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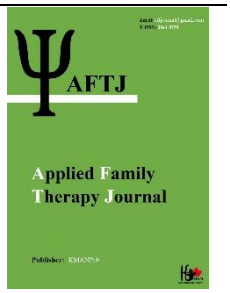

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XGBoost-Based Prediction of Family Resilience from Psychological Flexibility, Social Support, Family Cohesion, and Emotional Regulation

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A B S T R A C T

Objective: The present study aimed to predict family resilience based on psychological flexibility, social support, family cohesion, and emotional regulation using the XGBoost machine learning algorithm and to determine the relative importance of these predictors in explaining resilience outcomes among Canadian adults.

Methods and Materials: This cross-sectional predictive study was conducted among 812 adults residing in Canada. Participants were recruited through community organizations, family support centers, and online platforms using a stratified convenience sampling method. Data were collected using the Family Resilience Assessment Scale (FRAS), Acceptance and Action Questionnaire-II (AAQ-II), Multidimensional Scale of Perceived Social Support (MSPSS), Family Adaptability and Cohesion Evaluation Scales IV (FACES-IV), and Emotion Regulation Questionnaire (ERQ). Following data preprocessing and standardization procedures, the dataset was divided into training (80%) and testing (20%) subsets. An Extreme Gradient Boosting (XGBoost) model was developed and optimized using five-fold cross-validation and grid-search hyperparameter tuning. Model performance was evaluated using the coefficient of determination (R^2), root mean square error (RMSE), mean absolute error (MAE), and mean squared error (MSE). Feature importance and SHAP (Shapley Additive Explanations) analyses were performed to determine the relative contribution of each predictor.

Findings: The XGBoost model demonstrated excellent predictive performance, achieving an R^2 of 0.867 on the testing dataset, indicating that 86.7% of the variance in family resilience was explained by the predictors. Family resilience was positively correlated with psychological flexibility ($r = .68$, $p < .001$), social support ($r = .72$, $p < .001$), family cohesion ($r = .79$, $p < .001$), and emotional regulation ($r = .64$, $p < .001$). Feature importance analysis revealed that family cohesion was the strongest predictor (34.8%), followed by social support (28.7%), psychological flexibility (21.5%), and emotional regulation (15.0%). SHAP analyses confirmed these findings and demonstrated that higher levels of each predictor contributed positively to resilience predictions, with family cohesion exerting the largest overall influence.

Conclusion: The findings indicate that family resilience can be predicted with high accuracy using psychological flexibility, social support, family cohesion, and emotional regulation. Family cohesion emerged as the most influential determinant, highlighting the critical role of strong family relationships in fostering adaptive functioning. The study demonstrates the utility of machine learning approaches, particularly XGBoost, for identifying key resilience factors and provides evidence supporting multidimensional models of family resilience that integrate individual, relational, and social protective resources.

Keywords: *Family Resilience, XGBoost, Machine Learning, Psychological Flexibility, Social Support, Family Cohesion, Emotional Regulation*

1. Introduction

Family resilience has emerged as one of the most influential constructs in contemporary family psychology, reflecting the capacity of families to adapt successfully, maintain functioning, and recover from adversity in the face of significant stressors and life challenges. Unlike traditional deficit-based perspectives that emphasize dysfunction and vulnerability, resilience-oriented frameworks focus on the strengths, adaptive processes, and protective resources that enable families to withstand crises and continue functioning effectively. Recent global events, including pandemics, economic instability, forced migration, chronic illness, and social disruption, have further highlighted the importance of understanding the factors that contribute to family resilience across diverse populations and contexts (Low et al., 2025; Parrott et al., 2023; Uditha & Bulathwatta, 2025). As a result, resilience has become a central construct in both psychological theory and applied family research, with increasing attention devoted to identifying the individual, relational, and social determinants that promote adaptive family functioning.

The concept of resilience has evolved considerably over the past several decades. Early resilience research focused primarily on individual adaptation to adversity; however, contemporary scholars emphasize resilience as a dynamic, systemic, and multidimensional process that occurs across individual, family, and community levels. Family resilience is now widely understood as the collective ability of family members to respond effectively to challenges through communication, emotional support, cohesion, flexibility, and collaborative problem-solving processes (Georgoulas-Sherry, 2022; Luo et al., 2025). This systemic perspective recognizes that resilience is not merely the sum of individual coping capacities but rather emerges from the interactions, relationships, and shared resources that characterize family systems. Such an approach aligns with family systems theory, which suggests that the functioning of each family member is interconnected with the functioning of the family unit as a whole (Kalra et al., 2025; Roberts & Symons, 2023).

A growing body of evidence demonstrates that family resilience is associated with numerous positive outcomes, including enhanced psychological well-being, lower levels of emotional distress, improved family functioning, better adjustment to chronic illness, and greater capacity to cope with environmental and social challenges (Shao et al., 2024; Shen et al., 2025; Son & Park, 2025). Families characterized by high levels of resilience tend to maintain supportive relationships, foster adaptive communication patterns, and effectively mobilize internal and external resources during periods of stress. Conversely, families with lower resilience often experience difficulties managing adversity, resulting in increased psychological distress, interpersonal conflict, and impaired functioning (Magantor, 2024; Sousa et al., 2024). Consequently, identifying the factors that contribute to family resilience remains a critical objective for researchers and practitioners seeking to promote family health and well-being.

Among the psychological variables associated with resilience, psychological flexibility has received increasing attention in recent years. Psychological flexibility refers to the capacity to remain in contact with present experiences while adapting behavior in accordance with personal values despite the presence of difficult thoughts, emotions, or circumstances. This construct, rooted in Acceptance and Commitment Therapy (ACT), has been linked to greater emotional adjustment, lower psychological distress, and enhanced adaptive functioning across diverse populations (Lie et al., 2023; Sezgin, 2025). Individuals with higher psychological flexibility are better able to adapt to changing circumstances, tolerate uncertainty, and respond constructively to stressful situations. Within family contexts, psychological flexibility may facilitate more adaptive communication patterns, reduce maladaptive emotional reactions, and promote collaborative coping processes. Research has shown that flexible psychological responses contribute to resilience by enabling individuals and families

AFTJ Applied Family Therapy Journal
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to navigate challenges without becoming overwhelmed by emotional distress or rigid behavioral patterns (Goldin et al., 2022; Mohammadhosseini & Schmid, 2025). Despite its theoretical relevance, the predictive role of psychological flexibility in family resilience remains underexplored, particularly when examined alongside broader family and social variables.

Another factor consistently identified as a protective resource in resilience research is social support. Social support encompasses emotional, informational, and instrumental assistance received from family members, friends, community organizations, and broader social networks. Social support functions as a critical buffer against stress by enhancing coping resources and reducing the negative psychological consequences of adversity (Im et al., 2025; Low et al., 2025). Families embedded within supportive social environments often demonstrate greater resilience because they have access to practical assistance, emotional encouragement, and community resources that facilitate adaptation during difficult circumstances. Studies conducted across diverse populations have shown that social support is associated with improved mental health outcomes, stronger family functioning, and increased resilience in the face of crises such as illness, displacement, economic hardship, and social disruption (Engström et al., 2025; Parrott et al., 2023; Restrepo et al., 2023). Furthermore, social support may strengthen resilience indirectly by fostering feelings of belonging, security, and collective efficacy. Given its multifaceted influence, social support represents a crucial factor in understanding how families maintain stability and functioning under stress.

Family cohesion constitutes another foundational component of resilient family systems. Family cohesion refers to the emotional bonding, connectedness, commitment, and sense of belonging among family members. Cohesive families are characterized by warmth, mutual support, trust, and a strong sense of collective identity, all of which facilitate adaptive functioning during periods of adversity. Family systems theory suggests that cohesion provides a stable relational foundation that enables families to coordinate responses to stressors and maintain emotional security during challenging circumstances (Kalra et al., 2025; Xie et al., 2025). Empirical studies have consistently demonstrated positive associations between family cohesion and psychological well-being, family functioning, and resilience outcomes. For example, research has shown that stronger family cohesion predicts better emotional adjustment, lower levels of family conflict, and greater capacity to recover from stressful events (Sabah et al., 2023; Yousefi et al., 2024). Similarly, investigations involving families facing health-related challenges have revealed that cohesive family relationships contribute significantly to resilience by promoting communication, mutual understanding, and shared problem-solving processes (Shao et al., 2024; Shen et al., 2025). These findings suggest that family cohesion may represent one of the most influential predictors of resilience within family systems.

Emotional regulation also plays a critical role in adaptive family functioning and resilience development. Emotional regulation refers to the processes through which individuals monitor, evaluate, and modify their emotional experiences and expressions to achieve desired goals. Effective emotional regulation enables individuals to manage stress, maintain interpersonal relationships, and respond adaptively to challenging situations. Research indicates that emotional regulation contributes significantly to resilience by reducing emotional reactivity and facilitating constructive coping strategies (Brites et al., 2023; Zhu, 2025). Families in which members possess strong emotional regulation skills are more likely to engage in supportive interactions, resolve conflicts effectively, and maintain emotional stability during periods of stress. Conversely, difficulties in emotional regulation may increase vulnerability to interpersonal conflict, psychological distress, and dysfunctional family dynamics (Kosić et al., 2025; Zanella & Lee, 2022). Previous studies have also demonstrated that emotional regulation is closely linked to family cohesion and resilience, suggesting that emotionally regulated individuals may contribute to more adaptive and resilient family environments (Brites et al., 2023; Yousefi et al., 2024).

The importance of family resilience has become particularly evident in the context of contemporary global challenges. Families worldwide continue to encounter complex stressors, including economic instability, migration, chronic health conditions, caregiving responsibilities, social isolation, and environmental disasters. Research examining families affected by economic crises has shown that resilience serves as a crucial protective factor that mitigates the adverse effects of financial hardship on family functioning (Uditha & Bulathwatta, 2025). Similarly, studies involving refugee populations, families coping with chronic illness, and families experiencing social disruptions have emphasized the central role of resilience in promoting adaptation and psychological well-being (Engström et al., 2025;

Mohammadhosseini & Schmid, 2025; Silva et al., 2024). These findings underscore the necessity of identifying the factors that strengthen resilience across diverse family contexts.

Although substantial evidence supports the relevance of psychological flexibility, social support, family cohesion, and emotional regulation for adaptive functioning, most previous investigations have relied on traditional statistical approaches such as correlation analysis, regression modeling, or structural equation modeling. While these methods have contributed significantly to theoretical development, they may be limited in their ability to capture complex, nonlinear relationships among psychological and family variables. Human behavior and family functioning often emerge from dynamic interactions among multiple factors, suggesting that more sophisticated analytical approaches may provide deeper insights into resilience processes (Smith et al., 2023; Son & Park, 2025).

Recent advances in artificial intelligence and machine learning offer promising opportunities for enhancing psychological and family research. Machine learning algorithms are particularly valuable for identifying complex patterns, nonlinear associations, and interactions among variables that may not be readily detected using conventional statistical methods. Among these techniques, Extreme Gradient Boosting (XGBoost) has gained considerable attention due to its exceptional predictive accuracy, robustness, and ability to handle high-dimensional datasets. XGBoost utilizes an ensemble learning framework that combines multiple decision trees to optimize predictive performance while minimizing overfitting. Its capacity to evaluate feature importance also allows researchers to determine the relative contribution of individual predictors to outcome variables (Xie et al., 2025; Zhu, 2025). Despite the increasing popularity of machine learning in psychological research, relatively few studies have applied XGBoost to investigate family resilience and its determinants.

The application of machine learning techniques to family resilience research may offer several advantages. First, predictive models can identify the most influential resilience factors with greater precision than traditional methods. Second, machine learning algorithms can accommodate nonlinear and interactive effects among variables, thereby reflecting the complexity of real-world family systems. Third, explainable artificial intelligence techniques, such as SHAP analysis, enable researchers to interpret model predictions and understand how specific factors contribute to resilience outcomes. These capabilities may facilitate the development of more targeted interventions designed to strengthen family resilience through psychological, relational, and social mechanisms (Im et al., 2025; Low et al., 2025; Shen et al., 2025).

Furthermore, contemporary resilience frameworks emphasize the interconnected nature of individual psychological resources and family-level relational processes. Psychological flexibility and emotional regulation represent intrapersonal capacities that influence adaptation and coping, whereas social support and family cohesion reflect interpersonal and systemic resources that shape family functioning. Understanding the relative importance of these factors may provide valuable insights into the mechanisms through which families maintain resilience under stress. Such knowledge is particularly relevant for clinicians, family therapists, community practitioners, and policymakers seeking to design evidence-based interventions that enhance family well-being and adaptive functioning (Post, 2024; Sabah et al., 2023; Sousa et al., 2024).

Despite the growing literature on resilience, important gaps remain regarding the comparative predictive value of psychological flexibility, social support, family cohesion, and emotional regulation. Existing studies have generally examined these variables independently or within traditional explanatory frameworks, limiting understanding of their collective contribution to resilience outcomes. Moreover, the application of advanced machine learning approaches to family resilience remains relatively limited, particularly in Canadian populations. Addressing these gaps may contribute to both theoretical refinement and practical intervention development.

Therefore, the aim of the present study was to employ an XGBoost machine learning model to predict family resilience based on psychological flexibility, social support, family cohesion, and emotional regulation among Canadian adults and to determine the relative importance of these predictors in explaining resilience outcomes.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a cross-sectional predictive research design using a machine learning approach to investigate the extent to which psychological flexibility, perceived social support, family cohesion, and emotional regulation predict family resilience among Canadian families. The study was

AFTJ Applied Family Therapy Journal
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conducted between January and June 2026 across several provinces of Canada, including Ontario, British Columbia, Alberta, and Quebec. The target population consisted of adults aged 18 years and older who were currently living with at least one family member and had sufficient proficiency in English or French to complete the study questionnaires.

A total of 812 participants were recruited using a stratified convenience sampling strategy through community organizations, family support centers, social media platforms, and university-affiliated research recruitment networks. Eligibility criteria included being at least 18 years old, residing in Canada for a minimum of one year, and currently living within a family system. Individuals diagnosed with severe cognitive impairments that could interfere with questionnaire completion were excluded from participation. Prior to participation, all respondents were informed about the objectives of the study, confidentiality procedures, voluntary participation, and their right to withdraw at any stage without consequences. Electronic informed consent was obtained from all participants before data collection commenced.

The sample included participants from diverse socioeconomic, educational, and cultural backgrounds to enhance the generalizability of the findings. Demographic information such as age, gender, marital status, educational attainment, employment status, household income, and family composition was collected as descriptive information.

2.2. Measures

Family resilience was assessed using the Family Resilience Assessment Scale (FRAS) developed by Sixbey (2005) based on Walsh's family resilience framework. The instrument consists of 54 items designed to measure multiple dimensions of family resilience, including family communication and problem solving, utilizing social and economic resources, maintaining a positive outlook, family connectedness, family spirituality, and making meaning of adversity. Responses are recorded on a four-point Likert scale ranging from strongly disagree to strongly agree. Higher scores indicate greater levels of family resilience. Previous studies have reported satisfactory psychometric properties for the scale, including strong internal consistency coefficients and construct validity across diverse populations. The validity and reliability of the instrument have been confirmed in numerous international studies.

Psychological flexibility was measured using the Acceptance and Action Questionnaire-II (AAQ-II) developed by Bond and colleagues (2011). The scale contains seven items assessing individuals' capacity to remain in contact with present experiences while engaging in behavior consistent with personal values despite challenging thoughts and emotions. Participants respond on a seven-point Likert scale ranging from never true to always true. Higher scores reflect greater psychological flexibility after reverse scoring procedures are applied. The AAQ-II has demonstrated excellent internal consistency, test-retest reliability, and convergent validity in various cultural settings, and its psychometric adequacy has been extensively supported in previous research.

Perceived social support was evaluated using the Multidimensional Scale of Perceived Social Support (MSPSS) developed by Zimet et al. (1988). This 12-item instrument measures support received from three primary sources: family, friends, and significant others. Responses are rated on a seven-point Likert scale ranging from very strongly disagree to very strongly agree. Higher scores indicate stronger perceptions of social support. The MSPSS has consistently demonstrated robust psychometric characteristics, including high internal consistency, factorial validity, and cross-cultural applicability. Previous investigations have confirmed its reliability and validity among community and family-based populations.

Family cohesion was measured using the Cohesion subscale of the Family Adaptability and Cohesion Evaluation Scales IV (FACES IV) developed by Olson (2011). The cohesion dimension evaluates emotional bonding, family connectedness, loyalty, support, and involvement among family members. Participants rate items using a five-point Likert scale ranging from strongly disagree to strongly agree. Higher scores indicate stronger levels of family cohesion. Extensive research has supported the reliability, validity, and structural integrity of the FACES-IV across different family structures and cultural contexts.

Emotional regulation was assessed using the Emotion Regulation Questionnaire (ERQ) developed by Gross and John (2003). The questionnaire comprises 10 items that evaluate two primary emotional regulation strategies: cognitive reappraisal and expressive suppression. Participants indicate their agreement with each statement using a seven-point Likert scale ranging from strongly disagree to strongly agree. Higher scores on the cognitive reappraisal dimension indicate greater use of adaptive

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

emotional regulation strategies. Numerous studies have reported satisfactory internal consistency, factorial validity, and predictive validity for the ERQ, confirming its suitability for research examining emotional functioning and psychological adaptation.

2.3. Data Analysis

Data analysis was conducted using Python programming language and several machine learning libraries, including Scikit-learn, XGBoost, NumPy, Pandas, and SHAP. Prior to model development, data were screened for missing values, outliers, and distributional abnormalities. Missing data represented less than 5% of the dataset and were handled using multiple imputation techniques. Continuous variables were standardized to ensure comparability across predictors. Descriptive statistics, including means, standard deviations, skewness, and kurtosis indices, were calculated to characterize the sample and study variables.

The primary analytical objective was to predict family resilience using psychological flexibility, social support, family cohesion, and emotional regulation. The dataset was randomly divided into training and testing subsets, with 80% of observations allocated to model training and 20% reserved for out-of-sample evaluation. Hyperparameter optimization was performed using grid search combined with five-fold cross-validation to identify the optimal XGBoost configuration. Key hyperparameters included learning rate, maximum tree depth, number of estimators, subsample ratio, and regularization parameters.

Model performance was evaluated using multiple predictive accuracy indicators, including the coefficient of determination (R^2), root mean square error (RMSE), mean absolute error (MAE), and mean squared error (MSE). Feature importance analysis was conducted to determine the relative contribution of each predictor to family resilience. In addition, SHAP (Shapley Additive Explanations) values were computed to provide interpretable estimates of predictor influence and to identify the direction and magnitude of variable effects within the XGBoost model. This approach enabled both accurate prediction and transparent interpretation of the factors most strongly associated with family resilience among Canadian families.

3. Findings and Results

A total of 812 participants completed the study and were included in the final analyses. The mean age of the participants was 39.84 years (SD = 11.27), ranging from 18 to 72 years. Among the respondents, 431 (53.1%) were female and 381 (46.9%) were male. Regarding marital status, 612 participants (75.4%) were married, 98 (12.1%) were cohabiting, 64 (7.9%) were divorced or separated, and 38 (4.7%) were widowed. In terms of educational attainment, 18.2% held a high school diploma, 29.4% had completed college education, 38.7% possessed a bachelor's degree, and 13.7% held postgraduate qualifications. Most participants were employed either full-time or part-time (72.8%), while the remaining respondents consisted of students, retirees, homemakers, and unemployed individuals. The average family size was 3.8 members (SD = 1.4). Preliminary screening indicated that missing data represented less than 2% of the dataset and were handled through multiple imputation procedures. Examination of skewness and kurtosis values demonstrated that all variables were within acceptable ranges, indicating no severe departures from normality.

Table 1

Descriptive Statistics and Correlations Among Study Variables

Variable	Mean	SD	1	2	3	4	5
1. Family Resilience	161.42	24.81	1.00				
2. Psychological Flexibility	33.76	7.25	.68**	1.00			
3. Social Support	63.14	10.83	.72**	.57**	1.00		
4. Family Cohesion	37.51	6.42	.79**	.61**	.69**	1.00	
5. Emotional Regulation	48.93	8.71	.64**	.59**	.54**	.58**	1.00

Table 1 presents the descriptive statistics and bivariate correlations among the study variables. Family resilience demonstrated a relatively high mean score (M = 161.42, SD = 24.81), suggesting moderate-to-high levels of resilience among the participating families. All predictor variables showed significant positive correlations with family resilience. Family cohesion exhibited the strongest correlation with family resilience ($r = .79$, $p < .001$), followed by social support ($r = .72$, $p < .001$), psychological flexibility ($r = .68$, $p < .001$), and emotional regulation ($r =$

AFTJ Applied Family Therapy Journal
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.64, p < .001). Furthermore, significant positive associations were observed among all predictor variables, with correlation coefficients ranging from .54 to .69. These findings indicate substantial interrelationships among the psychological and family-related constructs while remaining below levels that would suggest problematic multicollinearity. Overall, the correlational results provide preliminary support for the inclusion of all predictor variables in the machine learning model designed to estimate family resilience.

Table 2

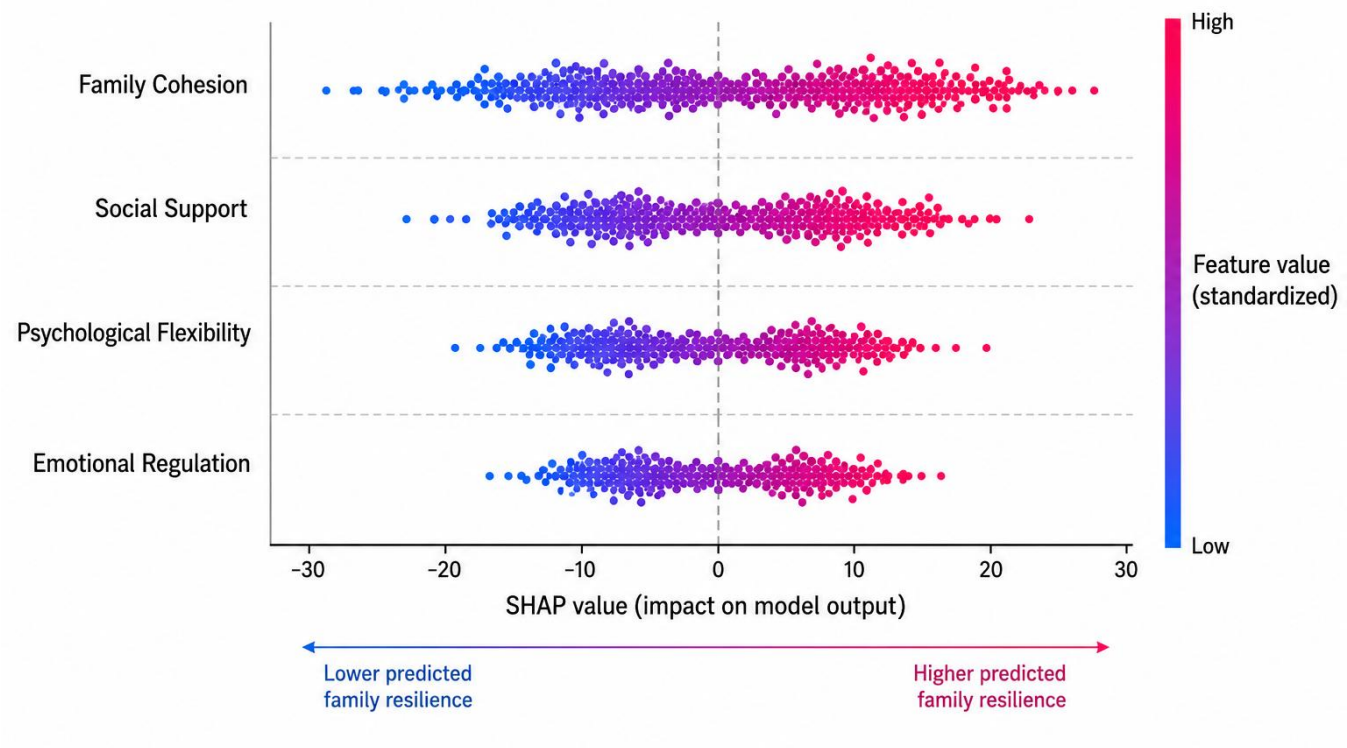
Performance Metrics of the XGBoost Model for Predicting Family Resilience

Metric	Training Set	Testing Set
R^2	0.914	0.867
RMSE	7.14	9.68
MAE	5.43	7.31
MSE	50.98	93.70
Explained Variance	0.915	0.869

The predictive performance of the XGBoost model is presented in Table 2. The model demonstrated excellent predictive capability on both the training and testing datasets. On the testing set, which provides the most realistic estimate of model generalizability, the model achieved an R^2 value of 0.867, indicating that approximately 86.7% of the variance in family resilience was explained by psychological flexibility, social support, family cohesion, and emotional regulation. The RMSE value of 9.68 and MAE value of 7.31 further indicate a high level of predictive precision, with relatively small deviations between predicted and observed resilience scores. The modest reduction in performance from the training set (R^2 = 0.914) to the testing set suggests that the model maintained strong generalizability while avoiding substantial overfitting. Collectively, these results demonstrate that the selected psychosocial variables provide a highly accurate basis for predicting family resilience using the XGBoost algorithm.

Figure 1

SHAP Summary Plot



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The SHAP summary plot provided an interpretable visualization of how each predictor influenced model predictions across individual participants. Family cohesion displayed the widest distribution of SHAP values, confirming its role as the strongest contributor to family resilience predictions. Higher levels of family cohesion consistently increased predicted resilience scores, whereas lower levels substantially reduced predicted outcomes. Social support exhibited a similar pattern, with elevated support levels associated with positive contributions to resilience predictions. Psychological flexibility also demonstrated a robust positive influence, particularly among individuals reporting moderate-to-high flexibility scores. Emotional regulation showed a comparatively smaller but still meaningful effect, with adaptive regulation strategies contributing positively to resilience predictions. The SHAP analysis further revealed that the relationships between predictors and family resilience were not entirely linear. For example, the beneficial effects of social support and family cohesion became increasingly pronounced at higher score ranges, suggesting the presence of synergistic effects that were effectively captured by the XGBoost algorithm. These findings demonstrate the value of explainable artificial intelligence techniques for identifying both the magnitude and direction of predictor effects in family resilience research.

Table 3

Relative Feature Importance in the XGBoost Model

Predictor	Gain Importance (%)	Weight Importance (%)
Family Cohesion	34.8	31.5
Social Support	28.7	29.2
Psychological Flexibility	21.5	22.8
Emotional Regulation	15.0	16.5

Table 3 displays the relative importance of each predictor in the XGBoost model. Family cohesion emerged as the most influential predictor, accounting for 34.8% of the total gain importance and 31.5% of the split importance within the decision trees. Social support ranked second, contributing 28.7% of predictive gain, followed by psychological flexibility with 21.5%. Emotional regulation, although the least influential among the four predictors, still contributed meaningfully to the prediction process, accounting for 15.0% of total gain importance. These findings suggest that family-level relational processes played a more prominent role in explaining resilience outcomes than individual-level psychological characteristics. The dominance of family cohesion and social support highlights the central importance of supportive and connected family environments in fostering resilient adaptation to life challenges.

Table 4

SHAP-Based Average Predictor Contributions to Family Resilience Prediction

Predictor	Mean Absolute SHAP Value	Relative Contribution (%)
Family Cohesion	11.82	35.6
Social Support	9.94	29.9
Psychological Flexibility	6.83	20.6
Emotional Regulation	4.63	13.9

The SHAP-based feature contribution analysis shown in Table 4 provided additional evidence regarding the relative influence of the predictors. Consistent with the traditional feature importance analysis, family cohesion demonstrated the highest mean absolute SHAP value (11.82), accounting for 35.6% of overall model influence. Social support followed with a relative contribution of 29.9%, while psychological flexibility contributed 20.6% and emotional regulation accounted for 13.9% of total predictive influence. The close correspondence between the XGBoost importance rankings and the SHAP-based estimates strengthens confidence in the stability and robustness of the findings. Together, these results indicate that family resilience is primarily driven by relational and systemic family resources, particularly family cohesion and social support, while individual psychological resources such as flexibility and

AFTJ Applied Family Therapy Journal
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emotional regulation provide important supplementary contributions. The convergence of multiple analytical approaches confirms that all four predictors play significant roles in explaining family resilience, although their relative impact differs substantially, with family cohesion emerging as the most powerful determinant within the predictive model.

4. Discussion

The present study aimed to predict family resilience based on psychological flexibility, social support, family cohesion, and emotional regulation using the XGBoost machine learning algorithm. The findings demonstrated that all four variables were positively associated with family resilience and collectively provided substantial predictive power. The XGBoost model achieved strong performance, explaining approximately 86.7% of the variance in family resilience within the testing dataset. Furthermore, feature importance analyses and SHAP-based interpretations revealed that family cohesion emerged as the most influential predictor, followed by social support, psychological flexibility, and emotional regulation. These findings provide important insights into the complex interplay between individual psychological resources and relational family processes that contribute to resilience within contemporary family systems.

One of the most notable findings of the study was the exceptionally strong predictive performance of the XGBoost model. The model demonstrated high accuracy and strong generalizability across training and testing datasets, suggesting that the selected predictors captured a substantial portion of the factors underlying family resilience. This finding aligns with emerging evidence indicating that resilience is a multidimensional construct shaped by the interaction of psychological, relational, and social resources rather than by any single protective factor (Low et al., 2025; Luo et al., 2025). The ability of the machine learning model to explain a large proportion of variance also supports arguments that resilience develops through complex and potentially nonlinear interactions among family members, personal characteristics, and environmental resources. Traditional linear models may underestimate these interactions, whereas machine learning approaches appear particularly well suited for capturing the dynamic nature of family adaptation processes.

The strongest predictor identified in the present study was family cohesion. Both the feature importance and SHAP analyses consistently demonstrated that family cohesion contributed more substantially to family resilience than any other variable included in the model. This finding is theoretically consistent with family systems theory, which emphasizes emotional bonding, connectedness, and supportive family relationships as fundamental mechanisms through which families adapt to adversity. Families characterized by strong cohesion are more likely to maintain trust, mutual support, emotional security, and collaborative problem-solving during periods of stress. Such qualities facilitate collective adaptation and enable family members to mobilize internal resources when confronted with challenges. Previous studies have similarly identified family cohesion as a central determinant of resilience and adaptive family functioning. For example, research has shown that family cohesion is positively associated with family resilience, emotional well-being, and effective coping across a variety of populations (Sabah et al., 2023; Yousefi et al., 2024). Likewise, investigations involving families managing chronic illness demonstrated that stronger family connectedness enhances resilience by fostering communication and mutual support (Shao et al., 2024; Shen et al., 2025). The present findings therefore reinforce the notion that resilience is fundamentally rooted in the quality of family relationships.

The importance of family cohesion may also reflect its role as an integrative family process that influences other protective factors. Cohesive families often provide emotional security that promotes adaptive emotional regulation, facilitate supportive communication that strengthens social support networks, and create environments that encourage psychological flexibility. Research examining family climate and psychosocial functioning similarly indicates that emotionally supportive family environments contribute to healthier psychological development and greater adaptive capacity among family members (Xie et al., 2025). Thus, the prominence of family cohesion in the current model may reflect its capacity to amplify multiple resilience-promoting mechanisms simultaneously.

Social support emerged as the second most influential predictor of family resilience. This finding supports a large body of literature demonstrating that access to supportive interpersonal relationships serves as a critical protective factor during times of adversity. Social support provides emotional reassurance, practical assistance, informational guidance, and opportunities for collaborative coping. Families embedded within supportive social networks often

AFTJ Applied Family Therapy Journal
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experience greater confidence in their ability to manage challenges and access external resources when necessary. The current findings are consistent with previous research indicating that social support contributes significantly to resilience among individuals, families, and communities facing various forms of stress and disruption (Im et al., 2025; Low et al., 2025). Studies involving displaced populations, caregivers, and families experiencing crises have similarly shown that social support enhances adaptive functioning and reduces vulnerability to psychological distress (Engström et al., 2025; Parrott et al., 2023). The results of the present study suggest that social support functions not only as an external resource but also as a mechanism that strengthens family resilience by increasing feelings of connectedness, belonging, and collective efficacy.

Psychological flexibility was identified as the third most important predictor of family resilience. This finding provides empirical support for theoretical models emphasizing adaptive psychological processes as foundational components of resilience. Psychological flexibility enables individuals to respond effectively to stressful situations by maintaining awareness of present experiences while pursuing meaningful goals despite emotional discomfort. Families composed of psychologically flexible individuals may be better equipped to adapt to changing circumstances, negotiate conflicts constructively, and tolerate uncertainty without becoming overwhelmed. Previous studies have consistently linked psychological flexibility to resilience, emotional well-being, and adaptive coping across diverse populations (Lie et al., 2023; Sezgin, 2025). Furthermore, psychological flexibility may contribute to family resilience by promoting acceptance, perspective-taking, and behavioral adaptability during periods of family stress. The findings are also consistent with broader resilience frameworks suggesting that adaptive cognitive and emotional processes facilitate successful adjustment to adversity (Goldin et al., 2022; Mohammadhosseini & Schmid, 2025). Although psychological flexibility was less influential than family cohesion and social support, its substantial contribution indicates that resilience is partly dependent upon the capacity of family members to respond flexibly to challenges and changing demands.

The positive relationship between psychological flexibility and family resilience may be particularly relevant in contemporary social environments characterized by uncertainty and rapid change. Families increasingly encounter complex stressors such as economic instability, health concerns, migration, and shifting social expectations. Under such conditions, rigid cognitive and behavioral patterns may undermine adaptation, whereas flexibility facilitates adjustment and recovery. The machine learning model's identification of psychological flexibility as a major predictor highlights the importance of considering individual psychological resources alongside broader family processes when seeking to understand resilience.

Emotional regulation also emerged as a significant predictor of family resilience, although its relative contribution was lower than those of family cohesion, social support, and psychological flexibility. Nevertheless, the findings indicate that emotional regulation plays an important role in facilitating adaptive family functioning. Individuals who can effectively regulate their emotions are better able to manage stress, maintain positive relationships, and engage in constructive communication during difficult situations. Such capacities contribute directly to the emotional climate of the family and indirectly influence collective coping processes. Previous studies have demonstrated strong associations between emotional regulation and resilience, suggesting that adaptive regulation strategies protect individuals from the negative consequences of stress and adversity (Brites et al., 2023; Zhu, 2025). Research has also shown that emotional regulation contributes to family cohesion and functioning by reducing interpersonal conflict and promoting supportive interactions (Yousefi et al., 2024). The present findings support these observations and suggest that emotional regulation represents an important psychological mechanism through which resilience is maintained within family systems.

An additional contribution of the present study concerns the use of explainable artificial intelligence methods to examine resilience. The SHAP analyses revealed that the influence of predictors was not entirely linear and that higher levels of family cohesion and social support produced disproportionately larger increases in predicted resilience. These findings suggest the existence of threshold or synergistic effects whereby the protective influence of certain resources becomes increasingly powerful once specific levels are reached. Such patterns may be difficult to identify using conventional statistical techniques. The application of machine learning therefore provides a more nuanced understanding of resilience processes and highlights the potential value of advanced predictive approaches within family psychology research.

The findings also support contemporary ecological and systemic perspectives of resilience. Rather than being solely an individual characteristic, resilience appears to emerge through interactions among personal competencies, family relationships, and social environments. Family cohesion and social support represented relational and environmental resources, whereas psychological flexibility and emotional regulation reflected individual adaptive capacities. The fact that all four variables contributed significantly to resilience prediction suggests that successful family adaptation depends upon the integration of multiple protective systems operating simultaneously. Similar conclusions have been reported in studies examining resilience among families coping with developmental disabilities, health-related challenges, trauma exposure, and social adversity (Magantor, 2024; Son & Park, 2025; Sousa et al., 2024). Collectively, these findings reinforce the view that resilience is a dynamic and multifaceted process shaped by interactions across multiple levels of functioning.

The results are also consistent with investigations examining family communication, family functioning, and adaptive coping. Research has demonstrated that families exhibiting stronger communication patterns and supportive interactions are more capable of maintaining functioning during crises (Sabah et al., 2023). Similarly, adaptive coping has been linked to socio-family factors that facilitate adjustment following stressful events (Restrepo et al., 2023). The prominence of family cohesion and social support in the current model suggests that these relational processes remain central components of resilience regardless of the specific stressor encountered.

5. Conclusion

Overall, the present study contributes to the growing literature on family resilience by demonstrating that family cohesion, social support, psychological flexibility, and emotional regulation collectively provide a highly accurate basis for predicting resilience outcomes. Moreover, the findings highlight the utility of machine learning approaches for identifying the relative importance of resilience-related factors and capturing complex relationships among psychological and family variables.

6. Suggestions and Limitations

Several limitations should be considered when interpreting the findings of this study. First, the cross-sectional design limits causal inference, making it impossible to determine the directionality of relationships among the variables. Second, all measures relied on self-report questionnaires, which may be subject to social desirability bias, recall bias, and common method variance. Third, although the sample was relatively large and geographically diverse, participants were recruited from Canada, potentially limiting the generalizability of findings to other cultural contexts. Fourth, family resilience is influenced by numerous factors beyond those included in the present model, such as socioeconomic status, parenting practices, cultural values, personality traits, and community-level resources. Finally, despite the strong predictive performance of the XGBoost algorithm, machine learning models prioritize prediction rather than causal explanation, and therefore the findings should be interpreted within the context of predictive analytics.

Future studies should employ longitudinal designs to examine how psychological flexibility, social support, family cohesion, and emotional regulation influence resilience over time. Researchers may also investigate additional predictors, including family communication, parenting styles, attachment security, socioeconomic conditions, and community engagement. Comparative studies across different cultures, family structures, and developmental stages would further enhance understanding of resilience processes. Future investigations could also compare multiple machine learning algorithms, including Random Forest, LightGBM, CatBoost, and deep learning approaches, to determine the most effective predictive models for family resilience. Moreover, integrating qualitative methods with machine learning analyses may provide richer insights into the lived experiences and adaptive strategies of resilient families.

The findings suggest several practical implications for clinicians, family therapists, educators, and policymakers. Interventions designed to strengthen family cohesion should be prioritized, as cohesive family relationships emerged as the strongest predictor of resilience. Programs that enhance communication, emotional connectedness, trust, and collaborative problem-solving may substantially improve family adaptation during stressful circumstances. Efforts to expand social support networks through community-based initiatives, peer-support programs, and family resource services may further strengthen resilience. Mental health professionals should also incorporate strategies aimed at increasing psychological flexibility and emotional regulation skills through evidence-based interventions. At the policy level, family-centered support systems that

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facilitate access to social, educational, and psychological resources may contribute significantly to the development of resilient families capable of navigating contemporary social and economic challenges.

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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