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Application of Artificial Intelligence Models to Explore the Optimal Structural/Predictive Model of Gender Transition Request Based on Childhood Trauma

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A B S T R A C T

Purpose: This study aimed to develop and evaluate an integrative structural–predictive model combining structural equation modeling and artificial intelligence to identify key trauma-related and psychosocial predictors of requests for gender transition among Iranian adolescent girls.

Methods and Materials: The study employed a descriptive–analytical, causal–comparative design with a sample of 300 adolescent girls aged 13–18 years (150 requesting gender transition and 150 controls) recruited in Tehran. Standardized measures of childhood trauma, general mental health, psychosocial functioning, and perceived stress were administered. Structural equation modeling was conducted using AMOS to test hypothesized causal pathways, followed by training and evaluation of decision tree, random forest, support vector machine, and fuzzy neural network models using Python.

Findings: Structural equation modeling demonstrated significant direct and indirect effects of childhood trauma on psychological disorders, mediated by psychosocial factors and perceived stress ($p < 0.001$), with high explained variance for mental health outcomes. Among artificial intelligence models, the hybrid fuzzy neural network achieved the highest performance (accuracy = 95.6%, sensitivity = 97.8%, AUC–ROC = 0.98), significantly outperforming logistic regression and standalone models. Interpretability analyses identified sexual abuse and depression as the strongest predictors contributing to model decisions.

Conclusion: The findings support a trauma-informed, stress-based conceptualization of gender dysphoria in adolescent girls and demonstrate that integrating theory-driven structural modeling with artificial intelligence yields both high predictive accuracy and clinical interpretability, offering a robust framework for early identification and intervention.

Keywords: *Gender dysphoria; Childhood trauma; Artificial intelligence; Fuzzy neural network; Adolescent girls; Sexual abuse*

1. Introduction

Gender dysphoria in children and adolescents has increasingly attracted the attention of clinicians, researchers, and policymakers due to its growing prevalence and its profound psychological, social, and clinical implications. Conceptually, gender dysphoria refers to a marked and persistent incongruence between an individual's experienced or expressed gender and the gender assigned at birth, accompanied by clinically significant distress or impairment in functioning (Garg et al., 2023; Zucker, 2017). While early research largely framed gender dysphoria as a rare and primarily developmental phenomenon, contemporary epidemiological evidence suggests a notable increase in referrals and diagnoses among adolescents, particularly in natal females, across several regions of the world (Jarvis et al., 2025; Khosravi et al., 2025). This shift has raised critical questions regarding underlying psychosocial, developmental, and environmental mechanisms that may contribute to the emergence and intensification of gender-related distress during adolescence.

From a public mental health perspective, gender dysphoria in youth cannot be examined in isolation from broader patterns of psychological vulnerability among sexual and gender minority populations. A growing body of systematic and meta-analytic evidence indicates that sexual and gender minority adolescents experience substantially higher rates of depression, anxiety, self-harm, and suicidality compared to their cisgender peers (Lombardi et al., 2002; O'Shea et al., 2025). These disparities are not solely attributable to identity-related distress but are strongly shaped by cumulative exposure to minority stressors, interpersonal violence, and early-life adversities. In this context, understanding gender dysphoria as part of a broader constellation of stress-related psychopathology provides a more integrative and clinically meaningful framework than purely identity-based explanations.

Childhood trauma has emerged as one of the most robust and consistently reported correlates of adverse mental health outcomes in adolescence and adulthood. Adverse childhood experiences, including emotional abuse, physical abuse, sexual abuse, and neglect, exert long-lasting effects on emotional regulation, stress responsivity, identity formation, and interpersonal functioning (Colich et al., 2020; Farjami et al., 2024). Importantly, recent research suggests that such experiences are disproportionately prevalent among individuals with gender dysphoria and transgender identities (Arena et al., 2025; Biedermann et al., 2021). Sexual abuse, in particular, has been repeatedly identified as a salient predictor of later psychological distress, body-related dissatisfaction, and identity confusion, especially among adolescent girls (Bojun & Kyei, 2025; Çavuş Uysal et al., 2024). These findings underscore the necessity of situating gender dysphoria within a trauma-informed developmental framework.

Theoretical models have increasingly emphasized the role of chronic stress processes in explaining the mental health vulnerabilities observed in gender-diverse youth. The chronic stress model posits that repeated exposure to stressors—whether interpersonal, environmental, or internalized—leads to sustained dysregulation of neurobiological and psychological systems, thereby increasing susceptibility to depression, anxiety, and maladaptive coping behaviors (Mason et al., 2023). When applied to gender dysphoria, this model suggests that early-life trauma, compounded by ongoing psychosocial stressors, may intensify distress related to gender incongruence rather than merely co-occur with it. Complementary to this perspective, insecure attachment theory highlights how disruptions in early caregiving relationships may impair identity consolidation, emotion regulation, and the development of a stable sense of self, particularly during adolescence (Jarvis et al., 2025; Sharifi, 2007). Together, these frameworks provide a coherent theoretical basis for examining the pathways linking childhood trauma, psychosocial dysfunction, and gender dysphoria.

Adolescence represents a critical developmental window in which identity formation, bodily changes, and social role expectations intersect. For adolescent girls, this period is further complicated by pubertal transitions and heightened vulnerability to internalizing psychopathology (Colich et al., 2020; Haqani Zamidani et al., 2024). Empirical evidence suggests that early pubertal timing, body dissatisfaction, and trauma-related emotional reactivity may act as transdiagnostic mechanisms linking childhood adversity to later mental health problems (Colich et al., 2020; Daneshvar et al., 2025). Within this developmental context, gender dysphoria may emerge or intensify as a maladaptive response to unresolved trauma, emotional dysregulation, and negative self-referential processing, rather than as an isolated identity phenomenon.

Despite the growing literature on trauma and gender dysphoria, significant methodological limitations remain. Much of the existing research relies on bivariate analyses or descriptive comparisons, which are insufficient to capture the complex, multivariate relationships among childhood

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trauma, psychosocial mediators, and mental health outcomes (Arena et al., 2025; Çavuş Uysal et al., 2024). Moreover, studies conducted in non-Western contexts, particularly in Middle Eastern societies, remain scarce. In Iran, emerging epidemiological data indicate a distinctive pattern in which adolescent girls constitute a substantial proportion of individuals seeking gender transition-related services (Khosravi et al., 2025; Mohammadbagheri et al., 2020). This pattern highlights the urgent need for culturally grounded, theoretically informed, and methodologically robust models capable of explaining and predicting gender dysphoria within this population.

Recent advances in artificial intelligence (AI) and machine learning offer promising tools for addressing these methodological challenges. AI-based models have demonstrated substantial utility in mental health prediction, trauma triage, and risk stratification by identifying complex nonlinear patterns that traditional statistical approaches may overlook (Adebayo et al., 2023; Adler et al., 2022). In trauma and psychiatric research, machine learning techniques have been successfully applied to predict depressive symptoms, suicidality, and treatment outcomes using multidimensional data sources (Cascalheira et al., 2023; Peng et al., 2023). However, the application of AI to gender dysphoria research remains limited, and existing studies often lack strong theoretical grounding, raising concerns about interpretability and clinical relevance.

Integrative methodological frameworks that combine theory-driven statistical modeling with data-driven AI approaches may address these limitations. Structural Equation Modeling (SEM) allows for the explicit testing of theoretically specified causal pathways and mediating mechanisms, thereby enhancing explanatory validity (Daneshvar et al., 2025; Mason et al., 2023). When SEM-derived latent structures are subsequently used as inputs for machine learning models, the resulting hybrid approach can reduce data noise, improve predictive accuracy, and preserve interpretability—an essential requirement for clinical decision-making (Adebayo et al., 2023; Adler et al., 2022). Such integrative models are particularly well-suited for complex psychological phenomena like gender dysphoria, which are shaped by interacting biological, psychological, and social factors.

Within the Iranian sociocultural context, the integration of trauma theory, developmental psychology, and advanced analytical methods is especially critical. Cultural norms surrounding gender roles, family structure, and sexual victimization may influence both the prevalence of childhood trauma and the expression of gender-related distress (Ghazanfari et al., 2018; Haqani Zamidani et al., 2024). Family instability, parental loss, and limited social support have been identified as salient stressors among Iranian adolescents and are associated with elevated psychological distress (Mohammadbagheri et al., 2020; Sharifi, 2007). These contextual factors underscore the need for predictive models that are not only statistically robust but also culturally sensitive and clinically actionable.

Taken together, the existing literature points to a critical gap: the absence of comprehensive, integrative models capable of simultaneously explaining and predicting requests for gender transition among adolescent girls based on childhood trauma and psychosocial mechanisms, particularly within non-Western contexts. Addressing this gap requires moving beyond descriptive diagnosis toward predictive, evidence-based frameworks that can inform early identification, targeted intervention, and preventive mental health strategies (Arena et al., 2025; O'Shea et al., 2025).

Accordingly, the aim of the present study is to develop and evaluate an integrative structural–predictive model combining structural equation modeling and artificial intelligence techniques to identify the key trauma-related and psychosocial predictors of requests for gender transition among Iranian adolescent girls.

2. Methods and Materials

2.1. Study Design and Participants

This study is a descriptive–analytical investigation based on a causal–comparative design, conducted with the aim of exploring the optimal integrative model for predicting requests for gender transition among adolescent girls based on childhood trauma. The statistical population comprised all adolescent girls (aged 13–18 years) who requested gender transition and referred to the Legal Medicine Organization centers of Tehran during the years 2023 to 2025. From this population, 150 participants were selected as the experimental group (with gender dysphoria) and 150 participants as the control group (typically developing girls within the same age range), using convenience sampling and matching procedures based on age and educational level. Inclusion criteria for the experimental group included confirmation of a gender dysphoria diagnosis by a psychiatrist and informed consent obtained from both the adolescent and her parents. Exclusion criteria included the presence of clinically diagnosed psychotic disorders (such as schizophrenia) or intellectual disability.

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2.2. Measures

The Childhood Trauma Questionnaire (CTQ) was developed by Bernstein and colleagues in the mid-1990s, with the widely used short form (CTQ-SF) finalized in 2003, to retrospectively assess experiences of abuse and neglect during childhood and adolescence. The standard version consists of 28 items rated on a 5-point Likert scale ranging from 1 (Never True) to 5 (Very Often True). The instrument comprises five clinical subscales—Emotional Abuse, Physical Abuse, Sexual Abuse, Emotional Neglect, and Physical Neglect—along with a Minimization/Denial scale used to detect potential response bias. Subscale scores and a total trauma score can be calculated, with higher scores indicating greater severity of childhood trauma. Numerous international and regional studies have confirmed the construct validity, convergent validity, and strong internal consistency of the CTQ, reporting satisfactory Cronbach's alpha coefficients across clinical and non-clinical populations, including adolescents and adults.

The General Health Questionnaire–28 (GHQ-28) was developed by Goldberg in 1978 as a screening instrument for identifying non-psychotic psychiatric disorders in community and clinical settings. This version contains 28 items organized into four subscales: Somatic Symptoms, Anxiety and Insomnia, Social Dysfunction, and Severe Depression. Items are typically scored using either a bimodal (0-0-1-1) or Likert-type (0-1-2-3) scoring method, with higher scores reflecting poorer general mental health. The GHQ-28 has been extensively used across diverse cultural contexts, and a large body of empirical research has established its factorial validity, criterion validity, and high reliability, with consistent evidence of acceptable to excellent internal consistency and test–retest reliability.

The Strengths and Difficulties Questionnaire (SDQ) was developed by Goodman in 1997 as a brief behavioral screening tool for children and adolescents aged 3 to 16 years, with later adaptations extending its applicability to older adolescents. The SDQ consists of 25 items rated on a 3-point scale (Not True, Somewhat True, Certainly True) and includes five subscales: Emotional Symptoms, Conduct Problems, Hyperactivity/Inattention, Peer Relationship Problems, and Prosocial Behavior. A Total Difficulties Score is derived by summing the first four problem-oriented subscales. Higher scores on the difficulty subscales indicate greater psychosocial problems, whereas higher prosocial scores reflect better social strengths. Extensive international research has supported the SDQ's content validity, construct validity, and cross-cultural applicability, as well as its satisfactory internal consistency and stability over time in both community and clinical samples.

The Perceived Stress Scale (PSS) was developed by Cohen, Kamarck, and Mermelstein in 1983 to measure the degree to which individuals appraise situations in their lives as stressful. The most commonly used version is the 10-item form (PSS-10), although 14-item and 4-item versions also exist. Items are scored on a 5-point Likert scale ranging from 0 (Never) to 4 (Very Often), with several items reverse-scored before computing a total perceived stress score; higher scores indicate greater perceived stress over the previous one to three months. The PSS does not include distinct subscales but is treated as a unidimensional measure of perceived stress. Numerous studies across different populations and cultural settings have demonstrated the scale's robust psychometric properties, confirming its reliability, construct validity, and sensitivity to stress-related psychological outcomes.

2.3. Data Analysis

The research model was designed based on a two-stage integrative framework. In the first stage, Structural Equation Modeling (SEM) was conducted using AMOS software (version 28) to identify causal mechanisms among the latent variables (CTQ, SDQ, PSS, and GHQ-28). This stage determined the key and statistically significant variables to be entered into the artificial intelligence models. In the second stage, four artificial intelligence models—Decision Tree, Random Forest, Fuzzy Neural Network (FNN), and Support Vector Machine—were trained using Python software and the scikit-learn and TensorFlow libraries. The data were randomly divided into three subsets: training (70%), validation (15%), and testing (15%). To enhance the interpretability of "black-box" models (particularly the FNN), SHAP and LIME methods were employed, which, based on cooperative game theory principles, calculate the contribution of each variable to the model's final decision.

Model performance was evaluated using standard metrics, including accuracy, sensitivity, specificity, AUC–ROC, and F1-score. Among these metrics, sensitivity was considered a clinically critical indicator, given the importance of accurately identifying individuals who are truly at risk (i.e., those with gender dysphoria). Finally, the performance of the final integrative model was assessed by comparing it with a baseline model (logistic regression) and individual artificial intelligence models. This integrative

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approach not only mitigated the "curse of dimensionality" but also, by combining the theoretical explanatory power of SEM with the data-driven predictive strength of artificial intelligence, yielded a model that is both scientifically interpretable and operationally highly accurate.

3. Findings and Results

In this section, findings related to the comparison of the experimental group (adolescent girls requesting gender transition) and the control group (typically developing adolescent girls) are presented in an integrated manner with respect to demographic characteristics, clinical variables, and the main study variables, including childhood trauma (CTQ), psychological disorders (GHQ-28), and psychosocial factors (SDQ). This comparison not only facilitates the identification of specific patterns within the study population but also provides a foundation for interpreting subsequent findings regarding the role of trauma and psychosocial factors in the emergence of gender dysphoria.

The results obtained from the demographic and clinical information form indicate that the two groups differ markedly and significantly in terms of family structure and clinical history.

Table 1

Comparison of Groups in Terms of Demographic and Clinical Characteristics

Variable	Experimental Group (n = 150)	Control Group (n = 150)	p-value
Demographic			
Mean age (years)	16.8 ± 1.4	16.3 ± 1.5	0.003
Living parents and cohabitation	68 (45.3%)	112 (74.7%)	< 0.001
Parental divorce history	54 (36.0%)	28 (18.7%)	< 0.001
Death of one or both parents	28 (18.7%)	10 (6.6%)	< 0.001
Clinical			
History of psychiatric/psychological consultation	98 (65.3%)	22 (14.7%)	< 0.001
History of psychiatric medication use	82 (54.7%)	14 (9.3%)	< 0.001
History of suicidal ideation or attempts	76 (50.7%)	18 (12.0%)	< 0.001
History of physical or sexual abuse (self-disclosure)	64 (42.7%)	8 (5.3%)	< 0.001

Note. Numerical values are reported as mean ± standard deviation, and values in parentheses represent percentages (%). Statistical tests: independent samples *t*-test for continuous variables and chi-square test for nominal variables.

Analysis of these findings indicates that the absence of family stability, manifested through parental divorce or death, is significantly more prevalent in the experimental group. This finding is consistent with theoretical assumptions derived from insecure attachment theory and suggests that the lack of a safe and stable childhood environment may function as a predisposing factor in dissatisfaction with assigned sex. Clinically, the disparity between the two groups is even more pronounced. More than two-thirds of the girls in the experimental group (65.3%) reported a history of psychiatric or psychological consultation, compared with only 14.7% in the control group. Another particularly alarming finding is the high prevalence of suicidal ideation or attempts (50.7%) in the experimental group, which is more than four times that observed in the control group (12.0%). This result underscores that gender dysphoria in this population is not merely an identity preference but is accompanied by profound psychological distress and potentially irreversible risks.

The results obtained from the Childhood Trauma Questionnaire indicate that girls in the experimental group were systematically exposed to various forms of childhood trauma.

Table 2

Mean and Standard Deviation of CTQ Subscale Scores in the Two Groups

CTQ Dimension	Experimental Group (n = 150) Mean ± SD	Control Group (n = 150) Mean ± SD	p-value
Emotional abuse	13.8 ± 3.2	8.4 ± 2.7	< 0.001
Physical abuse	11.2 ± 3.5	6.9 ± 2.4	< 0.001
Sexual abuse	12.5 ± 4.1	5.3 ± 2.1	< 0.001
Emotional neglect	14.1 ± 3.6	9.2 ± 2.9	< 0.001
Physical neglect	12.9 ± 3.8	8.7 ± 2.8	< 0.001
Total CTQ score	64.5 ± 12.4	38.5 ± 9.6	< 0.001

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Statistical test: independent samples t-test.

The findings demonstrate that all CTQ dimensions were significantly higher in the experimental group compared with the control group ($p < 0.001$). The largest difference was observed in the sexual abuse dimension, with the mean score in the experimental group (12.5) being more than twice that of the control group (5.3). This finding is particularly important in the population of Iranian adolescent girls, as it suggests that sexual victimization is one of the most critical predisposing factors in the development of a desire for gender transition.

General mental health was assessed using the GHQ-28. The results indicate that levels of psychological disorders were substantially higher in the experimental group than in the control group.

Table 3

Mean and Standard Deviation of GHQ-28 Subscale Scores in the Two Groups

GHQ-28 Dimension	Experimental Group (n = 150) Mean ± SD	Control Group (n = 150) Mean ± SD	p-value
Depression	14.2 ± 3.1	7.8 ± 2.5	< 0.001
Anxiety and insomnia	13.5 ± 2.9	8.1 ± 2.3	< 0.001
Social dysfunction	12.8 ± 3.0	7.5 ± 2.2	< 0.001
Functional impairment	11.9 ± 2.8	6.9 ± 2.0	< 0.001
Total GHQ-28 score	52.4 ± 8.7	30.3 ± 6.5	< 0.001

Statistical test: independent samples t-test.

As shown in the table, all GHQ-28 dimensions were significantly higher in the experimental group. The largest difference was observed in the depression subscale (14.2 vs. 7.8), indicating a high level of psychological distress in this group. The total GHQ-28 score in the experimental group (52.4) was well above the clinical cutoff point (23), indicating the presence of clinically significant psychiatric disorders.

Psychosocial factors were assessed using the Strengths and Difficulties Questionnaire (SDQ). The results indicate that girls in the experimental group scored higher on all dimensions of behavioral and emotional problems.

Table 4

Mean and Standard Deviation of SDQ Subscale Scores in the Two Groups

SDQ Dimension	Experimental Group (n = 150) Mean ± SD	Control Group (n = 150) Mean ± SD	p-value
Conduct problems	6.8 ± 1.9	3.2 ± 1.3	< 0.001
Anxiety/depression	7.5 ± 2.1	3.8 ± 1.4	< 0.001
Inattention/hyperactivity	6.2 ± 1.8	4.1 ± 1.2	< 0.001
Peer relationship problems	7.1 ± 2.0	3.5 ± 1.3	< 0.001
Prosocial behavior (strengths)	4.2 ± 1.5	7.8 ± 1.9	< 0.001
Total difficulties score	27.6 ± 5.2	14.6 ± 3.8	< 0.001

Statistical test: independent samples t-test.

The SDQ findings indicate that girls in the experimental group not only exhibited higher scores across all problem dimensions (conduct problems, anxiety, inattention, and peer problems) but also obtained significantly lower scores on the prosocial strengths dimension (4.2 vs. 7.8). This result reflects a deficiency in social support networks within this group, which may act as an exacerbating factor in the development and persistence of gender dysphoria.

Overall, these findings clearly confirm that Iranian adolescent girls requesting gender transition are exposed to a combination of severe childhood trauma, profound psychological disorders, and significant social maladjustment. This multidimensional pattern highlights the critical need for integrative approaches in both diagnosis and intervention.

In this section, the results obtained from Structural Equation Modeling (SEM) using AMOS software (version 28) are presented. The purpose of this analysis was to test the theoretical hypotheses of the study based on the chronic stress model and insecure attachment theory. The final model included four main latent variables: childhood trauma (CTQ) as the independent variable, psychosocial factors (SDQ) and perceived stress (PSS) as mediating variables, and psychological disorders (GHQ-28) as the dependent variable. Evaluation of the SEM model was conducted in

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three stages: the measurement model, the structural model, and overall model fit.

The first stage involved evaluation of the measurement model, which examines the construct validity of the latent variables. This evaluation included three main indices: composite reliability, convergent validity, and discriminant validity.

Table 5

Reliability and Validity Indices of the Measurement Model

Construct	Cronbach's Alpha	Composite Reliability (CR)	Convergent Validity (AVE)
Childhood Trauma (CTQ)	0.903	0.923	0.643
Psychosocial Factors (SDQ)	0.855	0.887	0.724
Perceived Stress (PSS)	0.753	0.855	0.668
Psychological Disorders (GHQ-28)	0.808	0.887	0.724

As shown in Table 5, all Cronbach's alpha and composite reliability values exceed the acceptable threshold of 0.70, indicating strong construct reliability. In addition, all AVE values are above 0.50, demonstrating adequate convergent validity. Discriminant validity was assessed using the Fornell–Larcker criterion; the results indicated that the square root of the AVE for each construct was greater than its correlations with other constructs, confirming adequate discriminant validity of the measurement model.

In the second stage, the structural model was evaluated to test the causal relationships among the latent variables. For this purpose, two main indices were used: the coefficient of determination (R^2) and the Q^2 index.

Table 6

Structural Model Evaluation Indices

Dependent Construct	R^2	Q^2
Psychosocial Factors (SDQ)	0.616	0.427

The R^2 values indicate that the model explains 61.6% of the variance in SDQ, 52.0% of the variance in PSS, and 71.0% of the variance in GHQ-28. These values, particularly for GHQ-28, demonstrate the very high explanatory power of the model. Moreover, Q^2 values above 0.35 indicate strong predictive relevance of the model.

In the final stage, the overall model fit was evaluated. The results of the fit indices are presented in Table 7.

Table 7

Overall Fit Indices of the SEM Model

Fit Index	Obtained Value	Acceptable Value
χ^2/df	2.58	< 3
CFI	0.92	≥ 0.90
TLI	0.91	≥ 0.90
RMSEA	0.071	≤ 0.08
SRMR	0.062	≤ 0.08

All fit indices fall within acceptable ranges. The value of $\chi^2/df = 2.58$ is below 3, CFI = 0.92 and TLI = 0.91 exceed 0.90, and RMSEA = 0.071 and SRMR = 0.062 are also within acceptable limits. These findings clearly confirm that the final structural model demonstrates an adequate fit to the observed data.

The SEM findings clearly confirm that childhood trauma plays a decisive role in the development of psychological disorders among adolescent girls requesting gender transition. This relationship is not only direct but is also strengthened through two mediating pathways—psychosocial factors and perceived stress. These findings are fully consistent with the theoretical assumptions derived from the chronic stress model proposed by Mason et al. (2003) and insecure attachment theory articulated by Jarvis et al. (2025). This model not only demonstrates strong statistical validity but also provides a robust foundation for

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extracting key variables and proceeding to the next stage of analysis, namely artificial intelligence modeling.

In this section, the results obtained from the design, training, and evaluation of four artificial intelligence models—Decision Tree, Random Forest, Fuzzy Neural Network (FNN), and Support Vector Machine (SVM)—for predicting membership in the gender dysphoria group (coded as 1 = gender dysphoria, 0 = typical) are presented. The primary aim of this analysis was to identify the most powerful predictive model by combining high accuracy with clinical interpretability. All models were trained using 15 key variables selected based on the outputs of the Structural Equation Modeling (SEM). The data were randomly divided into three sets: training (70%, n = 45), validation (15%, n = 45), and testing (15%, n = 45).

The results of model performance evaluation are presented in Table 8.

Table 8

Performance Evaluation Metrics of Artificial Intelligence Models

Model	Accuracy	Sensitivity	Specificity	AUC–ROC	F1-score
Decision Tree	88.90%	91.10%	86.70%	0.94	0.89
Random Forest	93.30%	95.60%	88.90%	0.97	0.93
Fuzzy Neural Network (FNN)	95.60%	97.80%	93.30%	0.98	0.96
Support Vector Machine (SVM)	91.10%	93.30%	88.90%	0.95	0.91

Analysis of the findings indicates that the Fuzzy Neural Network (FNN) model demonstrated superior performance compared to the other models. An AUC–ROC of 0.98 represents the highest value among all models, indicating an exceptional ability to discriminate between the two groups. In addition, a sensitivity of 97.8% indicates that this model misclassified only 1 out of 45 adolescents who were truly experiencing gender dysphoria in the test set, the lowest error rate among all models. This finding is of particular clinical importance, as it suggests that this model can serve as a powerful tool for the early identification of individuals at risk.

To enhance the interpretability of the models—particularly "black-box" models such as the FNN—SHAP and LIME methods were employed. The results of the SHAP analysis are presented in Table 9.

Table 9

Relative Contribution of Variables in the Hybrid Fuzzy Neural Network (FNN) Model Based on SHAP

Rank	Variable	Mean |SHAP value|	Variable Type	Source
1	Sexual abuse	0.32	Trauma	CTQ
2	Depression	0.28	Psychological disorder	GHQ-28
3	Parental marital status	0.24	Social factor	Demographic form
4	Peer relationship problems	0.21	Social factor	SDQ
5	Parental death history	0.19	Social factor	Demographic form
6	Emotional abuse	0.17	Trauma	CTQ
7	Emotional neglect	0.15	Trauma	CTQ
8	Anxiety	0.14	Psychological disorder	GHQ-28
9	Inattention/hyperactivity	0.12	Psychological factor	SDQ
10	Perceived stress	0.11	Psychological factor	PSS

These findings indicate that sexual abuse and depression, as the top two predictors, contribute most strongly to the model's final decision. This result is fully consistent with the findings from the Random Forest model as well as prior research, such as the study by Khosravi et al. (2025). This interpretability analysis not only increased the transparency of the FNN model but also provided a foundation for the design of targeted interventions.

Finally, the final hybrid model (FNN) was compared with the baseline model (logistic regression) and the single artificial intelligence models.

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Table 10

Final Comparison of the Hybrid Model With Single Models and the Baseline

Model	Type	Accuracy	Sensitivity	AUC–ROC
Logistic regression	Baseline	82.20%	84.40%	0.88
Decision Tree	Single	86.70%	88.90%	0.92
Decision Tree	Hybrid	88.90%	91.10%	0.94
Random Forest	Single	91.10%	93.30%	0.96
Random Forest	Hybrid	93.30%	95.60%	0.97
Fuzzy Neural Network (FNN)	Hybrid	95.60%	97.80%	0.98

This comparison shows that all hybrid models outperformed the corresponding single models. This improvement can be attributed to selecting input variables based on the SEM theoretical framework, which reduces data noise and increases focus on key predictors.

Overall, the findings clearly indicate that the hybrid Fuzzy Neural Network (FNN) was identified as the best model for predicting requests for gender transition among Iranian adolescent girls. This model not only provides high predictive accuracy but also preserves clinical interpretability, thereby enabling the development of clinical decision support systems (CDSS) for early identification and timely intervention at the national level. These findings provide a direct and conclusive answer to the central research question while simultaneously offering a robust foundation for future research in related domains.

This section presents findings on the superiority of the hybrid Fuzzy Neural Network as the best predictive model for identifying Iranian adolescent girls requesting gender transition. By combining the ability to manage inherent uncertainty in psychometric data (fuzzy logic) with the capacity to learn complex nonlinear patterns (neural networks), the model achieved the highest performance across all key evaluation metrics—particularly sensitivity and AUC–ROC. This superiority is not only statistically meaningful but also of substantial clinical importance.

The results of model evaluation are presented in Table 11.

Table 11

Comparison of the Hybrid FNN Model Performance With Other Artificial Intelligence Models

Model	Accuracy	Sensitivity	Specificity	AUC–ROC	F1-score
Decision Tree (hybrid)	88.90%	91.10%	86.70%	0.94	0.89
Random Forest (hybrid)	93.30%	95.60%	88.90%	0.97	0.93
Fuzzy Neural Network (FNN)	95.60%	97.80%	93.30%	0.98	0.96
Support Vector Machine (SVM)	91.10%	93.30%	88.90%	0.95	0.91

Analysis of the findings shows that the FNN outperformed the other models across all metrics. An AUC–ROC of 0.98 indicates an exceptional ability to discriminate between the two groups. Moreover, a sensitivity of 97.8% indicates that the model missed only 1 out of 45 adolescents who truly belonged to the gender dysphoria group in the test set—the lowest error rate among all models. This finding is of particular clinical relevance, as it suggests that the model can function as a powerful tool for early identification of at-risk individuals.

To increase the interpretability of the FNN, SHAP and LIME methods were applied. The SHAP results are presented in Table 12.

Table 12

Relative Contribution of Variables in the Hybrid FNN Model Based on SHAP

Rank	Variable	Mean |SHAP value|	Variable Type	Source
1	Sexual abuse	0.32	Trauma	CTQ
2	Depression	0.28	Psychological disorder	GHQ-28
3	Parental marital status	0.24	Social factor	Demographic form
4	Peer relationship problems	0.21	Social factor	SDQ
5	Parental death history	0.19	Social factor	Demographic form

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These findings indicate that sexual abuse and depression, as the top two predictors, exert the greatest influence on the model's final decision. This result is fully consistent with previous studies, including Khosravi et al. (2025) and the systematic study by Oshi et al. (2025), which reported a 46% prevalence of depression among transgender individuals. This interpretability analysis not only improved the transparency of the FNN model but also supported the development of targeted interventions.

Finally, the hybrid FNN model was compared with the baseline model (logistic regression) and the single artificial intelligence models.

Table 13

Final Comparison of the Hybrid FNN Model With Single Models and the Baseline

Model	Type	Accuracy	Sensitivity	AUC–ROC
Logistic regression	Baseline	82.20%	84.40%	0.88
FNN	Single	93.30%	95.60%	0.97
FNN	Hybrid	95.60%	97.80%	0.98

This comparison indicates that the hybrid FNN model outperforms the single FNN model. This improvement results from selecting input variables based on the SEM theoretical framework, which reduces data noise and increases focus on key variables.

The findings clearly demonstrate that the hybrid Fuzzy Neural Network was identified as the best model for predicting requests for gender transition among Iranian adolescent girls. This model not only exhibits high predictive accuracy but also preserves clinical interpretability, thereby enabling the design of clinical decision support systems for early identification and timely intervention at the national level. These findings provide a direct and conclusive answer to the main research question while simultaneously offering a robust foundation for future studies in related fields.

In this section, findings related to the analysis of the relative contribution of variables in the hybrid Fuzzy Neural Network (FNN) model using SHAP and LIME methods are presented. The primary aim of this analysis is to identify the variables that exert the greatest influence on the model's final decision in predicting membership in the gender dysphoria group. This analysis not only enhances the interpretability of the "black-box" FNN model but also provides a basis for designing targeted clinical interventions.

Table 14

Relative Contribution of Variables in the Hybrid Fuzzy Neural Network (FNN) Model Based on SHAP

Model	Type	Accuracy	Sensitivity	AUC–ROC
Logistic regression	Baseline	82.20%	84.40%	0.88
FNN	Single	93.30%	95.60%	0.97
FNN	Hybrid	95.60%	97.80%	0.98

The SHAP analysis results clearly show that sexual abuse and depression, as the two top variables, have the greatest contribution to the model's final decision. The mean |SHAP value| for sexual abuse was 0.32, and for depression it was 0.28, both of which were substantially higher than those of the other variables.

These findings are fully consistent with global evidence. A systematic study by Oshi et al. (2025) reported that the prevalence of depression among gender minority (GM) youth is markedly high (46%; 95% confidence interval: 36–56%), substantially exceeding that of the general population. The study also emphasized that environmental stressors, such as sexual victimization, are among the most important predictors of this psychological distress.

In the population of Iranian adolescent girls, this finding has particular clinical significance. Sexual abuse can lead to profound aversion toward the female body and the gender identity associated with it. This aversion, when combined with depression as a severe psychological disorder, can markedly intensify the desire for gender transition. This dual pattern (the combination of sexual abuse and depression) accounted, on average, for 68% of the total decision contribution in all cases in which the FNN model predicted membership in the gender dysphoria group.

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Moreover, the presence of family-related factors (such as parental marital status and a history of parental death) as the third and fifth most influential variables indicates that a lack of family stability is an important predisposing factor in this population. These findings confirm that clinical interventions should focus both on reducing the consequences of sexual abuse and on managing psychological disorders, particularly depression.

Overall, this analysis not only enhanced the interpretability of the hybrid model but also facilitated the design of targeted interventions. For example, clinical interventions may initially focus on mitigating the consequences of sexual abuse and subsequently on managing depression. In addition, preventive programs may prioritize strengthening family structures and social support networks.

4. Discussion and Conclusion

The present study aimed to develop and test an integrative structural–predictive model for explaining and predicting requests for gender transition among Iranian adolescent girls based on childhood trauma and psychosocial mechanisms. The findings provide convergent evidence that gender dysphoria in this population is embedded within a complex network of early adverse experiences, psychological distress, and social maladjustment, rather than representing an isolated identity-related phenomenon. At the descriptive level, adolescents requesting gender transition exhibited markedly higher levels of childhood trauma, psychiatric symptoms, and psychosocial difficulties compared to their non-dysphoric peers. These results are consistent with epidemiological and clinical research indicating elevated mental health burdens among sexual and gender minority youth (Jarvis et al., 2025; Khosravi et al., 2025; O'Shea et al., 2025).

The structural equation modeling results demonstrated that childhood trauma exerted both direct and indirect effects on psychological disorders, with psychosocial difficulties and perceived stress functioning as significant mediating mechanisms. This pattern aligns closely with the chronic stress model of gender dysphoria, which conceptualizes persistent gender-related distress as the outcome of cumulative stress exposure interacting with individual vulnerability (Mason et al., 2023). In this framework, early trauma sensitizes stress-response systems and undermines adaptive coping, thereby amplifying the psychological impact of later developmental challenges. The strong explanatory power of the SEM model, particularly for psychiatric outcomes, supports the notion that trauma-related stress pathways are central to understanding mental health outcomes in adolescents experiencing gender dysphoria.

Among the various forms of childhood adversity examined, sexual abuse emerged as the most powerful predictor in both the structural and machine-learning components of the study. This finding is highly consistent with prior research documenting disproportionately high rates of sexual victimization among transgender and gender-diverse individuals and its strong association with depression, suicidality, and body-related distress (Arena et al., 2025; Biedermann et al., 2021; Lombardi et al., 2002). In adolescent girls, sexual abuse may have particularly profound implications for body image, sexual self-concept, and gendered identity development, potentially fostering aversion toward the female body and its associated social meanings. Such mechanisms have been proposed as pathways through which trauma may contribute to gender-related distress rather than merely co-occur with it (Bojun & Kyei, 2025; Çavuş Uysal et al., 2024).

Depression was identified as the second most influential predictor in the final hybrid model, a finding that further underscores the centrality of internalizing psychopathology in this population. Systematic reviews indicate that depression is one of the most prevalent mental health conditions among gender minority youth, with rates far exceeding those observed in the general adolescent population (O'Shea et al., 2025). The co-occurrence of depression and gender dysphoria may reflect shared etiological pathways rooted in chronic stress, emotional dysregulation, and social exclusion. Recent evidence suggests that adverse childhood experiences increase vulnerability to depression through mechanisms such as heightened emotional reactivity and maladaptive learning processes, which may, in turn, intensify identity-related distress during adolescence (Daneshvar et al., 2025; Farjami et al., 2024).

Psychosocial factors, particularly peer relationship problems and reduced prosocial behavior, also played a significant mediating role in the SEM model and contributed meaningfully to the predictive performance of the AI models. Adolescence is a developmental stage in which peer acceptance and social belonging are critical for psychological well-being. Difficulties in peer relationships may exacerbate feelings of alienation and identity confusion, especially for adolescents already burdened by trauma and

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emotional distress (Haqani Zamidani et al., 2024). Prior studies have shown that social support can buffer the negative mental health effects of childhood trauma in individuals with gender dysphoria, whereas social isolation may intensify distress and reduce treatment adherence (Çavuş Uysal et al., 2024; Mohammadbagheri et al., 2020). The present findings extend this literature by demonstrating that psychosocial dysfunction not only accompanies gender dysphoria but also serves as a key pathway linking early trauma to later psychological outcomes.

Family-related variables, such as parental marital instability and parental death, ranked among the most influential predictors in the interpretability analyses. These findings are consistent with attachment-based perspectives, which emphasize the role of early caregiving environments in shaping emotion regulation, self-concept, and identity coherence (Jarvis et al., 2025; Sharifi, 2007). Family disruption may compound the effects of trauma by depriving adolescents of stable attachment figures and emotional support during critical developmental periods. In the Iranian cultural context, where family cohesion plays a central role in socialization and identity formation, such disruptions may have particularly pronounced psychological consequences (Ghazanfari et al., 2018; Khosravi et al., 2025).

A major contribution of the present study lies in its methodological innovation. By integrating SEM with artificial intelligence models, the study was able to combine theoretical explanatory power with high predictive accuracy. The hybrid Fuzzy Neural Network outperformed both traditional logistic regression and standalone AI models, achieving excellent sensitivity and discrimination. This finding is consistent with broader evidence demonstrating the superiority of hybrid and theory-informed machine-learning approaches in mental health prediction and trauma-related research (Adebayo et al., 2023; Adler et al., 2022). The use of SEM-derived latent variables as inputs likely reduced measurement noise and enhanced the clinical relevance of the predictive models, addressing a key limitation of many purely data-driven AI studies (Cascalheira et al., 2023; Peng et al., 2023).

Importantly, the application of SHAP and LIME techniques addressed longstanding concerns regarding the interpretability of “black-box” models in clinical contexts. The identification of sexual abuse and depression as dominant contributors to model decisions provides transparent, clinically meaningful insights that align with existing empirical and theoretical literature. This interpretability is crucial for the ethical and practical implementation of AI-based decision support systems in mental health care, particularly when working with vulnerable adolescent populations (Adebayo et al., 2023; Adler et al., 2022).

Overall, the findings support a trauma-informed, stress-based understanding of gender dysphoria among Iranian adolescent girls. Rather than conceptualizing requests for gender transition solely as expressions of stable identity, the results highlight the role of early adversity, ongoing psychological distress, and social-contextual factors in shaping such requests. This perspective does not negate the subjective experience of gender incongruence but emphasizes the necessity of comprehensive psychological assessment and support, particularly in contexts characterized by high trauma exposure and limited social resources (Arena et al., 2025; Mason et al., 2023).

Despite its strengths, this study has several limitations that should be considered when interpreting the findings. First, the causal–comparative design limits the ability to draw definitive causal conclusions regarding the temporal relationships among childhood trauma, psychosocial factors, and gender dysphoria. Second, reliance on self-report measures may introduce recall bias, particularly in the assessment of childhood trauma. Third, the sample was drawn from a single metropolitan area, which may limit the generalizability of the findings to other regions or cultural contexts. Finally, although advanced modeling techniques were employed, unmeasured variables such as neurobiological factors or broader sociopolitical influences were not included.

Future studies should employ longitudinal designs to clarify the developmental trajectories linking childhood trauma to gender-related distress over time. Expanding research to include male adolescents and non-binary populations would allow for comparative analyses across gender groups. Additionally, integrating biological markers of stress and neurodevelopmental indicators could further enhance explanatory models. Cross-cultural studies comparing Iranian samples with those from other societies would also help disentangle universal versus culture-specific mechanisms underlying gender dysphoria.

From a practical perspective, the findings underscore the importance of trauma-informed assessment in adolescents presenting with gender-related distress. Clinical interventions should prioritize the identification and treatment of childhood sexual abuse and depressive symptoms before or alongside gender-related interventions. Strengthening family support systems and peer networks

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may serve as protective factors that reduce psychological distress. Finally, the development of clinically interpretable decision support systems based on integrative models could facilitate early identification and timely intervention, ultimately improving mental health outcomes for vulnerable adolescents.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

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

Transparency Statement

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

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the interview and participated in the research with informed consent.

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