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Support Vector Machine Prediction of Adolescent Anxiety Based on Nomophobia, Fear of Missing Out (FoMO), Perfectionism, Cognitive Fusion, and Parent–Child Communication

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ABSTRACT

Objective: The present study aimed to predict adolescent anxiety using a Support Vector Machine (SVM) model based on nomophobia, Fear of Missing Out (FoMO), perfectionism, cognitive fusion, and parent–child communication among Tunisian adolescents.

Methods and Materials: The study employed a cross-sectional correlational design with a machine learning approach. The statistical population consisted of secondary school adolescents in Tunisia during the 2025–2026 academic year. Using multistage cluster random sampling, 742 students were selected, of whom 718 valid questionnaires were retained for final analysis after data screening. Data were collected using the Beck Anxiety Inventory, Nomophobia Questionnaire, Fear of Missing Out Scale, Multidimensional Perfectionism Scale, Cognitive Fusion Questionnaire, and Parent–Adolescent Communication Scale. Descriptive statistics and Pearson correlation analyses were conducted using SPSS-27, while machine learning analyses were performed using Python and Scikit-learn libraries. The dataset was divided into training and testing subsets using an 80/20 ratio, and a radial basis function kernel Support Vector Machine model with five-fold cross-validation was implemented to predict adolescent anxiety.

Findings: The findings indicated significant positive correlations between adolescent anxiety and nomophobia, FoMO, perfectionism, and cognitive fusion, while parent–child communication demonstrated a significant negative relationship with anxiety symptoms. Cognitive fusion emerged as the strongest predictor variable, followed by nomophobia, parent–child communication, FoMO, and perfectionism. The Support Vector Machine model demonstrated high predictive performance, achieving 88.76% classification accuracy in the testing dataset, with an F1-score of 87.16% and an area under the curve (AUC) value of 0.91. The confusion matrix additionally revealed high sensitivity and specificity in distinguishing adolescents with elevated anxiety symptoms from those with lower anxiety levels.

Conclusion: The results demonstrated that adolescent anxiety can be effectively predicted through the combined influence of cognitive, technological, emotional, and family-related factors using machine learning techniques. Cognitive fusion and nomophobia represented the strongest psychological risk factors, while healthy parent–child communication functioned as a protective factor against

anxiety symptoms. The findings support the usefulness of Support Vector Machine models in adolescent mental health screening and highlight the importance of addressing maladaptive cognitive processes, digital dependency, and family communication patterns in preventive and intervention programs targeting adolescent anxiety.

Keywords: *Adolescent Anxiety, Support Vector Machine, Nomophobia, Fear of Missing Out, Perfectionism, Cognitive Fusion, Parent–Child Communication, Machine Learning, Mental Health, Adolescents*

1. Introduction

Adolescence represents a highly sensitive developmental period characterized by profound biological, cognitive, emotional, and social transitions that substantially influence psychological functioning and mental health trajectories. During this stage, individuals experience increased academic expectations, intensified peer comparison, identity exploration, emotional instability, and heightened sensitivity to social evaluation, all of which may increase vulnerability to anxiety-related symptoms (Lin & Guo, 2024; Pérez-Jorge et al., 2024). Anxiety disorders are among the most prevalent psychological conditions during adolescence and are associated with impairments in academic performance, interpersonal functioning, emotional regulation, and long-term psychosocial adjustment. Contemporary research has demonstrated that adolescent anxiety is increasingly shaped by the interaction between traditional psychosocial risk factors and rapidly evolving digital experiences, particularly excessive smartphone use, social media dependence, and technologically mediated social comparison (Cataldo et al., 2021; Viola, 2021). The widespread integration of smartphones and social networking platforms into adolescents' daily routines has transformed communication patterns, emotional experiences, and identity formation processes, thereby introducing new forms of psychological vulnerability that were largely absent in previous generations (Hong, 2025; Zhang, 2025). Consequently, understanding adolescent anxiety requires multidimensional models capable of simultaneously examining cognitive, emotional, interpersonal, and technology-related variables within integrated predictive frameworks.

One of the most significant emerging constructs associated with adolescent mental health is nomophobia, commonly conceptualized as the fear or anxiety experienced when individuals are unable to access or use their mobile phones. Nomophobia has increasingly attracted scholarly attention because smartphones have become central tools for communication, emotional reassurance, information seeking, and social validation among adolescents (Derbich et al., 2024; Rahmah et al., 2024). Adolescents frequently

rely on smartphones to maintain peer relationships, monitor social activities, and regulate emotional discomfort, thereby creating psychological dependency on continuous digital connectivity (Ilmiah et al., 2021; Kadan, 2023). Empirical studies have consistently demonstrated that excessive smartphone attachment is associated with stress, sleep disturbance, depressive symptoms, emotional dysregulation, and social anxiety (Bhuvaneswari & E, 2021; Özdemir et al., 2022). Recent evidence further suggests that nomophobia may directly disrupt cognitive and socioemotional development by increasing emotional instability, attentional fragmentation, and social insecurity among adolescents (Hong, 2025). Moreover, symptom network analyses have indicated that nomophobia symptoms are strongly interconnected with social networking addiction, FoMO, and broader indicators of psychological distress (Zhang, 2025). Studies have also demonstrated that loneliness, emotional neglect, attachment insecurity, and dysfunctional family dynamics contribute significantly to nomophobia development (Saladino, 2025; Soleymani et al., 2023). Such findings indicate that nomophobia should not be conceptualized merely as problematic technology use, but rather as a multidimensional psychological phenomenon closely associated with anxiety vulnerability and emotional maladjustment during adolescence.

Closely related to nomophobia is the construct of Fear of Missing Out (FoMO), which refers to persistent apprehension that others may be experiencing rewarding social events in one's absence. FoMO has become particularly prevalent among adolescents because developmental needs for peer belonging, social approval, and interpersonal validation are intensified during this stage of life (Ruben, 2022). The permanent accessibility of social media platforms encourages adolescents to continuously monitor peer activities and social interactions, often resulting in heightened social comparison, emotional dissatisfaction, and fear of exclusion (Cataldo et al., 2021; Viola, 2021). Emerging evidence has shown that FoMO functions as a significant mediator between problematic smartphone use and psychological distress, particularly anxiety symptoms and emotional insecurity (Zhang, 2025). Adolescents with elevated FoMO frequently demonstrate

compulsive checking behaviors, reduced attentional control, disrupted sleep patterns, and increased rumination regarding peer acceptance and social adequacy (Rahmah et al., 2024; Ruben, 2022). In addition, FoMO has been associated with procrastination, emotional instability, poor self-regulation, and maladaptive coping mechanisms that negatively affect adolescent wellbeing (Pérez-Jorge et al., 2024). Since adolescents are particularly vulnerable to social comparison processes and peer influence, persistent fears of exclusion from online interactions may amplify psychological tension and contribute substantially to anxiety-related symptoms.

Another important psychological factor strongly associated with adolescent anxiety is perfectionism. Perfectionism is generally defined as a multidimensional personality disposition characterized by excessively high standards, harsh self-evaluation, fear of mistakes, and concerns regarding external evaluation (Flett & Hewitt, 2022a, 2022b). Contemporary developmental perspectives emphasize that perfectionism often emerges during childhood and adolescence through interactions involving parental expectations, achievement pressures, social comparison, and conditional approval experiences (Flett & Hewitt, 2022c). Adolescents with perfectionistic tendencies frequently experience chronic dissatisfaction, heightened self-criticism, emotional rigidity, and persistent fear of failure, all of which contribute to increased anxiety vulnerability (Baytemir, 2022; Hameed & Arzeen, 2023). Research has demonstrated that perfectionism is associated with a broad range of psychological difficulties including stress, eating disorders, obsessive-compulsive symptoms, academic burnout, and emotional maladjustment (Egan et al., 2023; O'Brien et al., 2024). Furthermore, perfectionistic adolescents often exhibit reduced adaptability and impaired resilience when facing academic or interpersonal challenges (Flett & Hewitt, 2022c). Studies have additionally shown that perfectionistic tendencies may interact with smartphone addiction and digital dependency processes, thereby intensifying psychosomatic symptoms and emotional distress (Amirian et al., 2022). Within educational and performance-oriented environments, adolescents may internalize unrealistic standards regarding academic success, social appearance, and peer approval, which can further exacerbate anxiety symptoms (Jeong & Ryan, 2021; Smith et al., 2024). Consequently, perfectionism appears to constitute a critical cognitive-personality factor influencing adolescent emotional wellbeing.

Cognitive fusion also represents a theoretically important predictor of anxiety symptoms among adolescents.

Cognitive fusion refers to the tendency to become excessively entangled with thoughts, internal experiences, and self-evaluative cognitions to the extent that these mental events dominate behavior and emotional functioning. Individuals with elevated cognitive fusion frequently interpret thoughts as literal truths rather than transient cognitive experiences, thereby increasing vulnerability to anxiety, rumination, and maladaptive coping strategies (Khadem et al., 2023). Cognitive fusion has been extensively discussed within Acceptance and Commitment Therapy frameworks and has been linked to psychological inflexibility, obsessive thinking patterns, emotional rigidity, and heightened emotional reactivity (Cervin et al., 2022). Adolescents who experience strong cognitive fusion may become preoccupied with fears of rejection, social inadequacy, or personal failure, which subsequently intensifies emotional distress and anxiety symptoms. Research investigating obsessive beliefs and metacognitive processes has shown that maladaptive cognitive patterns are closely associated with anxiety-related psychopathology and emotional dysregulation in both adolescents and parents (Chessell et al., 2021; Misir & Özbek, 2025). Furthermore, studies examining obsessive-compulsive symptoms indicate that dysfunctional cognitive beliefs, perfectionistic concerns, and thought-action fusion are strongly interconnected psychological processes that contribute to persistent anxiety and emotional instability (Cervin et al., 2022; Khadem et al., 2023). Since adolescents are still developing advanced emotional regulation capacities and cognitive flexibility, heightened cognitive fusion may significantly amplify the impact of social stressors and digital pressures on mental health outcomes.

In addition to cognitive and technological influences, family processes continue to exert a major influence on adolescent psychological adjustment. Parent-child communication constitutes one of the most important protective factors associated with emotional resilience, self-esteem development, and adaptive coping among adolescents (Li, 2024). Open communication patterns characterized by emotional warmth, empathy, validation, and supportive guidance have consistently been associated with lower levels of anxiety and psychological distress. Conversely, dysfunctional communication patterns involving criticism, overcontrol, emotional invalidation, or hyper-parenting behaviors may increase emotional insecurity and anxiety vulnerability (Journault et al., 2025). Recent findings suggest that parental threat perception, excessive monitoring, and unrealistic achievement

expectations may intensify adolescent stress responses and emotional dysregulation (Journault et al., 2025). Family triangulation and impaired differentiation of self have additionally been associated with increased smartphone addiction and emotional dependency among adolescents (Kurşuncu, 2023). Moreover, attachment-related experiences and relational insecurity have been shown to influence loneliness, emotional distress, and maladaptive coping strategies in young people (G. & R., 2024). Parent-related perfectionistic expectations may also contribute significantly to adolescents' fear of failure and academic anxiety (Baytemir, 2022). Consequently, parent-child communication should be understood not merely as a contextual family variable but as a core interpersonal mechanism shaping emotional regulation, self-concept, and psychological adaptation during adolescence.

Although previous studies have independently examined nomophobia, FoMO, perfectionism, cognitive fusion, and family processes, important conceptual and methodological gaps remain within the literature. Most previous investigations have relied on traditional correlational or regression-based methods that may inadequately capture complex nonlinear interactions among psychological variables (Lin & Guo, 2024). Moreover, existing research often examines these constructs in isolation despite evidence suggesting that they operate through interconnected cognitive, emotional, technological, and interpersonal mechanisms. Adolescents simultaneously navigate digital dependency, social comparison pressures, academic demands, perfectionistic standards, and family expectations, making multidimensional prediction models especially important for understanding anxiety risk. Machine learning approaches offer significant advantages in this context because they allow researchers to identify hidden patterns, nonlinear relationships, and complex interactions among predictors with greater predictive accuracy than conventional statistical techniques. Support Vector Machine algorithms, in particular, are highly effective for psychological classification problems involving multidimensional predictors and complex decision boundaries. Despite growing interest in artificial intelligence applications within mental health research, relatively few studies have utilized Support Vector Machine models to predict adolescent anxiety based on integrated psychological and technology-related variables. Existing investigations focusing on nomophobia and mental health have largely emphasized descriptive associations rather than predictive modeling approaches (Derbich et al., 2024; Rahmah et al.,

2024). Similarly, research on perfectionism and adolescent anxiety has predominantly focused on clinical or educational outcomes without integrating digital behavioral variables and family communication processes into comprehensive predictive frameworks (Egan et al., 2023; Hameed & Arzeen, 2023).

Furthermore, cultural context represents an important consideration in adolescent mental health research. Adolescents in North African societies increasingly encounter rapid digitalization, shifting family structures, intensified academic competition, and evolving peer interaction patterns, all of which may influence anxiety experiences and technology-related behaviors. However, empirical investigations examining these phenomena within Tunisian adolescent populations remain limited. The integration of machine learning techniques within culturally relevant adolescent mental health research may therefore provide important insights for prevention, screening, and intervention efforts in educational and clinical settings. By simultaneously examining nomophobia, FoMO, perfectionism, cognitive fusion, and parent-child communication, the present study seeks to provide a multidimensional understanding of anxiety prediction among adolescents while advancing the application of Support Vector Machine methodologies within developmental psychopathology research.

Therefore, the aim of the present study was to predict adolescent anxiety using a Support Vector Machine model based on nomophobia, Fear of Missing Out (FoMO), perfectionism, cognitive fusion, and parent-child communication among Tunisian adolescents.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a cross-sectional correlational design with a predictive machine learning approach to investigate the extent to which nomophobia, Fear of Missing Out (FoMO), perfectionism, cognitive fusion, and parent-child communication could predict anxiety symptoms among adolescents. The study was conducted in Tunisia during the 2025–2026 academic year and specifically targeted secondary school students enrolled in public and private educational institutions in Tunis, Sfax, and Sousse. Given the predictive nature of the research and the intention to develop a robust Support Vector Machine (SVM) model with sufficient generalizability, a relatively large sample was considered necessary. A total of 742

adolescents participated in the study. Participants were selected using a multistage cluster random sampling method. Initially, several secondary schools were randomly selected from different educational districts in the three target cities. Subsequently, classrooms within each school were randomly chosen, and all eligible students in the selected classrooms were invited to participate in the research.

The inclusion criteria consisted of being between 15 and 18 years of age, current enrollment in secondary education, ability to comprehend the Arabic or French versions of the questionnaires, and provision of informed consent by both the participants and their parents or legal guardians. Students with severe psychiatric disorders previously diagnosed by a psychiatrist, severe neurological conditions, or incomplete questionnaire responses were excluded from the final analysis. Prior to data collection, the objectives and procedures of the study were thoroughly explained to school administrators, parents, and students. Participants were assured that all responses would remain anonymous and confidential and that participation was entirely voluntary. Data collection was carried out in classroom settings under the supervision of trained research assistants. The average completion time for the questionnaires ranged between 35 and 45 minutes. After screening for missing values, response inconsistencies, and multivariate outliers, 718 questionnaires were retained for final statistical and machine learning analyses.

2.2. Measures

Adolescent anxiety was assessed using the Beck Anxiety Inventory developed by Aaron T. Beck and colleagues in 1988. The inventory consists of 21 items designed to measure the severity of anxiety symptoms experienced during the previous week. Each item is rated on a four-point Likert scale ranging from 0 (not at all) to 3 (severely), resulting in total scores ranging from 0 to 63, with higher scores indicating greater anxiety severity. The scale evaluates physiological, cognitive, and emotional manifestations of anxiety, including nervousness, fear, inability to relax, and somatic symptoms. The Beck Anxiety Inventory has demonstrated strong psychometric properties across adolescent and adult populations, with high internal consistency coefficients and satisfactory convergent validity reported in previous international studies. In the present study, Cronbach's alpha coefficient for the scale was calculated and indicated excellent internal reliability.

Nomophobia was measured using the Nomophobia Questionnaire developed by Caglar Yildirim and Correia in 2015. This instrument contains 20 items distributed across four dimensions including inability to communicate, losing connectedness, inability to access information, and giving up convenience. Responses are scored on a seven-point Likert continuum ranging from strongly disagree to strongly agree. Higher scores represent greater levels of nomophobia and smartphone-related dependency. The questionnaire has been widely employed in studies involving adolescents and university students and has demonstrated strong construct validity and internal consistency in different cultural contexts. The Arabic and French versions used in the present study were subjected to translation and back-translation procedures to ensure linguistic equivalence and cultural appropriateness for Tunisian adolescents.

Fear of Missing Out was evaluated using the FoMO Scale developed by Andrew K. Przybylski and colleagues in 2013. The scale consists of 10 items assessing individuals' apprehension that others may be having rewarding experiences from which they are absent. Participants respond using a five-point Likert scale ranging from 1 (not at all true of me) to 5 (extremely true of me). Higher total scores indicate greater FoMO tendencies and increased social monitoring behavior associated with digital engagement. Previous studies have reported acceptable psychometric characteristics for adolescent samples, including satisfactory reliability coefficients and factorial validity. In the current study, the scale demonstrated strong internal consistency and was considered appropriate for evaluating technology-related social anxiety among Tunisian adolescents.

Perfectionism was assessed using the Multidimensional Perfectionism Scale developed by Paul L. Hewitt and Gordon L. Flett in 1991. The instrument contains 45 items measuring three dimensions of perfectionism including self-oriented perfectionism, other-oriented perfectionism, and socially prescribed perfectionism. Participants rate each statement on a seven-point Likert scale ranging from strongly disagree to strongly agree. Higher scores indicate greater perfectionistic tendencies. The scale has been extensively used in adolescent mental health research and has demonstrated robust psychometric properties in multicultural settings. In the current investigation, reliability analyses confirmed satisfactory internal consistency coefficients for both the total scale and subscales.

Cognitive fusion was measured using the Cognitive Fusion Questionnaire developed by Frank W. Bond and

colleagues in 2011. The questionnaire includes 7 items designed to assess the extent to which individuals become entangled with their thoughts and allow cognitive experiences to dominate behavior and emotional functioning. Responses are rated on a seven-point Likert scale ranging from never true to always true. Higher scores indicate stronger cognitive fusion and lower psychological flexibility. The Cognitive Fusion Questionnaire has shown strong reliability and validity across clinical and non-clinical populations and has frequently been utilized in adolescent psychological research related to anxiety, depression, and emotional dysregulation. In the present study, the scale exhibited satisfactory psychometric performance.

Parent-child communication was evaluated using the Parent-Adolescent Communication Scale developed by Howard Barnes and Olson in 1982. The scale consists of 20 items examining open communication patterns and communication problems between adolescents and their parents. Participants respond on a five-point Likert scale ranging from strongly disagree to strongly agree. Higher scores on the open communication dimension indicate healthier communication patterns, whereas higher scores on the communication problems dimension reflect dysfunctional interaction patterns within the family environment. The scale has been widely used in family psychology and adolescent behavioral studies and has demonstrated satisfactory reliability and validity across different cultures and languages. For the present study, culturally adapted Arabic and French versions were administered, and reliability analyses confirmed acceptable internal consistency coefficients.

2.3. Data Analysis

Data analysis was performed using both conventional statistical techniques and machine learning procedures. Initially, descriptive statistics including means, standard deviations, skewness, and kurtosis values were calculated for all study variables to assess distributional properties and identify potential anomalies in the dataset. Pearson correlation coefficients were computed to examine bivariate associations between adolescent anxiety, nomophobia, FoMO, perfectionism, cognitive fusion, and parent-child communication. Preliminary analyses also included assessment of missing data patterns, multicollinearity diagnostics, and normalization procedures. Continuous variables were standardized using z-score normalization prior to implementation of the machine learning algorithms

in order to improve model stability and predictive performance.

The predictive component of the study was conducted using a Support Vector Machine algorithm with supervised learning architecture. The SVM model was implemented using a radial basis function kernel because of its ability to capture nonlinear relationships among psychological variables and improve classification accuracy. Anxiety scores were categorized into low-anxiety and high-anxiety groups based on standardized clinical cutoff criteria. The dataset was randomly divided into training and testing subsets, with 80% of the data allocated to model training and 20% reserved for testing and validation. A five-fold cross-validation procedure was employed to minimize overfitting and enhance generalizability of the predictive model. Hyperparameter optimization was conducted through grid search procedures involving adjustment of the regularization parameter and kernel gamma values.

Model performance was evaluated using several classification metrics including accuracy, precision, recall, F1-score, and area under the receiver operating characteristic curve (AUC). Confusion matrix analyses were additionally performed to determine the sensitivity and specificity of the classification outcomes. Feature importance analyses were subsequently conducted to identify the relative contribution of nomophobia, FoMO, perfectionism, cognitive fusion, and parent-child communication in predicting adolescent anxiety. Statistical analyses were performed using SPSS version 27, whereas machine learning analyses and SVM implementation were conducted using Python programming language libraries including Scikit-learn, NumPy, Pandas, and Matplotlib. The significance level for inferential statistical analyses was set at $p < .05$.

3. Findings and Results

A total of 718 adolescents were included in the final analyses after data screening and removal of incomplete questionnaires and multivariate outliers. The participants ranged in age from 15 to 18 years, with a mean age of 16.54 years ($SD = 1.02$). Among the participants, 381 students (53.06%) were female and 337 students (46.94%) were male. Regarding educational level, 228 students (31.75%) were enrolled in the first year of secondary school, 241 students (33.57%) were in the second year, and 249 students (34.68%) were in the final year of secondary education. Approximately 64.21% of participants reported daily smartphone usage exceeding five hours, while 71.44%

indicated that social media constituted their primary online activity. In terms of parental educational background, 38.16% of fathers and 34.82% of mothers possessed university-level education. The preliminary screening analyses demonstrated acceptable normality for all study variables, as skewness and kurtosis values remained within

the acceptable range of ± 2 . No evidence of severe multicollinearity was observed among predictor variables, and tolerance statistics and variance inflation factors confirmed the suitability of the data for subsequent machine learning and inferential analyses.

Table 1

Means, Standard Deviations, and Correlations Among Study Variables

Variables	Mean	SD	1	2	3	4	5	6
1. Adolescent Anxiety	27.84	10.63	1					
2. Nomophobia	71.26	18.91	.62**	1				
3. FoMO	29.18	7.34	.58**	.66**	1			
4. Perfectionism	91.45	16.27	.49**	.38**	.41**	1		
5. Cognitive Fusion	35.92	9.11	.69**	.52**	.47**	.55**	1	
6. Parent-Child Communication	58.73	11.46	-.57**	-.39**	-.34**	-.29**	-.48**	1

As shown in Table 1, adolescent anxiety demonstrated statistically significant positive correlations with nomophobia, FoMO, perfectionism, and cognitive fusion, while parent-child communication was negatively associated with anxiety symptoms. Among the predictor variables, cognitive fusion exhibited the strongest positive relationship with adolescent anxiety ($r = .69, p < .01$), indicating that adolescents who experienced greater entanglement with distressing thoughts and internal experiences also reported substantially higher anxiety levels. Nomophobia also demonstrated a strong positive association with anxiety ($r = .62, p < .01$), suggesting that excessive dependence on smartphones and fear of digital disconnection may contribute meaningfully to emotional distress during adolescence. FoMO showed a moderate-to-strong correlation with anxiety symptoms ($r = .58, p < .01$),

reflecting the psychological vulnerability associated with social comparison, online exclusion concerns, and persistent monitoring of peer activities through social media platforms. Perfectionism was moderately correlated with anxiety ($r = .49, p < .01$), implying that rigid self-expectations and fear of failure may increase emotional pressure and psychological tension among adolescents. In contrast, parent-child communication displayed a substantial negative relationship with anxiety ($r = -.57, p < .01$), indicating that supportive and open family communication patterns may function as protective factors against emotional maladjustment. Furthermore, the intercorrelations among predictor variables were statistically significant but remained below critical multicollinearity thresholds, thereby supporting the appropriateness of including all variables within the Support Vector Machine prediction model.

Table 2

Performance Indicators of the Support Vector Machine Model in Predicting Adolescent Anxiety

Performance Metric	Training Set	Testing Set
Accuracy	91.42%	88.76%
Precision	90.15%	87.49%
Recall	89.71%	86.83%
F1-Score	89.93%	87.16%
AUC	0.94	0.91

The results presented in Table 2 indicate that the Support Vector Machine model demonstrated high predictive performance in identifying adolescents with elevated anxiety symptoms. The classification accuracy achieved by the model reached 91.42% in the training dataset and remained highly satisfactory in the testing dataset at 88.76%,

suggesting strong model generalizability and limited overfitting. Similarly, precision and recall values exceeded 86% in the testing phase, indicating that the algorithm was highly effective in correctly distinguishing adolescents with high anxiety from those with lower anxiety levels. The F1-score of 87.16% in the testing dataset further reflected a

balanced predictive capability between sensitivity and specificity. Moreover, the area under the receiver operating characteristic curve reached 0.91 in the testing dataset, which is considered an excellent level of discriminative performance in psychological classification studies. These findings collectively demonstrate that the combination of nomophobia, FoMO, perfectionism, cognitive fusion, and

parent–child communication can effectively predict anxiety symptoms among adolescents using nonlinear machine learning techniques. The relatively small reduction in performance indicators between the training and testing datasets also suggests that the model maintained strong stability and robustness across different subsamples.

Table 3

Feature Importance Scores of Predictor Variables in the Support Vector Machine Model

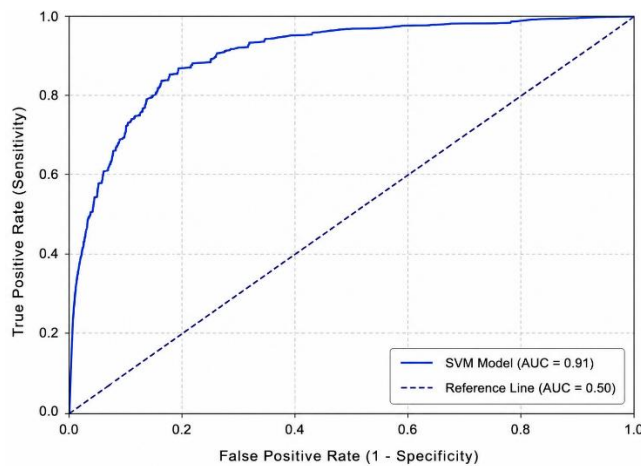
Predictor Variable	Importance Score
Cognitive Fusion	0.31
Nomophobia	0.26
Parent–Child Communication	0.19
FoMO	0.15
Perfectionism	0.09

The feature importance analysis presented in Table 3 revealed that cognitive fusion emerged as the strongest predictor of adolescent anxiety within the Support Vector Machine model, accounting for the highest contribution score (0.31). This finding indicates that adolescents who become excessively fused with distressing cognitions and negative internal experiences are particularly vulnerable to heightened anxiety symptoms. Nomophobia represented the second most influential predictor variable (0.26), highlighting the increasingly central role of smartphone dependency and digital disconnection anxiety in adolescent psychological functioning. Parent–child communication was identified as the third strongest predictor (0.19), suggesting that healthy communication patterns within the family

environment may substantially buffer against emotional distress and anxiety-related symptoms. FoMO also contributed meaningfully to the predictive model (0.15), emphasizing the psychological consequences of online social comparison and fear of social exclusion in digitally connected youth populations. Although perfectionism demonstrated the lowest importance score among the included predictors (0.09), it still contributed significantly to the overall prediction model and remained associated with anxiety vulnerability. Collectively, these findings suggest that cognitive-emotional processes and technology-related psychosocial experiences may play a more dominant role in adolescent anxiety prediction than personality-based perfectionistic tendencies alone.

Figure 1

Receiver Operating Characteristic (ROC) Curve of the Support Vector Machine Model for Predicting Adolescent Anxiety



The ROC analysis demonstrated that the Support Vector Machine model possessed excellent discriminatory power in differentiating adolescents with high anxiety symptoms from those with lower symptom severity. The curve remained consistently above the diagonal reference line throughout all threshold levels, reflecting superior classification performance relative to random prediction. The area under the curve value of 0.91 indicated that the model achieved highly accurate sensitivity and specificity balance across classification thresholds. This finding further

confirms the suitability of machine learning approaches for psychological risk prediction in adolescent populations and supports the integration of cognitive, emotional, technological, and family-related variables within predictive mental health frameworks. The ROC findings additionally suggest that the present model may have potential utility for early screening and preventive intervention efforts in educational and clinical contexts where timely identification of anxiety vulnerability among adolescents is critical.

Table 4

Confusion Matrix Results for the Testing Dataset

Actual Classification	Predicted Low Anxiety	Predicted High Anxiety
Low Anxiety	67	9
High Anxiety	7	61

The confusion matrix results shown in Table 4 provide further evidence regarding the effectiveness of the Support Vector Machine model in accurately classifying adolescents according to anxiety severity levels. Among adolescents who actually belonged to the low-anxiety group, 67 participants were correctly classified, whereas only 9 participants were incorrectly categorized as high anxiety. Similarly, among participants with clinically elevated anxiety symptoms, 61 adolescents were accurately identified by the model, while merely 7 participants were misclassified. These findings indicate that the algorithm demonstrated strong sensitivity in detecting adolescents at risk for anxiety while simultaneously maintaining satisfactory specificity in identifying psychologically healthier participants. The relatively low number of false-positive and false-negative classifications reflects the efficiency of the machine learning approach and suggests that the integrated psychosocial predictors used in the present study provide meaningful information for anxiety classification. The confusion matrix outcomes also reinforce the practical applicability of Support Vector Machine techniques for psychological assessment contexts, particularly in school-based mental health screening programs where accurate identification of vulnerable adolescents is essential for prevention and intervention planning.

nomophobia, Fear of Missing Out (FoMO), perfectionism, cognitive fusion, and parent–child communication among Tunisian adolescents. The findings demonstrated that the proposed machine learning model achieved high predictive performance, indicating that these psychosocial and cognitive variables collectively provide substantial explanatory power in identifying adolescents at risk for elevated anxiety symptoms. The results further revealed that adolescent anxiety was positively associated with nomophobia, FoMO, perfectionism, and cognitive fusion, whereas parent–child communication was negatively associated with anxiety symptoms. Among the predictor variables, cognitive fusion emerged as the strongest contributor to anxiety prediction, followed by nomophobia, parent–child communication, FoMO, and perfectionism. These findings support multidimensional conceptualizations of adolescent anxiety suggesting that contemporary anxiety experiences are shaped not only by traditional cognitive and personality-related vulnerabilities but also by technology-mediated social experiences and family relational processes.

One of the most important findings of the present study was the strong positive relationship between nomophobia and adolescent anxiety. This result is consistent with prior studies demonstrating that excessive dependence on smartphones and fear of digital disconnection are associated with heightened emotional distress, social insecurity, and anxiety symptoms among adolescents and young adults (Derbich et al., 2024; Rahmah et al., 2024). Smartphones have increasingly become primary tools for emotional reassurance, peer interaction, identity validation, and social participation among adolescents, making separation from

4. Discussion

The present study aimed to predict adolescent anxiety using a Support Vector Machine model based on

these devices psychologically threatening for many individuals (Ilmiah et al., 2021; Kadan, 2023). Adolescents with elevated nomophobia may continuously monitor messages, notifications, and social media updates in an attempt to reduce uncertainty and maintain feelings of connectedness, yet these behaviors paradoxically increase psychological dependence and emotional instability. Previous research has similarly shown that nomophobia is associated with stress, sleep disturbance, social phobia, and broader mental health problems (Bhuvanewari & E, 2021; Özdemir et al., 2022). The findings also align with studies suggesting that smartphone addiction and digital dependency negatively influence cognitive and socioemotional development by impairing attentional control, emotional regulation, and interpersonal security (Hong, 2025). Furthermore, evidence indicates that nomophobia frequently coexists with attachment insecurity, loneliness, and emotional vulnerability (Saladino, 2025; Soleymani et al., 2023). From a psychological perspective, adolescents may use smartphones as compensatory tools for managing insecurity, reducing social uncertainty, and regulating distressing emotions, thereby strengthening maladaptive dependency patterns that contribute to anxiety symptoms over time.

The findings also demonstrated that FoMO was positively associated with adolescent anxiety and contributed significantly to the predictive model. This result supports previous investigations indicating that persistent fears of social exclusion and missing rewarding experiences increase emotional vulnerability among adolescents (Ruben, 2022; Zhang, 2025). Adolescence is characterized by heightened sensitivity to peer approval and social belonging, making individuals especially susceptible to social comparison processes facilitated through digital platforms. Social media environments constantly expose adolescents to idealized representations of peers' lives, achievements, and relationships, which may intensify feelings of inadequacy, exclusion, and insecurity (Cataldo et al., 2021; Viola, 2021). Adolescents experiencing elevated FoMO may engage in compulsive social monitoring behaviors and persistent online engagement in order to avoid perceived social disconnection, yet such patterns often increase emotional exhaustion and anxiety. Recent symptom network analyses have shown that FoMO occupies a central role in the relationship between social networking addiction and psychological distress (Zhang, 2025). The present findings therefore reinforce the idea that digitally mediated social comparison and peer-monitoring behaviors have become

major psychological stressors within adolescent populations. Additionally, adolescents with high FoMO may experience chronic anticipatory anxiety concerning social exclusion and peer evaluation, which can negatively affect self-esteem, concentration, sleep quality, and emotional stability.

Another important finding was the significant predictive role of perfectionism in adolescent anxiety. Although perfectionism contributed less strongly than cognitive fusion and nomophobia, it nevertheless remained a meaningful component of the predictive model. This finding is consistent with developmental and clinical research indicating that perfectionistic tendencies are closely associated with fear of failure, excessive self-criticism, emotional rigidity, and anxiety vulnerability (Flett & Hewitt, 2022a, 2022b). Perfectionistic adolescents often establish unrealistically high standards for academic performance, social acceptance, and personal achievement while simultaneously interpreting mistakes as indicators of personal inadequacy. Such cognitive patterns generate chronic psychological pressure and increase sensitivity to evaluation and criticism (Hameed & Arzeen, 2023). The findings are also supported by studies demonstrating that perfectionism contributes to stress-related disorders, eating pathology, and emotional maladjustment among adolescents (Egan et al., 2023; O'Brien et al., 2024). Furthermore, perfectionistic tendencies may become intensified in highly competitive educational environments where adolescents experience pressure from parents, teachers, and peers regarding achievement and success (Baytemir, 2022). The present findings additionally support theoretical perspectives emphasizing that perfectionism develops through interactions involving parental expectations, conditional acceptance, and social comparison processes (Flett & Hewitt, 2022c). Since digital environments also encourage constant comparison and performance evaluation, perfectionistic adolescents may become increasingly vulnerable to anxiety symptoms within online social contexts.

The strongest predictor of adolescent anxiety in the current study was cognitive fusion. This finding highlights the central role of maladaptive cognitive processes in adolescent emotional functioning and aligns with psychological flexibility models emphasizing the importance of cognitive detachment and adaptive emotional processing (Khadem et al., 2023). Adolescents with elevated cognitive fusion may become excessively entangled with negative thoughts, self-critical beliefs, fears of rejection, and catastrophic interpretations of social experiences. Instead of

perceiving thoughts as temporary mental events, cognitively fused adolescents often interpret them as accurate reflections of reality, thereby increasing emotional distress and behavioral avoidance. Previous research examining obsessive beliefs and thought-action fusion has similarly shown strong associations between maladaptive cognitive processing and anxiety-related psychopathology (Cervin et al., 2022; Chessell et al., 2021). The present findings also align with studies indicating that rumination, obsessive thinking patterns, and metacognitive distortions significantly contribute to emotional dysregulation among adolescents and parents (Misir & Özbek, 2025). From a developmental perspective, adolescents may lack fully developed emotional regulation capacities and cognitive flexibility, making them particularly vulnerable to persistent self-critical and anxiety-provoking thought patterns. Consequently, cognitive fusion may amplify the emotional effects of perfectionism, FoMO, and digital dependency by increasing adolescents' tendency to internalize distressing cognitions and social evaluations.

The negative association between parent-child communication and adolescent anxiety also represents a highly important finding of the present study. Adolescents who reported healthier and more open communication with parents demonstrated significantly lower anxiety levels, highlighting the protective role of supportive family relationships. This finding is consistent with previous studies emphasizing that emotionally responsive parenting and supportive communication patterns contribute positively to adolescent emotional regulation, self-esteem, and resilience (Li, 2024). Conversely, dysfunctional communication characterized by criticism, overcontrol, emotional invalidation, or hyper-parenting may increase insecurity, perfectionistic concerns, and anxiety symptoms among adolescents (Journault et al., 2025). Family environments strongly influence adolescents' coping styles, emotional development, and sense of interpersonal safety. Adolescents who feel understood and emotionally supported by parents may possess greater confidence in managing social stressors and emotional difficulties. In contrast, adolescents exposed to excessive parental monitoring, unrealistic expectations, or emotionally distant communication may develop heightened anxiety and dependency on external validation. Previous findings have additionally shown that family triangulation and impaired differentiation processes contribute to problematic smartphone use and emotional insecurity (Kurşuncu, 2023). Moreover, attachment-related insecurity and loneliness have

been linked to psychological vulnerability among young people (G. & R., 2024). Thus, the present results reinforce the importance of family communication as a buffering factor against both technology-related and cognitive-emotional risk factors associated with adolescent anxiety.

5. Conclusion

An additional contribution of the current study involves the successful application of a Support Vector Machine model in predicting adolescent anxiety. The high classification accuracy, precision, recall, and AUC values obtained in the present study indicate that machine learning approaches may offer valuable tools for psychological screening and risk identification. Traditional statistical approaches often assume linear relationships among variables, whereas adolescent psychological functioning is shaped by complex and nonlinear interactions among cognitive, emotional, interpersonal, and technological influences. The strong performance of the Support Vector Machine model therefore suggests that machine learning methodologies may enhance the precision of mental health prediction within adolescent populations. These findings support broader trends emphasizing the integration of artificial intelligence techniques into psychological assessment and preventive mental health research (Lin & Guo, 2024). The present study additionally extends previous nomophobia and adolescent mental health research by integrating multiple psychosocial variables into a unified predictive framework rather than examining isolated associations (Derbich et al., 2024; Rahmah et al., 2024). Consequently, the findings provide further evidence that adolescent anxiety should be conceptualized as a multidimensional phenomenon emerging from interactions among digital behavior, maladaptive cognition, perfectionistic tendencies, and family relational dynamics.

6. Limitations & Suggestions

One limitation of the present study is the cross-sectional design, which prevents causal interpretations regarding the relationships among nomophobia, FoMO, perfectionism, cognitive fusion, parent-child communication, and adolescent anxiety. Although the Support Vector Machine model demonstrated strong predictive performance, longitudinal investigations are necessary to determine how these variables interact over time and contribute to the development or maintenance of anxiety symptoms. Another limitation involves the use of self-report questionnaires,

which may be influenced by response bias, social desirability, and subjective interpretation. Additionally, the sample was limited to Tunisian secondary school students, which may restrict the generalizability of the findings to adolescents from other cultural or socioeconomic contexts. Furthermore, variables such as depression, academic burnout, cyberbullying exposure, and personality traits were not included in the predictive model and may also influence adolescent anxiety outcomes.

Future research should employ longitudinal and multi-wave designs to examine developmental changes in anxiety vulnerability and digital dependency across adolescence. Researchers are encouraged to investigate additional psychological and contextual variables including emotional regulation, self-esteem, sleep quality, cybervictimization, attachment insecurity, and peer relationship quality in order to develop more comprehensive predictive models. Comparative cross-cultural studies would also be valuable for examining whether the relationships identified in the present study differ across societies with varying technological practices, parenting norms, and educational systems. Moreover, future investigations could compare different machine learning algorithms such as Random Forest, XGBoost, Deep Neural Networks, and ensemble learning models in order to identify the most accurate predictive approaches for adolescent mental health classification.

The findings of the present study have important practical implications for schools, families, clinicians, and policymakers. Educational institutions should develop psychoeducational programs aimed at increasing adolescents' awareness regarding healthy smartphone use, emotional regulation, perfectionistic thinking, and social media-related stress. School counselors and mental health professionals may benefit from incorporating interventions targeting cognitive fusion, maladaptive perfectionism, and FoMO-related anxiety into preventive and therapeutic programs. Parents should also be educated regarding the importance of supportive communication, emotional validation, and balanced digital monitoring practices in promoting adolescent psychological wellbeing. Furthermore, the successful implementation of the Support Vector Machine model suggests that machine learning-based screening tools may eventually assist schools and mental health services in identifying adolescents at elevated risk for anxiety and providing early intervention before symptoms become more severe and persistent.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

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

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this article.

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