

LightGBM-Based Prediction of Marital Satisfaction Using Emotional, Sexual, and Communication Indicators

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ABSTRACT

Objective: This study aimed to develop and evaluate a Light Gradient Boosting Machine (LightGBM) model for predicting marital satisfaction based on emotional, sexual, communication, demographic, and relationship-related indicators among married adults in Canada.

Methods and Materials: This cross-sectional predictive study included 462 married adults residing in Canada. Participants completed standardized measures of marital satisfaction, emotional intelligence, perceived emotional support, sexual satisfaction, sexual communication, sexual-need compatibility, and marital communication patterns, together with demographic and relationship-related questionnaires. Marital satisfaction was modeled as a continuous outcome. The dataset was divided into training and independent test sets using an 80:20 allocation. Five-fold cross-validation was applied within the training set for hyperparameter optimization. LightGBM performance was compared with multiple linear regression, Elastic Net, random forest, and XGBoost models. Predictive performance was assessed using R^2 , root mean squared error (RMSE), and mean absolute error (MAE). SHapley Additive exPlanations (SHAP) were used to determine predictor importance and interpret nonlinear and interaction effects.

Findings: LightGBM demonstrated the strongest predictive performance, explaining 77.2% of the variance in marital satisfaction in the independent test set ($R^2 = .772$, RMSE = 3.09, MAE = 2.34), compared with XGBoost ($R^2 = .739$), random forest ($R^2 = .704$), Elastic Net ($R^2 = .617$), and multiple linear regression ($R^2 = .598$). SHAP analysis identified sexual satisfaction as the most influential predictor, followed by perceived emotional support, constructive communication, demand-withdraw communication, sexual communication, emotion regulation, sexual-need compatibility, and mutual avoidance. Age and duration of marriage showed comparatively small predictive contributions. Important interactions were observed between sexual satisfaction and sexual communication and between emotional support and constructive communication.

Conclusion: Marital satisfaction was predicted with high accuracy by a multidimensional combination of sexual, emotional, and communication characteristics, with LightGBM outperforming conventional linear and alternative machine-learning models.

Keywords: marital satisfaction; LightGBM; machine learning; sexual satisfaction; emotional support; marital communication; emotion regulation; SHAP

1. Introduction

Marital satisfaction is a multidimensional construct reflecting the degree to which individuals perceive their marital relationship as rewarding, supportive, emotionally secure, communicative, intimate, and consistent with their expectations. It is not merely the absence of marital conflict; rather, it represents a dynamic evaluation of the quality of interaction between partners across emotional, sexual, communicative, practical, and contextual domains. The marital relationship is continuously shaped by changes in individual development, family responsibilities, occupational demands, health conditions, financial pressures, and broader social circumstances. Consequently, marital satisfaction may fluctuate across the life course and in response to acute or chronic stressors. Research on couples confronting bereavement, chronic illness, financial strain, and other major life transitions has demonstrated that relationship quality can either function as a protective interpersonal resource or deteriorate when partners are unable to coordinate coping, intimacy, and communication effectively (Buchanan, 2022; Valente et al., 2022; Wickrama et al., 2022). This dynamic nature of marital functioning underscores the importance of identifying combinations of relational characteristics that distinguish more satisfying marriages from relationships characterized by poorer adjustment.

Contemporary perspectives increasingly conceptualize marital satisfaction as the product of interdependent processes rather than the consequence of a single personality characteristic or isolated relationship behavior. Emotional functioning, sexual satisfaction, intimacy, conflict management, perceived partner responsiveness, and patterns of dyadic coping interact over time and may strengthen or undermine relationship quality. Network-based evidence indicates that personality, relational goals, marital adjustment, and psychological well-being are connected through multiple divergent pathways rather than through a simple linear sequence (Gyeong & Shin, 2026). Similarly, research on dyadic coping in couples facing serious illness emphasizes that each partner's emotional and behavioral response affects the other's adaptation, producing reciprocal patterns that may either enhance relational resilience or intensify distress (Cao, 2026; Jie, 2026). Such findings are particularly relevant to the prediction of marital satisfaction because they suggest that relational outcomes are likely to emerge from complex interactions, nonlinear effects, and threshold patterns among multiple psychosocial indicators.

The emotional domain is central to these processes. Emotional intelligence involves the ability to recognize, understand, use, and regulate one's own and others' emotions, and these capacities are especially relevant in close relationships where partners must interpret emotionally charged interactions and regulate responses during conflict. Emotional intelligence has been linked with dyadic adjustment among married couples, suggesting that individuals who are more capable of identifying and managing emotions may navigate interpersonal demands more successfully (Zaidi et al., 2022). Emotional regulation is likewise critical because ineffective regulation may intensify negative affect, increase defensive responses, interfere with empathy, and reduce the capacity to resolve disagreements constructively. Family relationships represent a major context in which emotion regulation strategies are learned, expressed, and reinforced, and maladaptive emotional responses can become recurring interpersonal patterns within couples (Duca et al., 2023). Attachment-related emotional regulation may also shape relational outcomes across generations, particularly when insecure interpersonal expectations affect emotional responsiveness, vulnerability, and communication between partners (Ibrahim et al., 2023).

Emotional support and validation constitute additional relational mechanisms through which emotional functioning may influence marital satisfaction. Feeling understood, accepted, and emotionally supported by a spouse can strengthen security and intimacy, particularly during periods of physiological, psychological, or situational stress. Among menopausal women, spousal support has been associated with sexual attitudes and adaptation to menopausal symptoms, illustrating how emotional support can affect both relational and sexual experiences (Küçükkaya et al., 2026). Empathy and validation have also emerged as important interpersonal processes among couples coping with chronic pain, where a partner's capacity to acknowledge and respond appropriately to distress may influence both psychological and relational outcomes (Teichmüller et al., 2025). Conversely, relational histories involving trauma may complicate emotional closeness. A history of childhood abuse can interfere with adult relationship satisfaction, affecting not only trauma survivors but also their romantic partners through dyadic pathways (Finzi-Dottan & Gewirtz-Meydan, 2023). Interventions focusing on emotional processing further indicate that improvements in emotional engagement can contribute to greater intimacy, adjustment, and forgiveness among couples facing severe relational

disruptions such as extramarital affairs (Torani & Fard, 2024).

Sexual functioning represents another major component of marital quality and is closely intertwined with emotional connection and communication. Sexual satisfaction is not reducible to sexual frequency or physiological function; it encompasses subjective pleasure, mutual responsiveness, emotional closeness, perceived compatibility, body-related confidence, and the extent to which partners can communicate their needs. Research among married women has shown that sexual-related factors are significantly associated with broader life satisfaction, highlighting the importance of the sexual relationship within general well-being (Bahrami et al., 2023). Body image and body-shape satisfaction may also affect personal intimacy and sexual satisfaction, suggesting that individual self-perceptions can enter the marital system through sexual and emotional pathways (Farhan & Ismail, 2022). During pregnancy, relationship satisfaction and body-image-related quality of life are also associated with sexual functioning, indicating that changes in physical self-perception and relational dynamics may jointly shape intimate experiences across major life transitions (Daniluc et al., 2025).

The association between emotional functioning and sexuality is particularly important. Emotional intelligence may facilitate sexual communication, improve interpretation of a partner's emotional and physical cues, reduce avoidance, and support the negotiation of needs and boundaries. Evidence examining emotional intelligence and sexual satisfaction has suggested meaningful relationships between these domains (Özbay & Balaban, 2024). Relationship-level patterns may further determine whether emotional capacities translate into positive intimate experiences. Latent-profile research examining love styles, conflict, emotional intelligence, and sexual satisfaction indicates that these variables form distinguishable relational configurations rather than operating independently (Castillo-López et al., 2025). This implies that high emotional competence may have different implications depending on the broader communication and intimacy environment of the couple. Sexual satisfaction should therefore be considered alongside emotional and interactional indicators when predicting marital satisfaction.

Communication represents the behavioral channel through which many emotional and sexual processes are expressed. Constructive communication enables partners to articulate needs, clarify misunderstandings, negotiate disagreements, and express emotional and sexual concerns

in ways that preserve mutual respect. In contrast, criticism, avoidance, withdrawal, and demand-withdraw interaction can maintain unresolved conflict and progressively weaken intimacy. Evidence from couple interventions supports the importance of communication patterns in marital functioning. Gottman-oriented systemic cognitive couple therapy has been shown to influence marital conflict, communication patterns, and alexithymia among couples experiencing marital problems (Salehi et al., 2024). Communication-skills training based on transactional analysis has similarly improved marital adjustment among menopausal women, demonstrating that relationship quality may change when partners develop more adaptive interactional skills (Enjezab et al., 2023). Mindfulness is also associated with relationship quality and conflict-resolution strategies, suggesting that the ability to maintain nonreactive awareness may support more constructive interpersonal responses during disagreement (Mandal & Lip, 2022).

Communication and intimacy become especially important when couples encounter stressful or stigmatizing experiences. Domestic abuse and trauma can substantially disrupt spousal intimacy, although culturally sensitive relational interventions may facilitate improvements in closeness and functioning (Rowland et al., 2024). Weight stigma within romantic relationships may likewise affect emotional security, body image, intimacy, and partner interactions, illustrating how social judgments can enter the private relational environment (Schmidt et al., 2022). In clinical and health-related contexts, dyadic approaches increasingly recognize that partners should be considered an interacting system rather than two isolated individuals. Research on couples adapting to prostate cancer, for example, emphasizes reciprocal psychosocial adjustment and the importance of dyadic relational processes (Castro et al., 2024). Interventions for breast cancer patients and spousal caregivers have similarly incorporated structured dyadic coping to strengthen psychological and relational adaptation (C. Wang et al., 2025). Among patients recovering from acute myocardial infarction, combining music therapy with dyadic coping has also been associated with improvements in psychosocial adaptation and marital well-being (Y. Wang et al., 2025). Collectively, these studies reinforce the view that relationship satisfaction depends partly on how couples communicate, regulate emotions, and respond together to stress.

Marital functioning is also embedded in broader contextual conditions. The COVID-19 pandemic altered work arrangements, childcare responsibilities, household

routines, social support, and opportunities for privacy, thereby exposing couples to substantial relational stress. A systematic review of couple and parenting dynamics during the pandemic documented important changes in relationship processes under conditions of prolonged uncertainty and disrupted family routines (Sentieiro et al., 2025). Sleep represents another contextual factor closely linked to relationship functioning. Shared sleep environments may provide emotional closeness and security but may also generate difficulties when partners' sleep schedules, movement, health conditions, or preferences differ (Andersen et al., 2025). More broadly, romantic relationship experiences and sleep quality appear to influence one another through emotional, behavioral, and physiological mechanisms (Xie & Feeney, 2024). These findings illustrate that marital satisfaction is affected by complex reciprocal processes extending beyond traditional measures of conflict or affection.

The coexistence of numerous interacting predictors presents a methodological challenge. Conventional marital research has relied heavily on correlation, multiple regression, mediation, and structural equation modeling. These methods are valuable for theory testing and estimation of predefined relationships, but they usually require assumptions regarding functional form and often emphasize average linear effects. Marital satisfaction, however, may be influenced by nonlinear thresholds, conditional effects, and interactions. For example, very low emotional support may have a disproportionately negative impact, while increases beyond an already high level may yield diminishing returns. Similarly, high sexual satisfaction may contribute differently depending on whether sexual communication is open or restricted. Psychological factors underlying marital conflict may therefore require multivariate approaches capable of simultaneously evaluating competing and interacting dimensions (Majumder et al., 2024). Clinical evidence showing transformative changes in marital models also indicates that relationship patterns may be reorganized systemically rather than through isolated changes in individual variables (Figueiredo et al., 2024).

Machine-learning methods offer a complementary framework for addressing this complexity because their principal objective is accurate out-of-sample prediction rather than estimation of a restricted set of prespecified coefficients. Tree-based ensemble methods are particularly suitable for psychosocial datasets containing heterogeneous predictors because they can capture nonlinear effects, interactions, and complex decision boundaries with limited

need to specify these patterns in advance. Among these approaches, Light Gradient Boosting Machine (LightGBM) is a computationally efficient gradient-boosting algorithm that sequentially constructs decision trees to reduce prediction error. Its leaf-wise growth strategy, regularization mechanisms, and flexible treatment of heterogeneous features make it well suited to modeling relational phenomena in which emotional, sexual, communicative, and demographic factors may combine in non-additive ways. Although predictive modeling should not be interpreted as establishing causality, it can identify variables and combinations of variables that carry substantial information about an outcome and can reveal patterns that are difficult to detect through traditional linear analyses.

The interpretability of machine-learning models has also improved considerably through techniques such as SHapley Additive exPlanations (SHAP), which estimate the contribution of each predictor to model predictions at both global and individual levels. In marital research, this is particularly useful because clinicians and researchers require more than a high prediction score; they need to understand which features drive the model and in what direction. SHAP-based analysis can determine whether variables such as sexual satisfaction, emotional support, emotional regulation, constructive communication, or demand-withdraw interaction contribute positively or negatively to predicted marital satisfaction and whether these effects change across different levels of the predictor. Such an approach is consistent with emerging evidence that relationship functioning is heterogeneous and characterized by different profiles and pathways rather than a single universal pattern (Castillo-López et al., 2025; Gyeong & Shin, 2026).

The need for multivariate prediction is further supported by evidence that couple functioning changes across contexts and developmental periods. Health crises can alter intimacy and relational roles (Cao, 2026; Valente et al., 2022), financial strain can influence later-life well-being through trajectories of couple intimacy (Wickrama et al., 2022), and bereavement can profoundly reshape marital interaction after the death of a child (Buchanan, 2022). Similarly, couple responses to cancer reveal substantial heterogeneity in coping, communication, and adaptation (Jie, 2026; C. Wang et al., 2025). These findings caution against assuming that the influence of any single relational variable is uniform across individuals. Predictive models capable of detecting nonlinear and conditional relationships may therefore offer a more realistic representation of how multiple relational

resources and vulnerabilities combine to shape marital satisfaction.

Despite extensive research on emotional intelligence, emotion regulation, sexual satisfaction, intimacy, communication, dyadic coping, and marital adjustment, these domains are frequently investigated separately or through conventional explanatory models. There remains a need to integrate emotional, sexual, and communication indicators within a unified predictive framework capable of comparing their relative importance while accounting for nonlinear relationships and interactions. Such integration is particularly valuable because interventions commonly target these domains simultaneously. Couple therapies may improve communication, emotional awareness, conflict management, intimacy, and sexual functioning as interconnected components of the same relationship system (Salehi et al., 2024; Torani & Fard, 2024). Likewise, communication-based and dyadic interventions across menopause, chronic illness, and major life stressors have demonstrated that relational functioning can be modified through changes in partner interaction (Enjezab et al., 2023; Küçükkaya et al., 2026; Y. Wang et al., 2025). Identifying the strongest predictors within this broader relational system may therefore have theoretical value for understanding marital functioning and practical value for prioritizing assessment and intervention targets.

Accordingly, the present study aimed to develop and evaluate a LightGBM-based model for predicting marital satisfaction among married adults in Canada using emotional, sexual, communication, demographic, and relationship-related indicators and to identify the most influential predictors through SHAP-based model interpretation.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a quantitative, cross-sectional predictive design to develop and evaluate a machine-learning model for predicting marital satisfaction based on emotional, sexual, and communication-related indicators among married adults in Canada. The study population consisted of married individuals residing in Canada during the data-collection period. A total of 486 participants were initially recruited through community organizations, family and relationship counseling centers, social media advertisements, university-affiliated electronic notice boards, and online community networks in several Canadian

provinces. After screening the submitted questionnaires for eligibility, completeness, duplicate responses, and response-quality concerns, 462 participants were retained for the final analysis. This final sample size was considered adequate for the proposed machine-learning framework because it provided sufficient observations for model training, validation, and testing while maintaining an appropriate ratio between the number of candidate predictors and the number of participants. Participants were recruited using convenience and purposive sampling, with efforts made to obtain variability in age, duration of marriage, educational level, occupational status, and family characteristics. Eligibility criteria included being at least 18 years of age, currently legally married or living in a marital relationship recognized as equivalent for the purposes of the study, having been in the current relationship for at least one year, residing in Canada, being able to read and understand English, and providing informed consent for participation. Individuals were excluded if they reported being currently separated from their spouse, were in the process of divorce, submitted substantially incomplete questionnaires, or produced response patterns suggestive of careless or duplicate participation. Participation was voluntary, and respondents were informed that they could discontinue participation at any stage without providing a reason or experiencing any adverse consequence. No personally identifying information was included in the analytical dataset. The study procedures were designed in accordance with the ethical principles governing research involving human participants in Canada, including the principles of voluntary participation, confidentiality, privacy, and informed consent. Electronic informed consent was obtained before access to the research questionnaires was granted.

2.2. Measures

Data were collected using a demographic and relationship-information form together with standardized measures assessing marital satisfaction and the emotional, sexual, and communication domains theoretically associated with relationship functioning. Marital satisfaction, which constituted the primary outcome variable, was assessed using the 10-item Couples Satisfaction Index (CSI-10). The CSI-10 evaluates respondents' overall satisfaction, perceived quality, happiness, and functioning within their romantic relationship and has been widely used as a concise measure of relationship satisfaction. Items are scored using response formats that vary according to item content, and item scores

are summed to generate a total score, with higher values indicating greater marital or relationship satisfaction. The continuous CSI-10 total score was used as the primary dependent variable in the Light Gradient Boosting Machine regression model to preserve the full variability of marital satisfaction and avoid the information loss associated with arbitrary categorization. Internal consistency of the CSI-10 was assessed in the present sample using Cronbach's alpha and McDonald's omega before predictive modeling.

Emotional functioning within the marital relationship was assessed through indicators of emotional intelligence, emotional regulation, emotional responsiveness, and perceived emotional support. Emotional intelligence was measured using the Wong and Law Emotional Intelligence Scale (WLEIS), a 16-item self-report instrument covering self-emotion appraisal, others' emotion appraisal, use of emotion, and regulation of emotion. Items are rated on a Likert-type scale, with higher scores representing greater perceived emotional intelligence. Because interpersonal emotion recognition and regulation may influence the interpretation of a spouse's behavior, conflict management, intimacy, and relationship quality, both the overall emotional intelligence score and theoretically meaningful subscale scores were considered candidate predictors during model development. Perceived emotional support from the spouse was additionally evaluated through items assessing the extent to which participants experienced understanding, emotional availability, validation, and responsiveness within the relationship. Higher scores reflected stronger perceived emotional support. Before model estimation, the distribution, reliability, and redundancy of emotional-domain variables were examined to ensure that the predictive feature set represented conceptually relevant but sufficiently distinguishable emotional characteristics.

Sexual relationship functioning was assessed using the New Sexual Satisfaction Scale–Short Form (NSSS-S), which evaluates subjective satisfaction with sexual experiences and the relational and personal dimensions of sexual activity. The instrument assesses aspects such as sexual pleasure, emotional connection during sexual activity, satisfaction with sexual interactions, and perceived fulfillment of sexual needs. Participants rated each item according to their experience within their current marital relationship, with higher total scores indicating greater sexual satisfaction. Additional sexual-domain variables recorded for predictive purposes included perceived sexual communication, perceived compatibility of sexual needs, and self-reported frequency of sexual intimacy. These

variables were selected because sexual satisfaction is multidimensional and may not be fully represented by frequency of sexual activity alone. Participants were instructed that they could decline to respond to any item they considered uncomfortable; however, questionnaires with excessive missing information in the principal study measures were not retained for the final dataset. Sexual variables were treated as sensitive information and were collected anonymously to minimize social desirability pressure and concerns regarding disclosure.

Marital communication was assessed using the Communication Patterns Questionnaire–Short Form (CPQ-SF), which measures characteristic patterns occurring during discussions of relationship problems. The instrument captures constructive communication as well as dysfunctional interaction patterns, including mutual avoidance and demand-withdraw communication. Higher constructive-communication scores indicate greater use of collaborative discussion, mutual expression, problem solving, negotiation, and responsiveness, whereas higher scores on dysfunctional communication dimensions indicate greater reliance on avoidance, withdrawal, criticism, or asymmetric engagement during marital conflict. In addition to standardized communication scores, perceived ease of discussing emotional concerns and sexual needs with the spouse was included among the candidate communication predictors. Demographic and relationship-related characteristics were collected as potential contextual predictors and included age, gender, educational level, employment status, duration of marriage, number of children, previous marriage, and selected household characteristics. These variables were incorporated because marital satisfaction can vary according to individual and relational context and because their inclusion allowed the machine-learning algorithm to determine whether emotional, sexual, and communication indicators provided predictive information beyond basic demographic characteristics.

2.3. Data Analysis

Data analysis was conducted using Python and its machine-learning and statistical-analysis libraries. Initial data screening included examination of duplicate observations, impossible values, out-of-range responses, missingness, univariate distributions, and response consistency. Descriptive statistics were calculated for all study variables using means, standard deviations, medians,

ranges, frequencies, and percentages as appropriate to the level of measurement. Internal consistency of multi-item instruments was evaluated before predictive modeling. Missing-data patterns were examined to distinguish isolated missing observations from cases containing substantial questionnaire incompleteness. Participants with extensive missing data on the primary outcome or major predictor domains were excluded, whereas limited missing values among predictor variables were handled within the preprocessing pipeline using appropriate imputation procedures based exclusively on the training data to prevent information leakage. Categorical predictors were encoded in a format suitable for machine-learning analysis. Continuous predictors were inspected for extreme observations, although conventional standardization was not required for LightGBM because tree-based gradient-boosting algorithms are not dependent on the scale of predictor variables.

The primary predictive analysis was performed using the Light Gradient Boosting Machine (LightGBM) algorithm, with marital satisfaction score specified as a continuous outcome. LightGBM is a gradient-boosted decision-tree method that sequentially constructs decision trees to minimize prediction error and is particularly suitable for identifying nonlinear associations, threshold effects, and complex interactions among heterogeneous predictors. Emotional, sexual, communication, demographic, and relationship-related variables were initially entered as candidate features. The complete analytical dataset of 462 participants was divided into training and independent test sets using an 80:20 allocation, resulting in approximately 80% of cases being used for model development and 20% being reserved for final out-of-sample evaluation. The test set remained untouched throughout model selection and hyperparameter optimization. Within the training set, five-fold cross-validation was employed to estimate model performance and tune the LightGBM hyperparameters. Hyperparameter optimization focused on parameters controlling model complexity and regularization, including the number of boosting iterations, learning rate, maximum tree depth, number of leaves, minimum number of observations per leaf, feature-subsampling proportion, observation-subsampling proportion, and L1 and L2 regularization coefficients. Early stopping was applied during model development when additional boosting iterations failed to improve validation performance, thereby limiting unnecessary model complexity and reducing the risk of overfitting.

Predictive performance was evaluated primarily using the coefficient of determination (R^2), root mean squared error (RMSE), and mean absolute error (MAE). R^2 represented the proportion of variance in marital satisfaction explained by the model, whereas RMSE quantified prediction error while assigning greater weight to relatively large errors, and MAE represented the average absolute difference between observed and predicted marital satisfaction scores. Performance metrics obtained from cross-validation were used for model tuning, whereas final estimates of predictive performance were calculated only once using the independent test set. To provide a meaningful benchmark for evaluating the added value of the LightGBM algorithm, its performance was compared with a conventional multiple linear regression model and selected alternative machine-learning models using the same training and test partitions. This procedure allowed examination of whether nonlinear gradient boosting offered improved predictive accuracy beyond traditional linear modeling.

Model interpretability was evaluated using both native LightGBM feature-importance estimates and SHapley Additive exPlanations (SHAP). Feature importance was initially examined according to each predictor's contribution to tree-based decision making, while SHAP values were subsequently calculated to provide a more detailed and theoretically interpretable assessment of predictor contributions. Mean absolute SHAP values were used to rank the overall importance of emotional, sexual, communication, and contextual variables in predicting marital satisfaction. SHAP dependence patterns were examined to determine whether important predictors demonstrated approximately linear, nonlinear, threshold, or saturation relationships with the predicted outcome. Individual-level SHAP values were also used to determine whether specific predictor values increased or decreased the model's predicted marital satisfaction relative to the model's baseline prediction. Particular attention was given to whether indicators of emotional regulation, emotional support, sexual satisfaction, sexual communication, constructive marital communication, and dysfunctional communication patterns emerged among the strongest predictive features.

Several procedures were implemented to enhance the robustness and reproducibility of the predictive analysis. All preprocessing procedures that could learn information from the data, including imputation and feature transformation, were estimated within the training data rather than before the train-test split. Hyperparameter selection was performed

exclusively within the training set through cross-validation, and the independent test data were used only for final performance assessment. Random seeds were fixed for data partitioning and model-fitting procedures whenever supported by the analytical software to facilitate reproducibility. The magnitude of predictive performance, rather than statistical significance alone, was emphasized in interpreting the machine-learning results. Statistical analyses used for descriptive and supplementary inferential purposes were evaluated at a two-sided significance level of $p < .05$, whereas interpretation of the LightGBM model focused primarily on out-of-sample prediction accuracy and the relative contribution of predictor variables. This analytical strategy allowed the study to determine not only how accurately marital satisfaction could be predicted from emotional, sexual, and communication indicators, but also which individual and relational characteristics contributed most strongly to the model's predictions.

3. Findings and Results

A total of 462 married adults were included in the final analyses after data screening and application of the eligibility criteria. Participants ranged in age from 23 to 67

years, with a mean age of 41.38 years ($SD = 9.74$). Of the participants, 248 (53.7%) were women and 214 (46.3%) were men. The mean duration of marriage was 13.26 years ($SD = 8.61$), ranging from 1 to 39 years. Regarding educational attainment, 61 participants (13.2%) had completed high school or an equivalent qualification, 92 (19.9%) had completed college or technical education, 181 (39.2%) held a bachelor's degree, and 128 (27.7%) held a postgraduate degree. A total of 356 participants (77.1%) were employed either full-time or part-time, whereas 106 (22.9%) were unemployed, retired, studying, or otherwise outside paid employment at the time of assessment. In terms of parenthood, 118 participants (25.5%) reported having no children, 137 (29.7%) had one child, 146 (31.6%) had two children, and 61 (13.2%) had three or more children. Most respondents, 397 (85.9%), reported that their current marriage was their first marriage, whereas 65 (14.1%) had been married previously. Inspection of the demographic data indicated sufficient heterogeneity in age, marital duration, educational attainment, employment status, and family composition to permit examination of the predictive contribution of emotional, sexual, communication, and contextual indicators across a relatively diverse Canadian married sample.

Table 1

Descriptive Statistics and Reliability Coefficients for the Main Study Variables

Variable	Possible Range	Observed Range	Mean	SD	Cronbach's α	McDonald's ω
Marital satisfaction (CSI-10)	0–40	8–40	30.84	6.47	.94	.94
Overall emotional intelligence	16–112	43–111	82.16	13.08	.91	.92
Self-emotion appraisal	4–28	10–28	21.35	4.12	.84	.85
Others' emotion appraisal	4–28	9–28	20.48	4.31	.83	.84
Use of emotion	4–28	8–28	20.61	4.47	.86	.86
Regulation of emotion	4–28	7–28	19.72	4.89	.88	.88
Perceived emotional support	5–25	6–25	19.14	4.03	.90	.90
Sexual satisfaction	12–60	15–60	44.26	9.02	.93	.93
Sexual communication	5–25	5–25	18.71	4.51	.89	.89
Sexual-need compatibility	5–25	5–25	17.83	4.66	.87	.88
Sexual intimacy frequency	1–7	1–7	4.18	1.47	—	—
Constructive communication	3–27	5–27	20.62	4.77	.86	.87
Mutual avoidance	3–27	3–26	10.41	4.86	.84	.85
Demand-withdraw communication	6–54	6–49	21.38	8.17	.88	.88
Ease of discussing emotional concerns	1–5	1–5	3.86	1.02	—	—
Ease of discussing sexual needs	1–5	1–5	3.54	1.16	—	—

As shown in Table 1, participants generally reported moderate-to-high levels of marital satisfaction, although the observed range indicated substantial between-person variability that was appropriate for continuous predictive modeling. The mean CSI-10 score was 30.84 ($SD = 6.47$),

with scores spanning from 8 to 40. Emotional intelligence was also relatively high in the sample, with an overall mean of 82.16 ($SD = 13.08$). Among the emotional intelligence dimensions, self-emotion appraisal demonstrated the highest mean score, whereas regulation of emotion showed

comparatively greater variability, suggesting meaningful individual differences in participants' perceived ability to regulate emotional reactions within interpersonal situations. Perceived emotional support had a mean of 19.14 ($SD = 4.03$), indicating that most participants experienced at least moderate emotional responsiveness and support from their spouse. Sexual satisfaction averaged 44.26 ($SD = 9.02$), while sexual communication and sexual-need compatibility showed wider relative variation, supporting their inclusion as potentially discriminative predictors of marital satisfaction. Constructive communication was generally

more prominent than dysfunctional communication; however, both mutual avoidance and demand-withdraw interaction patterns displayed substantial variability across participants. The reliability estimates for all multi-item scales and subscales were satisfactory to excellent, with Cronbach's alpha coefficients ranging from .83 to .94 and McDonald's omega coefficients ranging from .84 to .94. These findings indicated adequate internal consistency and supported the use of the resulting scores as candidate features in the subsequent machine-learning analyses.

Table 2

Predictive Performance of LightGBM and Comparison Models on the Independent Test Set

Model	Cross-Validated R^2 , Mean $\pm$ SD	Test R^2	RMSE	MAE
Multiple linear regression	.612 $\pm$.041	.598	4.11	3.23
Elastic Net regression	.628 $\pm$.038	.617	4.01	3.10
Random forest regression	.711 $\pm$.035	.704	3.53	2.73
XGBoost regression	.747 $\pm$.032	.739	3.31	2.51
LightGBM regression	.781 $\pm$.028	.772	3.09	2.34

Table 2 presents the comparative predictive performance of the candidate models. The LightGBM model demonstrated the strongest overall out-of-sample performance and explained 77.2% of the variance in marital satisfaction in the independent test sample ($R^2 = .772$). Its RMSE of 3.09 indicated that the typical magnitude of prediction error was approximately three CSI-10 points, while the MAE of 2.34 showed that, on average, predicted marital satisfaction scores differed from observed values by slightly more than two points. The five-fold cross-validation result for LightGBM was also stable, with a mean R^2 of .781 and a comparatively small standard deviation of .028, suggesting that predictive performance was not dependent on a single favorable training-validation partition. XGBoost produced the second-best performance, with a test-set R^2 of

.739, RMSE of 3.31, and MAE of 2.51. Random forest regression achieved a lower but still substantial R^2 of .704, whereas Elastic Net and conventional multiple linear regression explained 61.7% and 59.8% of the variance, respectively. Relative to multiple linear regression, LightGBM increased explained out-of-sample variance by 17.4 percentage points and reduced MAE from 3.23 to 2.34. The superior performance of the gradient-boosting models over the linear approaches indicated that the relationships between emotional, sexual, communication, and contextual factors and marital satisfaction were not fully linear or additive. The results therefore supported the selection of LightGBM as the final predictive model for subsequent interpretation.

Table 3

Optimized LightGBM Hyperparameters and Final Model Characteristics

Hyperparameter / Characteristic	Final Value
Number of boosting iterations	436
Learning rate	0.031
Maximum tree depth	6
Number of leaves	27
Minimum observations per leaf	18
Feature fraction	0.82
Bagging fraction	0.85
Bagging frequency	1
L1 regularization	0.18

L2 regularization	0.74
Minimum split gain	0.02
Training cases	369
Independent test cases	93
Cross-validation folds	5
Early-stopping patience	50 rounds
Best cross-validation R ²	.781
Final test R ²	.772

As reported in Table 3, hyperparameter optimization produced a relatively conservative LightGBM architecture intended to balance predictive accuracy and generalizability. The final model used 436 boosting iterations with a learning rate of .031, allowing the model to construct the ensemble incrementally rather than relying on a small number of highly influential trees. Maximum tree depth was restricted to six and the number of leaves was set at 27, thereby permitting nonlinear partitioning while limiting excessive structural complexity. A minimum of 18 observations per terminal leaf was retained, which reduced the likelihood that the model would generate highly specific rules based on very small subsets of participants. Feature and observation subsampling were set at .82 and .85, respectively, introducing additional regularization by ensuring that individual boosting iterations did not use all predictors or

observations simultaneously. Both L1 and L2 penalties were retained in the optimized model, with a stronger L2 regularization coefficient of .74, indicating that model tuning favored shrinkage of overly complex decision structures. Early stopping was implemented with a patience criterion of 50 boosting rounds, and model training ceased when additional iterations no longer produced meaningful improvement in validation performance. Of the 462 participants, 369 were assigned to the model-development sample and 93 were retained as an independent test set. The similarity between the cross-validated R² of .781 and the final test-set R² of .772 indicated limited evidence of substantial overfitting and suggested that the optimized model generalized well to observations that had not contributed to feature selection or hyperparameter tuning.

Table 4

SHAP-Based Importance of Predictors in the Final LightGBM Model

Rank	Predictor	Mean Absolute SHAP Value	Relative Importance (%)	Predominant Association with Predicted Marital Satisfaction
1	Sexual satisfaction	2.184	16.9	Positive
2	Perceived emotional support	1.936	15.0	Positive
3	Constructive communication	1.721	13.3	Positive
4	Demand-withdraw communication	1.486	11.5	Negative
5	Sexual communication	1.273	9.8	Positive
6	Regulation of emotion	1.087	8.4	Positive
7	Sexual-need compatibility	0.941	7.3	Positive
8	Mutual avoidance	0.786	6.1	Negative
9	Ease of discussing emotional concerns	0.613	4.7	Positive
10	Others' emotion appraisal	0.478	3.7	Positive
11	Duration of marriage	0.261	2.0	Nonlinear
12	Age	0.168	1.3	Weak nonlinear

Table 4 summarizes the SHAP-based interpretation of the final LightGBM model and demonstrates that the most influential predictors were concentrated in the sexual, emotional, and communication domains rather than in demographic characteristics. Sexual satisfaction emerged as the strongest predictor, with a mean absolute SHAP value of 2.184 and a relative contribution of 16.9% among the

principal features. Higher sexual satisfaction generally shifted model predictions toward higher marital satisfaction, although the SHAP dependence pattern suggested that the increase was strongest from low to moderately high levels and became less pronounced at the upper end of the scale. Perceived emotional support ranked second, accounting for 15.0% of relative importance, and was consistently

associated with higher predicted marital satisfaction. Constructive communication was the third most influential predictor, whereas demand-withdraw communication ranked fourth and exerted a predominantly negative contribution. The opposing directions of these communication variables indicated that the model distinguished not only the presence of adaptive interaction but also the independent detrimental contribution of dysfunctional conflict processes. Sexual communication ranked fifth, followed by regulation of emotion and sexual-need compatibility, further emphasizing the importance of relational processes involving mutual disclosure, affect regulation, and perceived compatibility. Mutual avoidance also demonstrated a meaningful negative association, whereas ease of discussing emotional concerns contributed positively to predictions. Demographic variables were substantially less important than the principal relational predictors. Duration of marriage accounted for only 2.0% of relative importance and demonstrated a nonlinear relationship, while age accounted for 1.3%. These findings indicated that the predictive performance of the model was primarily driven by modifiable interpersonal and relational characteristics rather than by relatively fixed demographic factors.

SHAP dependence analysis further revealed several nonlinear patterns that would have been difficult to represent adequately using a conventional linear model. For sexual satisfaction, predicted marital satisfaction increased sharply as sexual satisfaction moved from low to moderate levels, after which the marginal increase gradually attenuated. Perceived emotional support demonstrated a similar but slightly more linear pattern, with especially low support scores producing large negative SHAP contributions. Constructive communication showed a threshold-type association in which participants scoring in the lower range experienced marked reductions in predicted marital satisfaction, whereas scores above approximately the upper-middle portion of the scale were associated with increasingly positive predictions. Demand-withdraw communication displayed the inverse pattern. Mild levels produced relatively small effects, but SHAP values became increasingly negative once demand-withdraw scores entered the upper range. Regulation of emotion was positively associated with marital satisfaction, particularly among participants who simultaneously reported stronger emotional support, suggesting that intrapersonal emotional regulation and interpersonal emotional responsiveness may operate synergistically. Sexual communication also interacted with

sexual satisfaction: high sexual satisfaction was associated with the most favorable predictions when accompanied by open communication regarding sexual needs, whereas the predictive advantage of sexual satisfaction was attenuated among individuals reporting poor sexual communication.

Examination of pairwise SHAP interaction values identified several particularly important combinations of predictors. The strongest interaction was observed between sexual satisfaction and sexual communication, followed by the interaction between perceived emotional support and constructive communication. Participants who simultaneously reported high sexual satisfaction and high sexual communication received substantially larger positive model contributions than would be expected from either feature considered independently. Similarly, high emotional support combined with constructive communication generated consistently favorable predictions of marital satisfaction. In contrast, high demand-withdraw communication reduced predicted marital satisfaction even among participants with moderate levels of emotional support, indicating that dysfunctional conflict processes could partially offset the benefits associated with otherwise supportive relationships. A further interaction was identified between emotional regulation and demand-withdraw communication, such that stronger emotional regulation appeared to buffer, but not completely eliminate, the negative contribution associated with frequent demand-withdraw patterns. These interaction findings provided additional evidence that marital satisfaction was best represented as the product of interdependent relational processes rather than as the simple sum of isolated predictors.

Prediction-error diagnostics showed that the final LightGBM model performed consistently across most of the observed marital-satisfaction range. Predicted and observed CSI-10 scores demonstrated a strong correspondence, and residuals were centered close to zero without evidence of a systematic tendency to overpredict or underpredict scores in the central portion of the distribution. Prediction errors were somewhat larger among participants with extremely low marital satisfaction, which was expected because relatively few observations were located at the lowest end of the CSI-10 distribution. Nevertheless, the model continued to distinguish these participants from those with moderate and high satisfaction. Inspection of residuals by gender, age category, educational level, and marital duration did not reveal substantial systematic subgroup bias. Mean absolute prediction error was similar for women and men, and no

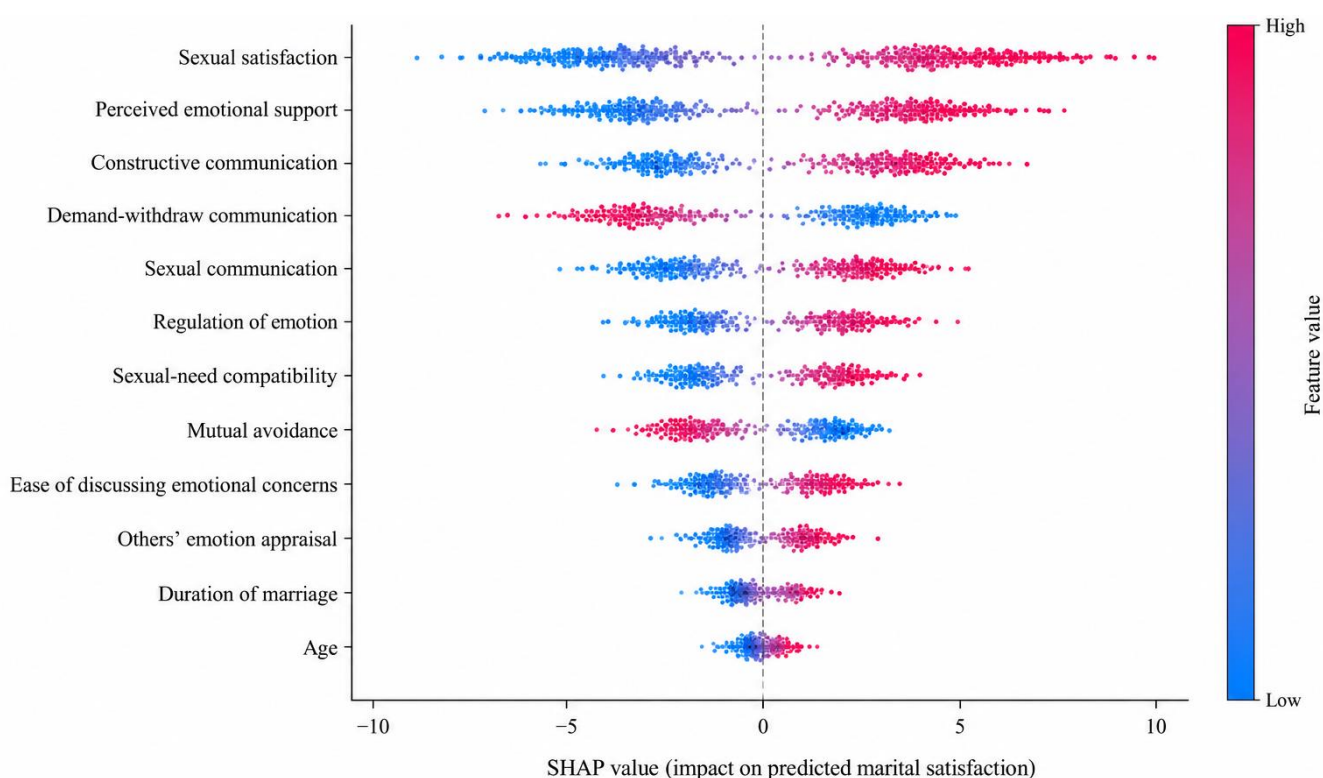
pronounced decline in predictive accuracy was observed among longer-married participants. These diagnostic findings strengthened the evidence that the model's test-set performance reflected generalized predictive patterns rather than an artifact of one demographic subgroup.

Sensitivity analyses were conducted to examine whether the superiority and interpretation of the LightGBM model remained stable under alternative modeling conditions. Re-estimating the model after excluding demographic predictors produced only a minor reduction in test-set R^2 , from .772 to .763, indicating that most predictive information originated from the emotional, sexual, and communication domains. Conversely, a model containing demographic and relationship-background variables alone produced substantially weaker performance, with an R^2 below .30. When only emotional indicators were included,

predictive accuracy improved considerably but remained lower than that of the complete model. Sexual indicators alone also demonstrated substantial predictive capacity, while communication variables alone yielded similarly meaningful but incomplete prediction. Combining emotional and communication indicators substantially improved performance, and the addition of sexual variables produced the best overall model. The progressive gain in accuracy across feature sets indicated that each relational domain contributed nonredundant predictive information and that the strongest predictions were achieved when marital satisfaction was conceptualized as a multidimensional outcome shaped jointly by emotional functioning, sexual relationship quality, and patterns of interpersonal communication.

Figure 1

SHAP Summary Plot Showing the Direction and Magnitude of the Most Important Predictors of Marital Satisfaction in the Final LightGBM Model



The SHAP summary plot visually demonstrated the distribution, direction, and magnitude of feature contributions across individual participants. Sexual satisfaction showed the widest overall spread of SHAP values, confirming its position as the most influential

predictor. Higher sexual satisfaction values clustered predominantly on the positive side of the SHAP axis, whereas lower values generated pronounced negative contributions. A comparable directional pattern was observed for perceived emotional support, constructive

communication, sexual communication, regulation of emotion, and sexual-need compatibility. In contrast, high values of demand-withdraw communication and mutual avoidance were concentrated on the negative side of the prediction distribution. The figure also illustrated substantial interindividual variation in the magnitude of these effects, reinforcing the advantage of a nonlinear individualized prediction approach. Demographic variables appeared near the lower portion of the importance ranking and exhibited considerably narrower SHAP distributions, further confirming that the model relied primarily on emotional, sexual, and communication characteristics in generating predictions of marital satisfaction.

4. Discussion

The present study developed and evaluated a LightGBM-based predictive model of marital satisfaction using emotional, sexual, communication, demographic, and relationship-related indicators among married adults in Canada. The findings showed that the final LightGBM model achieved strong out-of-sample predictive performance, explaining 77.2% of the variance in marital satisfaction in the independent test set and outperforming multiple linear regression, Elastic Net, random forest, and XGBoost models. SHAP-based interpretation indicated that sexual satisfaction was the most influential predictor, followed by perceived emotional support, constructive communication, demand-withdraw communication, sexual communication, regulation of emotion, sexual-need compatibility, and mutual avoidance. Demographic characteristics, including age and duration of marriage, contributed substantially less to prediction than relational and psychological variables. The model also identified nonlinear and interactive patterns, particularly between sexual satisfaction and sexual communication, perceived emotional support and constructive communication, and emotion regulation and demand-withdraw communication. Taken together, these findings suggest that marital satisfaction is better understood as an emergent property of interacting emotional, sexual, and communicative processes than as a direct consequence of demographic characteristics or isolated individual factors.

The strongest predictor in the model was sexual satisfaction. Higher levels of sexual satisfaction were generally associated with higher predicted marital satisfaction, while low sexual satisfaction produced some of the largest negative SHAP contributions. This result is

consistent with evidence indicating that sexual functioning is an integral component of broader relational and personal well-being. Bahrami et al. reported that sexual-related determinants were closely associated with life satisfaction among married women, demonstrating that satisfaction with sexual life is connected with wider evaluations of quality of life and relationship functioning (Bahrami et al., 2023). Similarly, Farhan and Ismail showed that sexual satisfaction is associated with intimacy and body-related perceptions among married women, indicating that sexual experience is embedded within emotional closeness and self-perception rather than operating as an isolated behavioral domain (Farhan & Ismail, 2022). The present findings extend this literature by showing that sexual satisfaction carries strong predictive information when simultaneously considered alongside emotional intelligence, support, communication patterns, and demographic variables.

The nonlinear pattern observed for sexual satisfaction is also theoretically meaningful. The largest gains in predicted marital satisfaction occurred as sexual satisfaction moved from low to moderate and moderately high levels, whereas additional increases at the highest levels produced smaller gains. This pattern suggests a threshold or diminishing-returns effect. Extremely poor sexual satisfaction may signal unmet needs, impaired intimacy, unresolved conflict, avoidance, or broader relational dissatisfaction, and improvement from such low levels may therefore correspond to substantial improvement in relationship evaluation. Once sexual satisfaction is already high, additional increases may contribute less because other aspects of the relationship become more important determinants of overall satisfaction. Evidence from pregnancy-related research similarly suggests that sexual functioning is jointly shaped by relationship satisfaction, body image, and broader psychosocial conditions (Daniluc et al., 2025). Research examining emotional intelligence and sexual satisfaction further indicates that sexual outcomes are interwoven with emotional capacities, communication, and interpersonal understanding (Özbay & Balaban, 2024). These findings support the interpretation that sexual satisfaction functions within a broader relational system rather than as a single independent determinant.

Perceived emotional support emerged as the second most important predictor and had a consistently positive relationship with predicted marital satisfaction. Participants who perceived their spouses as emotionally available, understanding, responsive, and validating were more likely to receive higher predicted marital satisfaction scores. This

finding is compatible with relational theories emphasizing perceived partner responsiveness as a central mechanism of intimacy. Emotional support may communicate acceptance, safety, and commitment, particularly when partners are dealing with stress, health difficulties, or developmental transitions. In menopausal women, spousal support has been associated with sexual attitudes and adaptation to menopausal symptoms, demonstrating the importance of the partner as a source of emotional and relational support (Küçükkaya et al., 2026). The importance of empathy and validation has also been documented among couples coping with chronic pain, where supportive partner responses can influence both relational functioning and adaptation to persistent health-related stress (Teichmüller et al., 2025). The present findings therefore reinforce the view that emotional support is not merely a desirable relationship characteristic but a central predictive component of marital satisfaction.

The model further showed that constructive communication was among the strongest positive predictors, whereas demand-withdraw communication and mutual avoidance were strong negative predictors. This pattern highlights the distinction between adaptive and maladaptive communication processes. Constructive communication allows partners to express concerns, negotiate disagreements, clarify expectations, and repair relational ruptures. In contrast, demand-withdraw patterns can create cycles in which one partner increases pressure for engagement while the other disengages, thereby escalating frustration and reducing mutual understanding. Mutual avoidance may similarly preserve unresolved conflict by preventing meaningful discussion. Previous intervention studies support the importance of communication patterns in marital functioning. Gottman-oriented couple therapy has been shown to improve marital conflicts and communication patterns among couples experiencing relationship difficulties (Salehi et al., 2024). Communication-skills training based on transactional analysis has also improved marital adjustment, suggesting that communication is modifiable and that changes in interaction style can translate into broader improvements in relationship functioning (Enjezab et al., 2023). These findings align closely with the present model, in which communication-related features accounted for a substantial proportion of predictive importance.

The importance of communication also appears to extend beyond ordinary marital conflict to severe relational adversity. Emotion-focused couple therapy has been

associated with improved intimacy, marital adjustment, and forgiveness among couples with a history of extramarital affairs (Torani & Fard, 2024). Likewise, intervention research among women experiencing trauma symptoms related to domestic abuse has shown that spousal intimacy can change through culturally embedded relational interventions (Rowland et al., 2024). These studies suggest that relationship communication and intimacy are dynamic rather than fixed and may change even after substantial relational injury. The present findings are compatible with this perspective because the strongest predictors were predominantly relational processes that are theoretically amenable to intervention rather than fixed demographic characteristics.

Sexual communication was another prominent predictor and showed a positive relationship with marital satisfaction. More importantly, SHAP interaction analysis indicated that sexual communication strengthened the positive contribution of sexual satisfaction. Participants with high sexual satisfaction and open sexual communication received more favorable predictions than those with similar levels of sexual satisfaction but poorer communication regarding sexual needs. This interaction suggests that the subjective quality of sexual experiences may be enhanced when partners are able to discuss preferences, needs, boundaries, concerns, and expectations openly. Sexual satisfaction without effective communication may be less stable because misunderstandings and unexpressed needs can persist beneath apparently satisfactory sexual functioning. The finding is consistent with evidence showing that love styles, conflict patterns, emotional intelligence, and sexual satisfaction cluster into distinct relational profiles (Castillo-López et al., 2025). Such profile-based evidence supports the present finding that sexual and communicative processes are interdependent rather than merely additive.

Emotion regulation also emerged as an important positive predictor. Participants reporting stronger regulation of emotion tended to have higher predicted marital satisfaction, especially when dysfunctional communication patterns were lower. Emotional regulation likely contributes to relationship quality by allowing individuals to tolerate distress, delay reactive responses, express negative emotions more constructively, and recover more effectively after conflict. Emotional processes are deeply embedded in family relationships, and difficulties in emotion regulation can intensify interpersonal problems when anger, anxiety, shame, or frustration are expressed through criticism, defensiveness, or withdrawal (Duca et al., 2023). Research

on attachment and couple therapy similarly suggests that emotional regulation is linked to relational outcomes through patterns of security, vulnerability, and responsiveness (Ibrahim et al., 2023). Consistent with these studies, the present results indicate that emotion regulation may act as an intrapersonal capacity that shapes interpersonal interaction.

The interaction between emotion regulation and demand-withdraw communication is particularly notable. Stronger emotion regulation appeared to reduce, although not fully eliminate, the negative contribution associated with frequent demand-withdraw behavior. This suggests a potential buffering mechanism whereby individuals who are better able to manage emotional arousal may prevent conflict cycles from escalating to the same extent as individuals with poorer regulation. However, the inability of emotion regulation to completely neutralize the negative contribution of demand-withdraw patterns indicates that individual emotional competence cannot fully compensate for chronically dysfunctional couple interaction. This interpretation is consistent with evidence linking emotional intelligence to dyadic adjustment in married couples (Zaidi et al., 2022). It also aligns with research showing that mindfulness is related to both relationship quality and conflict-resolution strategies, potentially because mindful awareness promotes emotional regulation and reduces automatic reactive behavior during interpersonal conflict (Mandal & Lip, 2022).

The interaction between perceived emotional support and constructive communication provides further evidence that relationship processes operate synergistically. Emotional support may be more meaningful when it is communicated through attentive listening, collaborative discussion, validation, and responsiveness. Conversely, communication that is technically frequent but emotionally unresponsive may not create a strong sense of support. This interpretation is compatible with dyadic approaches to relationship functioning in the context of serious illness. Studies of breast cancer, prostate cancer, and other chronic health conditions have repeatedly emphasized that couples cope through reciprocal patterns of communication, emotional support, and shared adaptation (Castro et al., 2024; Valente et al., 2022; C. Wang et al., 2025). Dyadic coping research also suggests that relational well-being depends on how partners perceive and respond to one another's stress rather than solely on the objective severity of the stressor (Cao, 2026; Jie, 2026). The present findings extend this framework

beyond illness contexts by showing that similar dyadic mechanisms are central to general marital satisfaction.

The superiority of LightGBM over conventional multiple linear regression is another important finding. The difference in predictive performance suggests that marital satisfaction may not be adequately represented by a purely linear and additive model. The LightGBM model was able to capture threshold effects, diminishing returns, and interactions among relational predictors. This is consistent with emerging evidence that marital adjustment and psychological well-being are connected through complex networks rather than simple one-directional pathways. Gyeong and Shin demonstrated divergent pathways linking personality, approach-avoidance goals, marital adjustment, and psychological well-being, highlighting the interdependent architecture of relationship functioning (Gyeong & Shin, 2026). Majumder et al. similarly emphasized the multidimensional nature of psychological factors involved in marital conflict and intervention priorities (Majumder et al., 2024). The present machine-learning findings therefore offer methodological support for conceptualizing marital satisfaction as a complex relational system.

The comparatively small contribution of demographic variables was also noteworthy. Age and duration of marriage contributed far less to prediction than sexual satisfaction, emotional support, and communication variables. This does not imply that demographic or life-course factors are irrelevant. Rather, it suggests that their predictive value may be mediated or moderated by more proximal relationship processes. For example, financial strain during midlife has been linked with later health and well-being partly through couple intimacy trajectories (Wickrama et al., 2022). Likewise, major relational stressors such as the death of a child can profoundly alter marital functioning, but partners vary considerably in how the relationship adapts to the event (Buchanan, 2022). Therefore, age or marital duration may provide contextual information, while the quality of emotional support, communication, intimacy, and coping may more directly determine how contextual pressures are experienced within the marriage.

The relatively low importance of age and duration of marriage also corresponds with research showing that relationship quality is highly sensitive to situational and dyadic conditions across the life course. The COVID-19 pandemic, for example, altered parenting responsibilities, work-family boundaries, stress levels, and relationship dynamics across couples of different ages and marital

durations (Sentieiro et al., 2025). Shared sleep conditions can also affect relationship health through both supportive and disruptive mechanisms (Andersen et al., 2025), while romantic relationship experiences and sleep quality appear to influence each other reciprocally (Xie & Feeney, 2024). These studies illustrate why static demographic measures may have limited predictive power when compared with dynamic relational processes.

The findings additionally support a systemic conceptualization of marital satisfaction. Relational difficulties often involve mutually reinforcing emotional, sexual, and communication problems rather than a single isolated deficit. A partner who feels emotionally unsupported may communicate less openly, experience greater conflict, and become less comfortable discussing sexual needs. Reduced sexual satisfaction may subsequently contribute to emotional distance and further deterioration in communication. Conversely, constructive communication can facilitate emotional validation and sexual disclosure, thereby promoting intimacy and satisfaction across multiple domains. Clinical case evidence describing transformative change in marital relational models supports the possibility that improvement may occur through reorganization of interconnected couple processes rather than through change in only one symptom or behavior (Figueiredo et al., 2024). Similarly, latent relationship profiles involving love styles, conflict, emotional intelligence, and sexual satisfaction suggest that distinct combinations of relational characteristics may characterize different levels of functioning (Castillo-López et al., 2025).

5. Conclusion

The present results also have relevance for couples coping with health-related stress. Research on dyadic coping in cardiac and oncology populations has demonstrated that interventions targeting shared coping processes can improve psychosocial adaptation and marital well-being (C. Wang et al., 2025; Y. Wang et al., 2025). Such evidence supports the broader principle identified in the current study: relationship satisfaction may be strengthened when partners are able to communicate effectively, provide emotional support, regulate distress, and respond jointly to shared challenges. The strong predictive roles of emotional and communication variables are therefore consistent with a substantial body of dyadic health research in which relationship quality functions both as a resource and as an outcome of coordinated coping.

6. Limitations & Suggestions

Several limitations should be considered when interpreting the findings. First, the cross-sectional design prevents causal inference, and the identified predictors should therefore be interpreted as variables that contributed to prediction rather than as established causes of marital satisfaction. Second, the study relied primarily on self-report measures, which may be influenced by social desirability, recall bias, shared method variance, and participants' current emotional state. This concern is particularly relevant for sensitive variables such as sexual satisfaction, sexual communication, and marital conflict. Third, although the sample included substantial variability in age, education, marital duration, and family composition, convenience and purposive recruitment may limit representativeness of the broader Canadian population. Individuals willing to participate in relationship research may differ systematically from those who do not participate. Fourth, the study collected information from individual respondents rather than matched marital dyads, meaning that the model represented one partner's perception of the relationship rather than the reciprocal experiences of both spouses. Fifth, some potentially relevant variables, including attachment insecurity, personality traits, financial stress, mental health, cultural background, parenting stress, relationship violence, physical health, and work-family conflict, were not incorporated into the final predictive framework. Finally, although the independent test set reduced the risk of overfitting, external validation in a completely independent Canadian or international sample would provide stronger evidence regarding transportability and generalizability.

Future research should replicate the predictive framework using longitudinal and dyadic designs in which both partners are assessed repeatedly across time. Such designs would make it possible to determine whether emotional, sexual, and communication variables predict subsequent changes in marital satisfaction rather than merely covarying with current satisfaction. Larger multi-site samples should be recruited across Canadian provinces and territories and should deliberately include greater cultural, linguistic, socioeconomic, sexual-orientation, and relationship-structure diversity. Future models could incorporate attachment style, personality, psychological distress, parenting demands, financial strain, sleep, physical health, work-family conflict, and major life events to determine whether these factors improve predictive accuracy beyond the current feature set. Dyadic machine-learning approaches

should also be developed to integrate characteristics of both partners and identify actor, partner, and interaction effects. Repeated-measures and temporal machine-learning models could be used to identify early-warning patterns preceding meaningful declines in relationship satisfaction. Comparative studies should additionally evaluate LightGBM against other interpretable and deep-learning approaches while emphasizing external validation, calibration, fairness across demographic subgroups, and clinically meaningful prediction thresholds. Future work could also examine whether SHAP-derived individual prediction profiles correspond to distinct therapeutic needs or treatment-response trajectories.

The findings suggest that assessment of marital satisfaction should extend beyond global satisfaction scores and include systematic evaluation of sexual satisfaction, emotional support, constructive and dysfunctional communication, sexual communication, emotional regulation, and perceived compatibility of needs. Couple therapists and relationship counselors may benefit from identifying each couple's specific pattern of protective and risk factors rather than assuming that the same pathway underlies dissatisfaction in all relationships. Particular attention should be given to low sexual satisfaction combined with poor sexual communication, low emotional support combined with weak constructive communication, and persistent demand-withdraw or avoidance patterns, because these combinations may signal broader relationship vulnerability. Interventions should therefore integrate emotional-regulation training, partner validation, communication restructuring, conflict de-escalation, and open discussion of sexual needs rather than treating these domains independently. Machine-learning models such as LightGBM may eventually support clinical decision-making by identifying individualized risk profiles and prioritizing areas for assessment, but they should be used as adjunctive tools rather than substitutes for comprehensive clinical judgment, direct couple assessment, and contextual understanding. Any future clinical implementation should emphasize transparency, privacy, informed consent, fairness, and careful interpretation of prediction as probabilistic information rather than deterministic classification.

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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 have equally contributed to the research process and the development of the manuscript.

Declaration

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

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