

Original article

Factors associated with major depressive symptoms in Salvadoran adolescents

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Abstract

Introduction. Depression is a major cause of disability, affecting 350 million people worldwide. The 2022 National Mental Health Survey reported that four out of ten Salvadoran adolescents have symptoms of major depressive disorder. **Objective.** Analyze the factors associated with symptoms of major depression in Salvadoran adolescents. **Methodology.** A cross-sectional analytical study was conducted using data from the 2022 National Mental Health Survey. The major depression variable was analyzed using two models: binomial logistic regression and random forests, with 80 % training and 20 % test sets. **Results.** A total of 1209 adolescents were studied; 33.5 % exhibited symptoms of major depression. The main associated factors were behavioral problems (OR 2.22; $p < 0.05$), low emotional expression within the family (OR 2.124; $p < 0.05$), as well as the presence of adult post-traumatic stress in the household (OR 2.91; $p < 0.05$), the level of COVID-19-related stress (OR 2.455; $p < 0.05$), and low adult resilience (OR 2.165; $p < 0.05$). Furthermore, the random forest analysis identified a history of depression in the adult and female sex as variables with the greatest predictive importance, whereas only the statistically significant variables in the logistic regression were considered associated factors. **Conclusion.** This study identified the following as the main factors associated with depressive symptoms consistent with major depression: the presence of post-traumatic stress disorder in an adult in the household, COVID-19-related stress, low adult resilience, borderline behavioral problems, and low emotional expression in adolescents.

Keywords

Major Depressive Disorder, Risk Factors, Mental Health, Adolescent.

Resumen

Introducción. La depresión es una causa importante de discapacidad, la cual afecta a 350 millones de personas en el mundo. La Encuesta Nacional de Salud Mental 2022 reportó que cuatro de cada diez adolescentes salvadoreños tienen síntomas de trastorno de depresión mayor. **Objetivo.** Analizar los factores asociados a síntomas de depresión mayor en adolescentes salvadoreños. **Metodología.** Se realizó un estudio transversal analítico con los datos de la Encuesta Nacional de Salud Mental 2022. La variable depresión mayor se analizó mediante dos modelos: regresión logística binomial y bosques aleatorios, en conjuntos de 80 % de entrenamiento y 20 % de prueba. **Resultados.** Se estudiaron 1209 adolescentes; el 33,5 % presentó síntomas de depresión mayor. Los principales factores asociados fueron problemas de comportamiento (OR 2,22; $p < 0,05$), baja expresión en la relación intrafamiliar (OR 2,124; $p < 0,05$), además de presencia de estrés postraumático del adulto en el hogar (OR 2,91; $p < 0,05$), grado de estrés por COVID-19 (OR 2,455; $p < 0,05$) y baja resiliencia del adulto (OR 2,165; $p < 0,05$). Además, el bosque aleatorio identificó el antecedente de depresión del adulto y el sexo femenino como variables de mayor importancia predictiva, mientras que solo las variables estadísticamente significativas en la regresión logística se consideraron factores asociados. **Conclusión.** El presente estudio identificó como principales factores asociados a la sintomatología depresiva compatible con depresión mayor la presencia de trastorno de estrés postraumático en el adulto del hogar, el estrés relacionado con la COVID-19, el bajo nivel de resiliencia del adulto, los problemas de comportamiento límite y la baja expresión emocional del adolescente.

Palabras clave

Trastorno Depresivo Mayor, Factores de Riesgo, Salud Mental, Adolescentes.



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Factores asociados a síntomas de depresión mayor en adolescentes salvadoreños

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Introduction

Depression contributes significantly to the global burden of disease;¹ it is estimated

to affect 350 million people worldwide, with prevalence rates ranging from 3.3 % to 21.4 %;² furthermore, it is one of the leading causes of disability.¹

Major depressive disorder (MDD) is a mental health disorder characterized by a persistently low mood, loss of interest or pleasure in activities that were previously rewarding, and the presence of physical and cognitive symptoms, such as fatigue, sleep disturbances, difficulty concentrating, and recurrent thoughts of death.³ This is a clinical diagnosis established using standardized criteria, such as those in the DSM-5 or the ICD-11. In population-based studies, assessment is typically conducted using standardized scales that identify clinically relevant depressive symptoms or probable cases of depression, without replacing a clinical diagnostic evaluation. In this study, the outcome corresponds to depressive symptoms identified using a validated scale.

Major depressive disorder appears to be caused by a combination of genetic, environmental, psychological, and biological factors.⁴ Furthermore, the transition to adulthood involves neurobiological and psychosocial changes; societal expectations and the assumption of new roles can generate stresses that compromise emotional stability.⁵

In El Salvador, the 2022 National Mental Health Survey (ENSM 2022) reported a 29.5 % prevalence of severe depressive symptoms and a 12.7 % prevalence of borderline depressive symptoms among adolescents; the survey showed that four out of ten adolescents have symptoms of major depressive disorder.⁶ Furthermore, it is known that approximately 50 % of mental disorders in adults are attributable to mental health problems in childhood or adolescence.^{7,8} These data highlight a significant problem and reveal the need for relevant, evidence-based interventions tailored to the country's sociocultural context and aimed at exploring the factors that influence major depressive disorder (MDD).

This study analyzes data from the 2022 ENSM to identify factors associated with depressive symptoms in adolescents aged 13 to 17 in El Salvador using logistic regression and, complementarily, to assess the predictive importance of the variables using a random forest model. This evidence aims to support the design of data-driven, equity-oriented mental health interventions and policies.

Methodology

An analytical cross-sectional study was conducted based on data from the 2022 ENSM, which was designed and implemented by the Ministry of Health under the technical management of the National

Institute of Health of El Salvador, with the aim of obtaining representative scientific evidence on the status of mental health problems in the Salvadoran population. In this analysis, the geographic distribution was divided into five health regions.⁶ The models were adjusted using sample weights to improve the representativeness of the estimates. For this study, adolescents aged 13 to 17 who completed the questionnaire corresponding to their age group were included, and data were integrated from the household questionnaires and those completed by an adult informant, selected at random from within the household. The initial dataset consisted of 1919 records, of which 1209 with complete information on the "major depression" variable were included; 710 were excluded due to incomplete data on the outcome variable. Through a data integration process, the adolescents' responses were linked to information from the household module and the adult module, the latter was completed by a randomly selected respondent within the adolescent's household. It should be noted that the study examined variables pertaining to both the adolescent and the adult who completed the household interview. The adult variables correspond to the adult randomly selected from the household during the 2022 ENSM. Consequently, these are interpreted as characteristics of the family context and not as specific attributes of the adolescent's primary caregiver or parents. It is worth noting that the variables were as follows: history of mental health issues in the household, history of post-traumatic stress disorder among adults in the household, presence of COVID-19-related stress among adults, and the adult's level of resilience, as well as unmet basic needs in the household.

Standardized psychometric instruments integrated into the 2022 ENSM were used for the adolescent population. The analytical variables were constructed based on the original scores and classified using population percentiles or criteria specific to each scale, in accordance with the methodological dictionary.

Symptoms of anxiety and depression were assessed using the Revised Child Anxiety and Depression Scale (Child version). The subscales and total scores were converted into age-adjusted percentiles and classified as high when they were at or above the 90th percentile, as between the 70th and 90th percentiles, and as normal when they were below the 70th percentile. The major depression subscale was used to identify clinically relevant depressive

symptoms.⁹ For the regression analysis, the variable “depressive symptoms consistent with major depression” was dichotomized based on the presence of at least some degree of depression.

Emotional symptoms and behavioral problems were assessed using the Strengths and Difficulties Questionnaire (SDQ). Scores were classified as abnormal when they were at or above the 90th percentile, as borderline between the 80th and 90th percentiles, and as normal when they were below the 80th percentile. On the prosocial behavior subscale, the classification was reversed: scores at or below the 10th percentile were classified as abnormal, scores between the 10th and 20th percentiles were classified as borderline, and scores at or above the 20th percentile were classified as normal.¹⁰

Exposure to traumatic events and associated symptoms were assessed using the Child and Adolescent Trauma Screen (CATS). Exposure to trauma was defined as a dichotomous variable based on the presence or absence of at least one traumatic event. Symptoms were classified as normal range (0-11 points), moderate trauma-related distress (12-20 points), and probable post-traumatic stress disorder (≥ 21 points), in accordance with the instrument's criteria.¹¹

Intrafamilial relationships were assessed using the Intrafamilial Relationship Assessment Scale, short form. The dimensions of attachment and support, emotional expression, and family difficulties were classified as high (> 75th percentile), moderate (25th to < 75th percentile), and low (< 25th percentile).¹²

Living conditions were assessed using the Unmet Basic Needs (UBN) method, which is used in Latin American countries to measure deprivation at the individual and household levels. This method classifies as UBN those individuals or households that exhibit at least one of the following deprivations: access to adequate housing, access to sanitation services, access to education, or economic capacity.¹³ The housing component of the NBI method included housing quality and overcrowding. Housing was considered inadequate when it had earthen floors or walls, roofs made of natural fibers such as straw or palm fronds, or the use of waste materials. Overcrowding was defined as three or more people living in the same room.¹³ Likewise, as part of the NBI method, access to sanitation services was assessed based on the type of excreta disposal system and the availability of basic services.¹³ Access to education was measured based on the attendance of school-age children at educational institutions. Economic capacity

was analyzed based on the probability of insufficient income, age, educational level, household size, and employment status of household members.

The COVID-19-related stress of the responsible adult and scores on the Revised Children's Anxiety and Depression Scale (RCADS),⁹ both collected in the 2022 ENSM, were included as explanatory variables to analyze their relationship with the presence of depressive symptoms in adolescents.

Normality was assessed for continuous quantitative variables using the Anderson-Darling test; based on the normality of the data, the interquartile range and the median were used. In addition, absolute and relative frequency tables were prepared for categorical variables. Differences in proportions were assessed using the chi-square test. Statistical significance was set at $p < 0.05$, with 95 % confidence intervals.

During the construction of the binomial logistic regression model, the independence of the observations, the absence of multicollinearity among the predictor variables (assessed using the Variance Inflation Factor), and the model's goodness of fit were verified. Model performance was evaluated using the ROC curve, the area under the curve (AUC), sensitivity, and specificity.

The dataset was divided into an 80 % training set and a 20 % test set. Imputation of missing data using the median for continuous variables and the mode for categorical variables, as well as class balancing using the Synthetic Minority Oversampling Technique (SMOTE), were performed only on the training set. Subsequently, the binomial logistic regression model and the random forest were fitted using the “trainControl” function from the “caret” package, with repeated cross-validation using five partitions and three repetitions, class probability calculations, and the “twoClassSummary” function to obtain metrics based on sensitivity, specificity, and AUC. Odds ratios (ORs) derived from logistic regression were estimated using the original dataset, while the SMOTE balancing technique was used only during the training of the predictive models to address class imbalance and was not used for estimating association measures.

Class balance was ensured in each iteration using the parameter `sampling = "smote"`, and the final predictions were saved using the option `savePredictions = "final"` to more accurately evaluate model performance. A random forest model was fitted using the same validation scheme to identify the variables most relevant to symptoms of major depression. The likelihood ratio test was used solely to assess the overall fit

of the binomial logistic regression model. Discriminative ability and predictive performance were evaluated using the ROC curve, AUC, and confusion matrix.

Descriptive analysis was performed using STATA version 16; data cleaning, preprocessing, the regression model, and the random forest model were performed in RStudio version 4.4.1.

The research involving secondary data analysis was conducted in accordance with Good Clinical Practice. The database was coded to maintain participant confidentiality, and the study protocol was approved by the local research ethics committee of the National Institute of Health under registration number CEINS/2025/008.

Results

Characterization of cases of major depression among adolescents in El Salvador

A total of 1209 adolescents were analyzed, of whom 61.5 % resided in rural areas and 52.6 % were female. The median age was 15 years ($Q1 = 14$; $Q3 = 16$), with a minimum age of 13 years and a maximum age of 17 years. 33.5 % exhibited clinically significant depressive symptoms. The distribution of sociodemographic and family characteristics according to the presence of depressive symptoms is presented in Table 1. No statistically significant differences were observed in rural/urban origin between adolescents with and without depressive symptoms ($p = 20$). With regard to sex, a higher proportion of cases of depressive symptoms was observed among males (64.4 %) compared to females (35.5 %), a statistically significant difference ($p < 0.01$). The in-person learning modality accounted for the largest proportion of students attending classes (67.9 %), with statistically significant differences ($p = 0.01$) (Table 1).

The classification of adolescents based on the presence of depressive symptoms and mental health variables (RCADS) is presented in Table 2. The results show the distribution of categories related to emotional symptoms, family relationships, support systems, family mental health history, and other psychological variables according to the presence or absence of depressive symptoms.

Statistically significant differences were observed in the distribution of emotional symptoms assessed using the emotional symptoms subscale (SDQ) between adolescents with and without depressive symptoms ($p < 0.01$). In the group with depressive

symptoms, 49.88 % had scores within the normal range, 14.57 % fell into the borderline category, and 35.56 % were in the abnormal category. Likewise, significant differences were found in difficulties with family relationships, where the “high” category was more prevalent among adolescents with depressive symptoms (57.53 %) compared to those without depressive symptoms (46.14 %) ($p < 0.01$). Statistically significant differences were also observed in family history of mental health issues, anxiety, and behavioral problems ($p < 0.01$).

Multivariate analysis

Among the major risk factors associated with depression in adolescents, the following were identified: post-traumatic stress disorder in an adult in the household (OR 2.910; 95 % CI 1.473-5.824; $p < 0.05$), level of stress due to COVID-19 in an adult (OR 2.455 (95 % CI 1.033-6.265; $p < 0.05$), borderline behavioral problems with a 2.220-fold increase in the probability of risk (95 % CI 1.201-4.132; $p < 0.05$), and low levels of resilience in adults (OR 2.165 (95 % CI 1.147-4.164; $p < 0.05$), followed by low emotional expression in adolescents (ERI), OR 2.124 (95 % CI 1.394-3.248; $p < 0.05$).

On these scales, the “normal/minimal distress” category corresponds to the absence of relevant symptoms in the assessed domain; therefore, these scores are interpreted as indicators of protection against depression.

Among the protective factors were scores indicating minimal distress on the Child and Adolescent Trauma Scale (CATS-C); OR of 0.129 (95 % CI 0.038-0.349; $p < 0.05$). The absence of anxiety, as measured by the RCADS scale, was significantly associated with an OR of 0.055 (95 % CI 0.026-0.109; $p < 0.05$).

Through the variable importance analysis of the random forest model, the main variables with predictive importance were identified (Table 4).

The logistic regression (LR) model showed an AUC of 0.821, with a sensitivity of 0.67 and a specificity of 0.84, indicating an adequate ability to identify cases of depression. Meanwhile, the random forest (RF) model had an AUC of 0.817, with a sensitivity of 0.86 and a specificity of 0.73. Although both models demonstrated similar discriminatory ability, the logistic regression model had a slightly higher AUC, indicating better overall performance; meanwhile, the random forest model achieved higher sensitivity, reflecting a greater ability to identify positive cases of depression (Figure 1).

Table 1. Distribution of adolescents by presence of depression symptoms and sociodemographic characteristics

Variable	Category	Depression symptoms			No depression symptoms			Total	<i>p</i> -value
		N	%	CI 95 %	N	%	CI 95 %		
Origin	Rural	239	59.01	[54.22 – 63.80]	505	62.81	[59.47 – 66.16]	744	0.20
	Urban	166	40.99	[36.20 – 45.78]	299	37.19	[33.85 – 40.54]	465	
Health Region	Eastern	109	26.91	[22.6 – 31.2]	175	21.77	[18.9 – 24.6]	284	< 0.01
	Central	74	18.27	[14.5 – 22.0]	136	16.92	[14.3 – 19.5]	210	
	Western	73	18.02	[14.3 – 21.7]	198	24.63	[21.7-27.65]	271	
	Metropolitan	54	13.33	[10.0 – 16.6]	87	10.82	[8.7 – 13.0]	141	
	Paracentral	25	6.17	[13.6 – 21.0]	46	5.72	[4.1 – 7.3]	71	
	No data	70	17.28	[24.6 – 36.4]	162	20.15	[17.4 – 22.9]	232	
Sex	Male	261	64.44	[59.78 – 69.11]	376	46.77	[43.32 – 50.23]	637	< 0.01
	Female	144	35.56	[30.89 – 40.22]	428	53.23	[49.78 – 56.68]	572	
Adult lives with teenager	Yes	216	53.33	[48.47 – 58.19]	456	56.72	[53.29 – 60.14]	672	< 0.01
	No	164	40.49	[35.71 – 45.27]	302	37.56	[34.21 – 40.91]	466	
	No data	25	6.17	[3.83 – 8.52]	46	5.72	[4.12 – 7.31]	71	
Literacy	Yes	403	99.50	[98.82 – 100.00]	796	99.00	[98.32 – 99.68]	1199	0.36
	No	2	0.49	[0.00 – 1.18]	8	1.00	[0.31 – 1.68]	10	
School attendance	Yes	360	88.89	[85.69 – 92.0]	687	85.45	[82.64 – 88.25]	1047	< 0.01
	No	43	10.62	[7.69 – 13.54]	117	14.55	[11.75 – 17.36]	160	
	No data	2	0.49	-	0	0.00	-	2	
Study modality	In person	275	67.90	[63.01 – 72.79]	556	69.15	[66.35 – 71.94]	831	< 0.01
	Combined	33	8.15	[5.36 – 10.95]	31	3.86	[2.51 – 5.20]	64	
	Virtual	9	2.22	[0.81 – 3.63]	12	1.49	[0.65 – 2.33]	21	
	No data	88	21.73	[17.36-26.10]	205	25.50	[22.52 – 28.48]	293	
Educational level	Basic	275	67.90	[63.32 – 72.48]	546	67.91	[64.49 – 71.33]	821	< 0.01
	High school	80	19.75	[15.87 – 23.62]	138	17.16	[14.43 – 19.90]	218	
	University	3	0.74	-	0	0.00	-	3	
	Technical	1	0.25	[0.00 – 0.74]	1	0.12	[0.00 – 0.36]	2	
	No data	46	11.36	[8.31 – 14.40]	119	14.80	[12.39 – 17.20]	165	
NBI*	Yes	201	49.63	[44.79 – 54.46]	405	50.37	[47.06 – 53.68]	606	< 0.01
	No	172	42.47	[37.62 – 47.32]	340	42.29	[38.96 – 45.61]	512	
	No data	32	7.90	[5.15 – 10.65]	59	7.34	[5.91 – 8.77]	91	
Total	-	405	33.54	[30.88 – 36.20]	804	66.46	[63.80 – 69.12]	1209	< 0.01

*NBI Unsatisfied basic needs.

Table 2. Distribution of adolescents by depression symptoms and mental health variables in the family context, ENSM 2022

Variable	Category	Depression symptoms			No depression symptoms			Total	p-value
		N	%	95% CI	N	%	95% CI		
Emotional symptoms	Normal	202	49.88	[45.0-54.7]	695	86.44	[84.1-88.8]	897	< 0.01
	Limit	59	14.57	[11.1-18.8]	42	5.22	[3.7-6.8]	101	
	Abnormal	144	35.56	[30.9-40.2]	67	8.33	[6.4-10.2]	211	
Difficulties in family relationships	Low	116	28.64	[24.3-33.0]	222	27.61	[24.5-30.7]	338	< 0.01
	Moderate	55	13.58	[10.3-16.9]	210	26.12	[23.1-29.2]	265	
	High	233	57.53	[52.7-62.4]	371	46.14	[42.7-49.6]	604	
	No data	1	0.25	[0.01-1.37]	1	0.12	[0.003-0.69]	2	
Expression in family relationships	Low	99	24.44	[20.3-28.6]	327	40.67	[37.3-44.1]	426	< 0.01
	Moderate	144	35.56	[31.1-40.0]	128	15.92	[13.1-18.7]	272	
	High	161	39.75	[35.1-44.4]	348	43.28	[39.9-46.6]	509	
	No data	1	0.25	[0.01-1.37]	1	0.12	[0.003-0.69]	2	
Family support	Low	81	20.00	[16.2-23.8]	266	33.08	[30.1-36.1]	347	< 0.01
	Moderate	103	25.43	[21.0-29.9]	113	14.06	[11.8-16.3]	216	
	High	220	54.32	[49.5-59.2]	424	52.74	[49.3-56.2]	644	
	No data	1	0.25	[0.01-1.37]	1	0.12	[0.003-0.69]	2	
Behavioral problems	Normal	267	65.9	[61.2 – 70.4]	652	81.1	[78.2-83.7]	919	< 0.01
	Limit	48	11.9	[9.0-15.4]	76	9.5	[7.6-11.7]	124	
	Abnormal	90	22.2	[18.3 – 26.5]	76	9.5	[7.6-11.7]	166	
Anxiety	Normal	121	29.9	[25.4 – 34.4]	667	82.96	[80.3-85.6]	788	< 0.01
	Limit	162	40.0	[35.2 – 44.8]	119	14.80	[12.4-17.2]	281	
	Abnormal	122	30.1	[25.6 – 34.6]	18	2.24	[1.2-3.3]	140	
History of adult post-traumatic stress disorder at home	Low	116	28.64	[24.3-33.0]	222	27.61	[24.5-30.7]	338	< 0.01
	Moderate	55	13.58	[10.3-16.9]	210	26.12	[23.1-29.2]	265	
	High	233	57.50	[52.7-62.3]	371	46.10	[42.7-49.5]	604	
	No data	1	0.20	[0.01-1.37]	1	0.10	[0.003-0.69]	2	
Family history of mental health	Yes	293	72.35	[67.8-76.9]	493	61.32	[58.0-64.6]	786	< 0.01
	No	87	21.48	[17.5-25.4]	265	32.96	[29.8-36.2]	352	
	No data	25	6.17	[4.1-8.3]	46	5.72	[4.2-7.4]	71	
Adult resilience level	Low	74	18.3	[14.5 – 22.1]	185	23.0	[20.1 – 25.9]	259	< 0.01
	Moderate	289	71.4	[67.0 – 75.8]	501	62.3	[59.0 – 65.6]	790	
	High	25	6.2	[3.9 – 8.5]	68	8.5	[6.6 – 10.4]	93	
	No data	19	4.2	[2.2 – 6.2]	50	6.2	[4.6 – 7.9]	69	
Total	-	405	33.49	[30.9 – 36.2]	804	66.50	[63.8 – 69.1]	1209	—

Table 3. Multivariate analysis of factors associated with major depression in adolescents

Variable		OR	IC 95 %	p-value
Intercept*		16.823	[2.175-136.558]	0.007
History of adult post-traumatic stress disorder at home		2.910	[1.473-5.824]	0.002
Presence of stress due to COVID-19 in adults		2.455	[1.033-6.265]	0.050
Adult depression at home		1.436	[1.007-2.054]	< 0.05
Borderline behavior problems (SDQ**)		2.220	[1.201-4.132]	0.011
Adult resilience level	Bajo	2.165	[1.147-4.164]	0.019
	Moderada	1.565	[0.898-2.791]	0.121
Expression level (ERI***)	Bajo	2.124	[1.394-3.248]	< 0.01
	Medio	1.034	[0.730-1.466]	0.850
Sex	Femenino	1.266	[0.938-1.707]	0.122
Origin	Urbano	1.254	[0.928-1.694]	0.140
Normal anxiety score on the scale (RCADS****)	Normal	0.055	[0.026-0.109]	< 0.01
Adult NBI		0.856	[0.286-2.858]	0.789

*Intercept: AUC: 0.821, precision: 0.7884, specificity: 0.8438, sensitivity: 0.6790

**SDQ: Strengths and difficulties questionnaire.

***ERI: Intrafamily relations evaluation scale.

****RCADS: Revised children's anxiety and depression scale.

Table 4. Importance of predictor variables in the random forest model for the identification of depressive symptoms in adolescents ENSM 2022

Variable	Relative importance (%)
RCADS normal anxiety	100.0
SDQ: Normal emotional symptoms.	52.5
Low adult resilience	39.3
SDQ: Borderline behavioral problems	37.6
Low ERI expression	20.4
Gender: Female	19.4
ERI: moderate difficulty	18.6
Post-traumatic stress disorder in adults	18.4
Adult depression at home (yes)	18.1
Urban area	17.1

Importance of variables estimated by the mean reduction in Gini impurity.

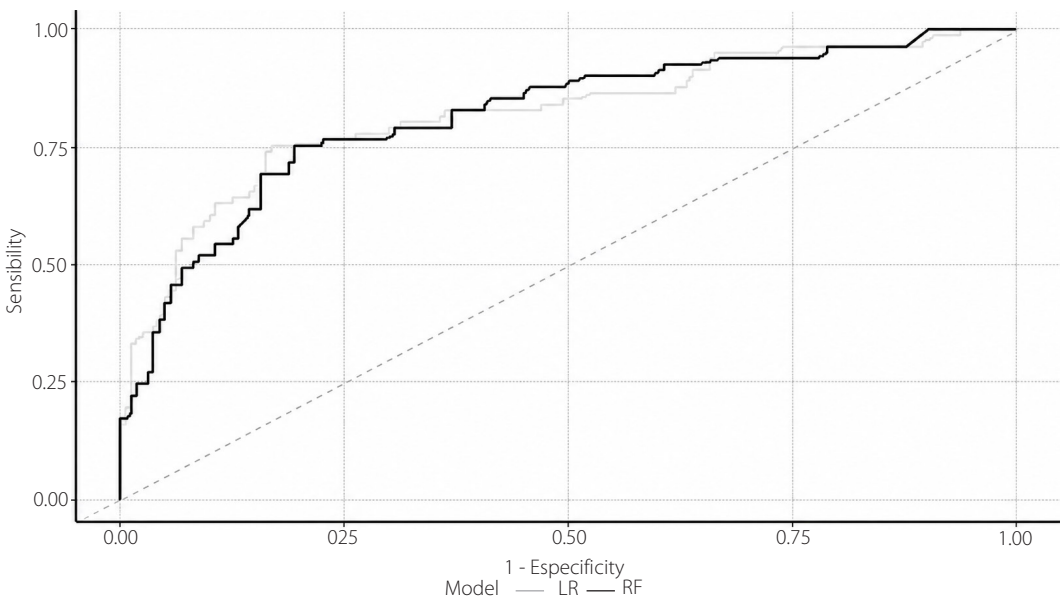


Figure 1. ROC (Receiver Operating Characteristic) curves to evaluate the discriminative ability of the logistic regression and random forest models in predicting symptoms of major depression in adolescents.

Discussion

This study provides insight into the prevalence and factors associated with MDD in the adolescent population of El Salvador, highlighting the magnitude of this mental health problem and its multifactorial nature. These findings underscore the value of using tools such as integrative models to address complex situations, promoting interventions that are both comprehensive and culturally sensitive.¹⁴ Major depressive disorder has been associated with maladaptive personality traits, family dynamics characterized by high levels of conflict, and poor communication, the latter two factors linked to higher levels of stress and a greater frequency of depressive symptoms within the family environment.¹⁴ Furthermore, PTSD in the home, especially when adolescents have been exposed

to domestic violence or abuse, is another factor associated with a higher likelihood of developing MDD.¹⁵ Similarly, the presence of COVID-19-related stress reported by the adult was also associated with this outcome.¹⁶ Studies show that stress related to COVID-19 may increase the likelihood of anxiety and depression symptoms in adolescents and young adults.¹⁷⁻¹⁹ The results show that households where an adult with depression was identified were more likely to report depressive symptoms consistent with major depression. This finding highlights the importance of the family context and its potential relationship with adolescents' mental health.²⁰ However, it is important to note that the participating adult was selected at random from within the household and was not necessarily the primary caregiver; therefore, the results should be interpreted as relationships

observed within the same family context. These results are consistent with research reporting how the family environment has been associated with the presence of mental health problems.²¹

Complementarily, studies using the Strengths and Difficulties Questionnaire have evidenced that adolescents with borderline or abnormal scores on the SDQ scale are more likely to develop mental health disorders such as depression in adolescence and early adulthood.²² Furthermore, a longitudinal study found that adolescents with borderline/high scores on the SDQ were six times more likely to experience depression in young adulthood (OR 6.2; 95 % CI 2.7-13.9) compared to those with scores within the normal range.²³

A relevant finding was the association between low adult resilience in the home and an increased risk of depressive symptoms in adolescents. This result could imply an intergenerational transmission mechanism, in which a less favorable emotional climate and reduced affective expression within the home increase adolescents' vulnerability to depression.²⁴⁻²⁶ It is worth noting that a study on expressed family emotion has examined its relationship with depressive symptoms during adolescence, assessing the diagnostic value of different dimensions of family functioning.²⁷

In contrast, some sociodemographic variables, such as female gender and urban residence, did not show statistically significant associations with the outcome in the present study. However, evidence indicates that major depressive disorder is approximately twice as common in women as in men; furthermore, a previous study found a higher proportion of adolescent students with depression residing in urban areas, at 21.4 %.²⁸

Furthermore, in this analysis, adolescents with normal trauma scores on the CATS scale for PTS symptoms were less likely to have MDD, suggesting that the absence of traumatic symptoms may be associated with lower vulnerability to depression. In contrast, several studies have indicated that exposure to traumatic events during adolescence is associated with an increased risk of depression and other internalizing disorders.^{29,30} However, in this study, the fact that participants had anxiety scores within the normal range does not rule out the possibility of developing MDD, since comorbidity between the two disorders is common at this stage of development; it is estimated that between 15 % and 75 % of adolescents with one of these disorders also exhibit the other.³¹

Similarly, the NBI level of the adult in the household did not show a significant association with the presence of MDD in adolescents within the analyzed model, although one study has shown that people with low incomes are 1.5 to three times more likely to develop depressive symptoms compared to those with high incomes.³²

The main limitation of this study was its cross-sectional design, which did not allow for the analysis of causal relationships. Additionally, information not captured in the original survey limits the comprehensiveness of the analysis. The exclusion of records with incomplete information may have introduced selection bias if the excluded participants differed from those included in the analysis. Similarly, potential nonresponse to some survey questions could have affected the representativeness of the results. However, among the strengths of the analysis, the study incorporated predictive models that combined logistic regression and machine learning techniques to evaluate variables using the random forest algorithm; these variables consisted of individual, family, and contextual factors associated with TDM in adolescents. Logistic regression allowed for the estimation of the association between the study factors and the outcome, while the random forest was used as an exploratory and predictive tool to identify the variables that contributed most to risk classification, although their importance should not be interpreted as a measure of epidemiological association or causality. Both approaches demonstrated adequate discriminatory power, highlighting the usefulness of machine learning models in identifying cases with depressive symptoms. This is consistent with studies indicating that these methods can improve the identification of at-risk individuals using multidomain data.^{33,34} Furthermore, there is a study in which these approaches were applied to predict depressive symptoms and prioritize the most relevant risk factors; for example, in a study conducted among adolescents in China, random forest algorithms were used to build predictive models capable of identifying key variables related to depression, such as lifestyle habits, socioeconomic factors, and family support, which demonstrated adequate discriminatory power and allowed for the exploration of nonlinear relationships between predictors and the risk of depressive symptoms.³⁵

In this context, the random forest algorithm's ability to handle high-dimensional datasets and model complex interactions among variables makes it a useful tool for studying depression in adolescents,

a phenomenon influenced by multiple interrelated factors.³⁶

Taken together, the results of this analysis provide evidence regarding the interactions among the studied variables and mental health in the group of adolescents analyzed. These findings help identify factors that, within the studied population, are associated with a higher risk of mental health problems, which could serve as a reference to guide future research and inform intervention strategies targeting adolescents in similar contexts. Furthermore, the results contribute to the generation of local evidence on adolescent mental health and well-being.

Conclusion

The main factors associated with depressive symptoms consistent with major depression were the presence of post-traumatic stress disorder in the adult household member, COVID-19-related stress, low resilience in the adult, borderline behavioral problems, and low emotional expression in the adolescent. These findings reinforce the importance of identifying adolescents who are more likely to exhibit depressive symptoms consistent with major depression. Furthermore, the combination of logistic regression and random forest models allowed for the identification of the most relevant predictors, providing complementary evidence for the analysis of this outcome.

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