

Support Vector Machine Classification of Cyberchondria Severity Based on Health Anxiety, Intolerance of Uncertainty, and Online Reassurance Seeking

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ABSTRACT

Objective: The present study aimed to classify cyberchondria severity based on health anxiety, intolerance of uncertainty, and online reassurance seeking using a Support Vector Machine model among adults living in Canada.

Methods and Materials: This applied, quantitative, cross-sectional study was conducted using a predictive machine-learning classification design. The statistical population included adults living in Canada who used the Internet to search for health-related information. A total of 426 participants were selected through online convenience sampling. Data were collected using the Cyberchondria Severity Scale-12, the Short Health Anxiety Inventory, the Intolerance of Uncertainty Scale-12, an online reassurance-seeking measure, and a demographic information form. Cyberchondria severity was classified into low, moderate, and high groups using percentile-based categorization. The dataset was divided into training and testing subsets using stratified sampling, with 70% of the data used for model training and 30% reserved for independent testing. Support Vector Machine models with different kernels were trained and compared through cross-validation, and the final model was evaluated using accuracy, precision, recall, F1-score, area under the curve, and confusion matrix analysis.

Findings: The radial basis function Support Vector Machine showed the best cross-validated performance and was selected as the final model. In the independent test set, the final model achieved an overall accuracy of 0.84, macro F1-score of 0.84, weighted F1-score of 0.84, and macro AUC of 0.92. Class-level results showed strong performance for low cyberchondria severity and high cyberchondria severity, with F1-scores of 0.87 and 0.89, respectively. The moderate severity group showed lower but acceptable classification performance, with an F1-score of 0.76. The confusion matrix indicated that classification errors

occurred mainly between adjacent severity categories, with no direct confusion between low and high severity groups. Permutation-based importance analysis indicated that online reassurance seeking was the strongest predictor, followed by health anxiety and intolerance of uncertainty.

Conclusion: The findings showed that cyberchondria severity can be accurately classified using a Support Vector Machine model based on health anxiety, intolerance of uncertainty, and online reassurance seeking. The results highlight the importance of anxiety-related cognition, difficulty tolerating health uncertainty, and repeated digital reassurance seeking in identifying individuals at greater risk for severe cyberchondria.

Keywords: *Cyberchondria; Support Vector Machine; Health Anxiety; Intolerance of Uncertainty; Online Reassurance Seeking; Machine Learning; Classification.*

1. Introduction

The expansion of digital health information has changed the way individuals interpret bodily sensations, evaluate health risks, and decide whether they need professional medical care. Search engines, online symptom checkers, social media platforms, health forums, and medical websites provide rapid access to information that may support health literacy and informed decision-making; however, the same information environment may also intensify uncertainty, fear, and repetitive checking among individuals who are vulnerable to anxiety about illness. In this context, cyberchondria has emerged as a clinically and socially relevant construct referring to excessive or distressing online health-related searching that increases, rather than reduces, anxiety about health. Although searching for health information is not inherently pathological, cyberchondria involves a maladaptive cycle in which ambiguous bodily sensations or health-related doubts trigger online searches, the search results increase perceived threat, and the individual continues searching in an attempt to obtain certainty or reassurance. This cycle may become repetitive, compulsive, and emotionally burdensome, particularly when the individual interprets common symptoms catastrophically or gives disproportionate credibility to alarming online information. Cyberchondria has therefore been conceptualized as an old phenomenon in a new guise, because longstanding health anxiety and hypochondriacal concerns are now expressed and amplified through digital technologies (Starcevic & Berle, 2015). Recent literature has further emphasized cyberchondria as a growing concern in contemporary mental health, especially because online health information is constantly available, uneven in quality, and often difficult for laypersons to interpret accurately (Mestre-Bach & Potenza, 2023; Varma & Singh, 2023).

The theoretical importance of cyberchondria lies in its position at the intersection of health anxiety, obsessive-

compulsive processes, uncertainty intolerance, reassurance seeking, and problematic Internet use. Individuals experiencing cyberchondria do not simply search for health information more often; rather, they may become trapped in a self-reinforcing pattern in which online searching heightens threat perception and increases the subjective need for further checking. Previous research has shown that cyberchondria is associated with anxiety sensitivity, hypochondriacal concerns, and Internet addiction, suggesting that it is not reducible to a single psychological mechanism but instead reflects a multidimensional pattern of affective, cognitive, and behavioral dysregulation (Abu Khait et al., 2023; Khait et al., 2022). The relationship between cyberchondria and Internet addiction is particularly important because online health searching may share features with other problematic online behaviors, including loss of control, repeated use despite distress, difficulty disengaging, and reliance on the Internet as a primary coping strategy (Ivanova & Karabeliova, 2014; Zareii & Zarnaghash, 2022). In this sense, cyberchondria may represent both an anxiety-related process and a problematic digital behavior, making it especially suitable for predictive modeling approaches that can integrate multiple psychological predictors simultaneously.

Health anxiety is one of the most central constructs in explaining cyberchondria severity. Health anxiety involves persistent fear or preoccupation concerning the possibility of having or developing a serious illness, often accompanied by selective attention to bodily sensations, catastrophic interpretation of benign symptoms, and difficulty accepting medical reassurance. In the digital environment, these tendencies may become intensified because online searches frequently expose users to worst-case explanations, rare diseases, contradictory information, and alarming personal narratives. As a result, people with elevated health anxiety may enter online searches seeking reassurance but leave with increased fear and a stronger conviction that additional

searching is necessary. Empirical work has repeatedly supported the association between cyberchondria and hypochondriacal or health-anxiety symptoms (Noor & Oglesby, 2015; Wearden et al., 2006). In clinical and non-clinical populations, individuals with higher health anxiety are more likely to interpret online medical information in a threatening way, to search repeatedly for explanations of bodily sensations, and to experience distress when they cannot achieve certainty. This makes health anxiety a theoretically necessary predictor in any model designed to classify cyberchondria severity.

The COVID-19 pandemic further demonstrated how health anxiety and digital searching may interact under conditions of heightened public threat. During periods of widespread uncertainty, rapidly changing health recommendations, and continuous media exposure, many individuals increased their use of online health information to understand symptoms, risks, and protective behaviors. However, for some individuals, this behavior was associated with greater distress rather than adaptive coping. Studies conducted during or in relation to the pandemic showed that cyberchondria was linked to fear of infection, somatic burden, psychological distress, and uncertainty, highlighting the role of contextual threat in activating online health anxiety processes (Dameery et al., 2020; Oniszczenko, 2021; Zolotareva, 2022). These findings suggest that cyberchondria is not merely a stable personality-like tendency but may be amplified by environmental conditions that increase perceived health risk and reduce subjective certainty. Nevertheless, even outside pandemic conditions, the general mechanism remains relevant: individuals confronted with ambiguous health information may respond with increased checking, reassurance seeking, and anxiety escalation.

Intolerance of uncertainty is another key psychological predictor of cyberchondria severity. It refers to a dispositional difficulty in accepting ambiguous, unpredictable, or incomplete information and is especially relevant to health concerns because bodily sensations and medical symptoms are often uncertain by nature. Many common physical sensations have multiple possible explanations, ranging from harmless to serious, and online searches may increase exposure to diagnostic ambiguity rather than resolving it. Individuals with high intolerance of uncertainty may perceive this ambiguity as unacceptable and may engage in repeated online searches to reduce uncertainty. However, because online information is often inconsistent, probabilistic, and difficult to interpret, repeated

searching may paradoxically increase uncertainty and distress. Research has indicated that intolerance of uncertainty is meaningfully associated with cyberchondria, health anxiety, and anxiety-spectrum processes (Fathi Avali Gheshlaqi & Najafi, 2023; Schenkel et al., 2021). Moreover, recent work has suggested that intolerance of uncertainty may mediate or explain the relationship between broader vulnerability factors and cyberchondria, including neuroticism and metacognitive beliefs about health (Torabi & Pourmohammad, 2025). This supports the view that intolerance of uncertainty is not merely a correlate of cyberchondria but may function as a core cognitive mechanism through which online health searching becomes excessive and distressing.

The relationship between intolerance of uncertainty and reassurance seeking is also important for understanding the behavioral maintenance of cyberchondria. When individuals cannot tolerate uncertainty, they may seek reassurance from physicians, family members, friends, or online sources. Although reassurance can temporarily reduce anxiety, its effects are often short-lived, and repeated reassurance seeking may undermine confidence in one's own judgment. In health contexts, online reassurance seeking may involve repeatedly searching symptoms, comparing personal sensations with diagnostic descriptions, reading medical forums, consulting symptom checkers, or seeking confirmation that a feared illness is absent. Studies on reassurance seeking have shown that it is associated with worry, attachment insecurity, obsessive beliefs, self-doubt, and anxiety-related interpersonal processes (Clark et al., 2020; Najafi et al., 2024). Although reassurance seeking is often studied in interpersonal contexts, its digital form is particularly relevant to cyberchondria because online platforms make reassurance immediately available but rarely definitive. The individual may therefore continue checking because each search result offers partial, conflicting, or conditional reassurance rather than stable certainty.

Excessive reassurance seeking has been examined across several psychological domains, including social anxiety, obsessive-compulsive symptoms, depression, attachment insecurity, and romantic relationships. These studies show that reassurance seeking is not a simple request for information; rather, it can become a repetitive safety behavior that maintains anxiety by preventing emotional tolerance of uncertainty and by reinforcing doubt. For example, excessive reassurance seeking has been linked to social anxiety and interpersonal dependency, suggesting that

anxious individuals may seek repeated confirmation to reduce perceived threat but may become increasingly reliant on external validation (Bui & Moscovitch, 2024; Starr et al., 2023). In obsessive-compulsive contexts, reassurance seeking may function as a compulsion aimed at neutralizing doubt or feared responsibility, and carer responses to reassurance seeking can influence symptom maintenance (Kobori et al., 2017). Online reassurance seeking has also been associated with obsessive-compulsive symptoms, shame, and fear of self, indicating that digital reassurance seeking may be connected to broader processes of doubt, self-evaluation, and threat monitoring (Parsons & Alden, 2022). These findings are highly relevant to cyberchondria because the online health-search process often begins as reassurance seeking but may become repetitive, anxiety-maintaining, and difficult to control.

The interpersonal literature also clarifies why reassurance seeking can become maladaptive even when it initially appears rational. Studies on attachment, romantic trust, depressive symptoms, and relationship maintenance show that repeated reassurance seeking may provide temporary relief while contributing to longer-term insecurity, dependence, and reduced confidence (Evraire et al., 2022; Fowler & Gasior, 2016). When translated into the online health context, this pattern suggests that repeated searches may reduce anxiety momentarily but strengthen the perceived need to check again in the future. The Internet becomes an external reassurance source, but because it cannot provide individualized clinical certainty in most cases, the reassurance obtained online remains unstable. Thus, cyberchondria severity may be especially high when online reassurance seeking is combined with health anxiety and intolerance of uncertainty. Health anxiety supplies the feared interpretation, intolerance of uncertainty makes ambiguity difficult to tolerate, and online reassurance seeking provides the behavioral pathway through which the cycle is repeated. This conceptual integration provides a strong rationale for examining these three variables together rather than treating them as separate predictors.

Another important issue is that not all individuals who search online for health information develop cyberchondria. Some individuals use online resources adaptively to prepare for medical consultations, learn about prevention, or understand treatment options. Therefore, the distinction between adaptive digital health engagement and cyberchondria depends partly on cognitive and emotional vulnerability factors. Health literacy may play a protective role by enabling individuals to evaluate the credibility,

relevance, and limitations of online health information. Research has suggested that health literacy may protect against cyberchondria by helping individuals interpret medical information more accurately and avoid unnecessary escalation of fear (Kobryn & Duplaga, 2024). This is particularly important in the Canadian context, where Internet access is widespread and individuals may encounter a large volume of health information before deciding whether to seek professional care. However, even individuals with access to high-quality information may experience cyberchondria if they are highly anxious about health, unable to tolerate uncertainty, or driven to seek repeated reassurance. Consequently, predictive models of cyberchondria severity should include psychological mechanisms that explain why the same information environment produces different outcomes across individuals.

Given the multidimensional nature of cyberchondria, traditional linear analyses may not fully capture the complexity of its predictors. Health anxiety, intolerance of uncertainty, and online reassurance seeking may not contribute to cyberchondria severity in a purely additive or linear manner. For example, moderate health anxiety may become more clinically relevant when combined with high intolerance of uncertainty, while reassurance seeking may be particularly predictive among individuals who already interpret ambiguous symptoms catastrophically. These possible nonlinear and interactive patterns make machine-learning classification methods appropriate for studying cyberchondria severity. Support Vector Machine classification is especially useful when the goal is to distinguish categories based on multidimensional predictor profiles. By identifying optimal decision boundaries between low, moderate, and high severity groups, SVM can provide a predictive framework that complements conventional correlational and regression-based approaches. Such an approach is consistent with the movement toward data-driven mental health assessment, in which classification models are used not only to test associations but also to estimate whether psychological variables can accurately distinguish risk groups.

The classification of cyberchondria severity has practical significance for prevention, screening, and intervention. If health anxiety, intolerance of uncertainty, and online reassurance seeking can accurately classify cyberchondria severity, clinicians and mental health professionals may be better able to identify individuals at risk for problematic online health searching before it becomes chronic or

severely impairing. This has direct implications for psychoeducation, cognitive-behavioral interventions, digital health literacy programs, and treatment planning. For example, individuals with high health anxiety may benefit from cognitive restructuring of catastrophic symptom interpretations, while individuals with high intolerance of uncertainty may require interventions that build tolerance for ambiguity and reduce compulsive checking. Individuals with elevated online reassurance seeking may need behavioral strategies to reduce repeated symptom searching and develop more adaptive forms of health-information use. Prior research has emphasized that cyberchondria has important implications for mental health professionals, particularly because it can overlap with anxiety sensitivity, hypochondria, obsessive-compulsive processes, and problematic Internet use (Abu Khait et al., 2023; Mrayyan et al., 2024). Accordingly, a classification model based on theoretically meaningful variables can contribute to both scientific understanding and clinical decision-making.

Despite the growing literature on cyberchondria, important gaps remain. Many studies have examined cyberchondria through bivariate associations or structural models, but fewer have evaluated whether psychological predictors can classify individuals into distinct severity groups with adequate accuracy. Moreover, while health anxiety, intolerance of uncertainty, and reassurance seeking have each been studied in relation to cyberchondria or related anxiety processes, their combined value in machine-learning classification remains insufficiently established. The present study addresses this gap by applying Support Vector Machine classification to predict cyberchondria severity among Canadian adults based on three theoretically central predictors. This approach allows the study to move beyond simple association and to examine whether cyberchondria severity can be meaningfully differentiated using a compact set of psychological and behavioral variables. The aim of the present study was to classify cyberchondria severity using a Support Vector Machine model based on health anxiety, intolerance of uncertainty, and online reassurance seeking among adults living in Canada.

2. Methods and Materials

2.1. Study Design and Participants

The present study was conducted using a quantitative, applied, cross-sectional, and predictive classification design. The main objective of the study was to classify the severity

of cyberchondria using a Support Vector Machine model based on health anxiety, intolerance of uncertainty, and online reassurance seeking. The statistical population consisted of adults living in Canada who had experience using the Internet to search for health-related information. The final sample included 426 participants from different provinces of Canada, selected through convenience sampling using online recruitment procedures. Participants were eligible for inclusion if they were at least 18 years old, lived in Canada at the time of data collection, had sufficient English-language proficiency to complete the questionnaires, and reported using online sources such as search engines, medical websites, health forums, or social media to obtain health-related information. Participants were excluded if they submitted incomplete questionnaires, gave patterned or inconsistent responses, or reported that they had never used the Internet for health-related searches. Before participation, all respondents were informed about the purpose of the study, the voluntary nature of participation, confidentiality of responses, and their right to withdraw from the study at any stage without consequence. Informed consent was obtained electronically before access to the questionnaire battery was provided. The sample size was considered adequate for machine-learning classification because it provided a sufficient number of observations across cyberchondria severity classes and allowed the dataset to be divided into training and testing subsets while preserving the distribution of the outcome categories.

2.2. Measures

Cyberchondria severity was assessed using the Cyberchondria Severity Scale-12. This instrument is the short form of the Cyberchondria Severity Scale originally developed by McElroy and Shevlin and later shortened by McElroy and colleagues to provide a concise measure of excessive and distressing online health searching. The CSS-12 contains 12 items and assesses four dimensions of cyberchondria, including excessiveness, distress, compulsion, and reassurance seeking. Items are scored on a five-point Likert scale ranging from never to always, with higher scores indicating greater severity of cyberchondria-related thoughts and behaviors. In the present study, the total cyberchondria score was used to determine the classification label. Because no universal clinical cut-off score has been established for cyberchondria severity, participants were categorized into low, moderate, and high cyberchondria severity groups using percentile-based classification of the

total score. This approach allowed the Support Vector Machine model to classify participants into empirically defined severity categories. The validity and reliability of the Cyberchondria Severity Scale and its short form have been confirmed in previous psychometric studies, and the scale has been widely used in research on online health searching, health anxiety, and problematic digital health behaviors.

Health anxiety was measured using the Short Health Anxiety Inventory developed by Salkovskis and colleagues. The instrument is designed to assess excessive concern about health, misinterpretation of bodily sensations, fear of illness, and perceived negative consequences of becoming ill. The short version commonly includes 18 items, each presented as a set of statements reflecting increasing severity of health anxiety symptoms. Respondents select the statement that best describes their experience, and item scores are summed to obtain a total health anxiety score. Higher scores indicate stronger health-related worry, greater preoccupation with bodily changes, and stronger fear of having or developing a serious illness. The Short Health Anxiety Inventory is suitable for both clinical and non-clinical samples because it assesses health anxiety independently of actual medical status. Previous studies have supported its internal consistency, construct validity, criterion validity, and sensitivity for distinguishing different levels of health anxiety.

Intolerance of uncertainty was assessed using the Intolerance of Uncertainty Scale-12 developed by Carleton and colleagues as a shortened form of the original Intolerance of Uncertainty Scale. This instrument contains 12 items and measures the tendency to perceive uncertain situations as stressful, threatening, unacceptable, or difficult to manage. The scale includes two main dimensions: prospective intolerance of uncertainty, which reflects desire for predictability and active information seeking in uncertain situations, and inhibitory intolerance of uncertainty, which reflects behavioral inhibition, avoidance, and difficulty functioning under uncertainty. Items are rated on a five-point Likert scale ranging from not at all characteristic of me to entirely characteristic of me. The total score is obtained by summing all item responses, with higher scores indicating greater intolerance of uncertainty. The IUS-12 has demonstrated strong internal consistency, stable factor structure, and good convergent validity in previous research, particularly in studies involving anxiety, worry, obsessive-compulsive symptoms, and health-related uncertainty.

Online reassurance seeking was assessed through the reassurance-seeking dimension of cyberchondria-related

online health behavior. This dimension reflects the extent to which individuals use online health information to reduce uncertainty, confirm feared diagnoses, compare symptoms with online descriptions, or seek repeated reassurance after becoming concerned about their health. In the present study, reassurance-seeking items were treated as a predictor variable in the machine-learning model, while the cyberchondria severity class was derived from the broader cyberchondria score. Higher scores on this component reflected a stronger tendency to rely on repeated online checking and confirmatory health searches as a means of reducing anxiety or uncertainty. The use of reassurance-seeking indicators was theoretically appropriate because reassurance seeking is considered one of the central behavioral mechanisms linking health anxiety, intolerance of uncertainty, and cyberchondria. Previous studies have supported the reliability and validity of reassurance-seeking indicators within cyberchondria assessment and have shown that reassurance-seeking behavior is meaningfully associated with problematic online health searching.

A demographic and background information form was also used to collect information about participants' age, gender, province of residence, educational level, employment status, self-reported physical health status, history of chronic illness, frequency of online health information searching, and preferred sources of health information. These variables were collected to describe the sample and to examine whether the data were suitable for classification analysis. The demographic form was not included in the main predictive model, because the purpose of the study was to classify cyberchondria severity specifically on the basis of health anxiety, intolerance of uncertainty, and online reassurance seeking.

2.3. Data analysis

Data analysis was performed in several stages. First, the dataset was screened for incomplete responses, duplicate entries, out-of-range values, and response patterns indicating insufficient attention. Cases with substantial missing data were removed from the dataset, while minor missing values were handled using appropriate imputation procedures when the proportion of missingness was negligible and random. Descriptive statistics, including mean, standard deviation, frequency, and percentage, were calculated to summarize participant characteristics and the distribution of the study variables. The internal consistency of the instruments was examined using Cronbach's alpha coefficients. Before

model development, predictor variables were standardized to ensure that differences in scale ranges did not disproportionately influence the Support Vector Machine algorithm. Cyberchondria severity was then transformed into a categorical outcome variable consisting of low, moderate, and high severity groups.

The Support Vector Machine classification model was used as the main predictive algorithm. SVM was selected because it is suitable for psychological classification problems in which the objective is to identify an optimal decision boundary between outcome classes based on multidimensional predictor patterns. Health anxiety, intolerance of uncertainty, and online reassurance seeking were entered as predictor variables, and cyberchondria severity class was entered as the target variable. The dataset was divided into training and testing subsets using a stratified procedure so that the proportion of low, moderate, and high cyberchondria severity cases remained comparable across both subsets. Seventy percent of the data were used for model training and thirty percent were reserved for final model testing. During the training phase, model parameters were optimized using cross-validation. Both linear and radial basis function kernels were examined, and the final model was selected based on cross-validated classification performance. Hyperparameters, including the regularization parameter and kernel coefficient, were tuned to improve generalizability and reduce the risk of overfitting.

Model performance was evaluated on the independent test set using accuracy, precision, recall, F1-score, and area under the receiver operating characteristic curve. Because the classification task involved three severity categories, macro-averaged and weighted-averaged performance indices were examined to determine whether the model performed consistently across all cyberchondria severity groups. The confusion matrix was inspected to identify the extent to which the model correctly classified participants into low, moderate, and high severity groups and to determine whether misclassifications occurred more frequently between adjacent severity levels. Feature contribution was examined through model-based procedures appropriate for SVM classification, including comparison of standardized predictor weights in the linear model and permutation-based importance analysis. These analyses

were used to determine the relative contribution of health anxiety, intolerance of uncertainty, and online reassurance seeking to the classification of cyberchondria severity. All analyses were conducted at a statistical significance level of .05 where inferential procedures were applied, and the machine-learning results were interpreted primarily on the basis of predictive performance and classification stability.

3. Findings and Results

The study was conducted on 426 adults living in Canada. The participants' age ranged from 18 to 64 years, with a mean age of 31.74 years and a standard deviation of 9.62 years. In terms of gender distribution, 252 participants were women, representing 59.2% of the sample; 166 participants were men, representing 39.0%; and 8 participants identified as non-binary, gender-diverse, or preferred not to specify, representing 1.9% of the sample. Regarding educational level, 48 participants had completed high school or lower levels of formal education, 113 had a college diploma or equivalent qualification, 175 held a bachelor's degree, and 90 had completed postgraduate education. In relation to employment status, 234 participants were employed full-time, 73 were employed part-time, 52 were students, 33 were unemployed or in occupational transition, and 34 reported other employment conditions, including retirement, self-employment, or unpaid caregiving roles. Participants were recruited from different Canadian provinces, with the largest proportion residing in Ontario, followed by British Columbia, Quebec, Alberta, and other provinces. In terms of health-related Internet use, 99 participants reported searching online for health information on a daily basis, 158 reported doing so several times per week, 107 searched approximately once per week, and 62 searched less than once per week. In addition, 139 participants reported having at least one chronic or recurring medical condition, whereas 287 did not report a chronic medical condition. Overall, the demographic findings showed that the sample was sufficiently diverse in terms of age, gender, education, employment status, province of residence, and frequency of online health-information seeking, making it appropriate for examining the psychological predictors of cyberchondria severity in a Canadian adult population.

Table 1

Descriptive Statistics, Reliability Coefficients, and Correlations among the Main Study Variables

Variable	M	SD	Observed range	Skewness	Kurtosis	Cronbach's alpha	1	2	3	4
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1. Cyberchondria severity	34.86	8.77	14–58	0.21	-0.43	0.89	—		
2. Health anxiety	22.41	8.18	3–48	0.39	-0.20	0.91	0.62***	—	
3. Intolerance of uncertainty	37.28	9.44	14–59	0.16	-0.38	0.88	0.54***	0.47***	—
4. Online reassurance seeking	18.67	5.42	6–30	0.28	-0.51	0.84	0.68***	0.55***	0.44***

The descriptive findings presented in Table 1 showed that the participants obtained a mean cyberchondria severity score of 34.86, indicating a moderate overall level of cyberchondria symptoms in the sample. The values of skewness and kurtosis for all main variables were within acceptable ranges, suggesting that the distributions did not show serious deviation from normality and were appropriate for subsequent statistical and machine-learning analyses. The reliability coefficients of the instruments were also satisfactory, with Cronbach's alpha values ranging from 0.84 to 0.91. These coefficients indicated good internal consistency for cyberchondria severity, health anxiety, intolerance of uncertainty, and online reassurance seeking. The correlation matrix demonstrated that all predictor variables were positively and significantly associated with cyberchondria severity. The strongest correlation was observed between online reassurance seeking and cyberchondria severity, followed by health anxiety and intolerance of uncertainty. This pattern suggests that participants who more frequently searched online to obtain reassurance about health concerns also tended to report higher levels of cyberchondria. Similarly, individuals with stronger health anxiety and greater difficulty tolerating

uncertainty were more likely to experience severe cyberchondria-related thoughts and behaviors. The correlations among the predictor variables were moderate rather than excessive, indicating that the predictors were related but not redundant. Therefore, the three variables were retained simultaneously in the Support Vector Machine classification model.

Cyberchondria severity scores were then transformed into three classification groups using percentile-based categorization. Accordingly, 142 participants were classified in the low cyberchondria severity group, 142 in the moderate cyberchondria severity group, and 142 in the high cyberchondria severity group. The balanced distribution of participants across the three outcome classes provided a suitable basis for supervised classification and reduced the possibility that the model would favor one severity class because of unequal class size. The total dataset was divided into a training set and a testing set using stratified sampling. The training set included 298 participants, and the independent testing set included 128 participants. Stratification preserved the proportional representation of the low, moderate, and high cyberchondria severity classes in both subsets.

Table 2

Hyperparameter Tuning and Cross-Validation Results for Candidate Support Vector Machine Models

SVM model	Kernel	Main optimized parameters	Cross-validated accuracy	Cross-validated macro F1-score	Cross-validated macro AUC	Model status
Model 1	Linear	C = 1.00	0.79	0.78	0.88	Not selected
Model 2	Radial basis function	C = 10.00; gamma = 0.10	0.85	0.84	0.92	Selected final model
Model 3	Polynomial	C = 1.00; degree = 2; gamma = 0.10	0.81	0.80	0.89	Not selected
Model 4	Sigmoid	C = 1.00; gamma = 0.01	0.72	0.71	0.80	Not selected

The cross-validation results in Table 2 indicated that the radial basis function Support Vector Machine produced the strongest classification performance among the candidate models. Although the linear model demonstrated acceptable performance, its lower cross-validated accuracy and macro F1-score suggested that the relationship between the predictors and cyberchondria severity was not fully linear. The polynomial model performed better than the sigmoid model but did not exceed the radial basis function model. The sigmoid kernel had the weakest performance, indicating

that it was less suitable for separating the cyberchondria severity classes in the present dataset. The radial basis function model achieved a cross-validated accuracy of 0.85, a macro F1-score of 0.84, and a macro area under the curve of 0.92. These values indicated that the selected model had strong discriminatory ability and maintained balanced performance across the three cyberchondria severity classes. Therefore, the radial basis function kernel with a regularization parameter of C = 10.00 and gamma = 0.10 was

retained as the final optimized classification model and was subsequently evaluated on the independent test set.

Table 3

Classification Performance of the Final RBF-SVM Model on the Independent Test Set

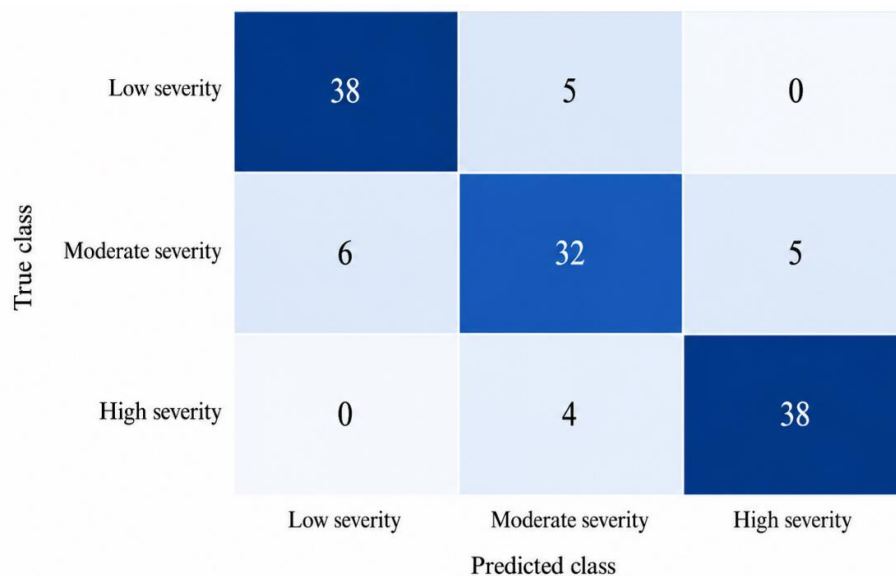
Cyberchondria severity class	Precision	Recall	F1-score	One-vs-rest AUC	Support
Low severity	0.86	0.88	0.87	0.94	43
Moderate severity	0.78	0.74	0.76	0.87	43
High severity	0.88	0.90	0.89	0.95	42
Macro average	0.84	0.84	0.84	0.92	128
Weighted average	0.84	0.84	0.84	0.92	128

The final RBF-SVM model demonstrated strong predictive performance on the independent test set. The overall classification accuracy was 0.84, indicating that the model correctly classified 84% of participants into low, moderate, or high cyberchondria severity groups. The balanced accuracy was also 0.84, showing that the model did not perform well merely because of class distribution but instead maintained comparable sensitivity across severity categories. The macro-averaged F1-score was 0.84, which confirmed that the model achieved a good balance between precision and recall across the three classes. The highest classification performance was observed for the high cyberchondria severity group, with a precision of 0.88, recall of 0.90, F1-score of 0.89, and one-vs-rest AUC of 0.95. This indicates that the model was particularly effective in

detecting individuals with more severe cyberchondria symptoms. The low severity group was also classified with high accuracy, as reflected in a precision of 0.86, recall of 0.88, F1-score of 0.87, and AUC of 0.94. The moderate severity group showed comparatively lower but still acceptable performance, with a precision of 0.78, recall of 0.74, F1-score of 0.76, and AUC of 0.87. This weaker performance for the moderate group suggests that participants with moderate cyberchondria severity shared psychological characteristics with both low- and high-severity participants, making this class more difficult to distinguish. The Cohen's kappa coefficient for the final model was 0.77, indicating substantial agreement between the predicted and actual severity classifications beyond chance.

Figure 1

Confusion Matrix of the Optimized RBF-SVM Model for Cyberchondria Severity Classification



Overall accuracy = 0.84; N = 128

The confusion matrix showed that the optimized RBF-SVM model classified most participants correctly across the three cyberchondria severity groups. Among participants with low cyberchondria severity, 38 were correctly classified as low severity, whereas 5 were misclassified as moderate severity and none were misclassified as high severity. Among participants with moderate cyberchondria severity, 32 were correctly classified, while 6 were misclassified as low severity and 5 were misclassified as high severity. Among participants with high cyberchondria severity, 38 were correctly classified as high severity, whereas 4 were misclassified as moderate severity and none were misclassified as low severity. This pattern indicates that the model's errors were mostly limited to adjacent severity categories. Importantly, the model did not confuse low severity cases with high severity cases, nor did it classify high severity cases as low severity. This finding supports the discriminative validity of the model and suggests that health anxiety, intolerance of uncertainty, and online reassurance seeking provided meaningful information for separating individuals with clearly different levels of cyberchondria severity. The greater number of errors in the moderate group was expected because this group represented an intermediate level of symptom severity and therefore had more overlap with both neighboring classes.

Permutation-based predictor importance analysis further showed that online reassurance seeking was the strongest contributor to the classification of cyberchondria severity, followed by health anxiety and intolerance of uncertainty. Online reassurance seeking produced the largest reduction in model performance when permuted, indicating that repeated online checking, searching for symptom confirmation, and seeking reassurance through digital health information were central behavioral indicators of cyberchondria severity. Health anxiety was the second most important predictor, suggesting that fear of illness, preoccupation with bodily sensations, and catastrophic interpretation of physical symptoms played a major role in distinguishing cyberchondria severity classes. Intolerance of uncertainty also contributed meaningfully to classification, although its relative contribution was smaller than that of online reassurance seeking and health anxiety. This result indicates that difficulty tolerating ambiguous health-related information may intensify cyberchondria, especially when combined with anxious health-related beliefs and repetitive reassurance-seeking behavior. Overall, the findings supported the predictive role of all three variables and demonstrated that the Support Vector Machine model could

classify cyberchondria severity with substantial accuracy and clinically meaningful interpretability.

4. Discussion

The present study aimed to classify cyberchondria severity based on health anxiety, intolerance of uncertainty, and online reassurance seeking using a Support Vector Machine model among adults living in Canada. The findings showed that the optimized radial basis function Support Vector Machine model had strong classification performance, with an overall accuracy of 0.84, a macro F1-score of 0.84, and a macro AUC of 0.92. These findings indicate that the combination of the three psychological and behavioral predictors was sufficiently powerful to distinguish low, moderate, and high levels of cyberchondria severity. The results are consistent with the view that cyberchondria is not merely frequent online health searching, but rather a clinically meaningful pattern in which anxiety, uncertainty, and reassurance-seeking processes interact to produce excessive and distressing digital health behavior. This interpretation is aligned with conceptual accounts that describe cyberchondria as an anxiety-related phenomenon intensified by the modern digital information environment (Starcevic & Berle, 2015; Varma & Singh, 2023). It is also consistent with systematic and review-based evidence showing that cyberchondria is closely connected to the anxiety spectrum, especially health anxiety, obsessive-compulsive tendencies, uncertainty-related distress, and compulsive information seeking (Mestre-Bach & Potenza, 2023; Schenkel et al., 2021). Therefore, the high predictive performance of the SVM model supports the theoretical assumption that cyberchondria severity can be meaningfully classified through a compact set of psychological variables rather than through demographic or general Internet-use variables alone.

The strongest classification performance was observed for the high cyberchondria severity group, followed by the low severity group, while the moderate severity group was classified with comparatively lower precision and recall. This pattern is theoretically reasonable because individuals at the extremes of cyberchondria severity are more likely to show clear and differentiated psychological profiles. Participants in the high severity group likely had a stronger combination of health anxiety, intolerance of uncertainty, and online reassurance seeking, whereas those in the low severity group likely showed relatively limited involvement in this maladaptive cycle. The moderate group, by contrast,

represented an intermediate psychological profile and therefore showed greater overlap with both adjacent classes. The confusion matrix supported this interpretation, as misclassifications occurred mainly between neighboring categories and not between low and high severity groups. This indicates that the model preserved the ordinal meaning of cyberchondria severity and did not confuse clearly distinct clinical-risk profiles. Such a pattern is consistent with previous evidence showing that cyberchondria is distributed along a continuum, ranging from adaptive or mildly excessive health searches to more severe forms involving distress, compulsivity, and functional interference (Ivanova & Karabeliova, 2014; Noor & Oglesby, 2015). The results therefore suggest that machine-learning classification can provide a useful method for identifying individuals who are most likely to fall into clinically concerning cyberchondria profiles.

Among the predictors, online reassurance seeking had the greatest contribution to cyberchondria severity classification. This finding suggests that the behavioral tendency to repeatedly search for reassurance, confirmation, or symptom-related certainty online may be the most direct indicator of severe cyberchondria. Although individuals may begin online searches to reduce concern, online health information often contains ambiguity, alarming content, rare diagnostic possibilities, and conflicting explanations. Consequently, reassurance seeking may become paradoxical: instead of terminating anxiety, it may intensify doubt and generate further searching. The centrality of reassurance seeking in the present model is consistent with studies showing that reassurance seeking is associated with obsessive-compulsive symptoms, shame, fear of self, self-doubt, and anxiety-related maintenance processes (Najafi et al., 2024; Parsons & Alden, 2022). It also aligns with research demonstrating that excessive reassurance seeking is not limited to health contexts but is a transdiagnostic behavioral pattern observed in social anxiety, dependency, depressive symptoms, attachment insecurity, and relationship difficulties (Bui & Moscovitch, 2024; Evraire et al., 2022; Fowler & Gasiorek, 2016; Starr et al., 2023). In the context of cyberchondria, the Internet may function as a constantly available reassurance source; however, because online information cannot provide definitive individualized diagnosis in most cases, reassurance remains temporary and unstable. This explains why online reassurance seeking was the strongest predictor in the model.

Health anxiety was the second most important predictor in the classification of cyberchondria severity. This finding

supports the assumption that cyberchondria is strongly rooted in anxious preoccupation with illness, bodily sensations, and catastrophic interpretations of physical symptoms. Individuals with elevated health anxiety are more likely to monitor their bodies, interpret ambiguous symptoms as signs of serious disease, and seek repeated confirmation that they are not ill. When such individuals use the Internet for health information, they may selectively attend to threatening content, overestimate the probability of severe illness, and continue searching because each new piece of information generates additional doubt. The present findings are therefore consistent with previous studies linking cyberchondria to hypochondriacal concerns, anxiety sensitivity, and health anxiety (Abu Khait et al., 2023; Khait et al., 2022). They also support earlier evidence showing a relationship between hypochondriacal concerns and reassurance seeking, suggesting that health-related fear can increase the need for external confirmation (Wearden et al., 2006). The results further correspond with findings that cyberchondria has meaningful overlap with obsessive-compulsive symptoms, particularly where repeated checking and inability to tolerate doubt are present (Kobori et al., 2017; Noor & Oglesby, 2015). Accordingly, health anxiety appears to provide the emotional and cognitive foundation upon which cyberchondria develops, while online reassurance seeking provides the behavioral pathway through which the anxiety is repeatedly expressed.

Intolerance of uncertainty also contributed meaningfully to the classification model, although its relative importance was lower than online reassurance seeking and health anxiety. This result indicates that difficulty accepting uncertain health-related information plays a significant role in cyberchondria severity but may function more as an underlying vulnerability factor than as the most visible behavioral marker. Health information is inherently uncertain for non-specialists: symptoms may have multiple causes, medical probabilities are difficult to interpret, and online sources often present broad diagnostic possibilities without personal clinical evaluation. Individuals with high intolerance of uncertainty may experience this ambiguity as threatening and may engage in repeated searching to restore a sense of control. However, because online searches frequently increase rather than reduce ambiguity, uncertainty becomes a central mechanism in the maintenance of cyberchondria. This finding is consistent with research comparing intolerance of uncertainty, cyberchondria, and health anxiety across clinical and non-clinical groups (Fathi Avali Gheshlaqi & Najafi, 2023). It is

also supported by evidence that intolerance of uncertainty is associated with worry, reassurance seeking, and anxiety-related interpersonal processes (Clark et al., 2020). Moreover, recent findings suggest that intolerance of uncertainty may mediate the association between broader personality vulnerabilities and cyberchondria, especially when combined with metacognitive beliefs about health (Torabi & Pourmohammad, 2025). Therefore, intolerance of uncertainty appears to be an important cognitive mechanism that helps explain why some individuals continue searching even when online information fails to provide relief.

The findings also correspond with studies conducted during and after the COVID-19 pandemic, which showed that fear of infection, uncertainty, and psychological distress were strongly associated with cyberchondria. During public health crises, individuals are exposed to a high volume of health-related information, changing medical recommendations, and uncertainty about personal risk. This environment can activate both health anxiety and intolerance of uncertainty, thereby increasing repetitive online searching. Previous studies showed that cyberchondria was associated with fear of COVID-19, somatic burden, uncertainty, and psychological distress (Dameery et al., 2020; Oniszczenko, 2021; Zolotareva, 2022). The present findings extend this literature by showing that even outside an acute pandemic-focused design, the same psychological mechanisms remain useful for classifying cyberchondria severity. Similarly, previous work indicating that Internet addiction and COVID-19 anxiety predicted cyberchondria supports the present classification results, because problematic online engagement may interact with anxiety-related vulnerability to intensify repetitive health searches (Zareii & Zarnaghash, 2022). These convergent findings suggest that cyberchondria should be understood as a digital-age manifestation of health-related anxiety that becomes particularly problematic when individuals rely on online reassurance to manage uncertainty and perceived threat.

The present findings also have implications for the role of health literacy and digital information evaluation. Although this study focused on health anxiety, intolerance of uncertainty, and online reassurance seeking rather than health literacy, the high classification accuracy suggests that psychological vulnerability can strongly shape the way individuals use health information. Prior research has suggested that health literacy may protect against cyberchondria by enabling individuals to evaluate the credibility, relevance, and limitations of online health information (Kobryn & Duplaga, 2024). However, the

present results imply that even when health information is available, individuals with high health anxiety and intolerance of uncertainty may not use it adaptively. Instead, they may search repeatedly, interpret ambiguous content negatively, and become increasingly dependent on digital reassurance. Research among nurses has also shown that anxiety sensitivity can moderate the relationship between Internet addiction and cyberchondria, indicating that professional or educational exposure to health information does not necessarily eliminate psychological vulnerability (Mrayyan et al., 2024). Thus, interventions for cyberchondria should not focus only on improving access to reliable information; they should also target emotional and cognitive processes that determine how individuals interpret and respond to that information.

5. Conclusion

Overall, the findings confirm that cyberchondria severity can be meaningfully classified using a machine-learning model based on health anxiety, intolerance of uncertainty, and online reassurance seeking. The strong performance of the RBF-SVM model suggests that these variables may interact in nonlinear ways, making machine-learning approaches especially appropriate for identifying psychological risk profiles. From a theoretical perspective, the findings support an integrated model in which health anxiety generates illness-related threat perception, intolerance of uncertainty intensifies the need for certainty, and online reassurance seeking maintains the cycle through repeated checking. This model is consistent with literature describing cyberchondria as a multidimensional construct involving anxiety, compulsive searching, problematic Internet use, and reassurance-seeking mechanisms (Abu Khait et al., 2023; Mestre-Bach & Potenza, 2023; Schenkel et al., 2021). From a practical perspective, the findings indicate that screening for cyberchondria should include not only the frequency of online health searches but also the emotional motivation behind searching, the individual's tolerance of uncertain health information, and the degree to which searching is used as reassurance. Therefore, the present study contributes to the literature by demonstrating the predictive value of a theoretically grounded SVM classification model for identifying low, moderate, and high cyberchondria severity among Canadian adults.

6. Limitations & Suggestions

Regarding limitations, the present study was conducted using a cross-sectional design, which prevents causal conclusions about the relationships among health anxiety, intolerance of uncertainty, online reassurance seeking, and cyberchondria severity. Although the SVM model demonstrated strong classification performance, it cannot determine whether health anxiety causes cyberchondria, whether cyberchondria increases health anxiety, or whether both are influenced by other psychological and contextual factors. The use of self-report questionnaires may also have introduced response bias, social desirability effects, or inaccuracies in participants' estimation of their online health-search behavior. In addition, the sample was selected through online convenience sampling from adults living in Canada, which may limit the generalizability of the findings to individuals with limited Internet access, older adults with lower digital literacy, clinical populations, or people from different cultural and healthcare contexts. Another limitation is that cyberchondria severity was categorized using percentile-based classification rather than clinically established diagnostic thresholds, because universally accepted clinical cut-off scores for cyberchondria severity are not yet available. Finally, although the model included three theoretically important predictors, other relevant variables such as health literacy, anxiety sensitivity, obsessive-compulsive symptoms, depressive symptoms, metacognitive beliefs, trust in healthcare systems, chronic illness status, and frequency of medical consultation were not included in the final classification model.

Future research should use longitudinal designs to examine the temporal and causal pathways through which health anxiety, intolerance of uncertainty, and reassurance seeking contribute to the development and persistence of cyberchondria. Studies following participants over time would clarify whether online reassurance seeking predicts later increases in cyberchondria severity or whether individuals with severe cyberchondria increasingly rely on reassurance seeking as a coping strategy. Future studies should also test the model in clinical samples, including individuals with illness anxiety disorder, obsessive-compulsive disorder, generalized anxiety disorder, and medically unexplained symptoms, in order to determine whether the classification model remains accurate across different diagnostic groups. In addition, future research should compare SVM performance with other machine-learning algorithms such as random forest, gradient

boosting, logistic regression, neural networks, and ensemble models to identify the most robust method for cyberchondria classification. It would also be valuable to include behavioral digital trace indicators, such as frequency of symptom searches, time spent on medical websites, number of repeated searches for the same symptom, and use of symptom-checker applications, alongside self-report measures. Cross-cultural studies are also recommended to examine whether the predictors of cyberchondria severity differ across healthcare systems, cultural beliefs about illness, access to medical care, and public trust in online health information.

In practice, the findings suggest that mental health professionals, primary care providers, and digital health educators should assess not only whether individuals search online for health information, but why and how they engage in such searches. Individuals who repeatedly use online information to obtain reassurance, reduce doubt, or confirm feared diagnoses may be at increased risk for more severe cyberchondria. Clinical interventions should therefore target the cycle of anxiety, uncertainty, and reassurance seeking. Cognitive-behavioral strategies may help individuals identify catastrophic interpretations of bodily sensations, challenge threat-biased interpretations of online information, and reduce compulsive checking. Interventions focused on intolerance of uncertainty may help individuals tolerate ambiguous health sensations without immediately seeking digital reassurance. Digital health literacy programs should also teach users how to evaluate the credibility of online sources, understand the limits of symptom searches, and recognize when online searching is increasing rather than decreasing distress. In healthcare settings, professionals can provide clear guidance about appropriate online health-information use and encourage patients to discuss concerns directly with qualified providers rather than relying on repeated Internet searches. These practical strategies may help reduce maladaptive online reassurance seeking and support healthier engagement with digital health information.

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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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All authors equally contributed in this article.

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