domain limits the recognition of new correlates and factors that contribute to suicidal thoughts. By considering additional domains, we may gain a deeper understanding of suicidal ideation, which could inform more effective therapeutic strategies for suicide prevention [39].

Numerous studies have indicated that adverse childhood experiences can disrupt the development of the brain's reward system and affect future reward responses [40, 41]. The effectiveness of this reward circuit relies on the integration and coordination of molecular, cellular, synaptic, and network signals. If this circuit is immature during critical developmental stages, it can lead to neuropsychiatric disorders [15]. Research has sought to examine how reward learning is affected in individuals with a history of adverse childhood experiences. For

example, Hanson et al. [42] found that adolescents with behavioral problems, who had experienced physical abuse early in life, struggled to learn the stimuli associated with rewards. Additionally, these individuals were less likely to utilize information about familiar rewards in their environment, resulting in challenges when trying to understand the relationship between stimuli and rewards. Findings from another investigation revealed that individuals who experienced adverse childhood events but had not been diagnosed with MDD showed signs of disrupted reward learning [43]. Another study specifically examining Probabilistic Reinforcement Learning (PRL) reported that women with a history of childhood sexual abuse and a diagnosis of MDD performed poorly on tasks requiring the retrieval of previously learned information, compared to a control group. This poor performance was significantly correlated with self-harm and suicidal behaviors [44]. In summary, adverse childhood experiences are linked to negative emotional outcomes and abnormal functioning of the reward system [15]. This dysfunction affects components of reward learning, including PRL, which may increase susceptibility to various psychiatric disorders, including MDD and suicidality [43].

Emotional reactivity as a mediator

Emotional reactivity refers to the sensitivity, intensity, and persistence of negative emotional experiences. It is considered a component of temperament that influences how individuals respond to emotional stimuli [45]. Emotional reactivity is associated with irregularities in the limbic system, particularly involving the amygdala [46], which may lead to an exaggerated response to unfavorable experiences. This heightened sensitivity can contribute to an increased risk of severe emotional and behavioral responses, including suicidal thoughts and actions [47]. Individuals with high emotional reactivity typically respond to stressors by amplifying their negative emotions and misinterpreting events. They often report experiencing higher rates of external problems and depressive symptoms [48, 49]. Research indicates that those with elevated emotional reactivity are more likely to experience depressive symptoms when confronted with stress compared to individuals with lower levels of emotional reactivity [50, 51].

Emotional reactivity is one of the many risk factors associated with the emergence of suicidal ideation, and it has been widely studied [45]. Various theoretical frameworks highlight emotional reactivity as a significant contributor to suicidal thoughts. For example, the vulnerability-stress model (also known as the diathesis-stress model) suggests that individual vulnerabilities, when combined with negative life

stressors, can elevate the risk of developing suicidal ideation [52]. One such vulnerability is personality traits, including emotional reactivity [53]. Similarly, the Integrated Motivational-Volitional Model of Suicide [54] identifies emotional reactivity as a key vulnerability that can lead to the development of suicidal thoughts. The Escape Theory of Suicide suggests that suicidal thoughts and behaviors can serve as an escape from the unbearable state of one's mind. These feelings often arise from extreme emotional distress following a significant and traumatic event [55]. Nock et al. [45] have expanded on this theory by proposing that intense emotional reactivity can disrupt cognitive and behavioral control, leading to inappropriate responses, such as suicidal ideation, as a way to flee from negative emotional states. Their research indicates that higher levels of emotional reactivity correlate with an increased risk of suicidal thoughts. Additionally, other psychiatric disorders, such as mood disorders, anxiety disorders, and eating disorders, have also been linked to an elevated risk of suicidal ideation because they contribute to heightened emotional reactivity.

Empirical research has strongly supported the importance of emotional reactivity concerning suicidal ideation. Numerous studies have demonstrated a significant link between emotional reactivity and suicidal thoughts [45, 56, 57], particularly in adults [58]. For instance, Shapero et al. [57] investigated how emotional reactivity interacts with depressive symptoms and suicidal ideation and behavior in adults. Their findings revealed that higher emotional reactivity is directly and significantly associated with greater levels of depressive symptoms and suicidal thoughts.

Adverse childhood experiences are significant factors linked to emotional reactivity. Research indicates a strong association between an individual's temperament and their emotional responses, suggesting that this vulnerability can stem from early life experiences [59]. The family environment plays a crucial role in shaping a child's ability to regulate emotions. Children often develop their emotional skills and strategies by observing their parents' behaviors and the emotional atmosphere within their homes [60]. Several studies have explored the connection between adverse childhood experiences and emotional dysregulation (e.g., [61]). For instance, Kendler et al. [62] found that women with a history of sexual abuse exhibited more intense emotional reactions to stressful life events. Overall, research indicates that exposure to harmful events during childhood is generally associated with heightened emotional reactivity in adulthood [63, 64].

Current study

Adverse childhood experiences (ACEs) significantly impact the development of suicidal ideation in adulthood; however, not all adults with a history of such experiences experience suicidal thoughts. This variation may be due to the challenges that arise from ACEs, such as difficulties with processing emotions and heightened emotional reactivity, which can, in turn, influence suicidal ideation. Despite this understanding, the specific mediating mechanisms—how adverse childhood experiences relate to suicidal ideation—are not yet well understood. Therefore, the present study aimed to explore the relationship between adverse childhood experiences and suicidal ideation among Iranian patients with Major Depressive Disorder (MDD), specifically examining whether this association is mediated by probabilistic and reinforcement learning (PRL) and emotional reactivity. As shown in Fig. 1, we investigated the mediation model, which is grounded in established theoretical frameworks. However, it's crucial to note that our mediation aims and hypotheses are considered atemporal, meaning that causality cannot be inferred from the statistical analyses presented [65]. This study serves as an initial exploration in a largely under-researched area, providing insights that may inform future research efforts. In summary, the following hypotheses were proposed:

Hypothesis 1: adverse childhood experiences contribute to the development of suicidal ideation in patients with Major Depressive Disorder.

Hypothesis 2: emotional reactivity contributes to the development of suicidal ideation in patients with Major Depressive Disorder.

Hypothesis 3: probabilistic and reinforcement learning contribute to the development of suicidal ideation in patients with Major Depressive Disorder.

Hypothesis 4: adverse childhood experiences contribute to the development of suicidal ideation through the mediating role of Emotional reactivity in patients with Major Depressive Disorder.

Hypothesis 5: adverse childhood experiences contribute to the development of suicidal ideation through the mediating role of probabilistic and reinforcement learning in patients with Major Depressive Disorder.

Method

Participants and procedure

The Institutional Review Board of Shiraz University of Medical Sciences approved the study protocol (ID: IR.SUMS.REC.1401.637). The population for this correlational and cross-sectional study comprised all inpatients diagnosed with Major Depressive Disorder (MDD)

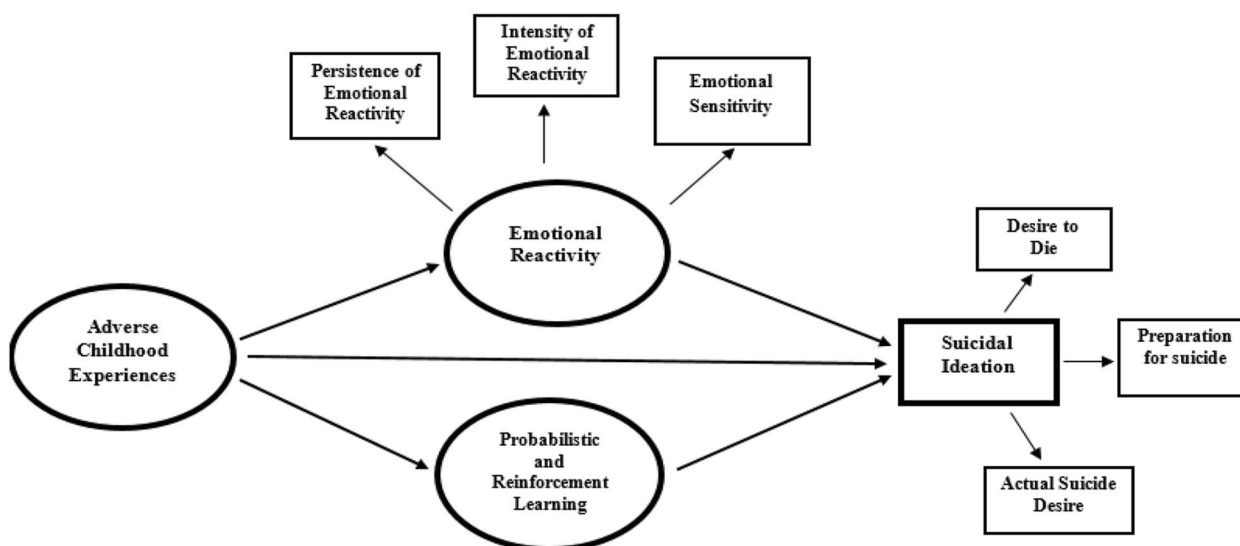


Fig. 1 The proposed model of suicidal ideation

at the Hafez and Ebne-Sina psychiatric hospitals in Shiraz, Iran. With the cooperation of hospital authorities, patients’ medical records were reviewed to identify potential participants based on specific inclusion and exclusion criteria. Participants who provided informed consent underwent a primary symptom screening assessment. For the evaluation of individuals with MDD, the researchers utilized the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Research Version (SCID-5-RV), the Positive Valence Systems Scale-21 (PVSS-21), and the Patient Health Questionnaire-9 (PHQ-9). Consistent with findings from previous studies [66], individuals who scored 10 or higher on the PHQ-9 proceeded to the structured clinical interview.

Several methods have been used to determine the sample size. Initially, the sample size was calculated using online software designed for sample size estimation in structural equations (Free Statistics Calculation, version 4.0) [67]. Based on the model’s 8 observed variables and 2 latent variables, the sample size was determined to be 198 participants. This calculation considered the predicted effect size of 0.19, a desired significance level of 0.05, and a statistical power level of 0.80. On the other hand, the sample size for the factor analysis can be determined based on the number of factors. For structural equation modeling (SEM), a minimum of 20 subjects is required for each factor (latent variable) [68]. Therefore, we established that at least 200 participants were needed for this study. In total, 215 individuals diagnosed with Major Depressive Disorder (MDD) who met the inclusion and exclusion criteria were selected as the study sample using

a convenience sampling method. The inclusion criteria for the study were: having a primary diagnosis of MDD, possessing at least a secondary education, and being aged between 18 and 65 years. The exclusion criteria included the presence of major comorbid disorders such as substance abuse, psychotic disorders, and bipolar disorders, as well as psychotic symptoms. These were determined through a review of medical records and self-reports. Other exclusion criteria included having severe physical health issues, visual or hearing impairments that could hinder participation, a history of neurological disorders, mental disabilities, and lack of literacy, which were assessed through self-reports and medical records. The research procedures were explained to all participants, who provided informed consent prior to participating. Each participant completed the PRT task along with demographic and self-report questionnaires (see Fig. 2).

Measures

The Structured Clinical Interview for Diagnostical and Statistical Manual for Mental Disorders-5-Research Version (SCID-5-RV)

The SCID-5-RV is a tool designed to assist mental health professionals in diagnosing psychiatric disorders [69]. This interview covers all relevant subgroups, severity levels, and course specifiers. Its screening feature makes the SCID-5-RV especially suitable for meeting the specific requirements of research studies. The SCID-5-RV is available in a standard “core” configuration, which includes disorders commonly assessed in research, as well as an “enhanced” configuration that adds probable disorders to the core set [66].

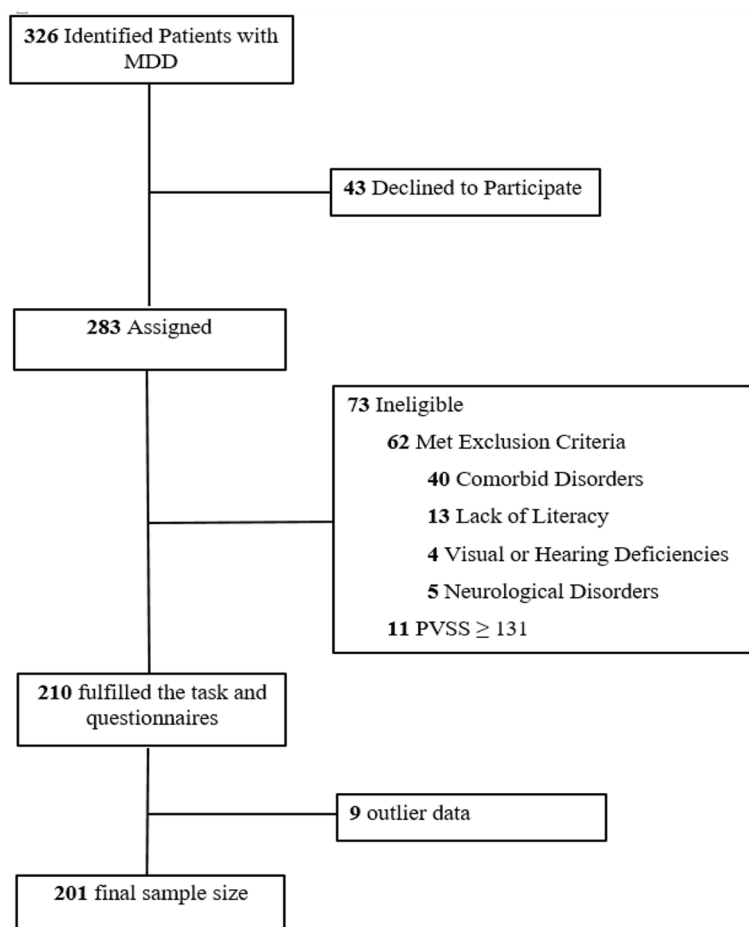


Fig. 2 Consort diagram

Patients’ Health Questionnaire (PHQ-9)

The PHQ-9 is a widely used tool for assessing Major Depressive Disorder (MDD) [70]. It is designed for screening, diagnosis, and evaluating the severity of depression. Respondents are asked to rate their experiences over the past two weeks using a four-point Likert scale, with scores ranging from 0 to 3 for each item. The total score is calculated by summing the scores of all items, resulting in a minimum score of 0 and a maximum score of 27. Depression severity is categorized based on cut-off points: scores of 5, 10, and 15 indicate mild, moderate, and severe levels of MDD, respectively. Many studies have used a cut-off score of 10 for diagnosing MDD so we also adopted this threshold for screening potential patients. Kroenke et al. [70] demonstrated that the PHQ-9 has satisfactory psychometric properties, with a Cronbach’s alpha coefficient between 0.86 and 0.89, indicating good internal consistency, and a test–retest reliability correlation of 0.84. Additionally, the PHQ-9 has been applied in Iranian research, which reported similar psychometric properties, including a Cronbach’s alpha

coefficient of 0.88 and a test–retest reliability coefficient of 0.79 [71].

Positive Valence System Scale-21 (PVSS-21)

The PVSS-21 is a tool used to assess six components of anhedonia: reward expectancy, reward valuation, effort valuation, reward anticipation, initial responsiveness, and reward satiation [72]. It utilizes a Likert scale ranging from 1 (extremely untrue of me) to 9 (extremely true of me). Scores for each dimension are summed, along with an overall score, to determine the severity of anhedonia. A cut-off score of 131 is used, where higher scores indicate a greater capacity for seeking pleasure, while lower scores suggest a diminished ability to seek pleasure. Khazanov et al. [72] reported that the questionnaire has good psychometric properties, with an overall Cronbach’s alpha coefficient of 0.93 and subscale coefficients ranging from 0.69 to 0.88. The test–retest reliability coefficient is 0.83. Since there is no existing version in Persian specific to Iran, the measure was translated and back-translated by experts, and its content validity was

confirmed by three independent expert translators. Additionally, the internal consistency of the scale was evaluated in a pilot study involving 55 participants, resulting in a satisfactory Cronbach's alpha of 0.75.

Probabilistic Reward Task (PRT)

The PRT is a recently recommended task for assessing positive reinforcement learning (PRL), incorporated into the Research Domain Criteria framework as one of the selected measures of positive valence systems. This computerized task uses visual discrimination and identification to quantify responses based on reward learning. It was originally developed and standardized by Pizzagalli et al. [73] to assess anhedonia phenotypes in individuals with mood disorders, including Major Depressive Disorder (MDD). The PRT has shown high diagnostic accuracy and good test–retest reliability ($r=0.57$). The task consists of three parts, each featuring 100 trials where cartoon faces are displayed in black font on a white background. Each trial has a fixed duration of 500 ms, followed by a face without a mouth. After a short delay of another 500 ms, either a long mouth (13 mm) or a short mouth (11.5 mm) appears for 100 ms, and participants must indicate the length of the mouth by pressing designated keys. Participants are instructed to maximize their rewards, which are monetary incentives, although not all correct responses will yield rewards. In each part, long and short mouths are generally presented in a quasi-random sequence, ensuring that no more than three consecutive presentations of the same stimulus occur. Each part includes 50 trials for short mouths and 50 trials for long mouths, with 60% of correct responses for one length (e.g., long mouth) receiving a reward (rich stimulus) and 20% of correct responses for the other length (e.g., short mouth) receiving a reward (lean stimulus). Thus, in each part, only 40 correct responses receive feedback based on monetary rewards [73].

The results of this task are based on the response bias score towards the affluent stimuli. This score reflects the subject's inclination to select responses linked to greater rewards and is calculated using the following formula.

$$\text{Response bias} : \log b = 1/2 \log \left(\frac{\text{Rich}_{\text{correct}} \times \text{Lean}_{\text{incorrect}}}{\text{Rich}_{\text{incorrect}} \times \text{Lean}_{\text{correct}}} \right)$$

This task demonstrated an acceptable level of reliability, with a Cronbach's α of 0.77 in the current study.

Emotional Reactivity Scale (ERS)

The ERS was developed by Nock et al. [45] to measure how individuals report their emotional reactions in response to various events. This scale consists of 21 items that evaluate three components of emotional sensitivity: 1. Emotional Sensitivity (e.g., "I tend to easily become

emotional") 2. Intensity of Emotional Reactivity (e.g., "I experience emotions with high intensity") 3. Persistence of Emotional Reactivity (e.g., "When I am angry or upset, it takes me longer than most people to calm down") Higher scores on the scale indicate greater emotional reactivity. The ERS has demonstrated acceptable levels of criterion and divergent validity, as well as high internal consistency ($\alpha=0.95$) [45, 74]. Additionally, the present study found that the scale has a reliable level of consistency, with a Cronbach's alpha of 0.76.

Beck Scale for Suicidal Ideation (BSSI)

The BSSI (Beck Scale for Suicidal Ideation) is a 19-item Likert scale used to detect and measure the severity of suicidal attitudes, behaviors, and planning over the previous weeks. The scale ranges from 0 to 2 [75] and assesses various factors, including the desire to die, active and passive suicidal tendencies, the duration and frequency of suicidal thoughts, feelings of self-control, inhibiting factors against suicide, and an individual's preparation for suicide. At the beginning of the scale, there are five screening items. If the responses indicate a tendency towards active or passive suicide, the individual is required to answer the remaining 14 items. The scale is divided into three subscales: the desire to die (5 items), preparation for suicide (7 items), and actual suicidal desire (4 items). Additionally, two items address factors that inhibit suicide or negate the desire for it. The overall score on the BSSI ranges from 0 to 38. Scores between 1 and 5 indicate the presence of suicidal thoughts, scores from 6 to 19 suggest preparation for suicide, and scores between 20 and 38 reflect a strong intention to commit suicide. The scale has demonstrated good psychometric properties. A study by Esfahani et al. [76] evaluated the reliability and validity of the BSSI in Iran, reporting a Cronbach's Alpha of 0.82.

The Modified Adverse Childhood Experiences – International Questionnaire (MACE-IQ)

The MACE-IQ was developed by the World Health Organization to explore various types of adverse childhood experiences, along with their intensity and impact on individuals. Multiple studies have investigated the reliability and validity of the questionnaire, demonstrating good internal consistency and test–retest reliability [77, 78]. Satinsky et al. [79] modified and revised the questionnaire, reducing the number of items to 16 and incorporating additional considerations related to food and water insecurity, which may occur in some regions [79]. In the revised version, the 16 items are categorized into nine types of experiences: 1. Physical abuse 2. Verbal or emotional abuse 3. Attempted or actual sexual abuse 4. Living with an adult suffering from alcohol or

drug addiction 5. Living with an adult who has a history of mental illness or has committed suicide 6. Having parents who live separately or are divorced 7. Living with an adult who has been imprisoned 8. Witnessing violence against one's mother or grandmother 9. Food or water insecurity When using this questionnaire, respondents are required to answer questions regarding the imprisonment of family members and parental divorce with "Yes" (1) or "No" (0). For other childhood stressors, respondents answer on a Likert scale that typically ranges from "Often" (3), "Several times" (2), "Once" (1), to "Never" (0). Scores range from 0 to 1, indicating minimal exposure to adverse childhood experiences; scores of 2 to 3 indicate low exposure, 4 to 5 indicate high exposure, and scores above 6 indicate maximum exposure. Since there was no version of this questionnaire available in Persian or specific to Iran, it was translated and back-translated by experts, with its content validity confirmed by three independent translators. Additionally, a pilot study evaluated the internal consistency of the scale, yielding a Cronbach's Alpha of 0.77, which is considered good.

Statistical analysis

The data were analyzed using SPSS (Version 26) and AMOS software (Version 26). First, Pearson correlation was employed to examine the basic relationships between the variables. Given the presence of latent variables, such as adverse childhood experiences, emotional reactivity, and PRL, we investigated the mediational hypotheses using structural equation modeling (SEM) in AMOS. Mediation was assessed through bootstrapping procedures. To evaluate the adequacy of the fit indices, we applied the criteria outlined by Kline [80].

Results

Demographic information and statistical variables at baseline are presented in Table 1.

Table 1 shows that the majority of participants were female, with either a diploma or secondary level of education. Regarding their socio-economic and employment status, most subjects belonged to the middle class and were unemployed. The reported mean scores for the study variables indicated a high exposure to adverse childhood experiences, low levels of probabilistic and reinforcement learning, mild preparation for suicide, and moderate emotional reactivity among the participants. Furthermore, the skewness and kurtosis indices were utilized to assess the normality of the data. Based on the information presented in Table 1, the kurtosis and skewness values range between -2 and $+2$, indicating that all research variables exhibit a normal or nearly normal distribution.

As shown in Table 2, the range of correlations between variables varied from 0.177 (between emotional sensitivity and actual suicide desire) to 0.770 (between desire to die and preparation for suicide). All the correlation coefficients were significant ($p < 0.05$).

All the research variables have observed the normality hypothesis. One of the essential presuppositions in the SEM method is the absence of extreme data. In this regard, 9 individuals were removed and the final sample size reached 201 (see Fig. 2). Moreover, multicollinearity results are presented in Table 3. The table indicates no collinearity present, as evidenced by the Eigenvalue values being greater than zero. Additionally, there is no collinearity among the measured variables, as suggested by the Condition Index values; a value above 30 indicates potential collinearity issues (Fig. 3).

The summary of the results of the goodness of fit indices for the indirect (full mediation model) and direct structural models are reported in Table 4.

In Table 5, the direct structural model indicates that adverse childhood experiences had a positive and significant direct effect on the total score of suicidal ideation ($\beta = 0.395$, $p < 0.001$). When examining the results from the mediator structural model, it was found that adverse childhood experiences also had a positive and significant effect on emotional reactivity ($\beta = 0.481$, $p < 0.001$). Additionally, the effect of adverse childhood experiences on proximal relational loss (PRL) was negative and significant ($\beta = -0.704$, $p < 0.001$). The dimensions of emotional reactivity positively and significantly affected components of suicidal ideation ($\beta = 0.210$, $p = 0.008$), while PRL was negatively and significantly associated with suicidal ideation ($\beta = 0.194$, $p = 0.034$). Research indicated that adverse childhood experiences did not have significant associations with dimensions of suicidal ideation ($\beta = 0.156$, $p = 0.115$). After incorporating the mediating variables—emotional reactivity and past relationships (PRL)—the beta value decreased from 0.395 (derived from the direct structural model) to 0.156 (from the mediational structural model) in the relationship between adverse childhood experiences and suicidal ideation. Therefore, unlike the direct model, the beta value in the mediation model was not significant ($p = 0.115$). This suggests that the dimensions of PRL and emotional reactivity mediated the relationship between adverse childhood experiences and suicidal ideation. Furthermore, there was substantial evidence that PRL and emotional reactivity significantly mediated the association. As shown in Table 6, a sample of 1,000 individuals was selected using the bootstrap method, resulting in a 95% confidence interval. The findings indicated a significant indirect effect of the adverse childhood experiences on the dimensions of suicidal ideation, with a value of 0.238

Table 1 Demographic information and statistical variables at baseline for participants

Variable	Participants (n = 201)				
	M	SD	N (%)	Kurtosis	Skewness
Age (years)	35.98	9.58			
Gender					
Men			73 (36.3)		
Women			128 (63.7)		
Marital Status					
Married			101 (50.2)		
Single			100 (49.8)		
Educational Attainment					
Secondary Education			57 (28.4)		
Diploma			68 (33.8)		
Bachelor of Arts			67 (33.3)		
Master of Arts			5 (2.5)		
Doctorate			4 (2)		
Socio-Economic Status					
Low			42 (20.9)		
Middle			116 (57.7)		
High			37 (18.4)		
Very High			6 (3.0)		
Employment Status					
Employed			59 (29.4)		
Unemployed			87 (43.3)		
Housewife			50 (24.9)		
University Student			5 (2.5)		
MACE- IQ	4.43	9.11		.15	-1.40
PRT	-.16	.32		-.12	-.92
BSSI	11.10	.70		-.67	.68
Desire to Die	4.24	3.05		.42	-1.02
Preparation for Suicide	4.59	4.65		.63	-.75
Actual Suicide Desire	2.27	2.99		1.39	1.37
ERS	58.50	1.60		-1.30	-.30
Persistence of Emotional Reactivity	29.72	8.73		-.49	-.76
Intensity of Emotional Reactivity	20.80	6.53		.08	-.30
Emotional Sensitivity	11.77	3.67		-.37	-1.17

MACE-IQ Modified Adverse Childhood Experiences- International Questionnaire, PRT Probabilistic Reward Task, BSSI Beck Scale for Suicidal Ideation, ERS Emotional Reactivity Scale

and a standard error of 0.072 ($p=0.003$). Since the significance level of the indirect effect is less than 0.05 and the value of zero does not fall within the lower and upper limits of the confidence interval (0.101 to 0.393), we conclude that this indirect effect is statistically significant.

Discussion

This study investigated the mediating role of emotional reactivity and psychological resilience (PRL) in the relationship between adverse childhood experiences and suicidal ideation in Iranian patients with Major Depressive Disorder (MDD). Our results indicated that the proposed

model demonstrated a good fit. We found that adverse childhood experiences, PRL, and emotional reactivity were all significantly associated with suicidal ideation in patients with MDD. Specifically, adverse childhood experiences, emotional reactivity, and PRL had direct relationships with suicidal ideation. Furthermore, adverse childhood experiences had a significant indirect association with suicidal ideation through emotional reactivity and PRL.

Greater adverse childhood experiences were directly and significantly linked to increased suicidal ideation among patients with Major Depressive Disorder (MDD).

Table 2 Correlation among model variables

Variables	1	2	3	4	5	6	7	8	9
1- Adverse Childhood Experiences	-	.438**	.435**	.369**	-.704**	.384**	.369**	.373**	.402**
2- Emotional Sensitivity		-	.752**	.722**	-.366**	.316**	.296**	.177**	.288**
3- Intensity of Emotional Reactivity			-	.716**	-.350**	.417**	.352**	.290**	.345**
4- Persistence of Emotional Reactivity				-	-.283**	.312**	.237**	.251**	.282**
5- PRL					-	-.328**	-.363**	.385**	-.386**
6- Desire to Die						-	.770**	.707**	.893**
7- Preparation for Suicide							-	.748**	.968**
8- Actual Suicide Desire								-	.913**
9- Suicidal ideation Total score									-

N=201

** P<.001

Table 3 Collinearity diagnostics

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions					
				(Constant)	Adverse Childhood Experience	Emotional Sensitivity	Intensity of Emotional Reactivity	Persistence of Emotional Reactivity	PRT
1	1	5.065	1.000	.00	.00	.00	.00	.00	.01
	2	.740	2.617	.01	.01	.00	.00	.00	.43
	3	.104	6.984	.00	.97	.01	.01	.01	.47
	4	.051	9.977	.97	.02	.02	.05	.05	.09
	5	.028	13.457	.00	.00	.09	.16	.93	.00
	6	.012	20.286	.02	.00	.88	.78	.00	.00

a. Dependent Variable: Suicidal ideation

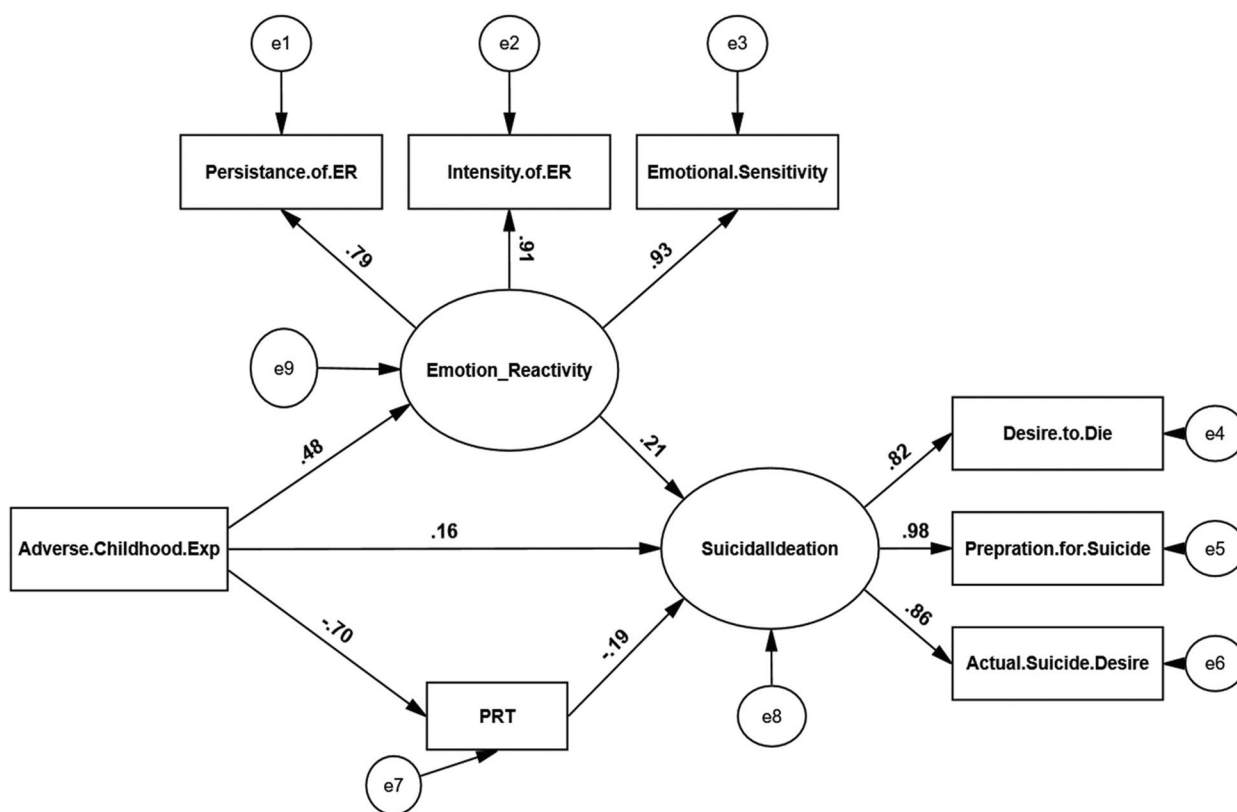
This finding aligns with other studies that have explored the impact of childhood trauma [15, 17, 18]. Previous research indicates that individuals who have experienced adverse childhood events tend to be more sensitive to various stressors in adulthood [22]. Consequently, even facing a minor stressor can trigger the onset of depression or suicidal thoughts and behaviors [17, 18].

Emotional reactivity played a significant and direct role in increasing suicidal ideation among patients with MDD. This finding is consistent with previous studies [45, 50, 51]. Emotional reactivity influences how individuals respond to emotional stimuli. When faced with stressful situations, high emotional reactivity can disrupt cognitive and behavioral control, leading to maladaptive responses, such as suicidal thoughts, as a means of escaping undesirable emotional states [45]. Consequently, individuals with elevated emotional reactivity are more likely to experience depressive symptoms, including suicidal ideation, after encountering stressors [50, 51].

Our findings indicated that PRL, which is associated with anhedonia in the context of positive valence systems, showed a significant and direct link to suicidal ideation

in patients with MDD. This aligns with other studies that have highlighted the substantial impact of anhedonia [38]- particularly PRL [44], on suicidal thoughts and behavior. According to Dombrowski and Hallquist [38], deficiencies in multiple reward processing mechanisms, such as impaired learning and reward valuation, can disrupt decision-making in individuals who contemplate suicide, ultimately increasing their suicide risk.

Adverse childhood experiences had a significant and indirect association with suicidal ideation through emotional reactivity. This finding aligns with previous studies [81–83] that highlighted the mediating role of resilience—one of the components of which is emotional reactivity—in the relationship between the distress caused by traumatic events and suicidal thoughts. In this context, DeCou and Lynch [81] concluded that emotional reactivity can represent a domain of resilience skills that is directly involved in the connection between psychopathological symptoms and suicidal ideation. Resilience is defined as a set of characteristics that enable individuals to withstand stressors and mitigate mental distress [84]. Therefore, it can protect individuals from the



Chi-square (df) = 34.797 (16); P value = .004 ; Relative Chi-Sq = 2.175;

GFI = .961 ; CFI = .983; IFI= .984 ; TLI=.971; RMSEA = .077

Fig. 3 Standard coefficients of direct routes in the proposed model of suicidal ideation

Table 4 Goodness-of-fit measures for path analysis

Models	χ^2	df	p	$\frac{\chi^2}{df}$ ≥ 3	GFI	CFI	IFI	TLI	RMSEA
					.90 ≥	.90 ≥	.90 ≥	.90 ≥	≥ .08
Direct Model	4.84	2	.088	2.42	.989	.994	.994	.983	.084
Mediation Model	34.80	17	.004	2.17	.961	.983	.984	.971	.077

Table 5 The direct and mediation models of adverse childhood experiences on suicidal ideation

Model	Path	Unstandardized Coefficient	Standard Error	Standardized Coefficient	Critical Values	Sig.
Direct Model	Adverse Childhood Experience → Suicidal Ideation	.109	.019	.395	5.67	<.001
Mediation Model	Adverse Childhood Experience → Emotional Reactivity	.152	.022	.481	6.87	<.001
	Adverse Childhood Experience → PRL	-.025	.002	-.704	-14.02	<.001
	Adverse Childhood Experience → Suicidal Ideation	.043	.027	.156	1.58	.115
	Emotional Reactivity → Suicidal Ideation	.181	.068	.210	2.65	.008
	PRL → Suicidal Ideation	-1.52	.719	-.194	-2.11	.034

Table 6 Summary of indirect results of changes based on the bootstrap method

Path	Standardized Indirect Effects	Standardized Indirect Effects– Standard Errors	Bootstrap CI 95%		
			Lower Bounds	Upper Bounds	Two-Tailed Significance
Adverse Childhood Experience→Suicidal Ideation	.238	.072	.101	.393	.003

negative consequences of distressing events [85]. It can be argued that individuals who experience adverse early life events are more vulnerable to suicidal thoughts due to weakened resilience and heightened emotional reactivity. Those with higher emotional reactivity often respond to stressful situations by amplifying negative emotions and interpreting events in a maladaptive manner. This group tends to report increased external problems and higher levels of depressive symptoms [48, 49]. Moreover, early life experiences significantly shape how individuals interpret and cope with various circumstances later in life. This aligns with the Stress Sensitization Model, which suggests that early life stressors affect people’s responses to future events [86, 87]. Adulthood is often one of the most challenging phases of life, as individuals encounter a range of stressful situations. Consequently, those with adverse childhood experiences may be more susceptible to these challenges due to their negative emotional responses, potentially leading to suicidal thoughts or even attempts.

Our findings indicated that adverse childhood experiences have a significant indirect association with suicidal ideation through PRL in depressed patients. This aligns with the research conducted by Pechtel and Pizzagalli [44], who examined reinforcement learning and maladaptive behaviors in women with a history of childhood sexual abuse. They discovered that, regardless of prior episodes of major depressive disorder (MDD), women who reported a history of sexual abuse during childhood exhibited various neural and behavioral deficits while completing the Probabilistic Reward Task. Additionally, suicidal behavior was associated with slower reaction times in tasks that involved decision-making based on motives. This suggests that adverse childhood experiences may have a detrimental impact on an individual’s cognitive abilities later in life. Such experiences can alter a person’s overall outlook on life and affect learning processes that rely on specific actions or stimuli to achieve desired outcomes [88, 89]. Individuals with a history of adverse early life experiences often believe that their actions or behaviors will lead to negative outcomes. Therefore, stable early care is essential for teaching them how to respond appropriately to rewards [90–92].

Furthermore, encountering a stressor later in life can worsen the effects of adverse childhood experiences on learning and memory [93]. As a result, adults who have experienced difficult childhoods may be more vulnerable to stress and may generalize the negative attitudes formed during their childhood to various situations. This can lead them to perceive themselves as weak in the face of challenges, potentially contributing to the development of suicidal thoughts and behaviors as a means to cope with such circumstances.

To the best of our knowledge, this study is the first to propose a structural model that investigates the mediating roles of emotional reactivity and probabilistic and reinforcement learning (PRL) in the relationship between adverse childhood experiences and suicidal ideation in patients with MDD. Our findings have significant clinical implications for clinicians working with MDD patients, especially those who report a history of adverse childhood experiences. We emphasize the necessity of assessing early-life trauma in patients with MDD. Additionally, our study highlights the need for policies and practices that raise awareness of childhood trauma within clinics that treat MDD patients. Given the substantial proportion of participants in our study who reported a history of adverse childhood experiences, implementing such policies and practices is essential. Furthermore, effective evaluation methods will enable clinicians to design therapeutic programs that consider the importance of emotional reactivity and reinforcement learning in patients with a background of adverse early life experiences. High emotional reactivity can be a significant risk factor for negative outcomes, such as suicide, in adulthood, particularly for individuals with a history of adverse early life experiences. This highlights the importance of developing interventions aimed at improving emotion regulation skills, aiding recovery from negative responses to stressors, and minimizing long-term disruptions in emotion regulation among those suffering from Major Depressive Disorder (MDD). Furthermore, clinical interventions that enhance resilience skills can effectively help prevent the consequences of traumatic experiences, such as suicidal ideation, in people with a background of adverse early life experiences.

Limitation

The current findings should be interpreted with several limitations in mind. First, most of the measures used in this study relied on self-reports, which can introduce bias. Second, other factors that were not explored in this research, such as hopelessness—which is associated with higher rates of suicidal ideation and attempts—may have influenced the relationships observed [94, 95]. Third, since this study is cross-sectional, it is not possible to draw conclusions about causality. Future research should utilize longitudinal designs and comprehensive clinical trials to assess variables that could affect these relationships and determine whether emotional reactivity and PRL are risk factors for suicidal ideation. Additionally, incorporating a concurrent laboratory assessment of patients' moment-to-moment emotional reactivity in future studies would enhance the construct validity of self-reported measures.

Abbreviations

MDD	Major Depressive Disorder
PRL	Probabilistic and Reinforcement Learning
PVSS-21	Positive Valence Systems Scale-21
PHQ-9	Patient Health Questionnaire-9
ERS	Emotional Reactivity Scale
BSSI	Beck Scale for Suicidal Ideation
MACE-IQ	Modified Adverse Childhood Experiences – International Questionnaire
SEM	Structural Equation Modeling ()
CFI	Comparative Fit Index
GFI	Goodness of Fit Index
IFI	Incremental Fit Index
TLI	Tucker-Lewis index
RMSEA	Root Mean Squared Error of Approximation

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Authors' contributions

s.Daneshvar, conceived the original idea, designed and directed the project, and developed the theoretical framework; Daneshvar, S., and Zeraatpisheh, Z., contributed to sample preparation and performing the experiments; Zand, S., carried out the implementation; Mohammadi Bytamar, J., performed the analytic calculations; Daneshvar, S., & Mohammadi Bytamar, J. wrote the article; Sahraian, A. conceived the study and was in charge of the overall direction and planning. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

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Data availability

There are no previously published or currently in-press works stemming from this same dataset. DOI for figshare.com: <https://doi.org/10.6084/m9.figshare.27522759>.

Declarations

Ethics approval and consent to participate

All experimental protocols were approved by the Institutional Review Board of the Shiraz University of Medical Sciences (ID: IR.SUMS.REC.1401.637) and all participants signed an informed consent prior to participation.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

- WHO. Depression and Other Common Mental Disorders Global Health Estimates. World Heal Organ. 2017;24. Available from: <https://apps.who.int/iris/handle/10665/254610>. Cited 2022 Sep 7.
- Lakdawalla Z, Hankin BL, Mermelstein R. Cognitive Theories of Depression in Children and Adolescents: A Conceptual and Quantitative Review. *Clin Child Fam Psychol Rev*. 2007;10(1):1–24. Available from: <https://link.springer.com/article/10.1007/s10567-006-0013-1>. Cited 2022 Sep 13.
- Nock MK, Green JG, Hwang I, McLaughlin KA, Sampson NA, Zaslavsky AM, et al. Prevalence, correlates, and treatment of lifetime suicidal behavior among adolescents: results from the National Comorbidity Survey Replication Adolescent Supplement. *JAMA Psychiat*. 2013;70(3):300–10.
- Baldessarini RJ, Forte A, Selle V, Sim K, Tondo L, Undurraga J, et al. Morbidity in depressive disorders. *Psychother Psychosom*. 2017;86(2):65–72.
- Ducasse D, Loas G, Dassa D, Gramaglia C, Zeppegno P, Guillaume S, et al. Anhedonia is associated with suicidal ideation independently of depression: A meta-analysis. *Depress Anxiety*. 2018;35(5):382–92.
- Zisook S, Planeta B, Hicks PB, Chen P, Davis LL, Villarreal G, et al. Childhood adversity and adulthood major depressive disorder. *Gen Hosp Psychiatry*. 2022;76:36–44. Available from: <https://www.sciencedirect.com/science/article/pii/S0163834322000408>.
- Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz AM, Edwards V, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) Study. *Am J Prev Med*. 1998;14(4):245–58.
- Hashemi L, Fanslow J, Gulliver P, McIntosh T. Exploring the health burden of cumulative and specific adverse childhood experiences in New Zealand: Results from a population-based study. *Child Abuse Negl*. 2021;122:105372. Available from: <https://www.sciencedirect.com/science/article/pii/S0145213421004415>.
- Merrick MT, Ports KA, Ford DC, Affi TO, Gershoff ET, Grogan-Kaylor A. Unpacking the impact of adverse childhood experiences on adult mental health. *Child Abuse Negl*. 2017;69:10–9. Available from: <https://www.sciencedirect.com/science/article/pii/S0145213417301084>.
- Miller DN. Child and adolescent suicidal behavior: School-based prevention, assessment, and intervention. 2011.
- Harmer B, Lee S, Duong T vi H, Saadabadi A. Suicidal Ideation. StatPearls Publishing, Treasure Island (FL); 2022. Available from: <http://europepmc.org/books/NBK565877>.
- Diagnostic and statistical manual of mental disorders (DSM-5). Arlington: American Psychiatric Publishing; 2013.
- Fuller-Thomson E, Dalton AD. Suicidal ideation among individuals whose parents have divorced: Findings from a representative Canadian community survey. *Psychiatry Res*. 2011;187(1–2):150–5. Available from: <https://doi.org/10.1016/j.psychres.2010.12.004>.
- Young R, Sweeting H, Ellaway A. Do schools differ in suicide risk? the influence of school and neighbourhood on attempted suicide, suicidal ideation and self-harm among secondary school pupils. *BMC Public Health*. 2011;11:1–15.
- Birnie MT, Kooiker CL, Short AK, Bolton JL, Chen Y, Baram TZ. Plasticity of the Reward Circuitry After Early-Life Adversity: Mechanisms and

- Significance. *Biol Psychiatry*. 2020;87(10):875–84. Available from: <https://doi.org/10.1016/j.biopsych.2019.12.018>.
16. Dickerson Mayes S, Calhoun SL, Baweja R, Mahr F. Suicide ideation and attempts in children with psychiatric disorders and typical development. *Crisis*. 2015;36(1):55–60.
 17. Coêlho BM, Andrade LH, Borges G, Santana GL, Viana MC, Wang YP. Do childhood adversities predict suicidality? Findings from the general population of the metropolitan area of São Paulo, Brazil. *PLoS One*. 2016;11(5):1–18. Available from: <https://doi.org/10.1371/journal.pone.0155639>.
 18. Dykxhoorn J, Hatcher S, Roy-Gagnon MH, Colman I. Early life predictors of adolescent suicidal thoughts and adverse outcomes in two population-based cohort studies. *PLoS ONE*. 2017;12(8):1–15.
 19. Giabbanelli PJ, Rice KL, Galgoczy MC, Nataraj N, Brown MM, Harper CR, et al. Pathways to suicide or collections of vicious cycles? Understanding the complexity of suicide through causal mapping. *Soc Netw Anal Min*. 2022;12(1):1–21.
 20. Hargreaves MK, Mouton CP, Liu J, Zhou YE, Blot WJ. Adverse childhood experiences and health care utilization in a low-income population. *J Health Care Poor Underserved*. 2019;30(2):749–67.
 21. Evans E, Hawton K, Rodham K. Factors associated with suicidal phenomena in adolescents: a systematic review of population-based studies. *Clin Psychol Rev*. 2004;24(8):957–79.
 22. Harkness KL, Bruce AE, Lumley MN. The role of childhood abuse and neglect in the sensitization to stressful life events in adolescent depression. *J Abnorm Psychol*. 2006;115(4):730–41.
 23. Pelizza L, Ferrari A. Anhedonia in schizophrenia and major depression: State or trait? *Ann Gen Psychiatry*. 2009;8:22.
 24. Cao B, Park C, Subramaniapillai M, Lee Y, Iacobucci M, Mansur RB, et al. The efficacy of vortioxetine on anhedonia in patients with major depressive disorder. *Front Psychiatr*. 2019;10. Available from: <https://pubmed.ncbi.nlm.nih.gov/30766492/>. Cited 2022 Sep 13.
 25. Spijker J, Bijl RV, de Graaf R, Nolen WA. Determinants of poor 1-year outcome of DSM-III-R major depression in the general population: results of the Netherlands Mental Health Survey and Incidence Study (NEMESIS). *Acta Psychiatr Scand*. 2001;103(2):122–30.
 26. Sandman CF, Craske MG. Psychological Treatments for Anhedonia. *Curr Top Behav Neurosci*. 2022;58:491–513.
 27. Klein ME, Grice AB, Sheth S, Go M, Murrough JW. Pharmacological Treatments for Anhedonia. *Curr Top Behav Neurosci*. 2022;58:467–89.
 28. Siddiqi SH, Haddad N, Fox MD. Circuit-Targeted Neuromodulation for Anhedonia. *Curr Top Behav Neurosci*. 2022;58:515–36. Available from: <https://pubmed.ncbi.nlm.nih.gov/35604569/>. Cited 2022 Sep 13.
 29. Auerbach RP, Pagliaccio D, Kirshenbaum JS. Anhedonia and Suicide. *Curr Top Behav Neurosci*. 2022;58:443–64. Available from: https://link.springer.com/chapter/10.1007/7854_2022_358. Cited 2022 Sep 13.
 30. Spitzer RL, Spitzer RL, Md KK, Williams JBW. Diagnostic and statistical manual of mental disorders, Third Edition. *Am Psychiatr Assoc*. 1980; Available from: <http://130.203.136.95/viewdoc/summary?doi=10.1.1.459.6032>. Cited 2022 Sep 13.
 31. Berridge KC, Robinson TE. Liking, wanting, and the incentive-sensitization theory of addiction. *Am Psychol*. 2016;71(8):670–9. Available from: <https://pubmed.ncbi.nlm.nih.gov/27977239/>. Cited 2022 Sep 13.
 32. Cooper JA, Arulpragasam AR, Treadway MT. Anhedonia in depression: biological mechanisms and computational models. *Curr Opin Behav Sci*. 2018;22:128–35. Available from: <https://www.sciencedirect.com/science/article/pii/S2352154617301973>
 33. Morris SE, Cuthbert BN. Research Domain Criteria: cognitive systems, neural circuits, and dimensions of behavior. *Dialogues Clin Neurosci*. 2012;14(1):29. Available from: <https://pubmed.ncbi.nlm.nih.gov/2141129/>. Cited 2022 Sep 13.
 34. National Institute of Mental Health. RDoC Changes to the Matrix (CMAT) Workgroup Update: Proposed Positive Valence Domain Revisions. 2018;1–21.
 35. Liu WH, Roiser JP, Wang LZ, Zhu YH, Huang J, Neumann DL, et al. Anhedonia is associated with blunted reward sensitivity in first-degree relatives of patients with major depression. *J Affect Disord*. 2016;190:640. Available from: <https://pubmed.ncbi.nlm.nih.gov/265330646/>. Cited 2022 Aug 31.
 36. Berridge KC, Robinson TE. Parsing reward. *Trends Neurosci*. 2003;26(9):507–13.
 37. Spijker J, De Graaf R, Ten Have M, Nolen WA, Speckens A. Predictors of suicidality in depressive spectrum disorders in the general population: Results of the Netherlands Mental Health Survey and Incidence Study. *Soc Psychiatry Psychiatr Epidemiol*. 2010;45(5):513–21.
 38. Dombrowski AY, Hallquist MN. The decision neuroscience perspective on suicidal behavior: Evidence and hypotheses. *Curr Opin Psychiatry*. 2017;30(1):7–14.
 39. Tsydes A, Owens M, Gibb BE. Blunted Neural Reward Responsiveness in Children With Recent Suicidal Ideation. *Clin Psychol Sci*. 2019;7(5):958–68.
 40. Chen Y, Baram TZ. Toward understanding how early-life stress reprograms cognitive and emotional brain networks. *Neuropsychopharmacology*. 2016;41(1):197–206.
 41. Grassi-Oliveira R, Honeycutt JA, Holland FH, Ganguly P, Brenhouse HC. Cognitive impairment effects of early life stress in adolescents can be predicted with early biomarkers: Impacts of sex, experience, and cytokines. *Psychoneuroendocrinology*. 2016;71:19–30.
 42. Hanson JL, van den Bos W, Roebor BJ, Rudolph KD, Davidson RJ, Pollak SD. Early adversity and learning: implications for typical and atypical behavioral development. *J Child Psychol Psychiatry Allied Discip*. 2017;58(7):770–8.
 43. Wilkinson MP, Slaney CL, Mellor JR, Jane Robinson ES. Investigation of reward learning and feedback sensitivity in non-clinical participants with a history of early life stress. *PLoS One*. 2021;16(12 December):1–20. Available from: <https://doi.org/10.1371/journal.pone.0260444>.
 44. Pechtel P, Pizzagalli DA. Disrupted reinforcement learning and maladaptive behavior in women with a history of childhood sexual abuse: a high-density event-related potential study. *JAMA Psychiatr*. 2013;70(5):499–507.
 45. Nock MK, Wedig MM, Holmberg EB, Hooley JM. The emotion reactivity scale: development, evaluation, and relation to self-injurious thoughts and behaviors. *Behav Ther*. 2008;39(2):107–16.
 46. Silbersweig D, Clarkin JF, Goldstein M, Kernberg OF, Tiescher O, Levy KN, et al. Failure of frontolimbic inhibitory function in the context of negative emotion in borderline personality disorder. *Am J Psychiatry*. 2007;164(12):1832–41.
 47. Rasch B, Spalek K, Buholzer S, Luechinger R, Boesiger P, Papassotiropoulos A, et al. A genetic variation of the noradrenergic system is related to differential amygdala activation during encoding of emotional memories. *Proc Natl Acad Sci U S A*. 2009;106(45):19191–6.
 48. Silk JS, Steinberg L, Morris AS. Adolescents' emotion regulation in daily life: links to depressive symptoms and problem behavior. *Child Dev*. 2003;74(6):1869–80.
 49. McLaughlin KA, Kubzansky LD, Dunn EC, Waldinger R, Vaillant G, Koenen KC. Childhood social environment, emotional reactivity to stress, and mood and anxiety disorders across the life course. *Depress Anxiety*. 2010;27(12):1087–94.
 50. Charbonneau AM, Mezulis AH, Hyde JS. Stress and emotional reactivity as explanations for gender differences in adolescents' depressive symptoms. *J Youth Adolesc*. 2009;38(8):1050–8.
 51. McLaughlin KA, Hatzenbuehler ML, Hilt LM. Emotion dysregulation as a mechanism linking peer victimization to internalizing symptoms in adolescents. *J Consult Clin Psychol*. 2009;77(5):894–904.
 52. Schotte DE, Clum GA. Problem-solving skills in suicidal psychiatric patients. *J Consult Clin Psychol*. 1987;55(1):49–54.
 53. Rabinowitz JA, Osgive I, Drabick DAG, Reynolds MD. Negative emotional reactivity moderates the relations between family cohesion and internalizing and externalizing symptoms in adolescence. *J Adolesc*. 2016;53:116–26.
 54. O'Connor RC, Kirtley OJ. The integrated motivational-volitional model of suicidal behaviour. *Philos Trans R Soc London Ser B, Biol Sci*. 2018;373(1754):20170268.
 55. Baumeister RF. Suicide as escape from self. *Psychol Rev*. 1990;97(1):90–113.
 56. Erbutto D, Innamorati M, Lamis DA, Berardelli I, Forte A, De Pisa E, et al. Mediators in the Association Between Affective Temperaments and Suicide Risk Among Psychiatric Inpatients. *Psychiatry*. 2018;81(3):240–57.
 57. Shapero BG, Farabaugh A, Terechina O, DeCross S, Cheung JC, Fava M, et al. Understanding the effects of emotional reactivity on depression and suicidal thoughts and behaviors: Moderating effects of childhood adversity and resilience. *J Affect Disord*. 2019;245:419–27.

58. Polanco-Roman L, Moore A, Tsydes A, Jacobson C, Miranda R. Emotion Reactivity, Comfort Expressing Emotions, and Future Suicidal Ideation in Emerging Adults. *J Clin Psychol*. 2018;74(1):123–35.
59. Zeman J, Cassano M, Perry-Parrish C, Stegall S. Emotion regulation in children and adolescents. *J Dev Behav Pediatr*. 2006;27(2):155–68.
60. Morris AS, Silk JS, Steinberg L, Myers SS, Robinson LR. The Role of the Family Context in the Development of Emotion Regulation. *Soc Dev*. 2007;16(2):361–88.
61. Dvir Y, Ford JD, Hill M, Frazier JA. Childhood maltreatment, emotional dysregulation, and psychiatric comorbidities. *Harv Rev Psychiatry*. 2014;22(3):149–61.
62. Kendler KS, Kuhn JW, Prescott CA. Childhood sexual abuse, stressful life events and risk for major depression in women. *Psychol Med*. 2004;34(8):1475–82.
63. Fitzgerald JM, Gorka SM, Kujawa A, DiGangi JA, Proescher E, Greenstein JE, et al. Neural indices of emotional reactivity and regulation predict course of PTSD symptoms in combat-exposed veterans. *Prog Neuropsychopharmacol Biol Psychiatry*. 2018;82:255–62.
64. Infurna FJ, Rivers CT, Reich J, Zautra AJ. Childhood trauma and personal mastery: their influence on emotional reactivity to everyday events in a community sample of middle-aged adults. *PLoS ONE*. 2015;10(4):e0121840.
65. Winer ES, Cervone D, Bryant J, McKinney C, Liu RT, Nadorff MR. Distinguishing mediational models and analyses in clinical psychology: atemporal associations do not imply causation. *J Clin Psychol*. 2016;72(9):947–55.
66. Moriarty AS, Res M, Gilbody S, Ph D, Mcmillan D, Ph D, et al. Screening and case finding for major depressive disorder using the Patient Health Questionnaire (PHQ-9): a meta-analysis. *Gen Hosp Psychiatry*. 2015;37(6):567–76. Available from: <https://doi.org/10.1016/j.genhosppsych.2015.06.012>.
67. Soper. A-priori Sample Size Calculator for Structural Equation Models [Software]. 2024. Available from: <https://www.danielsoper.com/statcalc>.
68. Jackson DL. Revisiting sample size and number of parameter estimates: some support for the N:q Hypothesis. *Struct Equ Model A Multidiscip J*. 2003;10(1):128–41. Available from: https://doi.org/10.1207/S15328007SEM1001_6.
69. American Psychiatric Association. The structured clinical interview for DSM-5[®]. 2019. Available from: <https://www.appi.org/products/structured-clinical-interview-for-dsm-5-scid-5>.
70. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med*. 2001;16(9):606–13.
71. Dadfar M, Kalibatseva Z, Lester D. Reliability and validity of the Farsi version of the Patient Health Questionnaire-9 (PHQ-9) with Iranian psychiatric outpatients. *Trends psychiatry Psychother*. 2018;40(2):144–51.
72. Khazanov GK, Ruscio AM, Forbes CN. The Positive Valence Systems Scale: Development and Validation. *Assessment*. 2020;27(5):1045–69. Available from: <https://doi.org/10.1177/1073191119869836>.
73. Pizzagalli DA, Jahn AL, O'Shea JP. Toward an objective characterization of an anhedonic phenotype: A signal-detection approach. *Biol Psychiatry*. 2005;57(4):319–27.
74. Evans SC, Blossom JB, Canter KS, Poppert-Cordts K, Kanine R, Garcia A, et al. Self-reported emotion reactivity among early-adolescent girls: evidence for convergent and discriminant validity in an urban community sample. *Behav Ther*. 2016;47(3):299–311.
75. Beck AT, Kovacs M, Weissman A. Assessment of suicidal intention: the Scale for Suicide Ideation. *J Consult Clin Psychol*. 1979;47(2):343–52.
76. Esfahani M, Hashemi Y, Alavi K. Psychometric assessment of Beck scale for suicidal ideation (BSSI) in general population in Tehran. *Med J Islam Repub Iran*. 2015;29(1). Available from: <http://mjiri.iums.ac.ir/article-1-3204-en.html>.
77. Ho GWK, Chan ACY, Chien WT, Bressington DT, Karatzias T. Examining patterns of adversity in Chinese young adults using the Adverse Childhood Experiences-International Questionnaire (ACE-IQ). *Child Abuse Negl*. 2019;88:179–88.
78. Kazeem OT. A Validation of the Adverse Childhood Experiences Scale in Nigeria. *Res Humanit Soc Sci*. 2015;5(11):18–23. Available from: <https://www.iiste.org/Journals/index.php/RHSS/article/view/23421>. Cited 2022 Nov 20.
79. Satinsky EN, Kakuikire B, Baguma C, Rasmussen JD, Ashaba S, Cooper-Vince CE, et al. Adverse childhood experiences, adult depression, and suicidal ideation in rural Uganda: A cross-sectional, population-based study. *PLoS Med*. 2021;18(5):e1003642.
80. Kline RB. Principles and practice of structural equation modeling (3. Baski). Guilford Press; 2011.
81. DeCou CR, Lynch SM. Emotional reactivity, trauma-related distress, and suicidal ideation among adolescent inpatient survivors of sexual abuse. *Child Abuse Negl*. 2019;89:155–64.
82. Deblinger E, Runyon MK, Steer RA. Profiles of Personal Resiliency in Youth Who Have Experienced Physical or Sexual Abuse. *J Psychoeduc Assess*. 2014;32(6):558–66. Available from: <https://doi.org/10.1177/0734282914527407>.
83. Laye AM, Mykota DB. Rural Canadian Youth Exposed to Physical Violence. *Can J Sch Psychol [Internet]*. 2014;29(1):21–39. Available from: <https://doi.org/10.1177/0829573514521772>.
84. Bonanno GA. Loss, trauma, and human resilience: have we underestimated the human capacity to thrive after extremely aversive events? *Am Psychol*. 2004;59(1):20–8.
85. Ellis B, Boyce W. Biological sensitivity to context. *Curr Dir Psychol Sci - CURR DIR PSYCHOL SCI*. 2008;17:183–7.
86. Hammen C, Henry R, Daley SE. Depression and sensitization to stressors among young women as a function of childhood adversity. *J Consult Clin Psychol*. 2000;68(5):782–7.
87. Shapero BG, Black SK, Liu RT, Klugman J, Bender RE, Abramson LY, et al. Stressful life events and depression symptoms: the effect of childhood emotional abuse on stress reactivity. *J Clin Psychol*. 2014;70(3):209–23.
88. Davis EP, Korja R, Karlsson L, Glynn LM, Sandman CA, Vegetabile B, et al. Across continents and demographics, unpredictable maternal signals are associated with children's cognitive function. *EBioMedicine*. 2019;46:256–63.
89. Davis EP, Stout SA, Molet J, Vegetabile B, Glynn LM, Sandman CA, et al. Exposure to unpredictable maternal sensory signals influences cognitive development across species. *Proc Natl Acad Sci U S A*. 2017;114(39):10390–5.
90. Molet J, Heins K, Zhuo X, Mei YT, Regev L, Baram TZ, et al. Fragmentation and high entropy of neonatal experience predict adolescent emotional outcome. *Transl Psychiatry*. 2016;6(1):e702.
91. Bolton JL, Molet J, Regev L, Chen Y, Rismanchi N, Haddad E, et al. Anhedonia following early-life adversity involves aberrant interaction of reward and anxiety circuits and is reversed by partial silencing of amygdala corticotropin-releasing hormone gene. *Biol Psychiatry*. 2018;83(2):137–47.
92. Uchida S, Hara K, Kobayashi A, Funato H, Hobara T, Otsuki K, et al. Early life stress enhances behavioral vulnerability to stress through the activation of REST4-mediated gene transcription in the medial prefrontal cortex of rodents. *J Neurosci Off J Soc Neurosci*. 2010;30(45):15007–18.
93. Molet J, Maras PM, Kinney-Lang E, Harris NG, Rashid F, Ivy AS, et al. MRI uncovers disrupted hippocampal microstructure that underlies memory impairments after early-life adversity. *Hippocampus*. 2016;26(12):1618–32.
94. Beck AT, Brown G, Berchick RJ, Stewart BL, Steer RA. Relationship between hopelessness and ultimate suicide: a replication with psychiatric outpatients. *Am J Psychiatry*. 1990;147(2):190–5.
95. Pompili M, Innamorati M, Forte A, Longo L, Mazzetta C, Erbutto D, et al. Insomnia as a predictor of high-lethality suicide attempts. *Int J Clin Pract*. 2013;67(12):1311–6.

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