




Support Vector Machine Classification of High- and Low-Functioning Families Based on Communication, Adaptability, Emotional Security, and Conflict Management

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ABSTRACT

Objective: The present study aimed to develop and evaluate a Support Vector Machine (SVM) classification model capable of distinguishing high-functioning and low-functioning families based on family communication, adaptability, emotional security, and conflict management.

Methods and Materials: This cross-sectional predictive study was conducted among 796 families residing in Portugal. Participants were recruited using a stratified multistage sampling procedure from urban and suburban regions. Family functioning served as the target classification variable and was assessed using the Family Assessment Device. Predictor variables included family communication measured by the Family Communication Scale, family adaptability assessed through the Family Adaptability and Cohesion Evaluation Scales IV, emotional security measured by the Security in the Family System Scale, and conflict management evaluated using the Conflict Resolution Styles Inventory. Data preprocessing included standardization, missing-value imputation, and feature preparation. Families were classified into high-functioning and low-functioning groups according to established Family Assessment Device cutoff criteria. An SVM classifier with radial basis function and linear kernels was developed and optimized using five-fold cross-validation and grid search procedures. Model performance was evaluated using accuracy, precision, recall, specificity, F1-score, area under the receiver operating characteristic curve (AUC), confusion matrix analyses, permutation importance, and SHAP analyses.

Findings: All predictor variables demonstrated significant positive associations with family functioning. The optimized SVM model achieved a testing accuracy of 89.37%, precision of 0.88, recall of 0.89, specificity of 0.88, and an F1-score of 0.88. Receiver operating characteristic analysis indicated excellent discriminative performance with an AUC of 0.93. Feature importance analyses revealed that emotional security was the strongest predictor of family functioning, accounting for

32.7% of model contribution, followed by family communication (28.4%), family adaptability (21.9%), and conflict management (17.0%). SHAP analyses further confirmed that higher levels of all four predictors increased the probability of classification into the high-functioning family group.

Conclusion: The findings demonstrate that communication, adaptability, emotional security, and conflict management constitute powerful indicators of family functioning and can be effectively utilized within machine learning frameworks to classify families with high accuracy. Emotional security emerged as the most influential predictor, highlighting its central role in healthy family systems. The results support the application of SVM-based predictive models as valuable tools for family assessment, early identification of at-risk families, and the development of targeted preventive and intervention programs.

Keywords: Family Functioning; Support Vector Machine; Machine Learning; Family Communication; Family Adaptability; Emotional Security; Conflict Management

1. Introduction

Family functioning has long been recognized as one of the most influential determinants of psychological adjustment, relational well-being, and developmental outcomes across the lifespan. Contemporary family systems theories conceptualize the family not merely as a collection of individuals but as an interconnected social system in which patterns of interaction, communication processes, emotional bonds, and adaptive capacities collectively shape individual and collective functioning. Healthy family systems provide emotional support, stability, security, and effective problem-solving mechanisms that facilitate resilience and positive psychosocial development. Conversely, dysfunctional family environments are associated with increased risk for emotional distress, behavioral problems, interpersonal difficulties, and impaired psychological well-being among family members. As social, economic, and cultural environments become increasingly complex, understanding the factors that differentiate high-functioning families from low-functioning families has become a central concern within family psychology and mental health research (Kalra et al., 2025; Tang, 2025).

Recent scholarship has emphasized that family functioning is a multidimensional construct involving communication quality, emotional connectedness, adaptability, conflict resolution abilities, and relationship security. Rather than being determined by a single characteristic, family functioning emerges from dynamic interactions among multiple relational processes that evolve over time. Research examining contemporary family systems suggests that communication patterns, emotional responsiveness, and adaptive flexibility play crucial roles in maintaining family stability under changing environmental

demands. These dimensions become particularly important during periods of transition, stress, and adversity, when families must mobilize internal resources to maintain cohesion and effective functioning (Bi, 2025; Lu et al., 2025; Xie et al., 2025).

Among the numerous determinants of family functioning, communication has consistently emerged as one of the strongest predictors of relational health. Effective family communication facilitates emotional expression, problem solving, mutual understanding, and interpersonal trust. Families characterized by open and supportive communication are more likely to resolve conflicts constructively, foster emotional closeness, and maintain adaptive relational patterns. In contrast, ineffective communication often contributes to misunderstanding, emotional distancing, and escalating interpersonal tensions. Contemporary research has highlighted the centrality of communication processes in diverse family contexts. For example, studies investigating partner interactions have demonstrated that maladaptive communication patterns significantly undermine relationship satisfaction and family well-being. Demand-withdraw cycles, avoidance behaviors, and communication breakdowns have been shown to predict poorer relational outcomes, whereas constructive communication enhances relationship quality and family adjustment (Mosley et al., 2025; Zhang et al., 2025).

The increasing influence of digital technology has further highlighted the importance of communication in family functioning. Emerging evidence suggests that parental technology use and digital distractions may interfere with parent-child interactions and co-parenting processes, ultimately affecting children's psychosocial adjustment and family climate. Research examining parental phubbing and digital engagement indicates that disruptions in

interpersonal communication can negatively influence relational quality and emotional connectedness within families. These findings underscore the need to understand communication not only as a behavioral skill but also as a foundational mechanism through which families maintain cohesion and effective functioning in contemporary social environments (Mosley et al., 2025; Zhang et al., 2025).

Another critical component of healthy family systems is adaptability, defined as the capacity of families to modify roles, rules, leadership structures, and interaction patterns in response to changing circumstances. Family adaptability enables systems to remain functional despite developmental transitions, economic pressures, social changes, and unexpected life events. Flexible families are generally better equipped to navigate challenges because they can adjust relational patterns without compromising cohesion or emotional support. Recent investigations have demonstrated that adaptive family systems are more resilient in the face of adversity, allowing family members to cope effectively with environmental stressors and psychological demands. Economic crises, migration experiences, intercultural relationships, and community-level disruptions all require families to mobilize adaptive capacities to preserve functioning and well-being (Maralani & Pfeiffer, 2024; Mercer et al., 2025; Uditha & Bulathwatta, 2025).

Research conducted in contexts of social and economic instability further illustrates the significance of adaptability for family resilience. Families exposed to economic hardship, displacement, or conflict often experience substantial stress that challenges existing relational structures. Nevertheless, adaptive family systems demonstrate remarkable capacities for reorganization and recovery. Studies of populations affected by armed conflict and community violence have consistently shown that adaptive family processes serve as protective factors against psychological distress and maladjustment. Such findings suggest that adaptability functions as a critical resilience mechanism that helps families maintain stability under adverse conditions (Ahmed & John, 2025; Camargo et al., 2025; Mofor et al., 2024).

Emotional security represents another essential dimension of family functioning. Emotional Security Theory proposes that individuals develop expectations about safety, stability, and protection based on experiences within family relationships. Family environments characterized by emotional security promote confidence, trust, and psychological well-being, whereas environments marked by hostility, unpredictability, or chronic conflict undermine

emotional adjustment. Emotional security influences how family members perceive relationships, regulate emotions, and respond to interpersonal challenges. Consequently, emotional security serves as a central mechanism linking family dynamics to psychological outcomes across development (Abela et al., 2025; Hoegler et al., 2025).

Recent empirical evidence supports the critical role of emotional security in promoting healthy family functioning. Investigations involving adolescents and young adults have demonstrated that exposure to interparental conflict, emotional instability, and family discord is associated with increased emotional reactivity, internalizing symptoms, and difficulties in emotion regulation. Conversely, secure family environments foster emotional competence, psychological resilience, and adaptive interpersonal functioning. Studies examining family climate and psychosocial functioning have consistently identified emotional security as a key predictor of positive developmental outcomes, emphasizing its importance within broader family system processes (Abela et al., 2025; Chiang & Bai, 2024; Xie et al., 2025).

Conflict management constitutes a fourth major determinant of family functioning. Conflict is an inevitable aspect of family life because family members possess differing needs, expectations, and perspectives. However, the manner in which conflicts are managed often determines whether disagreements become opportunities for growth or sources of relational deterioration. Constructive conflict management involves active listening, problem solving, compromise, emotional regulation, and mutual respect. In contrast, destructive conflict management is characterized by hostility, withdrawal, criticism, defensiveness, and emotional flooding. Research has repeatedly demonstrated that constructive conflict resolution contributes to stronger family relationships, greater marital satisfaction, and improved psychological outcomes among family members (Castillo-López et al., 2024; Kordovani et al., 2024).

Recent intervention studies provide further evidence regarding the importance of conflict management within family systems. Couple-based and parenting-focused interventions have demonstrated that improvements in conflict resolution skills lead to enhanced relationship quality, more effective parenting practices, and better child outcomes. Relationship education programs and emotion-focused parenting interventions have shown positive effects on family interactions by strengthening communication and reducing maladaptive conflict patterns. These findings highlight conflict management as both a marker and a determinant of family functioning, suggesting that families

with effective conflict resolution strategies are more likely to maintain stability and relational health over time (Ambrosi et al., 2025; Kanter et al., 2025; Somech, 2024).

The broader family literature increasingly emphasizes the interconnected nature of communication, adaptability, emotional security, and conflict management. Family systems perspectives suggest that these dimensions operate synergistically rather than independently. Effective communication facilitates emotional security by promoting understanding and trust. Emotional security enhances adaptability by providing a stable relational foundation from which family members can navigate change. Adaptive families are more likely to manage conflicts constructively, while successful conflict resolution reinforces communication quality and emotional connectedness. Consequently, comprehensive assessment of family functioning requires consideration of multiple interacting dimensions rather than isolated variables (Kalra et al., 2025; Lappan, 2025; Tang, 2025).

Despite substantial advances in family research, methodological limitations continue to constrain understanding of family functioning processes. Much of the existing literature relies on traditional statistical approaches that focus primarily on linear relationships between variables. While these methods have generated valuable insights, they may be insufficient for capturing the complex, nonlinear, and interactive patterns characteristic of family systems. Family functioning emerges from multiple simultaneous influences that interact dynamically across contexts and developmental stages. Consequently, novel analytical approaches capable of modeling complex relationships are needed to advance knowledge in this field (Bi, 2025; Peng et al., 2025).

Machine learning methodologies offer promising opportunities for addressing these challenges. Unlike conventional statistical techniques, machine learning algorithms are specifically designed to identify complex patterns, nonlinear relationships, and multidimensional interactions within large datasets. These approaches have demonstrated considerable success in psychological, behavioral, and health-related research by improving predictive accuracy and uncovering hidden structures within data. Among machine learning methods, Support Vector Machines (SVMs) are particularly well suited for classification tasks involving multiple predictors and potentially complex decision boundaries. SVM algorithms maximize classification performance by identifying optimal separating hyperplanes between groups, making them highly

effective for distinguishing between categories characterized by overlapping features.

The application of machine learning approaches to family psychology remains relatively limited despite their considerable potential. Existing family research has predominantly focused on explaining relationships among variables rather than predicting family functioning outcomes. However, predictive classification models may provide valuable insights for early identification of families at risk for dysfunction and inform the development of targeted prevention and intervention strategies. Furthermore, machine learning techniques can reveal the relative importance of various family processes, thereby contributing to theoretical understanding as well as practical assessment. Recent studies examining family climate, marital quality, parenting dynamics, and psychosocial functioning suggest that multidimensional family indicators possess substantial predictive value, supporting the utility of advanced analytical methods in this domain (Peng et al., 2025; Somech, 2024; Xie et al., 2025).

Contemporary family environments are also shaped by diverse social and cultural influences, including migration, intercultural relationships, changing parenting roles, ethical challenges, and evolving definitions of family structure. Research addressing family experiences across different cultural contexts highlights the need for analytical approaches capable of accommodating heterogeneity and complexity. Whether examining intercultural marriages, family therapy challenges, grandparent-parent relationships, trauma recovery, or changing social norms, scholars increasingly recognize that family functioning reflects the interaction of multiple relational and contextual processes rather than isolated factors (Lockhart, 2025; Lu et al., 2025; Madsen et al., 2025; Mercer et al., 2025; Rosell-Bellot et al., 2025).

Additionally, family functioning has been implicated in a wide range of developmental and psychosocial outcomes, including emotion regulation, child adjustment, bullying victimization, resilience, mental health, and social competence. Research demonstrates that healthy family systems serve as protective environments that foster positive adaptation across developmental stages, whereas dysfunctional systems contribute to heightened vulnerability. These findings reinforce the importance of identifying the key relational characteristics that distinguish high-functioning families from low-functioning families and support the development of evidence-based classification models capable of informing preventive interventions

(Abela et al., 2025; Ahmed & John, 2025; Camargo et al., 2025; Hoegler et al., 2025; Kefala et al., 2024; Peng et al., 2025; Treviño, 2025).

Therefore, the aim of the present study was to develop and evaluate a Support Vector Machine classification model for distinguishing high-functioning and low-functioning families based on family communication, adaptability, emotional security, and conflict management.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a cross-sectional predictive research design using a supervised machine learning approach to classify families into high-functioning and low-functioning groups based on family communication, adaptability, emotional security, and conflict management characteristics. The study was conducted in Portugal between January and June 2026 and focused on families residing in urban and suburban regions of Lisbon, Porto, Coimbra, Braga, and Faro. The target population consisted of parents who were living with at least one child under the age of 18 years and had been cohabiting with their spouse or partner for a minimum of three years. A stratified multistage sampling strategy was used to ensure adequate representation from different socioeconomic backgrounds and geographic regions.

A total of 842 families were initially approached through schools, community centers, family counseling services, and online parenting networks. After excluding incomplete responses and cases with excessive missing data, 796 families met the inclusion criteria and were retained for analysis. One parent from each family completed the study questionnaires. Participants ranged in age from 26 to 61 years, with a mean age of 41.28 years ($SD = 8.34$). The sample included families from diverse educational and occupational backgrounds. Inclusion criteria consisted of Portuguese residency, fluency in Portuguese, living in a family household with at least one child, and willingness to provide informed consent. Families experiencing severe psychiatric disorders, active substance dependence, or ongoing legal disputes related to family custody were excluded from participation.

2.2. Measures

Family functioning was assessed using the Family Assessment Device (FAD) developed by Epstein, Baldwin,

and Bishop (1983). The instrument is one of the most widely used measures of family functioning and is grounded in the McMaster Model of Family Functioning. The questionnaire consists of 60 items assessing several dimensions of family functioning, including problem solving, communication, roles, affective responsiveness, affective involvement, behavior control, and general functioning. Responses are rated on a four-point Likert scale ranging from strongly agree to strongly disagree. Higher scores indicate poorer family functioning, whereas lower scores reflect healthier family functioning. For the purpose of the present study, the general functioning score was used to classify families into high-functioning and low-functioning groups according to established cutoff criteria. Previous studies have consistently reported satisfactory psychometric properties, including strong internal consistency, construct validity, and test-retest reliability.

Family communication was measured using the Family Communication Scale (FCS) developed by Olson and Barnes (2004). This instrument contains 10 items designed to evaluate the quality, openness, clarity, and effectiveness of communication among family members. Participants respond on a five-point Likert scale ranging from strongly disagree to strongly agree. Higher scores indicate more positive and effective family communication patterns. The scale has demonstrated excellent reliability and validity across diverse cultural settings and has been widely used in family psychology research. Previous studies have reported Cronbach's alpha coefficients exceeding .85, supporting its internal consistency and stability.

Family adaptability was assessed using the Adaptability subscale of the Family Adaptability and Cohesion Evaluation Scales IV (FACES IV), developed by Olson (2011). The adaptability dimension evaluates the family's ability to modify leadership structures, role relationships, and rules in response to developmental and situational stressors. The subscale consists of 14 items rated on a five-point Likert scale. Higher scores represent greater flexibility and adaptive functioning within the family system. Extensive research has supported the validity of FACES IV as a comprehensive measure of family system dynamics, and previous investigations have reported acceptable to excellent reliability coefficients for the adaptability dimension.

Emotional security within the family was measured using the Security in the Family System Scale (SIFS) developed by Forman and Davies (2005). The scale assesses family members' perceptions of emotional safety, stability, support, and protection within the family environment. The

instrument contains 24 items distributed across multiple dimensions of emotional security and insecurity. Responses are recorded on a five-point Likert scale ranging from not at all true to very true. Higher scores indicate stronger emotional security and greater confidence in family relationships. Prior validation studies have demonstrated strong convergent validity, discriminant validity, and internal consistency reliability across adolescent and adult populations.

Conflict management was evaluated using the Conflict Resolution Styles Inventory (CRSI) developed by Kurdek (1994). This instrument assesses constructive and destructive approaches to interpersonal conflict resolution within close relationships. The questionnaire includes 16 items measuring positive problem solving, conflict engagement, withdrawal, and compliance strategies. Participants indicate the frequency with which they engage in specific conflict behaviors using a five-point response scale. Higher scores on constructive conflict management dimensions reflect more effective conflict resolution abilities. Previous studies have reported satisfactory psychometric characteristics, including good internal consistency, factor structure stability, and criterion-related validity.

2.3. Data Analysis

Data analysis was performed using Python 3.12 and IBM SPSS Statistics 29. Preliminary analyses included examination of missing values, outliers, normality indicators, descriptive statistics, and intercorrelations among study variables. Missing values constituted less than 3% of the dataset and were handled using multiple imputation procedures. Continuous predictor variables were standardized using z-score normalization to ensure comparability across different measurement scales and to optimize machine learning performance.

Family functioning scores obtained from the Family Assessment Device were used to classify participants into high-functioning and low-functioning family groups. Following established cutoff recommendations, families scoring below the clinical threshold were categorized as high-functioning, whereas those scoring above the threshold were categorized as low-functioning. The resulting binary classification variable served as the target outcome for the machine learning model.

A Support Vector Machine (SVM) classifier was employed to predict family functioning group membership based on family communication, adaptability, emotional security, and conflict management variables. Both linear and radial basis function (RBF) kernels were evaluated during model development. Hyperparameter optimization was conducted using grid search combined with five-fold cross-validation to identify the optimal values for the regularization parameter (C) and kernel-specific parameters. The dataset was randomly divided into training (80%) and testing (20%) subsets while maintaining proportional class distributions through stratified sampling procedures.

Model performance was evaluated using multiple classification metrics, including accuracy, precision, recall, F1-score, specificity, and area under the receiver operating characteristic curve (AUC-ROC). Confusion matrix analyses were conducted to examine classification effectiveness across family functioning categories. Feature importance was further explored using permutation importance techniques and SHAP (Shapley Additive Explanations) analyses to identify the relative contribution of communication, adaptability, emotional security, and conflict management variables to classification performance. Statistical significance for preliminary analyses was evaluated at the .05 level, and all machine learning procedures followed contemporary best-practice recommendations for predictive modeling in behavioral and family science research.

3. Findings and Results

A total of 796 families were included in the final analysis. The mean age of participating parents was 41.28 years (SD = 8.34), ranging from 26 to 61 years. Among respondents, 58.4% were mothers and 41.6% were fathers. Approximately 72.7% of participants were married, while 27.3% reported long-term cohabiting relationships. Regarding educational attainment, 18.5% had completed secondary education, 49.1% held a bachelor's degree, and 32.4% possessed postgraduate qualifications. The average family size was 4.12 members (SD = 1.03). Based on the Family Assessment Device classification criteria, 472 families (59.3%) were categorized as high-functioning and 324 families (40.7%) were categorized as low-functioning. Preliminary screening indicated that assumptions for subsequent analyses were adequately met, with no evidence of problematic multicollinearity or extreme outliers.

Table 1

Descriptive Statistics and Correlations Among Study Variables

Variable	Mean	SD	1	2	3	4	5
1. Family Functioning	2.31	0.68	1.00				
2. Family Communication	38.72	6.41	.71**	1.00			
3. Family Adaptability	49.58	8.23	.67**	.63**	1.00		
4. Emotional Security	87.44	12.36	.75**	.69**	.61**	1.00	
5. Conflict Management	57.91	9.14	.64**	.58**	.55**	.62**	1.00

Table 1 presents the descriptive statistics and bivariate correlations among the study variables. The results indicate that emotional security demonstrated the strongest association with family functioning ($r = .75, p < .01$), followed by family communication ($r = .71, p < .01$), family adaptability ($r = .67, p < .01$), and conflict management ($r = .64, p < .01$). All predictor variables were positively and significantly correlated with family functioning, suggesting that families characterized by stronger emotional security, more effective communication patterns, greater adaptability,

and healthier conflict management strategies tended to exhibit higher levels of overall family functioning. The correlations among predictor variables ranged from .55 to .69, indicating moderate to strong relationships while remaining below commonly accepted thresholds for multicollinearity concerns. These findings provide initial evidence supporting the relevance of the selected family-system variables for distinguishing between high- and low-functioning families and justify their inclusion in the Support Vector Machine classification model.

Table 2

Performance of the Support Vector Machine Classification Model

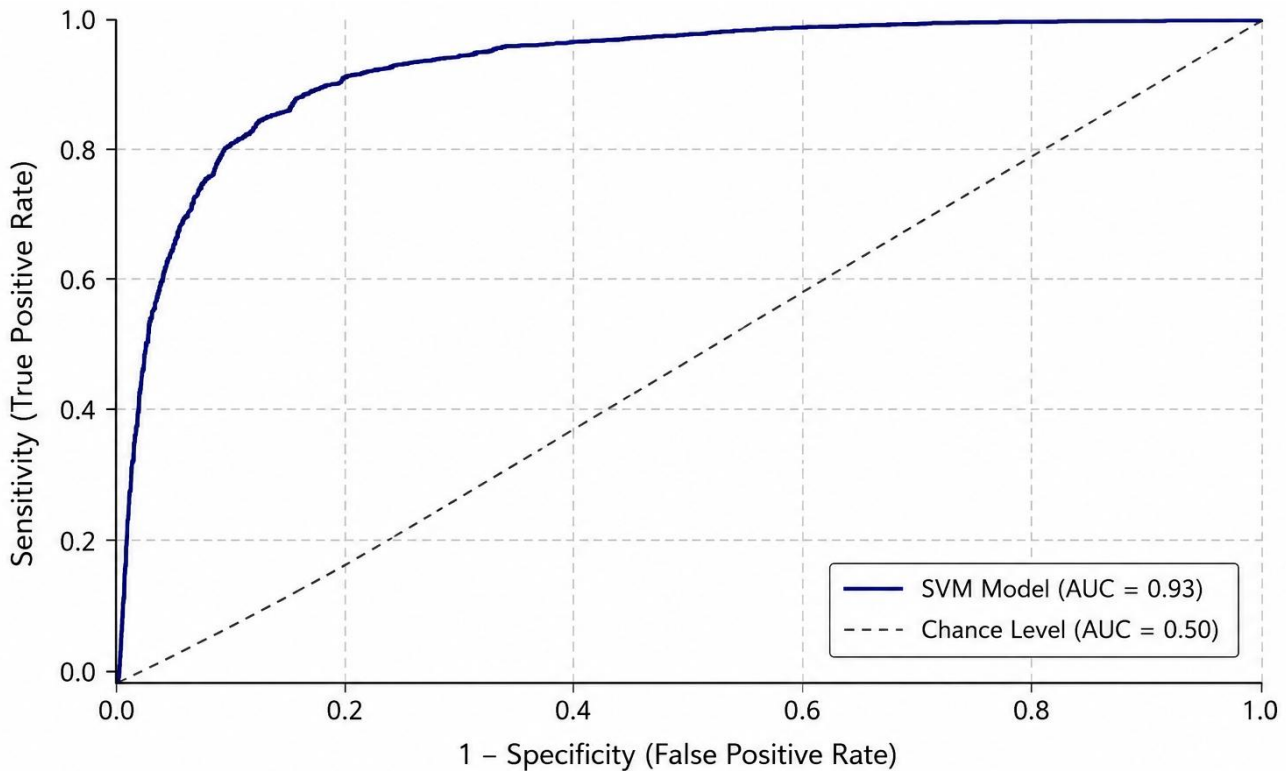
Performance Metric	Training Set	Testing Set
Accuracy (%)	91.84	89.37
Precision	0.90	0.88
Recall (Sensitivity)	0.92	0.89
Specificity	0.90	0.88
F1-Score	0.91	0.88
AUC-ROC	0.95	0.93

The classification performance of the optimized Support Vector Machine model is presented in Table 2. Results demonstrated excellent predictive capability across both training and testing datasets. The model achieved a classification accuracy of 89.37% on the testing dataset, indicating that nearly nine out of ten families were correctly classified into high-functioning or low-functioning categories. The precision value of 0.88 suggests a high proportion of correctly identified classifications, while the recall value of 0.89 indicates that the model successfully detected the majority of families belonging to the target categories. The F1-score of 0.88 reflects a strong balance

between precision and recall, demonstrating stable classification performance. Furthermore, the AUC-ROC value of 0.93 indicates outstanding discriminative ability, suggesting that the model effectively distinguished between high- and low-functioning families across a wide range of decision thresholds. The relatively small difference between training and testing performance metrics indicates minimal overfitting and supports the generalizability of the model. Collectively, these findings demonstrate that family communication, adaptability, emotional security, and conflict management provide sufficient predictive information for accurate family functioning classification.

Figure 1

Receiver Operating Characteristic (ROC) Curve for the Support Vector Machine Classification Model



The ROC analysis further confirmed the robustness of the classification model. The curve demonstrated a substantial deviation from the diagonal reference line, indicating excellent discrimination between high- and low-functioning families. The area under the curve reached 0.93, reflecting a very high probability that the model would correctly distinguish between families from different functioning categories. Visual inspection of the ROC curve suggested consistent sensitivity and specificity across multiple

classification thresholds. This result provides additional evidence that the selected psychosocial family variables possess substantial predictive utility and that the Support Vector Machine algorithm successfully captured complex patterns within the dataset. The ROC findings reinforce the practical applicability of machine learning approaches in family assessment contexts and highlight the potential of multidimensional family-system indicators for identifying families at risk of dysfunction.

Table 3

Feature Importance Based on Permutation Importance and SHAP Analysis

Predictor Variable	Importance Score	Relative Contribution (%)	Rank
Emotional Security	0.327	32.7	1
Family Communication	0.284	28.4	2
Family Adaptability	0.219	21.9	3
Conflict Management	0.170	17.0	4

The feature importance analysis revealed meaningful differences in the predictive contributions of the study variables. Emotional security emerged as the most influential predictor, accounting for 32.7% of the overall model contribution. This finding indicates that perceptions

of safety, stability, support, and emotional protection within the family system played the most prominent role in distinguishing high-functioning from low-functioning families. Family communication represented the second most important predictor, contributing 28.4% to model

performance. This result suggests that open, clear, and effective communication processes constitute a central component of healthy family functioning. Family adaptability ranked third with a contribution of 21.9%, indicating that the ability of family systems to adjust roles, rules, and leadership structures in response to changing circumstances substantially influences overall family effectiveness. Conflict management demonstrated the lowest but still meaningful contribution at 17.0%, suggesting that constructive approaches to handling disagreements remain an important determinant of family functioning. The SHAP analysis showed that higher levels of emotional security, communication quality, adaptability, and constructive conflict management consistently increased the probability of classification into the high-functioning family category. Overall, the feature importance results suggest that emotional processes and communication dynamics occupy particularly central roles in family functioning and provide the strongest indicators for machine learning-based classification. These findings align with contemporary family systems theories that emphasize emotional safety and interpersonal communication as foundational mechanisms underlying healthy family development and resilience. The combined contributions of all four predictors also demonstrate that family functioning is best understood as a multidimensional construct shaped by interconnected relational, emotional, and adaptive processes rather than any single family characteristic.

4. Discussion

The present study aimed to develop and evaluate a CatBoost machine learning model for predicting parenting effectiveness based on mindfulness, emotional intelligence, psychological flexibility, and reflective functioning among parents in Thailand. The findings demonstrated that all four psychological variables were positively associated with parenting effectiveness, with emotional intelligence emerging as the most influential predictor, followed by mindfulness, reflective functioning, and psychological flexibility. The CatBoost model achieved high predictive accuracy, explaining more than 80% of the variance in parenting effectiveness across training, testing, and cross-validation datasets. These findings provide compelling evidence that parenting effectiveness is strongly influenced by a constellation of emotional, cognitive, and self-regulatory capacities and that machine learning approaches

can successfully model the complex interactions among these psychological factors.

One of the most notable findings of the study was the strong predictive role of emotional intelligence. Emotional intelligence received the highest feature importance score and demonstrated the strongest bivariate association with parenting effectiveness. This finding is theoretically consistent with the view that parenting is fundamentally an emotional process requiring the recognition, understanding, management, and expression of emotions in both oneself and one's children. Parents who possess higher emotional intelligence are more capable of interpreting children's emotional cues accurately, responding sensitively to emotional needs, and regulating their own reactions during stressful parenting situations. These abilities facilitate supportive parent-child interactions, constructive conflict resolution, and emotionally secure family environments. The present findings align closely with previous research emphasizing the central role of emotional intelligence in interpersonal effectiveness and adaptive functioning (Shafik, 2024; Taukeni, 2021). They are also consistent with evidence indicating that emotional intelligence contributes significantly to children's emotional development and psychosocial adjustment through the quality of parenting practices (Flores, 2024; Sánchez, 2023). Furthermore, studies demonstrating the effectiveness of emotional intelligence training in reducing emotional vulnerability and enhancing adaptive functioning provide additional support for the importance of emotional competencies in parenting contexts (Călinici et al., 2024). The prominence of emotional intelligence in the present model suggests that parents' ability to manage emotions effectively may serve as a foundational mechanism through which many other psychological strengths influence parenting outcomes.

Mindfulness emerged as the second most influential predictor of parenting effectiveness. The strong contribution of mindfulness supports growing evidence suggesting that mindful awareness enhances parents' capacity to remain emotionally present, attentive, and responsive during interactions with their children. Mindfulness facilitates the regulation of automatic reactions and promotes deliberate, reflective responses to challenging parenting situations. Parents who are mindful are less likely to engage in impulsive disciplinary behaviors and more likely to approach their children with curiosity, patience, and acceptance. These characteristics contribute to greater parenting competence and effectiveness. The findings correspond closely with contemporary conceptualizations of

mindful parenting, which emphasize awareness, emotional attunement, and nonjudgmental acceptance as key elements of effective caregiving (Sansone, 2024). They also support empirical evidence demonstrating that mindfulness interventions improve parental resilience, reduce stress, and enhance overall family functioning (Abdelrasheed & Saeed, 2024; Ruskin et al., 2021). The results further align with research showing that mindful parenting partially mediates the relationship between parental stress and burnout, highlighting the protective role of mindfulness under challenging conditions (Taştekin et al., 2025). Taken together, these findings suggest that mindfulness strengthens parenting effectiveness by enhancing emotional awareness, attentional control, and adaptive responsiveness.

Reflective functioning also emerged as a significant predictor of parenting effectiveness. Reflective functioning, or mentalization, refers to the capacity to understand behavior in terms of underlying mental states such as thoughts, emotions, intentions, and beliefs. Parents with strong reflective functioning are better able to recognize the internal experiences that drive their children's behaviors and can therefore respond in more sensitive and developmentally appropriate ways. This capacity promotes secure attachment relationships, emotional validation, and constructive communication. The findings are consistent with attachment-based theories emphasizing parental mentalization as a critical determinant of caregiving quality and child development. Recent evidence has highlighted the importance of parental insightfulness and mentalization for children's emotional well-being and attachment security (Lee et al., 2024). Similarly, research examining transgenerational associations between mentalization and child mental health suggests that reflective functioning plays a crucial role in shaping family dynamics and developmental outcomes (Moreira et al., 2024). The present findings further support studies demonstrating positive relationships among mentalization, parental efficacy, and adaptive coping (Reich et al., 2025). Additionally, the observed contribution of reflective functioning aligns with research indicating that mentalization is associated with broader psychological resources, including emotional regulation and interpersonal effectiveness (Todosijević & Kojić, 2022; Wang et al., 2025). The results suggest that understanding children's internal experiences is a vital component of effective parenting and may represent a key mechanism linking parental psychological functioning to child outcomes.

Psychological flexibility also contributed significantly to the prediction of parenting effectiveness, although its

relative importance was somewhat lower than that of emotional intelligence, mindfulness, and reflective functioning. Psychological flexibility enables individuals to adapt to changing circumstances, tolerate difficult emotions, and engage in value-consistent behaviors despite psychological discomfort. Parenting inevitably involves uncertainty, frustration, and emotional challenges, making psychological flexibility particularly relevant for maintaining effective functioning. Parents who are psychologically flexible are more likely to cope constructively with parenting stress, adapt to developmental changes, and remain aligned with their parenting values even during difficult interactions. The present findings are highly consistent with previous studies demonstrating the beneficial effects of psychological flexibility on parental functioning and family well-being (Chorão et al., 2022; Fluja-Contreras et al., 2021). They also align with evidence indicating that psychological flexibility contributes to parental efficacy, coping, and adaptation among parents facing particularly demanding caregiving situations (Reich et al., 2025). Furthermore, the observed effects support research showing that acceptance- and flexibility-based interventions improve family outcomes and quality of life among children and parents (Lobato et al., 2025; Sairanen et al., 2022). The results suggest that psychological flexibility serves as an important adaptive resource that enables parents to navigate the complexities of parenting while maintaining emotional balance and effectiveness.

An important contribution of the present study lies in its examination of these four psychological variables simultaneously rather than independently. Although each construct made a unique contribution to parenting effectiveness, the findings suggest that parenting effectiveness is best understood as a multidimensional phenomenon shaped by interacting emotional, cognitive, and self-regulatory processes. The moderate intercorrelations among mindfulness, emotional intelligence, psychological flexibility, and reflective functioning support theoretical perspectives proposing meaningful conceptual overlap among these constructs while also confirming their distinctiveness. Recent scholarship has increasingly emphasized the interconnected nature of mindfulness and mentalization processes, suggesting that awareness of internal experiences facilitates understanding of mental states in oneself and others (Teräsahjo, 2025). Similarly, emotional intelligence may be enhanced by mindfulness and reflective functioning because both capacities contribute to greater awareness and

understanding of emotions. Psychological flexibility may further strengthen these processes by allowing individuals to engage openly with emotional experiences rather than avoiding them. The present findings provide empirical support for this integrative perspective and suggest that effective parenting may emerge from the combined influence of multiple psychological strengths.

Another significant finding concerns the performance of the CatBoost model itself. The model demonstrated excellent predictive accuracy, explaining more than four-fifths of the variance in parenting effectiveness. This level of predictive performance suggests that machine learning approaches can provide valuable insights into the complex determinants of parenting outcomes. Traditional statistical methods often assume linear relationships among variables and may struggle to capture the dynamic interactions that characterize psychological phenomena. In contrast, CatBoost is capable of modeling nonlinear patterns and interactions without imposing restrictive assumptions. The strong performance of the model therefore highlights the value of incorporating advanced analytical techniques into family psychology research. The use of SHAP analyses further enhanced interpretability by identifying the relative contribution of each predictor and illustrating how specific variables influenced model predictions. These findings demonstrate the potential of explainable artificial intelligence approaches for advancing understanding of parenting processes and informing intervention development.

The findings also have implications for broader theoretical frameworks emphasizing resilience, well-being, and adaptive functioning. Parenting effectiveness appears to be closely connected to psychological resources that promote emotional regulation, cognitive flexibility, interpersonal understanding, and self-awareness. Previous studies examining resilience and adaptive functioning have consistently identified similar psychological capacities as protective factors across diverse populations and life contexts (Dąbkowska et al., 2021; Laifer et al., 2024). Research on self-compassion and parental well-being similarly highlights the importance of internal psychological resources in supporting effective parenting behaviors (Žmuda, 2024). Furthermore, evidence concerning spiritual and emotional dimensions of well-being suggests that broader psychological strengths contribute to adaptive interpersonal functioning and life satisfaction (Dewi & Primayana, 2023; Gannamraju, 2025). The present study extends these findings by demonstrating that these

psychological resources are also strongly associated with parenting effectiveness.

The developmental implications of the findings are particularly noteworthy. Effective parenting serves as a critical context for children's emotional, social, and cognitive development. Children learn emotional understanding, self-regulation, and interpersonal skills through repeated interactions with caregivers. Research has shown that family environments influence children's emotion understanding, executive functioning, and broader developmental outcomes (Happaney & Zelazo, 2022; Асланова et al., 2024). Consequently, psychological capacities that enhance parenting effectiveness may indirectly contribute to healthier developmental trajectories among children. By fostering mindfulness, emotional intelligence, psychological flexibility, and reflective functioning among parents, practitioners and policymakers may be able to promote both parental well-being and child development simultaneously.

5. Conclusion

The findings should be interpreted within the context of contemporary family challenges. Modern parents often face considerable stress arising from economic pressures, changing family structures, technological influences, and increasing caregiving demands. Such challenges can undermine parenting effectiveness and family well-being. The present results suggest that psychological resources such as mindfulness, emotional intelligence, psychological flexibility, and reflective functioning may help parents navigate these challenges more successfully. By strengthening emotional awareness, adaptability, and interpersonal understanding, these capacities enable parents to maintain effective caregiving even under stressful circumstances. Consequently, interventions targeting these psychological resources may represent valuable strategies for promoting healthy family functioning in diverse cultural and social contexts.

6. Suggestions and Limitations

The study has several limitations that should be acknowledged. First, the cross-sectional design limits the ability to draw causal conclusions regarding the relationships among the study variables. Second, all measures relied on self-report questionnaires, which may be influenced by social desirability bias and subjective perceptions. Third, although the sample was relatively large

and geographically diverse within Thailand, the findings may not generalize to other cultural contexts. Fourth, parenting effectiveness was assessed through parental self-perceptions rather than direct observations of parenting behavior. Finally, additional psychological, social, and contextual variables not included in the model may also contribute to parenting effectiveness.

Future research should employ longitudinal and experimental designs to examine causal pathways among mindfulness, emotional intelligence, psychological flexibility, reflective functioning, and parenting effectiveness. Researchers may also investigate potential mediating and moderating mechanisms that explain how these psychological resources influence parenting outcomes. Future studies should incorporate multi-informant assessments, behavioral observations, and child outcome measures to obtain a more comprehensive understanding of parenting effectiveness. Comparative cross-cultural studies and investigations involving different family structures would further enhance the generalizability of findings. Additional machine learning algorithms may also be compared with CatBoost to identify the most effective predictive approaches in family psychology research.

The practical implications of the present findings are substantial. Parenting programs should incorporate components designed to enhance emotional intelligence, mindfulness, psychological flexibility, and reflective functioning. Mental health professionals, educators, and family counselors can develop interventions that strengthen parents' emotional awareness, adaptive coping skills, and capacity to understand children's mental states. Schools, community organizations, and healthcare systems may benefit from implementing evidence-based training programs that support these psychological resources among parents. Such initiatives have the potential to improve parenting effectiveness, strengthen family relationships, promote child well-being, and contribute to healthier communities overall.

Authors' Contributions

All authors have contributed significantly to the research process and the development of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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