

Random Forest Prediction of Adolescent Risk-Taking Behaviors Based on Sensation Seeking, Online Disinhibition, Emotional Impulsivity, Peer Deviance, and Executive Dysfunction

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ABSTRACT

Objective: The present study aimed to predict adolescent risk-taking behaviors using a Random Forest machine learning model based on sensation seeking, online disinhibition, emotional impulsivity, peer deviance, and executive dysfunction among adolescents in Argentina.

Methods and Materials: The study employed a cross-sectional predictive-correlational design with a machine learning framework. The statistical population consisted of Argentine adolescents enrolled in secondary schools in Buenos Aires, Córdoba, and Rosario during the 2025–2026 academic year. Using multistage cluster sampling, 1,284 adolescents aged 14 to 18 years were selected. Data were collected using the Adolescent Risk-Taking Questionnaire, Brief Sensation Seeking Scale, Online Disinhibition Scale, UPPS-P Negative Urgency Subscale, Peer Deviance Scale, and the Behavior Rating Inventory of Executive Function. Preliminary statistical analyses were conducted using SPSS-28, while the Random Forest predictive model was implemented in Python using the Scikit-learn library. Data were divided into training and testing subsets using an 80/20 split procedure. Model performance was evaluated through accuracy, precision, recall, F1-score, area under the curve (AUC), cross-validation scores, and SHAP feature-importance analyses.

Findings: The findings demonstrated significant positive correlations among all study variables. Peer deviance showed the strongest positive association with adolescent risk-taking behaviors, followed by emotional impulsivity and executive dysfunction. The Random Forest model demonstrated strong predictive performance, with testing accuracy of 0.87 and AUC of 0.90, indicating excellent classification capability. Feature importance analysis revealed that peer deviance was the most influential predictor, followed respectively by emotional impulsivity, executive dysfunction, online disinhibition, and sensation seeking. SHAP analyses further indicated substantial interaction effects among emotional, cognitive, and social variables in predicting adolescent risk-taking behaviors.

Conclusion: The findings suggest that adolescent risk-taking behaviors emerge through complex interactions among emotional dysregulation, cognitive-control deficits, peer-related influences, and digital behavioral tendencies. The strong performance of the Random Forest model highlights the usefulness of machine learning approaches for identifying high-risk adolescents and understanding

multidimensional psychosocial predictors of maladaptive behaviors. Early prevention efforts targeting emotional impulsivity, executive dysfunction, peer deviance, and online disinhibition may contribute significantly to reducing behavioral risk among adolescents.

Keywords: *Adolescent Risk-Taking, Random Forest, Emotional Impulsivity, Online Disinhibition, Peer Deviance, Executive Dysfunction, Sensation Seeking, Machine Learning, Adolescents, Behavioral Prediction*

1. Introduction

Adolescence represents one of the most developmentally sensitive stages of human life, characterized by profound neurobiological, emotional, cognitive, and social transformations that collectively increase vulnerability to risky and maladaptive behaviors. During this period, individuals frequently exhibit heightened tendencies toward sensation seeking, novelty exploration, emotional reactivity, and peer-oriented decision-making, all of which contribute to elevated rates of behavioral experimentation and risk-taking. Contemporary psychological and neuroscientific research has increasingly emphasized that adolescent risk-taking is not merely a product of poor judgment or immaturity, but rather the consequence of dynamic interactions among emotional dysregulation, neurocognitive development, environmental reinforcement, and personality-based vulnerabilities (Mazza et al., 2025). Risk-taking behaviors in adolescence include a broad spectrum of maladaptive activities such as reckless driving, substance experimentation, cyberdeviance, aggression, delinquency, unsafe internet practices, and antisocial conduct, many of which may produce enduring psychosocial consequences extending into adulthood. Recent systematic investigations have further demonstrated that modern forms of adolescent risk-taking are increasingly intertwined with digital environments, online socialization processes, and technologically mediated impulsive behavior patterns (María del Mar Simón et al., 2025). The rapid expansion of social networking platforms, online gaming ecosystems, and virtual peer communities has transformed the behavioral ecology of adolescents, creating new opportunities for impulsive decision-making, disinhibited communication, and exposure to deviant peer influences. Consequently, identifying the multidimensional predictors of adolescent risk-taking has become a major priority within clinical psychology, developmental psychopathology, behavioral neuroscience, and public mental health research.

Among the psychological constructs most consistently associated with adolescent risk-taking is sensation seeking, which refers to the tendency to pursue novel, intense, complex, and stimulating experiences despite potential negative consequences. Sensation seeking has repeatedly

been linked to impulsive behaviors, internet addiction, aggression, and risky social experimentation among adolescents and young adults (Li et al., 2023). Research has shown that adolescents characterized by elevated sensation-seeking traits are more likely to engage in dangerous online activities, substance use, reckless social behaviors, and deviance-oriented peer interactions (Siraj et al., 2021). Sensation seeking also appears to interact strongly with irritability, emotional instability, and reward sensitivity processes, suggesting that highly sensation-seeking adolescents may display impaired behavioral inhibition under emotionally stimulating conditions (Shaji et al., 2023). Furthermore, recent investigations into technology-related behavioral patterns have demonstrated significant associations between impulsive sensation seeking and nomophobia, compulsive smartphone use, and maladaptive digital engagement (El-Ashry et al., 2024). These findings support the notion that sensation seeking constitutes a critical psychological vulnerability factor within contemporary digital environments where immediate stimulation and reward accessibility are pervasive. At the neuropsychological level, sensation seeking has also been associated with altered reward processing mechanisms and impulsive cognitive styles, reinforcing its role as a central predictor of adolescent behavioral dysregulation (Kim, 2025).

Another major construct implicated in adolescent risk-taking involves online disinhibition and digital behavioral impulsivity. The online disinhibition effect refers to the reduction of behavioral restraint and self-monitoring that individuals experience during internet-mediated communication and interaction. Adolescents operating within anonymous or semi-anonymous digital contexts frequently display heightened impulsivity, aggression, deviant communication patterns, and reckless online engagement due to diminished social accountability and increased psychological distancing (Sharma et al., 2021). The emergence of cyberpsychopathy frameworks has further expanded understanding of how psychopathic tendencies, emotional coldness, impulsivity, manipulative behaviors, and antisocial traits may manifest within digital environments (Hudon et al., 2025). Studies examining cyber-aggression and digitally motivated deviance have

indicated that adolescents with higher levels of online disinhibition often exhibit greater involvement in cyberbullying, illegal online activities, antisocial digital communication, and technology-mediated aggression (DeMarsico et al., 2021). Social media environments have additionally been identified as important facilitators of deviance amplification, where peer reinforcement, social comparison, and algorithmic exposure to risky content increase susceptibility to maladaptive behavioral modeling (Cheng, 2023). Research on adolescent health-risk behaviors has similarly emphasized that digital media exposure can strengthen externalizing tendencies, impulsive responding, and risky experimentation patterns during adolescence (Jensen et al., 2022). These findings collectively suggest that online disinhibition represents an increasingly influential factor in contemporary adolescent risk-taking behavior.

Emotional impulsivity constitutes another central determinant of maladaptive adolescent behavior. Emotional impulsivity refers to the tendency to act rashly in response to intense affective states, particularly negative emotional experiences such as frustration, anxiety, anger, or sadness. Contemporary models of impulsivity distinguish emotional impulsivity from general trait impulsivity by emphasizing affect-driven failures in inhibitory control and emotional regulation (Joyner et al., 2021). Neuropsychological and electrophysiological studies have demonstrated that impulsive adolescents often display altered executive functioning, impaired emotional modulation, and dysregulated reward sensitivity processes (Kar et al., 2023). Emotional dysregulation has been strongly associated with risky behavior engagement, aggression, addictive tendencies, and externalizing psychopathology, particularly among adolescents experiencing elevated psychosocial stress or developmental vulnerabilities (Tan et al., 2023). Within addiction-related research, impulsivity has been identified as one of the strongest transdiagnostic mechanisms underlying compulsive behavioral patterns and maladaptive reward-seeking behaviors (Gullo et al., 2023). Recent therapeutic investigations have also shown that interventions targeting impulsivity and emotional dysregulation may substantially reduce maladaptive behavioral tendencies among high-risk populations (Cavicchioli et al., 2025). In addition, dimensional personality research has increasingly highlighted the relationship between disinhibition, emotional instability, and psychopathological vulnerability across both clinical and community populations (Lenzenweger et al., 2022). These findings indicate that emotional impulsivity is not only a

behavioral characteristic but also a core neuropsychological mechanism underlying adolescent maladaptive risk trajectories.

Peer deviance and antisocial socialization processes have similarly emerged as critical predictors of adolescent behavioral risk. Developmental theories consistently emphasize that adolescence is marked by increased reliance on peer acceptance, social validation, and group belonging, which substantially heightens susceptibility to deviant peer influence. Adolescents embedded within peer networks characterized by aggression, substance use, delinquency, or online deviance are significantly more likely to imitate and internalize maladaptive behaviors (Siraj et al., 2021). Contemporary research examining antisocial behavior among young adults has demonstrated that maladaptive beliefs, psychopathic traits, and social reinforcement mechanisms collectively contribute to elevated antisocial and deviant tendencies (Araújo et al., 2025). Studies on psychopathy-related personality structures further indicate that antisocial behavioral patterns are frequently associated with emotional detachment, deficient self-regulation, and maladaptive interpersonal functioning (Wallace et al., 2020). Childhood traumatic experiences, environmental adversity, and dysfunctional family environments may additionally intensify susceptibility to deviant peer affiliation and behavioral dysregulation (Moreira et al., 2022). Research involving children of alcoholic parents has similarly highlighted the role of adverse developmental experiences in shaping impulsive, emotionally unstable, and risk-oriented personality traits (Mansharamani et al., 2023). Psychopathic and disinhibitory personality traits have also been linked to maladaptive digital activities such as illegal downloading, unethical online behaviors, and deviant internet engagement (Satchell et al., 2021). Collectively, these findings suggest that peer deviance interacts dynamically with personality vulnerabilities and environmental influences in shaping adolescent risk-taking behaviors.

Executive dysfunction represents another highly relevant construct in understanding adolescent behavioral dysregulation. Executive functions encompass a range of higher-order cognitive processes including inhibitory control, planning, working memory, attentional regulation, cognitive flexibility, and self-monitoring. Deficits in these functions have consistently been associated with impulsive behavior, poor decision-making, emotional instability, and diminished behavioral regulation (Billen et al., 2022). Neurodevelopmental and brain-injury research has demonstrated that impaired executive functioning

contributes significantly to social disinhibition, impulsive aggression, and maladaptive behavioral outcomes (Skromanis et al., 2022). Studies involving traumatic brain injury populations have shown that disinhibition syndromes frequently emerge from disrupted frontal-lobe regulatory processes, resulting in reduced behavioral restraint and socially inappropriate actions (Hiraoka & Yagi, 2023). Evidence-based reviews of behavioral interventions for individuals with executive-function impairments further highlight the importance of self-regulation training and cognitive-behavioral approaches in reducing problematic behavior patterns (MacKenzie et al., 2024). Neuroscientific models of impulsivity have additionally demonstrated that executive dysfunction may reflect broader deficits in cognitive control systems associated with reward processing, emotional modulation, and inhibitory regulation (Tiego et al., 2022). Resting-state electrophysiological studies involving adolescent binge drinking populations have similarly shown that hyperconnectivity and deficient behavioral regulation may predispose adolescents to impulsive and risky behaviors (Antón-Toro et al., 2022). These findings collectively underscore the central role of executive dysfunction in adolescent maladaptive behavioral development.

In recent years, researchers have increasingly recognized that adolescent risk-taking behaviors emerge through highly complex and nonlinear interactions among emotional, cognitive, personality-based, and environmental variables. Traditional statistical models often struggle to capture the multidimensional and interactive nature of these relationships, particularly when variables display hierarchical, nonlinear, or synergistic effects. Consequently, machine learning methodologies have gained substantial attention within psychological and behavioral sciences due to their capacity to identify hidden patterns, optimize predictive accuracy, and model complex psychosocial interactions. Random Forest algorithms, in particular, have demonstrated strong utility in behavioral prediction because of their robustness against overfitting, flexibility in handling high-dimensional data, and ability to estimate variable importance within complex predictive systems (Karabatak, 2023). Precision-oriented approaches to impulsivity and behavioral dysregulation have further emphasized the need for multidimensional predictive frameworks capable of integrating neurocognitive, emotional, and environmental risk factors simultaneously (Rezapour et al., 2022). Moreover, contemporary psychological science increasingly conceptualizes personality pathology, disinhibition, and

maladaptive behavior as dimensional constructs rather than isolated diagnostic entities (Dargis et al., 2022). Trait disinhibition, impulsivity, psychopathic tendencies, antisocial behavior, and executive dysfunction appear to overlap substantially within broader self-regulatory vulnerability systems (Bertoldi et al., 2022). Despite growing interest in machine learning applications in behavioral sciences, relatively few studies have simultaneously examined sensation seeking, online disinhibition, emotional impulsivity, peer deviance, and executive dysfunction within a unified predictive model of adolescent risk-taking behavior. This gap is particularly important given the increasing digitalization of adolescent social life and the emergence of technology-mediated forms of impulsivity and deviance.

The present study therefore aimed to predict adolescent risk-taking behaviors using a Random Forest machine learning model based on sensation seeking, online disinhibition, emotional impulsivity, peer deviance, and executive dysfunction among Argentine adolescents.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a cross-sectional predictive-correlational design grounded in machine learning methodology to investigate the extent to which sensation seeking, online disinhibition, emotional impulsivity, peer deviance, and executive dysfunction could predict adolescent risk-taking behaviors. The study was conducted between September 2025 and February 2026 in urban and semi-urban regions of Buenos Aires, Córdoba, and Rosario in Argentina. The target population consisted of adolescents enrolled in public and private secondary schools. A multistage cluster sampling procedure was used to recruit participants from educational districts representing different socioeconomic backgrounds in order to maximize the heterogeneity of behavioral and psychosocial characteristics relevant to machine learning modeling. Initially, twelve secondary schools were randomly selected from official educational registries, after which classrooms were randomly chosen within each school. Students who met the inclusion criteria were invited to participate voluntarily.

The final sample consisted of 1,284 adolescents aged between 14 and 18 years, with a mean age of 16.12 years ($SD = 1.27$). Of the participants, 52.4% were female and 47.6% were male. Inclusion criteria included being enrolled in secondary education, having sufficient literacy to

complete self-report questionnaires, regular access to digital media and internet platforms, and parental consent for participants under the age of 18. Adolescents with diagnosed neurological disorders, severe cognitive impairments, psychotic-spectrum disorders, or incomplete questionnaire responses exceeding 15% of the survey content were excluded from the final analyses. Written informed consent was obtained from parents or legal guardians, and adolescents provided assent before participation. Participants were assured that their responses would remain anonymous and confidential and that they could withdraw from the study at any stage without penalty.

Data collection was carried out in classroom settings during regular school hours under the supervision of trained research assistants. Participants completed a battery of standardized psychological instruments in approximately 45 to 60 minutes. To reduce response bias and increase the reliability of responses, questionnaires were administered in randomized order across classrooms. In addition, a digital behavioral survey was integrated into the assessment process to capture online risk engagement patterns, including impulsive posting, participation in dangerous online challenges, exposure to deviant peer communities, and frequency of risky internet interactions. The collected data were subsequently coded and transferred into a secure encrypted database for preprocessing and machine learning analyses.

2.2. Measures

Risk-taking behaviors were assessed using the Adolescent Risk-Taking Questionnaire developed by Gullone et al. (2000). This instrument is one of the most widely used measures for evaluating engagement in behaviors associated with physical, social, legal, and health-related risks during adolescence. The questionnaire consists of 44 items rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The scale assesses several domains of adolescent risk-taking, including thrill-seeking activities, rebellious behavior, antisocial tendencies, unsafe internet use, and substance-related experimentation. Higher scores indicate greater engagement in risky behaviors. Previous studies conducted in multicultural adolescent populations have demonstrated strong psychometric properties for the scale, including acceptable construct validity and internal consistency coefficients ranging from 0.81 to 0.91. In the present study, Cronbach's alpha for the total scale was 0.89.

Sensation seeking was measured using the Brief Sensation Seeking Scale developed by Hoyle et al. (2002). This scale contains 8 items designed to assess the tendency to pursue novel, exciting, and stimulating experiences despite potential risks. Participants respond on a five-point Likert continuum ranging from strongly disagree to strongly agree. The instrument evaluates dimensions such as thrill and adventure seeking, boredom susceptibility, experience seeking, and disinhibition. Higher scores reflect elevated levels of sensation-seeking tendencies. Previous international studies involving adolescents and emerging adults have supported the factorial validity and reliability of the scale, with reported Cronbach's alpha coefficients generally above 0.80. In the present study, the internal consistency coefficient was 0.84.

Online disinhibition was assessed using the Online Disinhibition Scale developed by Udris (2014). The scale includes 11 items measuring impulsive and uninhibited behaviors in digital communication contexts. It assesses both benign and toxic forms of online disinhibition, including oversharing personal information, aggressive commenting, reckless online interactions, and reduced self-monitoring during internet use. Responses are scored on a five-point Likert scale ranging from never to always. Higher scores indicate greater online disinhibition tendencies. Previous research has demonstrated satisfactory convergent validity with problematic internet use and impulsivity measures, as well as internal consistency values exceeding 0.80. In this study, Cronbach's alpha was calculated at 0.86.

Emotional impulsivity was evaluated using the Negative Urgency subscale of the UPPS-P Impulsive Behavior Scale developed by Lynam et al. (2006). This subscale consists of 12 items that measure the tendency to act rashly under conditions of intense negative emotion. Participants rate statements on a four-point Likert scale ranging from agree strongly to disagree strongly. The measure captures emotional dysregulation associated with impulsive reactions, poor behavioral control during distress, and emotionally driven decision-making. Higher scores indicate stronger emotional impulsivity traits. Previous studies have established strong predictive validity for maladaptive behaviors including substance use, aggression, and risky decision-making among adolescents. In the current study, the subscale demonstrated excellent internal consistency with a Cronbach's alpha of 0.88.

Peer deviance was measured using the Peer Deviance Scale adapted from Dishion et al. (1991). This instrument assesses adolescents' exposure to peers who engage in

antisocial, delinquent, aggressive, or risky behaviors. The scale contains 15 items evaluating the frequency of peer involvement in behaviors such as substance use, school misconduct, vandalism, online harassment, and rule-breaking activities. Participants rate how many of their close friends engage in each behavior using a five-point response format. Higher scores represent greater affiliation with deviant peer networks. Prior studies have confirmed the predictive utility of the scale for adolescent conduct problems and risky behavioral trajectories. The reliability coefficient in the current sample was 0.87.

Executive dysfunction was assessed using the Behavior Rating Inventory of Executive Function–Self-Report Version developed by Guy et al. (2004). The instrument evaluates difficulties in executive processes including inhibitory control, emotional regulation, cognitive flexibility, planning, working memory, and self-monitoring. The self-report form used in this study consisted of 75 items rated on a three-point scale ranging from never to often. Higher scores indicate greater executive dysfunction. The instrument has demonstrated robust psychometric performance across adolescent populations and has frequently been used in studies examining behavioral dysregulation and impulsive behavior. In the current investigation, the total executive dysfunction index demonstrated a Cronbach’s alpha coefficient of 0.91.

2.3. Data Analysis

Data analysis was conducted using a combination of traditional statistical techniques and machine learning procedures. Preliminary analyses were performed using SPSS version 28 to examine missing values, descriptive statistics, skewness and kurtosis indices, multicollinearity, and reliability coefficients for all variables. Cases with excessive missing data were excluded, while remaining missing values were handled using expectation-maximization imputation procedures. Outliers were identified through Mahalanobis distance statistics and standardized residual inspection. All continuous variables were standardized prior to machine learning implementation in order to optimize algorithmic performance and reduce scaling bias.

The primary predictive model in this study was based on the Random Forest algorithm, implemented in Python using the Scikit-learn library. Random Forest was selected because of its high predictive accuracy, robustness against overfitting, ability to model nonlinear relationships, and

suitability for high-dimensional psychosocial datasets. The dataset was randomly divided into training and testing subsets using an 80/20 split procedure. The training dataset was used to construct and optimize the predictive model, while the testing dataset was reserved for evaluating generalization performance. Hyperparameter tuning was performed using grid search optimization combined with five-fold cross-validation procedures to identify the optimal number of decision trees, maximum tree depth, minimum samples per split, and feature selection thresholds.

Model performance was evaluated using multiple predictive metrics including accuracy, precision, recall, F1-score, area under the receiver operating characteristic curve (AUC), and confusion matrix indices. Feature importance analysis was subsequently conducted to determine the relative contribution of sensation seeking, online disinhibition, emotional impulsivity, peer deviance, and executive dysfunction to the prediction of adolescent risk-taking behaviors. To improve interpretability, Shapley Additive Explanations (SHAP) values were additionally calculated to identify the directional influence and interaction effects of predictor variables within the Random Forest model. Internal validation procedures indicated stable predictive performance across cross-validation folds, supporting the robustness and reproducibility of the machine learning framework used in the study.

3. Findings and Results

A total of 1,284 adolescents participated in the present study. Among the participants, 673 (52.4%) were female and 611 (47.6%) were male. The age of the participants ranged from 14 to 18 years, with a mean age of 16.12 years ($SD = 1.27$). Regarding educational level, 31.8% of the participants were enrolled in the first stage of secondary education, 35.6% in the second stage, and 32.6% in the final stage of high school. Approximately 58.9% of the adolescents attended public schools, whereas 41.1% attended private institutions. In terms of residential status, 69.7% lived in urban metropolitan regions and 30.3% resided in semi-urban areas. Descriptive screening analyses indicated that all variables were normally distributed within acceptable statistical ranges, with skewness values ranging from -1.08 to 1.14 and kurtosis values ranging from -0.92 to 1.21. Examination of multicollinearity showed no severe violations, as tolerance values exceeded 0.40 and variance inflation factor values remained below 3.50 for all predictor variables. Reliability analyses further demonstrated strong

internal consistency across all measures, with Cronbach’s alpha coefficients ranging from 0.84 to 0.91.

Table 1

Descriptive Statistics and Correlations Among Study Variables

Variables	Mean	SD	1	2	3	4	5	6
1. Risk-Taking Behaviors	96.42	18.73	1					
2. Sensation Seeking	27.15	5.94	0.61**	1				
3. Online Disinhibition	31.27	7.18	0.58**	0.49**	1			
4. Emotional Impulsivity	34.84	8.02	0.66**	0.53**	0.55**	1		
5. Peer Deviance	29.73	6.81	0.71**	0.57**	0.60**	0.63**	1	
6. Executive Dysfunction	83.91	14.66	0.64**	0.46**	0.51**	0.68**	0.59**	1

The descriptive and correlational findings demonstrated statistically significant positive associations among all study variables. Adolescent risk-taking behaviors showed the strongest correlation with peer deviance ($r = 0.71, p < .01$), indicating that adolescents embedded within deviant peer environments reported substantially greater involvement in risky and maladaptive behaviors. Emotional impulsivity also demonstrated a strong positive relationship with risk-taking behaviors ($r = 0.66, p < .01$), suggesting that adolescents who experienced difficulties regulating emotionally driven impulses were more likely to engage in unsafe and reckless actions. Executive dysfunction displayed a similarly elevated correlation with risk-taking behaviors ($r = 0.64, p < .01$), reflecting the central role of impaired inhibitory

control, deficient planning abilities, and weakened self-monitoring processes in adolescent behavioral dysregulation. Sensation seeking and online disinhibition were also positively and significantly associated with risk-taking tendencies, indicating that adolescents with heightened novelty-seeking dispositions and reduced online behavioral restraint exhibited increased vulnerability to risky activities across both digital and real-world environments. The moderate-to-strong intercorrelations among predictor variables further highlighted the multidimensional nature of adolescent risk-taking and supported the appropriateness of machine learning approaches capable of modeling nonlinear and interacting psychosocial influences.

Table 2

Random Forest Model Performance Indicators for Predicting Adolescent Risk-Taking Behaviors

Performance Metric	Training Set	Testing Set
Accuracy	0.91	0.87
Precision	0.89	0.85
Recall	0.90	0.86
F1-Score	0.89	0.85
AUC	0.94	0.90
Mean Squared Error	0.13	0.18
Cross-Validation Score	0.88	0.86

The Random Forest predictive model demonstrated strong and stable classification performance across both training and testing datasets. The model achieved an accuracy of 91% in the training phase and maintained a high predictive accuracy of 87% in the testing phase, indicating satisfactory generalizability and minimal overfitting. Precision and recall indices also remained consistently elevated across datasets, suggesting that the model effectively distinguished adolescents with high-risk behavioral profiles from those with lower levels of risk

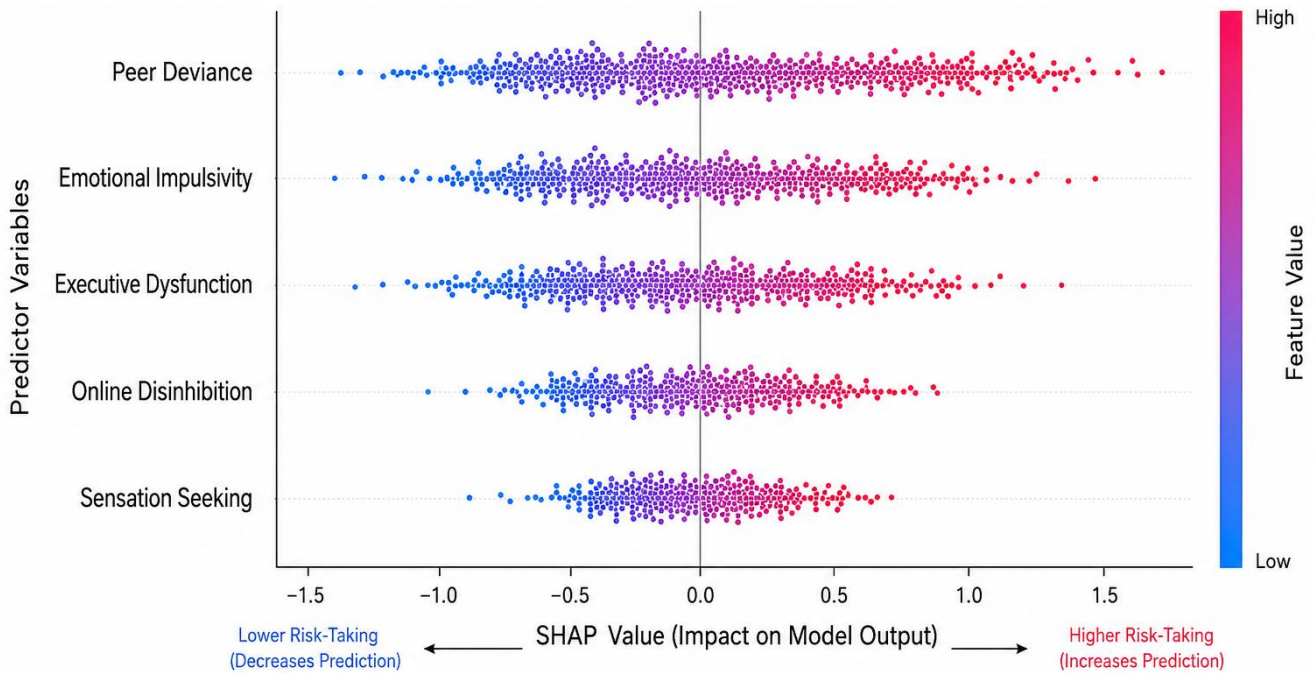
engagement. The area under the receiver operating characteristic curve reached 0.94 in the training dataset and 0.90 in the testing dataset, reflecting excellent discriminatory power and robust classification sensitivity. Furthermore, the low mean squared error values suggested that the predicted outputs closely approximated observed behavioral outcomes. Cross-validation analyses additionally confirmed the stability and reproducibility of the machine learning model across multiple subsamples, supporting the reliability of the Random Forest approach for identifying

complex psychosocial patterns underlying adolescent risk-taking behaviors. These findings collectively demonstrated that the combination of sensation seeking, online disinhibition, emotional impulsivity, peer deviance, and

executive dysfunction provided a highly effective predictive framework for understanding behavioral risk trajectories during adolescence.

Figure 1

SHAP Summary Plot Demonstrating the Relative Contribution of Predictor Variables to Adolescent Risk-Taking Behaviors



Note. Each point represents one adolescent. The position on the x-axis indicates the direction and magnitude of impact on predicted risk-taking behaviors. Colors represent the original feature value (blue = low, red = high).

The SHAP analysis revealed that peer deviance emerged as the most influential predictor of adolescent risk-taking behaviors within the Random Forest model, followed by emotional impulsivity and executive dysfunction. Adolescents reporting higher exposure to deviant peer groups exhibited markedly greater probabilities of engaging in high-risk behaviors, highlighting the powerful social reinforcement mechanisms associated with peer-based behavioral contagion during adolescence. Emotional impulsivity represented the second most influential variable, indicating that emotionally driven rash action substantially increased vulnerability to unsafe behaviors, particularly under conditions of distress or emotional instability. Executive dysfunction also exerted a substantial predictive influence, demonstrating that impaired inhibitory control

and planning capacities contributed significantly to maladaptive decision-making processes. Online disinhibition showed moderate but meaningful predictive power, particularly among adolescents characterized by elevated digital engagement and impulsive online communication patterns. Sensation seeking contributed positively to model predictions as well, although its relative influence was somewhat lower compared to peer and emotional-regulation variables. The SHAP distribution further indicated substantial interaction effects among predictors, suggesting that adolescents with simultaneous elevations in emotional impulsivity, executive dysfunction, and peer deviance represented the highest-risk subgroup within the dataset.

Table 3

Feature Importance Values in the Random Forest Prediction Model

Predictor Variables	Importance Score
Peer Deviance	0.31
Emotional Impulsivity	0.25
Executive Dysfunction	0.21
Online Disinhibition	0.14
Sensation Seeking	0.09

The feature importance analysis provided additional support for the central role of social and emotional dysregulation variables in predicting adolescent risk-taking behaviors. Peer deviance accounted for the largest proportion of predictive variance within the Random Forest model, reinforcing the proposition that affiliation with deviant peer networks constitutes one of the strongest contextual influences on adolescent behavioral outcomes. Emotional impulsivity emerged as the second most influential predictor, emphasizing the importance of affect-driven self-regulatory deficits in the development of risky and potentially harmful behaviors. Executive dysfunction also demonstrated substantial predictive weight, further supporting neuropsychological models suggesting that deficits in executive control mechanisms contribute to impaired behavioral inhibition and poor decision-making during adolescence. Online disinhibition displayed moderate predictive influence, indicating that adolescents who experience diminished behavioral restraint within digital environments may generalize impulsive tendencies across broader social and behavioral contexts. Sensation seeking, while statistically significant and positively associated with risk-taking, demonstrated the lowest relative importance within the model, suggesting that novelty-seeking tendencies alone may not fully account for the emergence of high-risk behavioral patterns unless accompanied by emotional dysregulation, cognitive-control impairments, or exposure to deviant social influences. Collectively, these findings highlighted the multifactorial and interactive structure of adolescent risk-taking behaviors and demonstrated the utility of machine learning methodologies for identifying the hierarchical contribution of psychosocial risk factors.

4. Discussion

The present study aimed to predict adolescent risk-taking behaviors using a Random Forest machine learning model based on sensation seeking, online disinhibition, emotional impulsivity, peer deviance, and executive dysfunction among adolescents in Argentina. The findings demonstrated that the proposed machine learning framework achieved

strong predictive performance across training and testing datasets, indicating that these psychosocial and neurocognitive variables collectively provide a robust explanatory structure for understanding adolescent behavioral risk. The results further revealed that peer deviance emerged as the strongest predictor of adolescent risk-taking behaviors, followed by emotional impulsivity, executive dysfunction, online disinhibition, and sensation seeking. The correlational analyses additionally demonstrated significant positive associations among all study variables, reinforcing the proposition that adolescent risk-taking behaviors arise through multidimensional interactions involving emotional dysregulation, social influence, impulsive cognition, and impaired behavioral control.

One of the most important findings of the study was the dominant predictive role of peer deviance in adolescent risk-taking behaviors. Adolescents who reported stronger affiliation with deviant peer groups demonstrated substantially higher levels of risky and maladaptive behaviors. This finding is highly consistent with developmental and social learning theories suggesting that peer groups become increasingly influential during adolescence due to heightened sensitivity to social acceptance, belongingness, and interpersonal reinforcement. The result aligns closely with the findings of (Siraj et al., 2021), who demonstrated that peer influence significantly predicts adolescent engagement in risky behaviors and amplifies impulsive decision-making tendencies. Similarly, the findings correspond with the work of (Araújo et al., 2025), who reported that antisocial behavior patterns among young adults are strongly associated with maladaptive beliefs and deviant interpersonal environments. The present findings may also be interpreted through the lens of digital peer contagion processes, whereby adolescents are increasingly exposed to deviant behavioral norms through online communities and social media platforms. Research conducted by (Cheng, 2023) emphasized that digital media environments facilitate the spread of deviance and socially reinforced maladaptive behavior, particularly among psychologically vulnerable adolescents. Moreover, the role of peer deviance in the present study supports broader

psychopathy-oriented perspectives suggesting that antisocial tendencies frequently emerge through interactions between personality vulnerabilities and reinforcing social contexts (Wallace et al., 2020). These findings collectively suggest that adolescent risk-taking is not solely an individual psychological phenomenon but also a socially embedded behavioral process shaped by peer dynamics and interpersonal modeling.

Another major finding of the study involved the strong predictive role of emotional impulsivity. Adolescents characterized by elevated emotional impulsivity demonstrated significantly greater involvement in risk-taking behaviors, indicating that affect-driven failures in self-regulation substantially contribute to maladaptive adolescent outcomes. This finding is highly consistent with the growing literature conceptualizing emotional impulsivity as a transdiagnostic mechanism underlying externalizing psychopathology, addiction vulnerability, and behavioral dysregulation. The result aligns with the theoretical distinction proposed by (Joyner et al., 2021), who emphasized that emotional disinhibition differs from general impulsivity because it specifically reflects deficits in emotional control under conditions of psychological distress. The findings also correspond with neuroscientific investigations indicating that impulsive individuals often display altered inhibitory processing and dysfunctional emotional modulation systems (Kar et al., 2023). In addition, studies focusing on emotional dysregulation have consistently shown that emotionally reactive adolescents are more likely to engage in substance use, aggression, reckless online behavior, and unsafe decision-making (Tan et al., 2023). The strong predictive influence of emotional impulsivity observed in the present study may also reflect impaired reward sensitivity and diminished tolerance for emotional discomfort, processes frequently implicated in addiction and compulsive behavior research (Gullo et al., 2023). Furthermore, therapeutic investigations conducted by (Cavicchioli et al., 2025) demonstrated that interventions targeting impulsivity and emotional dysregulation can effectively reduce maladaptive behavioral tendencies, further reinforcing the central role of emotional impulsivity in behavioral risk trajectories.

The findings also demonstrated that executive dysfunction significantly predicted adolescent risk-taking behaviors. Adolescents experiencing difficulties in inhibitory control, cognitive flexibility, emotional regulation, and planning abilities exhibited greater behavioral dysregulation and engagement in risky activities.

This finding supports neurodevelopmental theories emphasizing that adolescent behavioral instability is partially attributable to incomplete maturation of executive-control systems and prefrontal regulatory mechanisms. The result is highly consistent with studies demonstrating that impaired self-regulation contributes substantially to impulsive and antisocial behavior patterns (Billen et al., 2022). Likewise, the findings align with research conducted by (Skromanis et al., 2022), who identified social disinhibition and executive dysfunction as core components of maladaptive behavioral regulation. Neuropsychological evidence presented by (Hiraoka & Yagi, 2023) additionally demonstrated that disinhibited behavioral syndromes often emerge from disruptions in inhibitory control systems, leading to impulsive and socially inappropriate actions. The present findings further correspond with electrophysiological investigations by (Antón-Toro et al., 2022), who reported that adolescents displaying poorer behavioral regulation exhibited increased vulnerability to maladaptive substance-related behaviors. Moreover, neuroscience-informed models of impulsivity emphasize that executive dysfunction interacts dynamically with emotional instability and reward sensitivity processes, thereby intensifying risk-taking behaviors under emotionally stimulating conditions (Tiego et al., 2022). The present findings therefore reinforce the importance of executive-control deficits as foundational mechanisms underlying adolescent behavioral risk.

Online disinhibition also emerged as a meaningful predictor of adolescent risk-taking behaviors in the present study. Adolescents with higher levels of online disinhibition demonstrated increased vulnerability to impulsive, risky, and maladaptive behaviors across both digital and offline contexts. This finding reflects the increasingly important role of digital environments in shaping adolescent behavioral development. Contemporary adolescents spend substantial portions of their daily lives within technologically mediated social spaces where anonymity, reduced accountability, and social reinforcement may weaken behavioral restraint. The findings align closely with the work of (Sharma et al., 2021), who reported that deviant cyberspace use among adolescents is strongly associated with impulsive and maladaptive behavioral tendencies. Similarly, (DeMarsico et al., 2021) found that digital aggression and online deviance are frequently driven by motivational processes involving reduced self-monitoring and heightened impulsivity. The findings additionally support the cyberpsychopathy framework proposed by

(Hudon et al., 2025), which conceptualizes digital environments as contexts capable of amplifying psychopathic and antisocial personality traits. Furthermore, the results are consistent with research indicating that excessive social networking engagement and internet addiction are significantly associated with impulsive personality profiles and maladaptive psychosocial functioning (Peris et al., 2020). Studies by (Jensen et al., 2022) also demonstrated that digital media exposure contributes to adolescent externalizing behaviors and health-risk activities. The predictive role of online disinhibition observed in this study therefore highlights the need to conceptualize adolescent risk-taking within broader digital and cyberpsychological frameworks.

Although sensation seeking demonstrated the lowest relative feature importance within the Random Forest model, it remained a statistically significant predictor of adolescent risk-taking behaviors. Adolescents with elevated sensation-seeking tendencies reported greater involvement in risky and impulsive activities, supporting prior evidence linking novelty-seeking traits to maladaptive behavioral experimentation. This finding is consistent with studies showing that sensation seeking contributes to internet addiction, impulsive online engagement, and externalizing behavior among adolescents (Li et al., 2023). The result also aligns with the findings of (Shaji et al., 2023), who reported that sensation seeking is positively associated with irritability and behavioral instability among young populations. Furthermore, technology-oriented investigations have shown that impulsive sensation-seeking tendencies frequently co-occur with compulsive smartphone use and digital dependency behaviors (El-Ashry et al., 2024). The relatively lower predictive weight of sensation seeking in comparison to emotional impulsivity and peer deviance may indicate that novelty-seeking tendencies alone are insufficient to produce maladaptive behavioral outcomes unless combined with emotional dysregulation, deficient executive control, or reinforcing social environments. This interpretation is consistent with multidimensional models of personality pathology emphasizing that impulsive and antisocial behaviors emerge through interactions among personality traits, neurocognitive vulnerabilities, and environmental risk factors (Lenzenweger et al., 2022). In addition, studies examining psychopathic and disinhibitory personality structures suggest that sensation seeking often operates within broader behavioral systems involving impulsivity, emotional instability, and antisocial tendencies (Bertoldi et al., 2022).

5. Conclusion

The strong predictive performance of the Random Forest model further demonstrates the utility of machine learning approaches in psychological and behavioral research. Traditional statistical techniques often struggle to capture nonlinear relationships and complex interactions among psychosocial variables, whereas machine learning algorithms are specifically designed to detect multidimensional predictive structures. The high classification accuracy and stability observed in the present study suggest that machine learning models may provide important methodological advantages for identifying adolescents at elevated behavioral risk. These findings support contemporary perspectives advocating for precision-oriented and neuroscience-informed approaches to behavioral assessment and prevention (Rezapour et al., 2022). Furthermore, machine learning methodologies may facilitate earlier identification of high-risk adolescents by integrating emotional, cognitive, social, and digital-behavioral indicators into unified predictive systems. Such approaches are particularly important given the increasing complexity of adolescent behavioral environments and the growing influence of digital technologies on psychosocial development.

6. Limitations & Suggestions

One limitation of the present study involves its cross-sectional design, which restricts the ability to establish causal relationships among study variables. Although the machine learning model demonstrated strong predictive performance, it cannot determine the temporal directionality of the relationships between impulsivity, peer deviance, executive dysfunction, and risk-taking behaviors. Another limitation concerns reliance on self-report measures, which may have increased vulnerability to social desirability bias, inaccurate recall, or response distortion. Additionally, the study sample was restricted to adolescents from selected regions of Argentina, which may limit the generalizability of the findings to adolescents from different cultural, socioeconomic, or educational contexts. The study also focused primarily on psychosocial and neurocognitive predictors without incorporating biological, genetic, or family-system variables that may further contribute to adolescent behavioral risk.

Future research should employ longitudinal and developmental designs to examine the causal and temporal relationships among sensation seeking, emotional

impulsivity, executive dysfunction, peer deviance, and adolescent risk-taking behaviors. Researchers should also investigate whether these predictors operate differently across genders, developmental stages, or cultural contexts. Future studies may benefit from incorporating neurobiological indicators, behavioral tasks, ecological momentary assessment methods, and digital behavioral tracking technologies to improve predictive precision. Moreover, integrating deep learning and multimodal machine learning approaches may help identify hidden interaction patterns among emotional, cognitive, social, and environmental risk variables. Comparative studies examining offline and online forms of adolescent risk-taking would also provide valuable insight into the increasingly digitalized nature of behavioral dysregulation among youth populations.

The findings of the present study have important practical implications for educators, clinicians, school psychologists, policymakers, and mental health professionals working with adolescents. Prevention and intervention programs should prioritize emotional regulation training, executive-function enhancement, peer-resistance skills, and digital self-regulation strategies in order to reduce adolescent vulnerability to risky behaviors. School-based prevention initiatives may particularly benefit from integrating social-emotional learning programs with digital literacy education and impulse-control training. Early screening procedures targeting emotional impulsivity, peer deviance, and executive dysfunction could also assist schools and healthcare systems in identifying adolescents who may require additional psychosocial support. In addition, parents and educators should receive training regarding the impact of online disinhibition and digital peer influence on adolescent behavioral development. Machine learning frameworks similar to those used in the present study may ultimately contribute to the development of more personalized and data-driven prevention systems capable of identifying high-risk adolescents before maladaptive behavioral trajectories become deeply established.

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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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