

## Uncovering Nonlinear Dynamics in Intergenerational Anxiety: Support Vector Regression of Parental Psychological Control, Child Behavioral Inhibition, and Family Climate

Andrés. Benítez<sup>1</sup>, Mercy. Atieno<sup>2\*</sup>, Elpida. Christou<sup>3</sup>

<sup>1</sup> Department of Social Psychology, National University of Asunción, San Lorenzo, Paraguay

<sup>2</sup> Department of Community Psychology, Maseno University, Maseno, Kenya

<sup>3</sup> Department of Counseling Psychology, University of Cyprus, Nicosia, Cyprus

\* Corresponding author email address: mercy.atieno@maseno.ac.ke

### Article Info

#### Article type:

Original Article

#### How to cite this article:

Benítez, A., Atieno, M., & Christou, E. (2026). Uncovering Nonlinear Dynamics in Intergenerational Anxiety: Support Vector Regression of Parental Psychological Control, Child Behavioral Inhibition, and Family Climate. *Applied Family Therapy Journal*, 7(2), 1-11. <http://dx.doi.org/10.61838/kman.aftj.5245>



© 2026 the authors. Published by KMAN Publication Inc. (KMANPUB), Ontario, Canada. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) License.

### ABSTRACT

**Objective:** To utilize Support Vector Regression to uncover the complex, nonlinear dynamics and threshold effects characterizing the relationship between parental psychological control, child behavioral inhibition, family climate, and the manifestation of intergenerational anxiety symptoms in children.

**Methods and Materials:** This study employed a cross-sectional design encompassing 482 parent-child dyads recruited from Kenya. Primary data collection instruments included the Psychological Control Scale, the Behavioral Inhibition Questionnaire, the Family Environment Scale, and the Screen for Child Anxiety Related Emotional Disorders (SCARED). To analyze the multidimensional data, a Support Vector Regression model utilizing a Radial Basis Function kernel was implemented. Model hyperparameters were optimized via 10-fold cross-validation, and individual predictor contributions were evaluated using permutation feature importance.

**Findings:** The Support Vector Regression model demonstrated superior predictive capability, explaining 63% of the variance ( $R^2 = .63$ ) in child anxiety, significantly outperforming standard Multiple Linear Regression ( $R^2 = .41$ ). Permutation analysis identified child behavioral inhibition as the most critical predictor, accounting for a 42.5% increase in model error when neutralized, followed closely by parental psychological control (38.2%), family conflict (25.7%), and family cohesion (14.1%). Furthermore, partial dependence profiles revealed a critical toxicity threshold: child anxiety spiked exponentially only when parental psychological control exceeded 1.5 standard deviations above the mean, while high family conflict acted as a synergistic non-linear amplifier specifically for highly inhibited youth.

**Conclusion:** The intergenerational transmission of anxiety is fundamentally governed by complex, non-linear tipping points and synergistic temperamental vulnerabilities that are most accurately captured and understood through advanced machine learning models.

**Keywords:** Intergenerational Anxiety, Nonlinear Dynamics, Support Vector Regression, Parental Psychological Control, Child Behavioral Inhibition, Family Climate

## 1. Introduction

Childhood and adolescence represent critical developmental epochs wherein the foundation for lifelong emotional and behavioral regulation is firmly established. The trajectory of a child's psychosocial well-being is not formulated in isolation; rather, it is heavily contingent upon the intricate, bidirectional interplay of individual temperamental traits, familial dynamics, and the broader environmental contexts in which the child is embedded (López et al., 2021). A substantial proportion of pediatric psychopathology manifests primarily as internalizing symptoms, such as debilitating anxiety and depression, which can severely impair a child's developmental trajectory, cognitive functioning, and social integration. The capacity for effective emotion regulation acts as a foundational, core mediator that determines exactly how external family factors and stressors translate into these internalizing symptoms (Lin et al., 2024). When a child's regulatory capacity is fundamentally compromised by environmental or biological factors, they become highly vulnerable to clinical conditions such as separation anxiety disorder. The treatment of such deep-seated emotional dysregulation often necessitates highly targeted clinical interventions, such as attachment-based play therapy or cognitive-behavioral therapy, which are explicitly designed to restore emotional equilibrium, rebuild a sense of secure attachment, and ultimately improve the child's overall quality of life (Shamsabadi et al., 2024).

Central to the development, scaffolding, and maintenance of a child's emotional regulation capabilities is the quality and consistency of the parenting they receive. Parenting styles are not static, isolated constructs; they are fluid behaviors heavily influenced by the parents' own psychological well-being and are inextricably linked to systemic phenomena such as parental stress and parental burnout (Mikkonen et al., 2023). When caregivers experience chronically high levels of stress or burnout, their capacity for reflective functioning—the critical ability to accurately perceive and understand their own mental states as well as those of their developing child—can drastically diminish. Targeted interventions, such as the Circle of Security-Parenting program, have empirically demonstrated that purposefully enhancing this reflective capacity is absolutely crucial for fostering positive caregiver behaviors and reducing the transmission of anxiety (Dexter & Wong, 2024). Furthermore, highly structured video-feedback interventions aimed at explicitly promoting positive

parenting techniques and sensitive discipline have proven exceptionally effective in improving child attachment security and subsequently reducing the incidence of externalizing behaviors (van Ijzendoorn et al., 2023). This robust body of literature clearly emphasizes that the relational dynamics established between parent and child serve as the primary conduit for either transmitting deep-seated psychological vulnerabilities or building enduring emotional resilience.

The profound impact of these parent-child interactions is perhaps most extensively documented and acutely visible in clinical pediatric populations, particularly among youth exhibiting severe disruptive behavior disorders or attention-deficit/hyperactivity disorder. Multicenter randomized controlled trials have consistently highlighted the immense efficacy of behavior management training protocols that directly target and modify negative parent-child interactions to successfully mitigate preschool attention-deficit/hyperactivity disorder symptoms (Feng et al., 2023). Comprehensive systematic reviews further corroborate that behavioral parent training must be considered a foundational cornerstone of any effective intervention strategy for school-aged children struggling with disruptive behaviors (Marquet-Doléac et al., 2023). Recognizing the critical importance of these dyadic modifications, the accessibility of such interventions has been significantly expanded in recent years through online behavioral parenting platforms specifically targeting disruptive behavioral disorders across diverse geographic populations (McAloon & de la Poer Beresford, 2023). Beyond traditional parent training paradigms, treatment models utilizing specialized behavioral counseling in conjunction with therapies centered explicitly on repairing the parent-child relationship have shown substantial, long-term success in reducing the severity of externalizing symptoms (Tabrizi et al., 2023). In a similar vein, structured joint parent-child play therapies have emerged as highly effective, engaging mechanisms for decreasing impulsivity and enhancing the foundational social skills of children grappling with severe behavioral dysregulation (Zolfaghari & Shakerinasab 2023). Interestingly, emerging research indicates that even adjunctive physiological and lifestyle interventions, such as maintaining structured physical activity routines, intimately interact with these relational variables to positively influence the core characteristics and developmental outcomes of symptomatic children (Karimi Aliabad et al., 2024). Ultimately, these clinical insights underscore a fundamental developmental psychological principle: modifying the

behavioral and emotional exchanges between parent and child is the single most potent avenue for altering a child's psychological trajectory and preventing the onset of severe psychopathology.

However, the profound influence of parenting extends far beyond the mere mitigation of pathology; it deeply and fundamentally affects normative socio-emotional development and the cultivation of positive social traits. For instance, the successful manifestation of prosocial behavior in developing children is contingent upon an intricate, nuanced interaction between the child's inherent effortful control mechanisms and the implicitly held social and racial attitudes of their parents (Xu et al., 2023). Yet, when parenting practices deviate from supportive scaffolding and become characterized by psychological control, the developmental outcomes are markedly and predictably detrimental. Psychological control is a pervasive, insidious parenting tactic involving emotional manipulation, guilt induction, love withdrawal, and the systemic invalidation of the child's independent feelings and thoughts. Unlike behavioral control, which provides necessary structural boundaries and rules for safety, psychological control represents a highly intrusive violation of the child's internal psychological world. The constant, suffocating pressure to conform to parental emotional expectations frequently interacts with parental perfectionism and a rigid, unforgiving family climate, which fundamentally disrupts the child's innate capacity for authentic emotion regulation (Αντωνοπούλου et al., 2025). This specific, toxic form of parenting operates as a chronic, inescapable interpersonal stressor, effectively laying the neurobiological and psychological groundwork for severe internalizing psychopathology, particularly intergenerational anxiety.

Beyond the direct, dyadic interactions occurring between one specific parent and a child, the broader family emotional climate serves as an absolutely crucial contextual matrix that can either effectively buffer against or catastrophically exacerbate psychological distress. The family climate encapsulates the overarching emotional tone, the degree of cohesiveness, the level of expressiveness, and the frequency and intensity of conflict within the household environment. Extensive empirical research strongly indicates that a positive, warm family emotional climate is instrumental in facilitating healthy, open parent-adolescent communication, which subsequently acts as a powerful protective factor for adolescent psychosocial functioning and identity formation (Kapetanovic & Skoog, 2021). The deep neurobiological underpinnings of this phenomenon are becoming

increasingly recognized within the scientific community; atypical neural synchrony between children and parents during communicative tasks has been directly and robustly linked to negative family emotional climates and subsequent psychopathological symptoms in affected youth (Su et al., 2024). A supportive, cohesive family climate is absolutely foundational for fostering deep psychological resilience, a trait which is particularly vital for deterring the psychological tendency toward dangerous, high-risk behaviors among highly vulnerable and marginalized populations, such as working children (Zolnowri & Haghparast Lati, 2022). Furthermore, the overarching structural and emotional relations within the family unit heavily influence a developing adolescent's chosen identity style, their degree of psychological school bonding, and their innate capacity for self-compassion when facing adversity (Merati et al., 2022).

The critical protective function of the family climate is most rigorously tested and revealed under conditions of acute environmental or chronic internal stress. For example, during the unprecedented global disruption of the COVID-19 pandemic, the perceived quality of the family climate played a massively pivotal role in modulating the severe academic, social, and psychological stress experienced by isolated adolescents (Dahlia & Hastuti, 2022). In a similar context, the dynamic intersection of perceived parental roles and the broader, macro-level school climate significantly dictates the daily academic stress levels and emotional well-being of students navigating both rural and urban educational settings (Hernawati, 2024). In households facing profound, chronic psychological challenges—such as those dealing with the devastating impacts of harmful parental alcohol consumption—the family climate is predictably and tragically characterized by high, volatile conflict and severely low cohesion, creating a chronically toxic environment that fundamentally compromises long-term child well-being (Iacopetti et al., 2021). Even in the severe, traumatic context of domestic violence, specialized interventions that provide child-parent relationship therapy-based play support have demonstrated the remarkable capacity to positively alter the traumatized family climate by significantly reducing parental stress, fostering mutual acceptance, and ameliorating the manifestation of negative child behaviors (Günaydin & Zincir, 2024). Furthermore, for resilient parents navigating the profound, daily complexities of raising a child with autism, the application of integrative structural family therapy combined with advanced, multi-tiered stress models has proven highly effective in improving

both dyadic marital adjustment and the overall holistic emotional climate of the home (AlHorany et al., 2025).

Within this highly complex, interwoven familial ecosystem, the developing child is never merely a passive recipient of environmental forces, but rather an active participant possessing distinct, innate temperamental traits that continuously interact with their surroundings. One of the most critical temperamental profiles specifically related to the ultimate development of clinical anxiety is behavioral inhibition. Characterized by an innate, biologically driven tendency to respond to novel, unfamiliar people, situations, or objects with extreme caution, profound fear, and immediate withdrawal, behavioral inhibition represents a significant endogenous vulnerability. While behavioral inhibition alone does not inherently guarantee the development of a clinical anxiety disorder, it serves as a powerful, dormant catalyst when combined with an adverse, controlling family environment. When a highly behaviorally inhibited child is consistently subjected to high levels of parental psychological control, the child's natural, biological hesitancy is exponentially compounded by the parent's systematic invalidation of their autonomy. The child learns, through repeated interactions, that the external world is not only inherently threatening but that their own internal emotional compass is fundamentally flawed and unacceptable. This specific, highly volatile intersection—an endogenously inhibited child trapped within a highly controlling and conflict-ridden family climate—is theorized to be the primary, driving psychological engine behind the intergenerational transmission of severe anxiety disorders.

Despite the robust, theoretically sound framework linking parental psychological control, child behavioral inhibition, and family emotional climate to child anxiety, the vast majority of empirical research conducted in this specific domain has historically relied upon traditional, linear statistical models. Analytical techniques such as multiple linear regression and standard structural equation modeling fundamentally, and somewhat restrictively, assume that the complex relationships between these psychological variables operate in a constant, additive, and strictly proportional manner. However, human psychological development and complex family systems rarely, if ever, operate in strict, straight mathematical lines. It is highly probable, and theoretically consistent, that the underlying dynamics of intergenerational anxiety are actually characterized by deeply complex, non-linear patterns, such as sudden threshold effects, psychological saturation points, and exponential amplification loops. For instance, a certain

moderate degree of family conflict might be easily manageable by a child up to a specific cognitive threshold, beyond which its impact on a behaviorally inhibited child's anxiety becomes suddenly and exponentially severe. To accurately uncover and map these hidden, multidimensional complexities, advanced machine learning techniques are absolutely required. Support Vector Regression offers a highly sophisticated, robust methodological alternative to traditional analyses. By mathematically mapping multidimensional psychological data into a much higher-dimensional feature space using specialized kernel functions, Support Vector Regression is uniquely and specifically equipped to identify, model, and predict the intricate, non-linear curvature of human psychological phenomena without being artificially constrained by the rigid, often unrealistic assumptions of traditional linear modeling. The rigorous application of such advanced computational techniques is deeply essential for developing a significantly more accurate, nuanced, and ecologically valid understanding of exactly how anxiety is transmitted, maintained, and amplified within vulnerable family systems.

Therefore, the aim of the current study was to utilize Support Vector Regression to uncover the complex, nonlinear dynamics and threshold effects characterizing the relationship between parental psychological control, child behavioral inhibition, family climate, and the manifestation of intergenerational anxiety symptoms in children.

## 2. Methods and Materials

### 2.1. Study Design and Participants

This study employed a cross-sectional design to investigate the nonlinear relationships between parental psychological control, child behavioral inhibition, family climate, and child anxiety symptoms. The sample was composed of 482 parent-child dyads recruited from community settings, including schools and local gathering places, in Nairobi and Kiambu counties in Kenya. Recruitment was facilitated through partnerships with community leaders to ensure trust and cultural sensitivity. Inclusion criteria for participation required the child to be between the ages of 8 and 12 years, to have a primary caregiver willing to participate, and for both parent and child to be fluent in either English or Swahili. Dyads were excluded if the child had a formal diagnosis of a neurodevelopmental disorder or if either the parent or child was unable to provide informed consent or assent, respectively. The final sample consisted of parents with a

mean age of 38.4 years ( $SD = 6.2$ ) and children with a mean age of 10.1 years ( $SD = 1.5$ ). The sample was approximately balanced by child gender, with 249 (51.7%) identifying as male.

## 2.2. Measures

Data were collected using a battery of well-validated questionnaires administered by trained research assistants to ensure comprehension and standardized administration. Parental psychological control was assessed using the 18-item Psychological Control Scale (PCS), where parents rated their use of control tactics such as guilt induction and love withdrawal on a 5-point Likert scale. Child behavioral inhibition was measured through parental report on the Behavioral Inhibition Questionnaire (BIQ), a 20-item instrument designed to assess a child's tendency to exhibit fear and withdrawal in novel social and non-social situations. The family climate was evaluated using the Cohesion, Expressiveness, and Conflict subscales of the Family Environment Scale (FES). This widely used tool measures the social-environmental characteristics of families, providing insight into the quality of interpersonal relationships and family dynamics. The primary outcome variable, child anxiety, was measured using the Screen for Child Anxiety Related Emotional Disorders (SCARED). We utilized both the 41-item parent-report and child-report versions to create a composite anxiety score, providing a more robust and multi-informant measure of the child's anxiety symptomatology across domains such as panic disorder, generalized anxiety, and social anxiety. Demographic information, including parent age, child age, gender, and socioeconomic status, was also collected through a separate questionnaire.

## 2.3. Data Analysis

All data analyses were conducted using the R programming language with the 'e1071' package. Initial data screening was performed to handle missing data, which was minimal (less than 3%), using multiple imputation techniques. Descriptive statistics, including means and standard deviations, were calculated for all study variables. To address the primary research question regarding nonlinear dynamics, a Support Vector Regression (SVR) model was implemented. SVR was chosen over traditional linear regression due to its capacity to model complex, nonlinear relationships between predictors and an outcome variable by transforming the data into a higher-dimensional

feature space. The composite child anxiety score served as the dependent variable. The predictor variables included the total score for parental psychological control, the total score for child behavioral inhibition, and the subscale scores for family cohesion, expressiveness, and conflict. We employed a Radial Basis Function (RBF) kernel, as it is highly effective in capturing intricate patterns without prior assumptions about the data's functional form. To optimize model performance and prevent overfitting, a hyperparameter tuning process was conducted using a 10-fold cross-validation grid search. This procedure systematically identified the optimal values for the SVR model's key parameters: the cost parameter,  $C$ , which controls the trade-off between model complexity and error tolerance, and the kernel coefficient,  $\gamma$ , which defines the influence of a single training example. The final model's predictive accuracy was evaluated based on its performance on a held-out test set, using metrics including the Root Mean Squared Error (RMSE) and the coefficient of determination ( $R^2$ ) to quantify the proportion of variance in child anxiety explained by the predictors.

## 3. Findings and Results

Preliminary data screening confirmed that the assumptions of normality were reasonably met for all continuous variables, with skewness and kurtosis values falling within the acceptable range of  $-2$  to  $+2$ . There were no significant outliers that required removal, allowing the full sample of  $N = 482$  parent-child dyads to be retained for the primary analyses. Descriptive statistics and bivariate Pearson correlations for all main study variables, including the composite child anxiety score, parental psychological control, child behavioral inhibition, and the three family climate subscales, were computed to examine the fundamental linear relationships before applying the advanced machine learning models. As anticipated, child anxiety demonstrated significant, positive bivariate relationships with both parental psychological control and child behavioral inhibition, suggesting that higher levels of parental control and child temperamental fearfulness are associated with elevated anxiety symptoms. Furthermore, child anxiety was negatively correlated with family cohesion and expressiveness, while showing a strong positive correlation with family conflict. The descriptive statistics and complete correlation matrix are presented in Table 1. While these linear correlations provided a baseline understanding of the variable associations, they were

insufficient for capturing the complex, threshold-based interactions hypothesized in this study, necessitating the subsequent nonlinear analysis.

**Table 1**

*Descriptive Statistics and Bivariate Correlations Among Study Variables*

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5
1. Child Anxiety (Composite)	34.52	12.18	–				
2. Parental Psychological Control	48.31	14.65	.46***	–			
3. Child Behavioral Inhibition	52.19	16.42	.51***	.28***	–		
4. Family Cohesion	36.74	8.25	–.32***	–.41***	–.19***	–	
5. Family Expressiveness	32.10	7.91	–.27***	–.35***	–.15**	.54***	–
6. Family Conflict	28.45	9.33	.42***	.58***	.24***	–.61***	–.48***

Following the preliminary analyses, the Support Vector Regression model utilizing a Radial Basis Function kernel was developed and optimized to predict child anxiety. The primary objective of utilizing this methodology was to uncover nonlinear dynamics that traditional regression models often obscure. The optimization process relied on a rigorous 10-fold cross-validation grid search to tune the hyperparameters. The grid search evaluated a wide range of values, ultimately identifying the optimal cost parameter at  $C = 15$  and the optimal kernel coefficient at  $\gamma = 0.05$ . This specific combination of hyperparameters provided the most optimal balance, maximizing the model’s ability to capture the complex, multidimensional curvature of the data without falling into the trap of overfitting the training set. To

explicitly demonstrate the presence and importance of nonlinear dynamics in intergenerational anxiety, the performance of the optimized Support Vector Regression model was directly compared against a standard Multiple Linear Regression model using the exact same predictor variables. The performance metrics, evaluated on a 20% held-out test dataset ( $n = 96$ ), clearly indicated the superiority of the nonlinear approach. The Support Vector Regression model explained a substantially higher proportion of the variance in child anxiety symptoms and exhibited markedly lower error rates across all evaluated metrics compared to its linear counterpart. These comparative performance indicators are detailed in Table 2.

**Table 2**

*Predictive Performance Metrics: Standard Linear Regression vs. Support Vector Regression*

Model Type	<i>R</i> <sup>2</sup>	<i>MSE</i>	<i>RMSE</i>	<i>MAE</i>
Multiple Linear Regression	.41	87.54	9.35	7.62
Support Vector Regression (RBF)	.63	54.89	7.40	5.88

Because Support Vector Regression maps data into a high-dimensional feature space, it does not produce traditional, easily interpretable regression coefficients or standard  $p$ -values for individual predictors. Therefore, to elucidate the relative contribution of parental psychological control, child behavioral inhibition, and the family climate variables, a permutation feature importance technique was applied to the optimized model. This algorithm systematically shuffles the values of each predictor variable one at a time and measures the resulting percentage increase in the model’s Root Mean Squared Error. A larger increase in error signifies a greater importance of that variable in

accurately predicting child anxiety. The results of the permutation analysis revealed that child behavioral inhibition was the most critical predictor of the model’s accuracy, closely followed by parental psychological control. Among the family climate variables, family conflict emerged as the most influential factor, exerting a stronger predictive weight than both family cohesion and family expressiveness. The precise permutation importance scores, representing the relative degradation of model performance when each variable’s information was neutralized, are provided in Table 3.

**Table 3**

*Permutation Feature Importance for the Optimized Support Vector Regression Model*

Predictor Variable	Increase in <i>RMSE</i> (%)	Relative Rank
Child Behavioral Inhibition	42.5%	1
Parental Psychological Control	38.2%	2
Family Conflict	25.7%	3
Family Cohesion	14.1%	4
Family Expressiveness	9.8%	5

Beyond simply ranking the variables, the partial dependence profiles extracted from the Support Vector Regression model provided profound insights into the precise nature of the nonlinear dynamics characterizing these relationships. The visualization of the multidimensional space revealed a distinct threshold effect regarding parental psychological control. At lower to moderate levels of psychological control, increases in this parenting behavior corresponded to only marginal, linear increases in child anxiety. However, once the psychological control score surpassed a specific critical threshold (approximately 1.5 standard deviations above the mean), the trajectory of child anxiety spiked exponentially, suggesting a saturation point where the child’s coping mechanisms are suddenly overwhelmed. Furthermore, a complex, synergistic interaction was identified between child behavioral inhibition and family conflict. For children with low to moderate behavioral inhibition, the family conflict variable operated in a roughly linear fashion. Conversely, for highly inhibited children, the presence of elevated family conflict acted as a non-linear amplifier. In these specific dyads, the combination of high behavioral inhibition and high family conflict produced anxiety scores that were significantly more severe than what would be predicted by simply adding the independent linear effects of the two variables together. Similarly, family cohesion demonstrated a nonlinear buffering effect; it was highly protective against anxiety at moderate levels of parental psychological control, but its protective efficacy diminished drastically when parental psychological control entered the highest, toxic percentiles. These findings clearly illustrate that the transmission of intergenerational anxiety in this Kenyan sample is not a simple additive process, but rather a complex system of intersecting thresholds and amplification loops.

**4. Discussion**

The primary objective of this study was to move beyond traditional linear paradigms to uncover the hidden, nonlinear dynamics driving the intergenerational transmission of anxiety. By utilizing a Support Vector Regression model, this study demonstrated that the complex interplay between parental psychological control, child behavioral inhibition, and family climate cannot be accurately captured by simple additive equations. The finding that the Support Vector Regression model explained a robust 63% of the variance ( $R^2 = .63$ ) in child anxiety, compared to a mere 41% ( $R^2 = .41$ ) by standard Multiple Linear Regression, provides compelling quantitative evidence that intergenerational anxiety operates through intricate tipping points and saturation thresholds. The marked reduction in predictive error further highlights the superiority of this methodological approach. Ultimately, this aligns with the broader developmental perspective that individual and systemic psychosocial well-being is heavily contingent upon complex, multidimensional interactions rather than isolated variables (López et al., 2021). The familial environment operates as a highly sensitive structural network, where changes in one domain can trigger cascading, exponential effects in another (Merati et al., 2022).

The permutation feature importance analysis revealed that child behavioral inhibition was the most critical predictor of the model’s accuracy, driving a massive 42.5% increase in error when its data was neutralized. This outcome strongly supports the premise that a child’s innate regulatory capacity is the fundamental core around which environmental stressors revolve. Children with a high degree of behavioral inhibition possess inherently lower thresholds for physiological and emotional arousal. This biological vulnerability significantly disrupts standard emotion regulation, which acts as the primary mediator translating external family dysfunction into internalized

psychopathological symptoms (Lin et al., 2024). Just as a child's foundational effortful control mechanisms interact deeply with parental attitudes to shape developmental trajectories (Xu et al., 2023), and underlying physiological states influence behavioral manifestations in neurodivergent populations (Karimi Aliabad et al., 2024), innate fearfulness acts as a dormant catalyst. When regulation fails in these highly inhibited children, they become exceptionally prone to severe clinical manifestations like separation anxiety, necessitating highly specialized clinical interventions such as attachment-based play therapy to restore emotional equilibrium (Shamsabadi et al., 2024).

Furthermore, the extraction of partial dependence profiles from the Support Vector Regression model exposed a crucial non-linear threshold regarding parental psychological control, which was the second most important feature (38.2%). The model illustrated that child anxiety does not increase linearly with psychological control; rather, it spikes exponentially only after the control tactics surpass a threshold of approximately 1.5 standard deviations above the mean. At lower levels, a child's innate resilience appears capable of absorbing the stress, but crossing this toxic threshold fundamentally overwhelms their psychological defenses. This threshold effect provides profound context for understanding how severe parental stress and parental burnout precipitate catastrophic emotional dysregulation in children (Mikkonen et al., 2023). When parents operate under immense psychological strain or rigid perfectionism, they often lose their capacity for reflective functioning, resorting to intrusive emotional manipulation that systemically invalidates the child's autonomy (Dexter & Wong, 2024; Αντωνοπούλου et al., 2025). Preventing parents from crossing this dangerous threshold is precisely why interventions focusing heavily on video-feedback to explicitly promote sensitive discipline and positive parenting are so remarkably effective at reducing externalizing and internalizing symptoms (van Ijzendoorn et al., 2023).

The Support Vector Regression model also unveiled highly complex, synergistic interactions embedded within the broader family emotional climate. Family conflict (25.7% importance) did not merely add to a child's anxiety; it acted as a non-linear amplifier specifically for youth with high behavioral inhibition. This finding perfectly aligns with advanced neurobiological research demonstrating that negative family emotional climates manifest in atypical neural synchrony between parent and child, effectively hardwiring psychopathological symptoms into the

developing brain (Su et al., 2024). This toxic amplification mirrors the devastating psychological outcomes observed in chronically hostile environments, such as homes dealing with parental substance abuse (Iacopetti et al., 2021) or the profound trauma of domestic violence, where therapeutic play support is required to rebuild the shattered emotional climate (Günaydin & Zincir, 2024). Conversely, family cohesion (14.1% importance) demonstrated a conditional buffering effect. It powerfully protected against anxiety during moderate psychological control but lost its protective efficacy entirely when psychological control reached toxic extremes. This conditional nature of family cohesion explains its vital, yet fragile, role in facilitating healthy parent-adolescent communication (Kapetanovic & Skoog, 2021) and mitigating extreme distress during global crises like the COVID-19 pandemic (Dahlia & Hastuti, 2022). Whether navigating the dual pressures of rural or urban school climates (Hernawati, 2024) or protecting vulnerable working youth from high-risk behaviors (Zolnowri & Haghparast Lati, 2022), family cohesion is a primary defense, but it is not impervious to extreme parental toxicity.

Ultimately, these non-linear findings provide a robust explanatory framework for why highly targeted, multi-tiered interventions are so deeply necessary for treating severe pediatric psychopathology. Because variables like inhibition and conflict interact synergistically to amplify distress, standard counseling often falls short. This is why systematic reviews and multicenter trials consistently champion intensive behavioral management training and specialized online parenting interventions that directly dismantle toxic parent-child interactions (Feng et al., 2023; Marquet-Doléac et al., 2023; McAloon & de la Poer Beresford, 2023). Therapeutic models utilizing parent-child relationship treatments (Tabrizi et al., 2023), joint play therapies designed to foster safe emotional expression (Zolfaghari & Shakerinasab 2023), and integrative structural family therapy for highly stressed parents of children with developmental disorders (AlHorany et al., 2025) are successful precisely because they target the specific non-linear amplification loops identified in this study. By reducing extreme conflict and pulling parental behavior back below the toxic threshold, these evidence-based therapies allow the natural buffering effects of family cohesion to functionalize once again.

## 5. Conclusion

The application of Support Vector Regression in this study successfully illuminated the profound complexities underlying the intergenerational transmission of anxiety, proving that this phenomenon is governed by intricate, non-linear dynamics rather than simple, additive relationships. By mathematically mapping the interactions between innate child temperaments and the familial environment, the findings revealed critical saturation points, most notably a distinct threshold where parental psychological control abruptly triggers exponential spikes in child anxiety. Furthermore, the identification of a synergistic amplification loop between high child behavioral inhibition and severe family conflict demonstrates that vulnerable children do not merely experience stress; their endogenous traits multiply the impact of environmental toxicity. These discoveries fundamentally challenge traditional linear paradigms in developmental psychology, offering a more precise, multidimensional understanding of how family emotional climates can either conditionally buffer against psychological distress or catastrophically overwhelm a child's innate regulatory capacities.

## 6. Suggestions and Limitations

Despite the methodological strengths of utilizing advanced machine learning algorithms, this study is subject to several notable limitations. First, the cross-sectional design inherently precludes the ability to establish definitive temporal precedence or strict causal relationships between parental psychological control, family climate, and the onset of child anxiety symptoms. Second, while the sample of parent-child dyads from Kenya provides highly valuable insights into an underrepresented cultural demographic, the specific socio-cultural context and localized stressors of this population may limit the direct generalizability of the findings to drastically different global populations. Third, the reliance on self-report and parent-report questionnaires introduces the potential for shared method variance and social desirability bias, as parents may inadvertently underreport their use of harsh psychological control tactics or inaccurately estimate the internalizing symptoms of their children. Finally, the analysis did not account for potential genetic or physiological biomarkers, which could provide deeper insight into the biological underpinnings of behavioral inhibition and emotional regulation.

Future investigations should prioritize longitudinal research designs coupled with non-linear machine learning

models to track the dynamic evolution of intergenerational anxiety across different developmental epochs. It is vital to determine whether the psychological control thresholds identified in this study shift as children transition from middle childhood into early adolescence. Additionally, researchers should aim to replicate this Support Vector Regression methodology across diverse, cross-cultural samples to ascertain which non-linear interactions are universal human phenomena and which are heavily influenced by specific cultural paradigms regarding parenting and family hierarchy. Integrating physiological data, such as real-time autonomic nervous system monitoring or neuroimaging, with complex familial data could profoundly enhance predictive models, providing a holistic biosocial map of how acute family conflict translates into biological anxiety. Finally, future studies should utilize these non-linear predictive models to dynamically evaluate the efficacy of clinical interventions in real-time.

The findings of this study demand a fundamental shift in how clinical practitioners conceptualize and treat pediatric anxiety within family systems. Practitioners must move away from "one-size-fits-all" psychoeducation and instead utilize nuanced assessment tools designed to detect specific toxic thresholds, recognizing that a parent's psychological control may appear benign until a critical saturation point is reached. Clinical interventions should be hyper-tailored to the child's specific temperamental profile; for highly inhibited children, family therapy must aggressively target the reduction of household conflict, as this specific combination creates a highly volatile amplification loop for anxiety. Furthermore, parent-training programs should explicitly educate caregivers about these non-linear dynamics, helping them understand that pushing a sensitive child past their regulatory threshold causes exponential, rather than gradual, psychological harm. By focusing on restoring family cohesion and pulling parenting behaviors back from the brink of toxicity, clinicians can effectively dismantle the complex structural networks that sustain intergenerational mental health 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.

## Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

## Declaration of Interest

The authors report no conflict of interest.

## Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

## Ethical Considerations

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

## References

- AlHorany, A. K., Hassan, S. A., Juhari, R., & Aljaberi, M. A. (2025). Effectiveness of integrative structural family therapy and double ABCX model on marital adjustment and parenting stress among parents of children with autism: Randomized controlled trial. *Child & Family Behavior Therapy*, 47(1), 1-31.
- Dahlia, I., & Hastuti, D. (2022). Family Climate, Perception, and Adolescents' Stress Prior to and During Covid-19 Pandemic. *Journal of Child Family and Consumer Studies*, 1(2), 60-70. <https://doi.org/10.29244/jcfcs.1.2.60-70>
- Dexter, C. A., & Wong, K. (2024). Circle of security-parenting randomized waitlist control study: Change in reflective functioning explains positive caregiver behavior. *Journal of Child and Family Studies*, 33(2), 504-514. <https://doi.org/10.1007/s10826-023-02710-0>
- Feng, M., Xu, J., Zhai, M., Wu, Q., Chu, K., Xie, L., Luo, R., Li, H., Xu, Q., Xu, X., & Ke, X. (2023). Behavior Management Training for Parents of Children With Preschool ADHD Based on Parent-Child Interactions: A Multicenter Randomized Controlled, Follow-Up Study. *Behavioural neurology*, 2023, 1-13. <https://doi.org/10.1155/2023/3735634>
- Günaydin, Y., & Zincir, H. (2024). The effect of child-parent relationship therapy-based play support on parental stress and acceptance, and child behaviours in children who witness domestic violence: Randomized controlled study. *Australian and New Zealand Journal of Family Therapy*, 45(3), 336-348. <https://doi.org/10.1002/anzf.1579>
- Hernawati, N. (2024). The Effect of Parents' Role and School Climate on Academic Stress of Madrasah Aliyah's Students in Rural and Urban Area. *Journal of Child Family and*

- Consumer Studies*, 3(3), 154-166. <https://doi.org/10.29244/jcfcs.3.3.154-166>
- Iacopetti, C., Londi, I., Patussi, V., & Cosci, F. (2021). Family Climate in Children Living With Parents Who Harmfully Consume Alcohol. *Clinical Psychology & Psychotherapy*, 28(5), 1128-1134. <https://doi.org/10.1002/cpp.2562>
- Kapetanovic, S., & Skoog, T. (2021). The Role of the Family's Emotional Climate in the Links between Parent-Adolescent Communication and Adolescent Psychosocial Functioning. *Res Child Adolesc Psychopathol*, 49, 141-154. <https://doi.org/10.1007/s10802-020-00705-9>
- Karimi Aliabad, M., Najafian Razavi, M., Sadeghi, M., Farokhi, A., & Rezaei, M. (2024). The Effects of Physical Activity on Key Variables That Influence the Characteristics of Children with Attention Deficit Hyperactivity Disorder. *International Journal of Sport Studies for Health*, 7(4), 95-105. <https://doi.org/10.61838/kman.intjssh.7.4.10>
- Lin, S. C., Kehoe, C., Pozzi, E., Liontos, D., & Whittle, S. (2024). Research Review: Child emotion regulation mediates the association between family factors and internalizing symptoms in children and adolescents – a meta-analysis. *Journal of Child Psychology and Psychiatry*, 65(3), 260-274. <https://doi.org/10.1111/jcpp.13894>
- López, V., Torres-Vallejos, J., Ascorra, P., González, L., Ortiz, S., & Bilbao, M. (2021). Contributions of Individual, Family, and School Characteristics to Chilean Students' Social Well-Being at School [Original Research]. *Frontiers in psychology*, 12. <https://doi.org/10.3389/fpsyg.2021.620895>
- Marquet-Doléac, J., Biotteau, M., & Chaix, Y. (2023). Behavioral Parent Training for School-Aged Children With ADHD: A Systematic Review of Randomized Control Trials. *Journal of Attention Disorders*, 28(3), 377-393. <https://doi.org/10.1177/10870547231211595>
- McAloon, J., & de la Poer Beresford, K. (2023). Online Behavioral Parenting Interventions for Disruptive Behavioral Disorders: A PRISMA Based Systematic Review of Clinical Trials. *Child Psychiatry & Human Development*, 54(2), 379-396. <https://doi.org/10.1007/s10578-021-01253-z>
- Merati, A. R., Ghadampour, P. D. E., & Veiskarami, P. D. H. (2022). Modeling the Structural Relations among School Bonding, Identity Styles, and Family Climate with Mediation of Self-Compassion. *qjfr*, 18(4), 49-68. <http://qjfr.ir/article-1-1626-en.html>
- Mikkonen, K., Veikkola, H.-R., Sorkkila, M., & Aunola, K. (2023). Parenting styles of Finnish parents and their associations with parental burnout. *Current Psychology*, 42(25), 21412-21423. <https://doi.org/10.1007/s12144-022-03223-7>
- Shamsabadi, F., Mirzaian, B., & Abbasi, G. (2024). Comparison of the Effectiveness of Attachment-Based Play Therapy and Cognitive-Behavioral Therapy on Emotional Regulation and Quality of Life in Children with Separation Anxiety Disorder. *KMAN Counseling & Psychology Nexus*, 2(2), 220-229. <https://journals.kmanpub.com/index.php/psychnexus/article/view/3488>
- Su, H., Young, C. B., Han, Z. R., Xu, J., Xiong, B., Zhou, Z., Wang, J., Lei, H., Yang, Z., Chen, G., & Qin, S. (2024). Atypical Child-parent Neural Synchrony Is Linked to Negative Family Emotional Climate and Children's Psychopathological Symptoms. *American psychologist*, 79(2), 210-224. <https://doi.org/10.1037/amp0001173>
- Tabrizi, A., Tabrizi, M., & Esteki, M. (2023). Comparing the effectiveness of behavioral counseling model and treatment based on parent-child relationship on externalizing symptoms of Children with attention deficit/hyperactivity disorder. *Applied Family Therapy Journal (AFTJ)*, 4(3), 235-248. <https://doi.org/10.61838/kman.afj.4.3.15>

- van Ijzendoorn, M. H., Schuengel, C., Wang, Q., & Bakermans-Kranenburg, M. J. (2023). Improving parenting, child attachment, and externalizing behaviors: Meta-analysis of the first 25 randomized controlled trials on the effects of Video-feedback Intervention to promote Positive Parenting and Sensitive Discipline. *Development and Psychopathology*, 35(1), 241-256. <https://doi.org/10.1017/S0954579421001462>
- Xu, X., Spinrad, T. L., Xiao, S. X., Xu, J., Eisenberg, N., Laible, D., Berger, R. H., & Carlo, G. (2023). White Children's Prosocial Behavior Toward White Versus Black Peers: The Role of Children's Effortful Control and Parents' Implicit Racial Attitudes. *Child development*, 94(6), 1581-1594. <https://doi.org/10.1111/cdev.13948>
- Zolfaghari, M., & Shakerinasab, M. (2023). The Effectiveness of Parent-Child Joint Play on Reducing Impulsivity and Increasing Social Skills of Children with Attention Deficit/Hyperactivity Disorder. *Quarterly Psychology of Exceptional Individuals*, 13(50), 225-254. <https://www.magiran.com/paper/2639729>
- Zolnowri, R., & Haghparast Lati, T. (2022). The Role of Family Emotional Climate and Psychological Resilience in the Tendency Toward High-Risk Behaviors Among Working Children. The 8th International Conference on Religious and Islamic Studies, Law, Educational Sciences, and Psychology, Antwonpoúlou, K., Anastasopoulos, N., Alexopoulos, D. A., & Kouvava, S. (2025). Perfectionism, Family Climate and Emotion Regulation in Childhood. <https://doi.org/10.20944/preprints202509.1370.v1>