Edelweiss Applied Science and Technology

ISSN: 2576-8484 Vol. 9, No. 7, 150-161 2025 Publisher: Learning Gate DOI: 10.55214/25768484.v9i7.8556 © 2025 by the author; licensee Learning Gate

Marital maladjustment and its relationship to the emergence of borderline personality disorder symptoms in abused women

Majdi Alhajaj1*

¹Al-Ahliyya Amman University, College of Arts and Sciences, Jordan; m.alhajaj@ammanu.edu.jo (M.A.).

Abstract: The dysfunctions and disputes that impede the emotional and psychological health of partners in a marriage are referred to as marital maladjustment. Communication problems, emotional neglect, and physical or emotional abuse are some of the ways this maladjustment might manifest. These issues can significantly impact mental health, especially when abusive relationships are involved. This study examines the connection between marital maladjustment and the development of borderline personality disorder symptoms in abused women, as marital maladjustment may contribute to the manifestation of personality disorder symptoms in this population. A questionnaire was developed to investigate and establish a relationship between marital maladjustment and the emergence of borderline personality disorder symptoms in abused women. The sample consisted of 50 abused women exhibiting borderline personality disorder symptoms from various environments and regions in Jordan. The questionnaire comprised two sections: the first gathered demographic information, and the second contained 20 questions related to the core issue. The collected data were tabulated, analyzed, and discussed using appropriate statistical methods. Results indicated that 40% of the women reported that their husbands used violence for any reason or without reason, and 40% stated that their husbands beat them due to their mental illness. Additionally, 30% attributed the violence to their husbands' alcoholism. Furthermore, 60% of the sample identified inadequate housing as a cause of family violence, while 70% linked it to low family income. Regarding causes of violence, 70% cited discrimination between boys and girls within the family. Half of the participants acknowledged witnessing violence during childhood, which they believed contributed to their own victimization later. Moreover, 80% reported that their husbands used foul language during abuse, and 70% experienced physical violence with hard tools. The women in the sample reported suffering from physical injuries and psychological illnesses, with prevalence rates ranging from 60% to 90%. The study concludes that marital maladjustment has a significant effect on the development of borderline personality disorder symptoms in women. Childhood experiences of abuse also significantly influence the emergence of personality disorder symptoms. Marital maladjustment and the appearance of borderline personality disorder symptoms in abused women have notable effects on families. Finally, social problems and family income significantly impact marital maladjustment and the development of personality disorder symptoms in married women.

Keywords: Abuse, Borderline personality disorder symptoms, Marital maladjustment, Psychometric, Women.

1. Introduction

The mental health illness known as borderline personality disorder (BPD) is typified by widespread volatility in behavior, moods, interpersonal interactions, and self-image. Intense episodes of anxiety, sadness, and rage that last anywhere from a few hours to several days are common in people with BPD. A considerable amount of evidence reveals a strong relationship between early-life abuse, particularly within the family, and the development of BPD [1]. According to studies, women with BPD are more likely to have been the victims of violence in the past, including emotional, physical, and sexual abuse at the hands of caregivers. There is a complicated and multidimensional association between abused

women's development of BPD symptoms and marital maladjustment. BPD symptoms may develop or worsen as a result of ongoing exposure to intimate partner abuse and marital dysfunction, which can increase preexisting vulnerability. For example, it has been discovered that women who experience intimate partner abuse are more likely to have indications of personality disorders, including BPD [2]. Additionally, the emotional dysregulation associated with BPD may be exacerbated by maladaptive communication patterns in marriages, such as unpleasant interactions and misunderstandings. According to studies, people with BPD symptoms frequently use negative communication techniques, which can exacerbate marital problems and create a vicious circle of emotional instability. In conclusion, marital maladjustment is a major risk factor for the onset and aggravation of BPD symptoms in women, particularly when combined with abusive dynamics. In order to prevent and cure BPD, it is imperative to address these relational concerns, which emphasizes the value of therapy interventions that enhance marital relationships and offer support to abuse survivors [3].

2. Study Questions and Hypothesis

2.1. Study Questions

The study questions are

- Does the Marital maladjustment have an effect in producing a borderline personality disorder symptoms at women?
- Does the abused women at childhood has an effect on creating personality disorder symptoms for married women?
- What are effects of Marital maladjustment on emergence of borderline personality disorder symptoms in abused women?
- Does the social problems and income of the family effect on Marital maladjustment and creating personality disorder symptoms for married women?

2.2. Study Hypothesis

The study has the following hypotheses as shown in Table 1.

Table 1. Study Hypotheses

Study Hypo	theses.	
H1	$H1_0$	Marital maladjustment has no effect on developing a borderline personality disorder symptoms at women
	H1 ₁	Marital maladjustment has a significant effect on developing a borderline personality disorder symptoms at women
H2	H2 ₀	Abused women at childhood has no effect on creating personality disorder symptoms of married women
	H2 ₁	Abused women at childhood has a significant effect on creating personality disorder symptoms of married women
Нз	H3 ₀	Marital maladjustment and emergence of borderline personality disorder symptoms in abused women have no effects on the families
	H3 ₁	Marital maladjustment and emergence of borderline personality disorder symptoms in abused women have a significant effect on the families
H4	H4 ₀	Social problems and income of the family have no effects on Marital maladjustment and creating personality disorder symptoms for married women
	H4 ₁	Social problems and income of the family have a significant effect on Marital maladjustment and creating personality disorder symptoms for married women.

3. Literature Review

According to studies, people with BPD frequently have serious relationship dysfunctions, such as difficulties choosing a partner, forming a union, being happy in a relationship, and experiencing intimate violence. The fundamental traits of BPD, like emotional instability and interpersonal difficulties, are intimately associated with these dysfunctions. One important element determining the emergence of

Edelweiss Applied Science and Technology ISSN: 2576-8484 Vol. 9, No. 7: 150-161, 2025

DOI: 10.55214/25768484.v9i7.8556 © 2025 by the author; licensee Learning Gate BPD symptoms is the intensity of childhood sexual abuse (CSA) [4]. According to researchers, abused women have more severe personality disorder symptoms, and CSA is the most important risk factor that separates women with BPD from those without. The intricate connection between marital maladjustment and BPD symptoms is highlighted by the cyclical nature of violence in families, especially when it comes to BPD. It is essential to comprehend this cycle in order to create solutions that work [5]. Although they were a low publication related to this topic from authors in Jordan due to Covid-19 pandemic [6]. But all researchers attend for working hard to develop research to serve the development issues of Jordanian society and all efforts should be directed Towards Achieving Sustainable Development Goals in Light of National Strategy [7]. Many studies have been discussed this issue, in a population sample of 142 late-adolescent women, Daley, et al. [8] investigated the associations between symptoms of depression, other personality disorders, and borderline personality disorder (BPD) and dysfunctional romantic relationships. The 4-year romantic dysfunction (romantic chronic stress, disputes, partner satisfaction, abuse, and unwanted pregnancy) was predicted by BPD symptoms, but the relationships were not exclusive to BPD. Rather, a cumulative index of non-BPD Axis II pathology was a better predictor of relationship dysfunction. With the exception of unintended pregnancy, depression did not predict outcomes in a unique way when Axis II symptoms were taken into account. The findings imply that while interpersonal dysfunction is linked to BPD, the effect is a more universal phenomena that applies fairly widely to Axis II disorder. The findings further emphasize how crucial subclinical psychopathology is to the development of early close connections Daley, et al. [8]. Karsten, et al. [9] this study compared 156 female forensic psychiatric patients with a BPD diagnosis versus 113 females with an alternative diagnosis. Patient files were used to collect data on victimization, index offenses, occurrences during treatment, and demographic and mental features. The PCL-R and historical items from the HCR-20, including items from the new Female Additional Manual (FAM), were used to evaluate risk factors for recidivism. BPD women were more likely to have experienced childhood abuse and to have previously had outpatient therapy than non-BPD women. BPD women were more likely to be convicted of arson than to be guilty of (attempted) homicide. The BPD group experienced more aggressive episodes against themselves and others, as well as more comorbid substance addiction. The H-scale of the HCR-20/FAM and the PCL-R revealed a number of risk factors that are particularly significant for women with BPD, including impulsivity, poor behavioral control, and irresponsibility. The findings corroborate the clinical perception that women with BPD constitute a subgroup of female forensic psychiatric patients, with particular treatment and management goals Karsten, et al. [9]. Frederick and Laura [10] used the Coolidge Axis II Inventory principle, a self-report measure based on the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), to compare the personality profiles of women with multiple abusive relationship histories (N = 42) to either abused women with one abusive relationship (N = 33) or a control group (N = 52). Compared to women in the other two groups, women who experienced multiple abusive relationships were more likely to suffer from dependent, paranoid, and self-defeating personality disorders. The prevalence of depression and personality disorders was considerably higher among women in multiple abusive relationships and PTSD, respectively, than among women in single abusive relationships. Compared to women in the control group with matching marital status, women in abusive single relationships did not show higher levels of psychopathology. Discussions are held regarding methodological and theoretical concerns as well as suggested treatments Frederick and Laura [10]. Bozzatello, et al. [11] proved that childhood trauma contributed to the early onset of borderline personality disorder (BPD). In order to explain the evolutionary routes of BPD, the most realistic theoretical models are multifactorial, accounting for a variety of circumstances, including early trauma. In order to assess whether various forms of childhood trauma, such as physical and sexual abuse and neglect, raise the risk and influence the clinical picture of BPD, we looked at research that has been published on PubMed in the past 20 Multiple comorbidities, such as mood, anxiety, obsessive-compulsive, eating, dissociative, addictive, psychotic, and somatoform disorders, are frequently present in BPD, which is a result of childhood traumas. In these situations, it usually has a protracted course, is severe, and is resistant to

treatment. Patients with BPD are more likely to have experienced childhood abuse than people with other personality disorders. The HPA axis, neurotransmission pathways, endogenous opioid systems, gray matter volume, and white matter connections are among the biological systems that are impacted by adverse childhood events, and these alterations continue throughout adulthood. The relationship between genes (such as CRHR2 variations and FKBP5 polymorphisms) and environment (such as emotional neglect, physical and sexual abuse) is becoming more and more clear Bozzatello, et al. [11]. Ayirolimeethal, et al. [2] investigated how patients with emotionally unstable personality disorder adjusted to marriage. People between the ages of 18 and 45 who were diagnosed with Emotionally Unstable Personality Disorder according to the International Classification of Diseases-Diagnostic Criteria for Research (ICD 10-DCR) criteria, were living with their spouse at the time of the study, and were enrolled in a psychiatry department were the subjects of a cross-sectional study. The main tool for the study was the Locke Wallace Marital Adjustment Test (MAT). The pertinent variables were compared using the Chi-square test. Emotionally Unstable Personality Disorder participants indicated considerable marital dissatisfaction in 35% of the sample (n = 34). Comorbid mental illnesses were observed in 23.5% of the participants. There was a strong correlation between marital adjustment and the type of marriage. Some form of psychosocial help was given to 41.2%. Of the spouses, 23.5% had a history of mental illness, and 70.6% had a history of substance abuse. There was no discernible variation in MAT severity between EUPD subtypes. The study discovered that participants with Emotionally Unstable Personality Disorder had a significant degree of marital maladjustment Ayirolimeethal, et al. [2]. Kasalova, et al. [12] stated that the most frequent cause of decompensation of mental illnesses, including personality disorders, is partner conflict. Both the prediction of an individual's marital contentment and the overall satisfaction of the marriage are significantly influenced by personal traits. The Story Using the keywords "personality disorder," "partnership," "marital problems," and "marital conflicts," the PubMed, Web of Science, and Scopus databases were used to review books, articles, and book chapters published between 1956 and 2016. Reviews of pertinent papers were used to find other references. It is clear that individuals with personality disorders may find it difficult to meet the requirements for marital pleasure while readily meeting the requirements linked to the reasons for relationship breakdowns. Developing and maintaining a connection with a partner is extremely difficult for those with personality disorders. They have the inadvertent capacity to establish and sustain unhealthy connections. Inadequate comprehension of one or both partners' conduct may be the root cause of the correlation between a dysfunctional marriage and personality issues. Individuals with personality disorders frequently misunderstand and misinterpret others, communicate badly, and are more likely to be verbally and physically aggressive in social situations. They fail to see that their intrapersonal processes and their interactions with the outside world are the root cause of the challenges they have faced. People who suffer from specific personality disorders often look for and establish a pathologically steady relationship. It should be crucial to look at personality features first in order to comprehend the dynamics of such interactions. It should be advantageous for both partners to comprehend the maladaptive personality patterns within the partnership [12].

4. Methodology

The study concentrated on a questionnaire result used to investigate the opinion of abused women about the Marital maladjustment and its relationship to the emergence of borderline personality disorder symptoms, the questionnaire is composed of 2 sections and 20 questions. Section 1 concentrated on the demography information of the sample while the second section contains the core of the study which represents the sample response related to questions. The sample size is 50 ladies selected randomly from psychological clinics. Table 2 represents the questionnaire and answers of respondents.

Table 2.

Section 1	Demography information									
1	Job	Em	ployed	Unemployed						
		(60%							
2	Education	Diploma and low		Bac	helor	High Educatio				
		50%		30%		20%				
3	Family Monthly Income	< 300JD		300JD to 700JD		>700JD				
	, ,	60%		20%		20%				
4	Age	Less	than 20	20 to 30		>30				
		20%		60%		20%				
Section 2		Questi	onnaire Body							
Question Number	Question	(5) Always	(4) Most of the time	(3) some of the time	(2) Rarely	(1) Never				
1	My husband considers me responsible for	20%	20%	30%	20%	10%				
	all the problems within the family.									
2	He beats me up for no reason and for the most trivial reasons.	20%	40%	20%	10%	10%				
3	He constantly criticizes me and is not satisfied with anything I do.	45%	30%	10%	10%	5%				
4	He doesn't give me the chance to talk to him about things that interest me.	50%	30%	10%	5%	5%				
5	He abuses me because of his alcoholism.	30%	20%	20%	20%	10%				
6	He abuses me because of his mental illness.	10%	10%	20%	30%	30%				
7	Our inadequate housing is the cause of the problems.	30%	30%	20%	10%	10%				
8	Discrimination in treatment between boys and girls generates violence in the family.	40%	30%	10%	10%	10%				
9	When he feels that I am better than him, he abuses me.	40%	30%	10%	10%	10%				
10	The argument between us ends with him hitting me.	30%	20%	20%	20%	10%				
11	As a child, I witnessed violence among my family members.	30%	20%	20%	20%	10%				
12	My negligence in household duties exposes me to violence	30%	30%	30%	10%	0%				
13	My family's low income is the cause of all the problems.	40%	30%	10%	10%	10%				
14	He mistreats me and acts cruelly towards me	50%	30%	10%	5%	5%				
15	He hits me with whatever he finds in front of him.	40%	30%	10%	10%	10%				
16	He curses and uses foul language.	50%	30%	10%	5%	5%				
17	He beats me so hard that I have physical injuries that require treatment by a doctor.	50%	30%	10%	5%	5%				
18	I am not allowed to express my personal opinions.	50%	30%	10%	5%	5%				
19	He does not care about providing me with appropriate medical care.	40%	30%	10%	10%	10%				
20	I tend to stay alone away from others	60%	20%	10%	10%	0%				

5. Results and Discussion

5.1. First: Sample Demography Analysis

Figure 1 shows the distribution of the participated Women in the questionnaire related to their jobs.

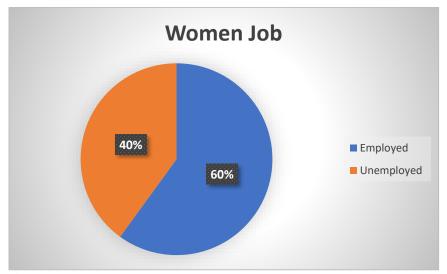


Figure 1. distribution of the participated Women in the questionnaire related to their jobs.

Figure 2 shows the distribution of the participated Women in the questionnaire related to their education.

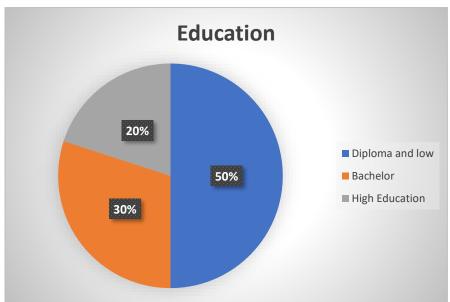


Figure 2.
Distribution of the participated Women in the questionnaire related to their education.

Figure 3 shows the distribution of the participated Women in the questionnaire related to their family income.

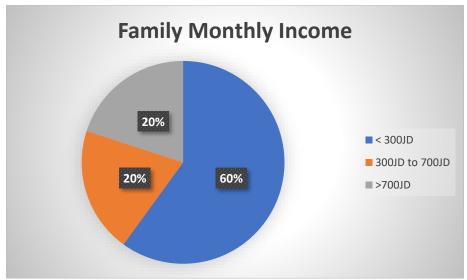


Figure 3.Distribution of the participated Women in the questionnaire related to their family income.

Figure 4 shows the distribution of the participated Women in the questionnaire related to their age.

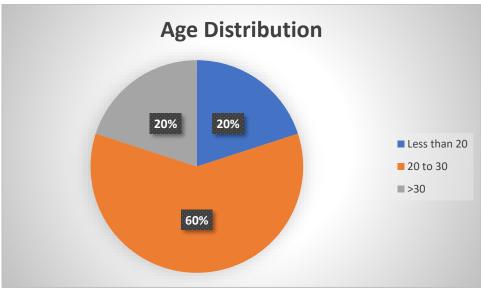


Figure 4. distribution of the participated Women in the questionnaire related to their age.

The responses of the women participated in the questionnaire are represented graphically for some of important questions as follows:

1- The response of the question" My husband beats me up for no reason and for the most trivial reasons" is shown in figure 5 below.

DOI: 10.55214/25768484.v9i7.8556 © 2025 by the author; licensee Learning Gate

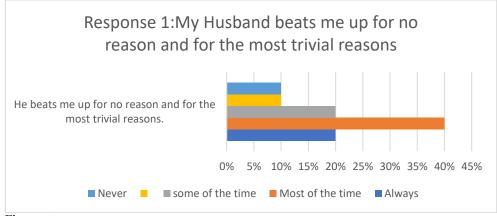


Figure 5. Respondents' answers ratio about abusing women.

Figure 6 shows some reasons of women abuse depending on respondents' answers.

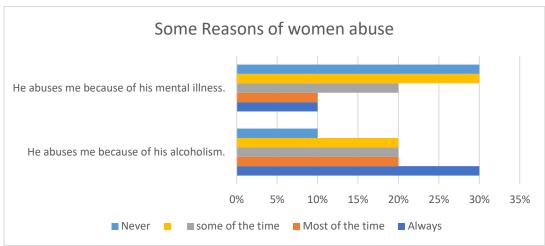


Figure 6. Reasons of women abuse depending on respondents' answers.

Figure 7 shows some reasons of women abuse depending on respondents' answers.

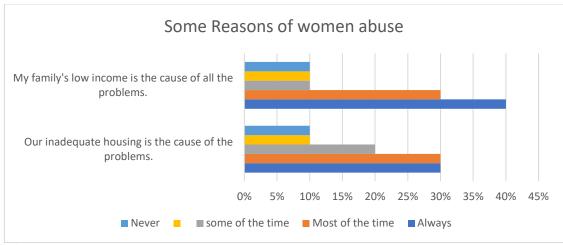


Figure 7. Some reasons of women abuse depending on respondents' answers.

Figure 8 shows the effects of the history life of the women and discrimination between boys and girls on abused women depending on respondents' answers.

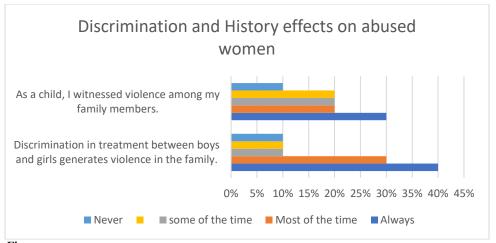


Figure 8.Effects of the history life of the women and discrimination between boys and girls on abused women depending on respondents' answers.

Figure 9 shows the Forms of abuse on women depending on respondents' answers.

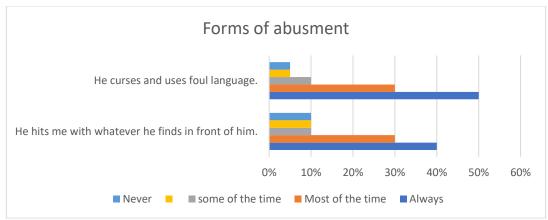
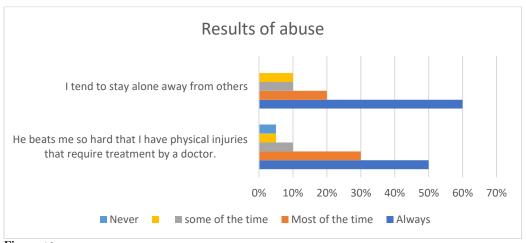


Figure 9. Forms of abuse on women depending on respondents' answers.

Figure 10 shows physical and psychological effects of abused women depending on respondents' answers.



Physical and psychological effects of abused women depending on respondents' answers.

6. Statistical Analysis

6.1. Hypotheses Analysis

The null hypothesis H_0 should be mentioned whether or not it was rejected at a given significance level (α -value) in order to highlight the outcomes of the hypothesis test. The "P-value" is the smallest level of significance. According to Montgomery and Runger [13] the P-value is the weight of achieving a statistic test value that is at least as high as what is seen when the null hypothesis is accepted. The chance of Type I error, or rejecting the null hypothesis while the hypothesis is true, is also represented by the P-value. Operationally, this investigation uses a significance level of 0.01 after calculating a P-value. Any hypothesis will be rejected if the P-value is less than significance level of α = 0.01. The necessary statistical tests are carried out using the statistical package for social sciences (SPSS), and a paired sample test and correlation are calculated to reflect the findings of testing hypotheses. Table 3 shows the outcomes of the statistical testing that was done. Let's use hypothesis H1 as an example to clarify Table 3. The paired sample correlation and paired sample test confirm that H1 has P-values approach to zero (i.e., P-value < 0.01) which means that H10 is rejected at a significance

level of (α =0.01). Thus, we can say that the alternative hypothesis $H1_1$ is supported (true). Similarly, the hypotheses (from H2 to H4) found to have P-values below 0.01 that indicates that the null hypotheses of all of them are rejected and the proposed alternative hypotheses of them are supported.

Table 3.

Results of the hypotheses testing.

Alternative Hypothesis	Relationship	Paired Sample Correlation		Paired Sample Test			Decision
riypotnesis		Pearson	<i>P</i> -value	<i>t</i> -value	DF	<i>P</i> -value	
$H1_1$	Marital maladjustment VS. developing a borderline personality disorder symptoms at women	0.994**	0.000	6.832	49	0.000	Reject $H1_0$
H2 ₁	Abused women at childhood VS. creating personality disorder symptoms of married women	0.962**	0.000	10.541	49	0.000	Reject H2 ₀
H3 ₁	Marital maladjustment and emergence of borderline personality disorder symptoms in abused women VS. families	0.985**	0.000	5.409	49	0.000	Reject H3 ₀
$H4_1$	Social problems and income of the family VS. Marital maladjustment and creating personality disorder symptoms for married women	0.958**	0.000	2.518	49	0.001	Reject H4 ₀

Note: **. Correlation is significant at the 0.01 level (2-tailed).

7. Results Discussion

From all previous figures which represented the relations between variables of the study, it is obvious that, the sample taken has a low education level (60% has a diploma or low), unemployed women in addition the age is between 20-30 years with low monthly income (60% < 300 JD/month). From figures, 40% of women under study expressed that their husbands used violence for any reason or without, and 40% of the sample stated that their husbands beat them because of their mental illness, and 30% because of their husband's alcoholism. In addition, 60% of the sample stated that inadequate housing is one of the causes of the violence inside the family, while 70% refereed this to the low monthly income of the family. On the other side, 70% of the studied sample stated that the discriminations between boys and girls inside the family is one of important reasons of violence and abuse to women. 50% of the sample agrees that they are witnessed violence when they were child which causes abused women later. Also, 80% of the sample stated that their husbands used a foul language and not polite words during abuse while 70% exposed to hit with hard tools and others. The abused women through the sample stated that they suffer from violence like physical injury or psychometric illnesses (60-90%) of the studied sample. Using Table 3 which represents the hypotheses test, the results showed that all null hypotheses are rejected and all alternative hypotheses are accepted.

8. Conclusion

This study discussed an important issue related to marital maladjustment and its relationship to the emergence of borderline personality disorder symptoms in abused women, the results of this study may lead to the following conclusions:

- Marital maladjustment has a significant effect on developing a borderline personality disorder symptoms at women
- Abused women at childhood has a significant effect on creating personality disorder symptoms of married women
- Marital maladjustment and emergence of borderline personality disorder symptoms in abused women have a significant effect on the families

• Social problems and income of the family have a significant effect on Marital maladjustment and creating personality disorder symptoms for married women

Transparency:

The author confirms that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Copyright:

© 2025 by the author. This open-access article is distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

References

- [1] M. C. Caballero Guzmán, L. T. Rodríguez Hernández, and J. J. Fernández Muñoz, "Borderline personality disorder and intimate partner violence: A ystematic review," *Papeles del Psicólogo/Psychologist Papers*, vol. 45, no. 1, pp. 48-55, 2024.
- [2] A. Ayirolimeethal, P. Abha, H. M. Tharayil, B. George, and V. Vidyadharan, "Marital adjustment in patients with emotionally unstable personality disorder," *Kerala Journal of Psychiatry*, vol. 31, no. 2, pp. 80-85, 2018.
- [3] E. Valero, A. Paillet, V. Ciudad-Fernández, and M. E. Aparicio-García, "Structural violence and the effects of the patriarchal structure on the diagnosis of borderline personality disorder (BDP): A critical study using tools on BPD symptoms and social violence," *International Journal of Environmental Research and Public Health*, vol. 22, no. 2, p. 196, 2025. https://doi.org/10.3390/ijerph22020196
- P. Pérez Longares, "Review of risk factors influencing borderline personality disorder," Bachelor's Thesis, Universidad de Valencia, Valencia, Spain, 2021.
- [5] G. Perrotta, "Borderline personality disorder: Definition, differential diagnosis, clinical contexts, and therapeutic approaches," *Annals of Psychiatry and Treatment*, vol. 4, no. 1, pp. 43-56, 2020.
- [6] S. S. Badrakhan, J. T. Hussein, O. Al Rawashdeh, and T. S. M. Haimur, "The repercussions of the COVID-19 pandemic on the research production of faculty members at Jordanian universities," *Dirasat: Human and Social Sciences*, vol. 51, no. 4, pp. 78–94, 2024. https://doi.org/10.35516/hum.v51i4.4185
- [7] S. Badrakhan, A. S. Eyad, O. Oqilat, J. Taha, and H. Doudeen, "Efforts towards achieving sustainable development goals in light of national strategy "Jordan's Vision 2025": Reality and challenges," *Journal of Educational and Social Research*, vol. 14, no. 4, p. 1, 2024.
- [8] S. E. Daley, B. Dorli, and H. Constance, "Borderline personality disorder symptoms as predictors of 4-year romantic relationship dysfunction in young women addressing issues of specificity," *Journal of Abnormal Psychology*, vol. 109, no. 3, pp. 451-460, 2000.
- [9] J. Karsten, D. V. Vivienne, and L. Marike, "Characteristics and offences of women with borderline personality disorder in forensic psychiatry: A multicentre study," *Psychology, Crime & Law*, vol. 22, no. 3, pp. 224–237, 2016. https://doi.org/10.1080/1068316X.2015.1077250
- [10] L. C. Frederick and W. A. Laura, "Personality profiles of women in multiple abusive relationships," *Journal of Family Violence*, vol. 17, no. 2, pp. 117–131, 2002.
- P. Bozzatello, P. Rocca, L. Baldassarri, M. Bosia, and S. Bellino, "The role of Trauma in early onset borderline personality disorder: A biopsychosocial perspective," Front. Psychiatry, vol. 12, p. 721361, 2021. https://doi.org/10.3389/fpsyt.2021.721361
- [12] P. Kasalova et al., "Personality disorder in marriage and partnership a narrative review," Neuroendocrinology Letters, vol. 39, no. 3, pp. 187–196, 2018.
- [13] D. Montgomery and G. Runger, Applied statistics and probability for engineers, 5th ed. Hoboken, NJ: John Wiley & Sons, 2011.