

Health anxiety and online health searching in a synthetic study of uncertainty and digital health literacy

arhama faridi

arhamafaridi@gmail.com

Queen Mary University of London

Research Article

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Abstract

Cyberchondria describes repeated online health searching accompanied by distress. This study used a reproducible synthetic dataset to demonstrate a model linking health anxiety with cyberchondria through intolerance of uncertainty and examining digital health literacy as a moderator. A fixed-seed simulation generated 450 artificial records with item-level responses within the scoring ranges of the SHAI, IUS, eHEALS, and CSS. Analyses included Pearson correlations, ordinary least-squares regression, and 5,000 percentile bootstrap resamples. Health anxiety was positively associated with cyberchondria ($r = .547$) and intolerance of uncertainty ($r = .528$), while intolerance of uncertainty was positively associated with cyberchondria ($r = .540$). The unmoderated indirect association was $B = 0.177$, 95% bootstrap CI [0.127, 0.231]. The integrated model explained 41.6% of synthetic cyberchondria variance. Its health anxiety by literacy interaction was negative ($B = -0.0134$, $p = .002$), with positive conditional health anxiety slopes of 0.465 at low literacy, 0.352 at mean literacy, and 0.240 at high literacy. All five model expectations matched the generated patterns; none was rejected within this single simulation. These outcomes partly recover relationships specified in the generating equations and do not independently confirm psychological mechanisms or protective effects in people. The study provides an auditable example of scoring, indirect-effect estimation, and interaction interpretation, with data available in Zenodo. Independent longitudinal research and repeated simulations are needed to assess substantive validity and methodological robustness.

Introduction

Online health information is now part of the way people understand symptoms, prepare for appointments, compare treatment options, and respond to health concerns. Access to information can support informed decisions, but the value of a search depends on its purpose, the quality of the material retrieved, and the way the information is interpreted. A search undertaken to answer a specific question may be useful and finite. A search undertaken to remove every possibility of serious illness can be difficult to complete because online information cannot provide individualized diagnostic certainty. This distinction makes the psychological function of searching as important as the amount of time spent searching.

Cyberchondria refers to excessive or repeated online health searching that is associated with distress or escalating anxiety. Starcevic and Berle (2013) helped clarify the concept as a problem involving health concern and Internet use rather than simply frequent searching. The term should be used carefully. A person managing an established medical condition may need to search often, and such activity is not necessarily maladaptive. The present manuscript therefore treats cyberchondria as a distress-related pattern represented by a psychological score, not as a diagnosis established from search frequency alone.

Health anxiety provides one plausible explanation for why searching becomes repetitive. When bodily sensations are interpreted as threatening, online searching may offer an immediate opportunity to seek

reassurance. However, the same search may present several explanations, including uncommon serious conditions, without clarifying their probability for the individual. A person can then continue searching to resolve the uncertainty introduced by the previous search. This proposed process links a concern about illness with an information environment that is abundant but difficult to interpret. The distinction between cyberchondria and ordinary health information seeking is supported by the synthesis of McMullan et al. (2019), which found different strengths of association with health anxiety across these outcomes.

The question is not only whether health anxiety and cyberchondria are associated, but also what might account for the association. Intolerance of uncertainty describes difficulty accepting situations in which an outcome is not fully known. Health concerns are particularly suited to this difficulty because uncertainty cannot always be eliminated, even after appropriate assessment. Fergus (2013, 2015) examined uncertainty-related vulnerability in relation to online medical searching and cyberchondria. These studies provide a reason to consider uncertainty in the conceptual model, while leaving open the direction of influence among anxiety, uncertainty, and searching.

Research also needs to separate stable differences between people from changes within the same person. In a four-wave survey of 5,322 respondents, te Poel et al. (2016) examined health anxiety and online health information seeking over time. More health-anxious respondents searched more, but evidence for reciprocity differed between participants with nonclinical and clinical levels of health anxiety. This qualification matters because a uniform cross-sectional model may conceal differences in how searching relates to distress. The present demonstration does not simulate time or clinical subgroups and cannot resolve that distinction.

Norr et al. (2015) examined anxiety sensitivity and intolerance of uncertainty as candidate vulnerabilities for cyberchondria. Alongside Fergus (2013, 2015), this work motivates studying more than health anxiety alone. The conceptual question is whether a difficulty with ambiguity contributes information beyond the general fear of illness. The current synthetic model addresses that question statistically by estimating uncertainty together with health anxiety. It cannot determine whether either construct is the more important clinical target because its coefficient sizes reflect selected score units and imposed relationships.

Digital health literacy introduces a complementary question about how people evaluate what they find. Norman and Skinner (2006) developed eHEALS to assess perceived ability to locate, understand, evaluate, and apply electronic health information. Greater perceived skill could help a person select credible sources and recognize the limits of online symptom descriptions. It could also coexist with frequent searching or unwarranted confidence. For this reason, literacy should not be assumed to protect every user in every context. Its role may depend on the intensity of health anxiety and on whether perceived competence corresponds to actual appraisal skill.

This manuscript uses a synthetic demonstration to examine an integrated statistical model. The records were generated computationally and were not obtained from adults completing questionnaires. The

purpose is to illustrate estimation, scoring, and transparent reporting when health anxiety has a direct association with cyberchondria, uncertainty forms an indirect pathway, and literacy modifies the direct association. Because those relationships are partly encoded in generation, the study cannot establish their existence in a human population. Its value lies in making the model, data, and calculations inspectable before considering an empirical application.

Study aims and questions

The primary aim was to demonstrate how an indirect association and an interaction can be estimated together using artificial item-level records. The specific objectives were to generate a reproducible dataset within established scale response ranges, verify the accuracy of total scores, describe the resulting distributions, estimate correlations and regression paths, evaluate an indirect association using bootstrap intervals, and examine conditional health anxiety slopes at different literacy levels. A further objective was to distinguish the numerical recovery of assumed patterns from substantive evidence about people.

The objectives distinguish three forms of evidence. Data integrity concerns whether the artificial items and totals are correctly coded. Statistical recovery concerns whether the fitted model detects patterns in the generated scores. Substantive validity concerns whether those patterns describe real people. This study addresses the first two. Its research aims therefore stop short of estimating prevalence, validating a diagnostic instrument, identifying causal mediation, or evaluating the benefit of literacy training. Those aims would require a different source of data and a design suited to the intended claim.

The study asked four related questions. First, how strongly were artificial health anxiety, uncertainty, literacy, and cyberchondria scores associated after adding measurement noise and discretizing item responses? Second, did an indirect association through uncertainty remain detectable in observed total scores? Third, did the negative latent interaction translate into a negative interaction in the fitted score model? Fourth, what did the resulting conditional slopes imply about the interpretation and limits of the synthetic model? These questions concern the behavior of the specified simulation rather than population prevalence or treatment effects.

Model expectations

The following hypotheses express expectations for the specified synthetic model. Their statistical status is reported separately from their empirical validity.

H1. Health anxiety would be positively associated with cyberchondria. Reviews by McMullan et al. (2019) and Schenkel et al. (2021) motivate this direction, while the simulation explicitly represents a positive anxiety association.

H2. Health anxiety would be positively associated with intolerance of uncertainty. The model assumes that higher health concern covaries with greater difficulty tolerating ambiguity, drawing on uncertainty-

focused cyberchondria research (Fergus, 2013, 2015; Norr et al., 2015). This proposed ordering is not a causal conclusion.

H3. Intolerance of uncertainty would be positively associated with cyberchondria. Uncertainty-related vulnerability provides the conceptual rationale for persistent checking, although its independent contribution depends on the other variables measured (Fergus, 2015; Fergus & Spada, 2017).

H4. A positive indirect association would connect health anxiety with cyberchondria through intolerance of uncertainty. The product-of-coefficients approach follows regression-based mediation analysis (Hayes, 2022). Cross-sectional estimates cannot establish the corresponding longitudinal mechanism (Maxwell & Cole, 2007).

H5. Digital health literacy would negatively moderate the direct association between health anxiety and cyberchondria. The expected product coefficient was negative, meaning a smaller positive anxiety slope at higher literacy. Literacy-related moderation research motivates examining this conditional relationship (Fang & Mushtaque, 2024), while the distinction between perceived and objective skill limits any protective interpretation (van der Vaart et al., 2011).

Literature review

Understanding cyberchondria

A useful literature review begins by distinguishing related constructs. Health anxiety concerns the interpretation of possible illness. Online health information seeking concerns an activity. Cyberchondria concerns a problematic relationship between searching and distress. These concepts can overlap without being interchangeable. McElroy and Shevlin (2014) developed the Cyberchondria Severity Scale to represent several dimensions, while McElroy et al. (2019) introduced the shorter CSS-12. This measurement development supports treating cyberchondria as more than a count of queries. A scale-based total summarizes responses across aspects of the construct, but it does not establish a clinical diagnosis or determine whether a specific search was medically appropriate.

This distinction has consequences for research design. Studies that measure only Internet use may combine adaptive information seeking with reassurance seeking. Studies that measure only health anxiety may not capture interference or search-related distress. A model should therefore specify both the psychological concern and the outcome it seeks to explain. It should also avoid interpreting the total score as a complete account of the behavior. Search context, the presence of an established condition, access to professional care, and the credibility of sources can matter even when two people have similar questionnaire scores.

Health anxiety and searching

The association between health anxiety and cyberchondria has been examined across individual studies and evidence syntheses. McMullan et al. (2019) reviewed relationships among health anxiety, online health information seeking, and cyberchondria. Schenkel et al. (2021) examined conceptualizations of cyberchondria and its relationship with the anxiety spectrum. Taken together, these reviews provide a basis for expecting a positive association, while also emphasizing that a correlation does not identify the sequence of events. People may search because they are worried, become worried after searching, or experience both processes over time.

For the present model, the theoretical significance of health anxiety is that it provides a motive to seek certainty about illness. The content of a search can then become a focus for further concern. An alarming possibility may receive more attention than a common benign explanation, and a reassuring explanation may not settle the remaining doubt. This is a proposed interpretation rather than a direct observation in the current dataset. The artificial records contain total scores, not search histories, and therefore cannot reveal whether a generated high score corresponds to checking, reassurance seeking, symptom monitoring, or another activity.

Uncertainty and repeated checking

Carleton et al. (2007) developed the short Intolerance of Uncertainty Scale as a measure of difficulty with uncertainty. The construct is relevant to a health search because the person may want a level of certainty that an Internet search cannot supply. The need to rule out every threatening explanation can make additional information less reassuring rather than more reassuring. Each source can introduce another possibility, creating a moving endpoint for the search. Theoretical models of this kind suggest that uncertainty may help organize the relationship between concern about illness and persistent information seeking.

Fergus (2013) examined when online medical searching was associated with health anxiety in relation to intolerance of uncertainty. Fergus (2015) extended work on uncertainty and anxiety sensitivity in relation to dimensions of cyberchondria. These studies support including uncertainty-related cognition in research, but they do not justify assuming that health anxiety necessarily causes uncertainty intolerance. In the present simulation, the path from health anxiety to uncertainty is an explicit mathematical choice. An empirical study would need to compare alternative explanations and use temporal information before describing that path as a developmental mechanism.

The distinction between an indirect association and a causal mediator is particularly important. An indirect association can arise when variables share common causes, when measurement error affects the paths, or when the ordering is specified without temporal evidence. Hayes (2022) provides a regression framework for estimating mediation and moderation, but the existence of an estimation framework does not resolve the substantive assumptions needed for causal interpretation. Here, the product of coefficients is treated as a statistical quantity. It summarizes the fitted artificial relationships and is not proof that changing uncertainty would change cyberchondria.

Other explanations

Uncertainty is one candidate among several. Blachnio et al. (2023) examined emotional functioning in the association between health anxiety and cyberchondria. Fergus and Spada (2017) examined problematic Internet use and metacognitive beliefs, reporting associations that extended beyond health anxiety alone. This wider literature challenges a model that treats uncertainty as the sole explanation. Beliefs about the usefulness or uncontrollability of searching, difficulty managing distress, and habitual Internet use may all be relevant. The present demonstration includes none of these additional constructs and therefore cannot test their relative contribution.

A more complete empirical model would need to distinguish explanation from statistical overlap. Adding many correlated psychological scales can change individual coefficients without showing that one construct is more important clinically. Researchers should specify why a variable is a confounder, a competing mechanism, a moderator, or an outcome before fitting the model. Otherwise, a large regression can obscure the conceptual question. The current model is intentionally limited so that its assumed direct, indirect, and conditional relationships can be inspected clearly. That simplicity improves transparency while reducing the breadth of substantive conclusions.

Digital health literacy

The concept of digital health literacy concerns the skills used to work with online health information. Norman and Skinner (2006) introduced eHEALS as a self-report measure of perceived capability. Its accessibility makes it useful for survey research, but a person reporting confidence may not perform equally well on a task requiring source comparison or evaluation of evidence. van der Vaart et al. (2011) examined the validity of eHEALS in adult populations and raised questions about its relationship with actual Internet performance. This distinction limits what can be inferred from a literacy total, particularly when it is used to explain protection from problematic searching.

Literacy could affect several points in a search. It may influence the initial choice of a source, the interpretation of a symptom list, the recognition of anecdotal material, or the decision to stop. These possibilities are conceptually distinct. A person may be good at locating material but less able to evaluate its relevance to an individual situation. Another person may accurately identify a credible source yet continue checking because the remaining uncertainty is difficult to tolerate. Consequently, a broad literacy score can combine skills and perceptions that do not have identical relationships with anxiety-driven searching.

Why moderation may matter

Fang and Mushtaque (2024) examined health literacy as a moderator in a model involving health anxiety, emotional regulation, and cyberchondria. This provides a basis for asking whether literacy changes the

strength of an association rather than only predicting an outcome directly. A main effect answers whether scores differ on average across literacy levels under the model. An interaction asks whether the relationship between health anxiety and cyberchondria differs depending on literacy. These questions should be separated because a small main association can coexist with a conditional relationship.

An interaction also requires careful interpretation. Its sign depends on coding, scale construction, the variables included, and the form of the model. A negative product coefficient does not by itself show that an intervention is effective. Conditional slopes help make the result more interpretable by showing the fitted association at specified literacy values. Those values should lie within the observed range. Extrapolating to unrealistic literacy scores can create a misleading impression that a relationship disappears. In this demonstration, the mean and one standard deviation below and above it were used to keep the description connected to the generated scores.

Longitudinal evidence

The longitudinal design of te Poel et al. (2016) is especially relevant because it treats searching and anxiety as potentially reciprocal rather than assuming a one-way sequence. Its subgroup differences indicate that an association observed across people is not automatically a uniform process within every person. A synthetic direct path can be useful for illustrating estimation, but it cannot replace a design that observes whether anxiety precedes searching, searching precedes anxiety, or both occur together. Consequently, the current positive associations should be compared with the direction of prior research rather than presented as a replication of its temporal findings.

Maxwell and Cole (2007) examined bias when cross-sectional mediation is used to represent longitudinal processes. Their methodological analysis gives an additional reason to distinguish a significant product coefficient from evidence of a mechanism unfolding over time. Bootstrap intervals address the uncertainty of an estimated indirect association under the fitted data structure; they do not correct an inappropriate causal ordering. For this manuscript, the indirect pathway is therefore interpreted as a property of the generated covariance pattern, and its role as a psychological mechanism remains a question for independent research.

Evidence for competing vulnerabilities

The work of Norr et al. (2015) and Fergus (2015) places uncertainty beside anxiety sensitivity rather than treating it as an isolated vulnerability. Fergus and Spada (2017) further show why metacognitive beliefs and problematic Internet use deserve attention. The shared implication is that cyberchondria may have several overlapping explanations. The present results are consistent with an uncertainty pathway under the chosen equations, but they do not exclude alternatives. An empirical extension should specify competing models in advance and assess whether uncertainty adds information when these other constructs are measured.

Theoretical agreement should also be separated from numerical agreement. A synthetic correlation of .547 can have the same direction as an association reported in previous research without constituting evidence that the population effect has been reproduced. The artificial coefficient depends on the chosen latent parameters, measurement noise, and discretization thresholds. Earlier studies provide reasons to consider a model; they cannot make its generated outcomes empirical. This distinction prevents citations from being used as retrospective validation of numbers produced by simulation.

Measurement and research gaps

The literature motivates an integrated model but leaves important questions unresolved. Temporal ordering requires repeated assessments or an experimental design. The role of literacy requires distinguishing perceived capability from demonstrated performance. The meaning of cyberchondria requires separating appropriate health searches from repetitive distress-related checking. Measures should also be evaluated in the populations where they are used rather than assuming that an established scale behaves identically across settings. An artificial dataset can demonstrate scoring and estimation but cannot supply these forms of evidence.

The present study addresses a narrower methodological need. It makes one model reproducible and shows how its reported statistics relate to exported item-level records. It does not claim to fill the empirical gaps identified above. The contribution is a worked example that exposes assumptions and supports later refinement. A stronger simulation study would vary those assumptions systematically across repeated datasets, while a stronger substantive study would obtain independent observations and test competing temporal and measurement explanations. Both developments are needed before describing the model as clinically established.

Methods

Study design

This study is a single synthetic cross-sectional demonstration with 450 artificial records. No individuals were recruited, no questionnaires were administered, and no clinical or personal records were used. The unit of analysis is a generated record rather than a participant. The sample size was retained from the original demonstration to permit comparable reporting; it was not justified by a prospective power analysis. Statistical hypothesis labels H1 to H5 refer to patterns evaluated within the generated data, not confirmatory tests in a recruited population.

The workflow had three stages. First, the latent relationships and response-generation rules were specified and a fixed-seed dataset was created. Second, the exported file was checked and analysed without changing its values to match the previous manuscript. Third, all dependent reporting was revised from those outputs. This sequence prevents the old numerical results from being retained when they no longer describe the supplied records. The accompanying generation script and analysis JSON provide the information needed to repeat the computations.

The study has no sampling frame, recruitment site, inclusion screening, exclusion process, compensation, or consent procedure because no people were involved. The artificial age and demographic categories describe generated records only. They are included to demonstrate reporting structure, not to claim representativeness. The model estimates associations within the constructed score distribution; it does not estimate population risk or diagnostic performance.

How the data were created

The dataset was generated using NumPy with random seed 20261003. Independent standard normal draws defined latent health anxiety X and electronic health literacy W . Latent intolerance of uncertainty was $M = 0.50X + \sqrt{0.75}E_M$. Latent cyberchondria was $Y = 0.45X + 0.40M - 0.12W - 0.10XW + 0.80E_Y$, where the residual draws E_M and E_Y were independent standard normal variables. These coefficients were specified as illustrative assumptions before examining the generated results. No seeds or parameters were selected to reproduce the previous numerical findings. The equations deliberately encode an indirect association and a negative interaction, so their recovery cannot be interpreted as new evidence that these relationships occur in adults.

For each construct, artificial item responses were generated from 0.75 times its latent score plus independent normal item noise with standard deviation 0.65 and item offsets spaced evenly from -0.25 to 0.25 . Responses were discretized at standard normal quantile thresholds into the relevant response categories. SHAI items used four categories coded 0 to 3; IUS, eHEALS, and CSS items used five categories coded 1 to 5. The resulting total scores were the sums of 18, 12, 8, and 12 items, respectively. Because discretization and measurement noise alter latent relationships, reported regression coefficients were estimated from the exported total scores rather than taken from the generating equations.

Generating items rather than drawing totals directly allowed the analysis to verify scale ranges and exact scoring. It also introduced a distinction between a latent relationship and the relationship observed after adding item noise. Each item had its own noise draw and a small fixed offset, so response categories varied across items within a record. Nonetheless, the common latent component imposed substantial covariance. This construction is intentionally simple and does not reproduce item wording, factor loadings estimated from a validation sample, or differential item functioning.

Artificial age was sampled uniformly from integers 18 to 65. Gender categories were sampled with probabilities 0.55 for woman, 0.43 for man, and 0.02 for other; education probabilities were 0.22 for high school or below, 0.52 for undergraduate, and 0.26 for postgraduate. Chronic-condition status used a Bernoulli probability of 0.22. Online search frequency used probabilities 0.20, 0.30, 0.35, and 0.15 for less than monthly, monthly, weekly, and daily, respectively. These descriptors were generated independently of the psychological latent variables and were not used as covariates. Their distributions are assumptions, not estimates of population prevalence.

Measures and scores

Health anxiety was represented by 18 artificial item codes matching the response range of the SHAI measure (Salkovskis et al., 2002). Total scores ranged from 0 to 54; higher scores represented higher levels of the construct. No actual scale questions were administered. Internal consistency in the generated responses was $\alpha = 0.943$. This coefficient reflects imposed shared latent structure and does not constitute psychometric validation. The eHEALS representation concerns perceived competence and does not model objective source appraisal performance.

Intolerance of uncertainty was represented by 12 artificial item codes matching the response range of the IUS measure (Carleton et al., 2007). Total scores ranged from 12 to 60; higher scores represented higher levels of the construct. No actual scale questions were administered. Internal consistency in the generated responses was $\alpha = 0.931$. This coefficient reflects imposed shared latent structure and does not constitute psychometric validation. The eHEALS representation concerns perceived competence and does not model objective source appraisal performance.

Perceived electronic health literacy was represented by 8 artificial item codes matching the response range of the eHEALS measure (Norman & Skinner, 2006). Total scores ranged from 8 to 40; higher scores represented higher levels of the construct. No actual scale questions were administered. Internal consistency in the generated responses was $\alpha = 0.891$. This coefficient reflects imposed shared latent structure and does not constitute psychometric validation. The eHEALS representation concerns perceived competence and does not model objective source appraisal performance.

Cyberchondria was represented by 12 artificial item codes matching the response range of the CSS measure (McElroy et al., 2019). Total scores ranged from 12 to 60; higher scores represented higher levels of the construct. No actual scale questions were administered. Internal consistency in the generated responses was $\alpha = 0.941$. This coefficient reflects imposed shared latent structure and does not constitute psychometric validation. The eHEALS representation concerns perceived competence and does not model objective source appraisal performance.

Data checks and analysis

The exported CSV was read back for analysis. Checks confirmed 450 unique synthetic identifiers, complete data, all item responses within their specified coding ranges, and exact agreement between each total and its item sum. No records were removed or imputed. Analyses used NumPy, pandas, and SciPy. Descriptive statistics used sample standard deviations. Cronbach's alpha was calculated from the item variances and total variance. Pearson correlations were evaluated with two-sided tests; their approximate 95% intervals used Fisher transformation. All estimates reported below were computed from the exported CSV.

Identifiers were checked for duplication, and missingness was checked across all columns. Range checks were applied separately to each item family before verifying that the total equalled the row sum. These are data-integrity checks rather than tests of whether the simulation resembles a particular population. No winsorization, transformation, outlier deletion, or complete-case filtering was required. Consequently, the analytical sample remained equal to the generated sample throughout all models.

For statistical mediation, ordinary least-squares models estimated the health anxiety to intolerance of uncertainty path and the joint health anxiety and intolerance of uncertainty associations with cyberchondria. The unstandardized indirect effect was the product of the two relevant coefficients. An integrated model included mean-centered health anxiety, uncentered intolerance of uncertainty, mean-centered literacy, and the centered health anxiety by literacy product. A reduced model omitted the interaction to estimate its incremental explained variance. Standard errors and coefficient confidence intervals used conventional ordinary least-squares covariance estimates and Student *t* distributions; robust standard errors were not used. These assumptions and the bounded ordinal score construction constrain inferential interpretation.

Mean-centering changes the interpretation of the lower-order regression coefficients without changing the fitted interaction model. The health anxiety coefficient in the integrated model represents its conditional association at mean literacy. The literacy coefficient represents its association at mean health anxiety. The interaction coefficient represents the change in the health anxiety slope for a one-point increase in literacy. The uncertainty coefficient is adjusted for the other included terms. All reported *B* coefficients are unstandardized, so their sizes depend on the score units and should not be compared as if they were standardized importance rankings.

The unmoderated and integrated indirect effects used 5,000 record-level bootstrap resamples with random seed 73103 and percentile 95% intervals. Each bootstrap resample refitted both component regressions. Conditional direct slopes were estimated at the literacy mean and one sample standard deviation below and above it, with standard errors calculated using the full coefficient covariance matrix. Statistical significance was evaluated at two-sided $p < .05$ without multiplicity correction. No Johnson-Neyman analysis was performed in this revision. Confidence intervals quantify sampling variation under the artificial model, not uncertainty about clinical population effects. One generated dataset was analysed, so this study does not estimate Monte Carlo bias, power, or coverage across repeated datasets.

Manuscript preparation

OpenAI ChatGPT assisted with drafting, revision, and preparation of the generation and analysis scripts. The reported results were computed programmatically from the exported artificial records. The author remains responsible for reviewing the text, code, references, and interpretation.

Results

Sample and score summaries

All 450 generated records were included. Artificial age had $M = 41.48$, $SD = 14.00$, with an allowable range of 18 to 65. Table 1 summarizes the generated descriptors. No demographic frequencies should be interpreted as information about a recruited population.

The age distribution reflects uniform generation rather than recruitment from a community sample. The categorical descriptors likewise reflect random draws from stated probabilities. Small differences between realized percentages and the assigned probabilities are expected because only 450 records were generated. No subgroup model was fitted, and the descriptors do not establish gender, education, age, or chronic-condition differences in cyberchondria.

Table 1
Characteristics of the Synthetic Sample

Characteristic	Category	<i>n</i>	%
Gender	Woman	249	55.3
	Man	192	42.7
	Other	9	2.0
Education	Undergraduate	221	49.1
	Postgraduate	137	30.4
	High school or below	92	20.4
Chronic condition	No	354	78.7
	Yes	96	21.3
Search frequency	Weekly	151	33.6
	Monthly	124	27.6
	Less than monthly	111	24.7
	Daily	64	14.2
Note. N = 450. All records are synthetic. Percentages may not sum to 100 because of rounding. Demographic variables were generated independently of the psychological scores.			

Table 2 reports the total-score distributions, internal consistency, and correlations. The simulated scale reliabilities were high because item responses shared a common generating variable. These values describe the artificial response structure and do not validate the original instruments or support claims about measurement quality in a human sample.

The generated means were 26.48 for health anxiety, 34.98 for uncertainty, 23.78 for literacy, and 35.49 for cyberchondria. The corresponding standard deviations were 14.15, 12.80, 8.38, and 13.64. These

distributions span broad portions of the allowable score ranges because the latent variables and quantile thresholds were chosen to create variation. They should not be used as normative reference values or interpreted as rates of clinical severity.

Table 2
Descriptive Statistics, Internal Consistency, and Correlations

Measure	<i>M</i>	<i>SD</i>	α	1	2	3	4
1. Health anxiety (SHAI)	26.48	14.15	.943	—			
2. Uncertainty (IUS)	34.98	12.80	.931	.528	—		
3. Digital literacy (eHEALS)	23.78	8.38	.891	.034	.005	—	
4. Cyberchondria (CSS)	35.49	13.64	.941	.547	.540	-.118	—
Note. N = 450. SHAI = Short Health Anxiety Inventory; IUS = Intolerance of Uncertainty Scale; eHEALS = eHealth Literacy Scale; CSS = Cyberchondria Severity Scale. Correlations are Pearson coefficients. Dashes on the diagonal indicate that self-correlations are not reported; blank cells above the diagonal are omitted to avoid repetition.							

Anxiety and uncertainty

Health anxiety and cyberchondria were correlated, $r = 0.547$, 95% CI [0.479, 0.608], $p < .001$.

Health anxiety and intolerance of uncertainty were correlated, $r = 0.528$, 95% CI [0.458, 0.592], $p < .001$.

Intolerance of uncertainty and cyberchondria were correlated, $r = 0.540$, 95% CI [0.471, 0.602], $p < .001$.

Literacy and cyberchondria were correlated, $r = -0.118$, 95% CI [-0.208, -0.026], $p = 0.012$.

The unmoderated model with health anxiety and intolerance of uncertainty explained 38.6% of synthetic outcome variance. Its direct health anxiety coefficient was $B = 0.350$, $SE = 0.042$, $p < .001$; the intolerance of uncertainty coefficient was $B = 0.371$, $SE = 0.047$, $p < .001$. The indirect effect was $B = 0.177$, bootstrap $SE = 0.027$, 95% percentile bootstrap CI [0.127, 0.231]. Table 3 reports the component estimates. This is an indirect statistical association within generated data, not evidence of a causal psychological mechanism.

The total health anxiety association was $B = 0.527$, whereas its adjusted direct coefficient in the two-predictor model was $B = 0.350$. The uncertainty path from health anxiety was $B = 0.478$, and the adjusted uncertainty association with cyberchondria was $B = 0.371$. Their product produced the indirect estimate of 0.177. This numerical decomposition helps explain how the estimated pathway relates to the regression outputs. It does not determine whether the same decomposition would hold under alternative temporal ordering, omitted confounding, or different measurement assumptions.

Table 3
Regression Coefficients and the Indirect Association

Estimate	<i>B</i>	<i>SE</i>	95% CI	<i>p</i>
Total health anxiety association	0.527	0.038	[0.452, 0.602]	< .001
Health anxiety to uncertainty	0.478	0.036	[0.406, 0.549]	< .001
Uncertainty to cyberchondria adjusted for anxiety	0.371	0.047	[0.279, 0.462]	< .001
Direct health anxiety association	0.350	0.042	[0.267, 0.433]	< .001
Indirect association	0.177	0.027	[0.127, 0.231]	—
Note. N = 450. B = unstandardized coefficient; SE = standard error; CI = confidence interval. The indirect association uses 5,000 percentile bootstrap resamples. All other intervals use conventional ordinary least-squares estimates. A dash indicates that a bootstrap p value was not calculated.				

The role of digital health literacy

The integrated model explained 41.6% of synthetic cyberchondria variance, $R^2 = 0.416$, adjusted $R^2 = 0.411$, $F(4, 445) = 79.28$, $p < .001$. The interaction was $B = -0.0134$, $SE = 0.0044$, $p = 0.002$, with $\Delta R^2 = 0.012$ relative to the model without the interaction. Table 4 reports the integrated coefficients and conditional slopes.

The interaction increased explained variance by approximately 1.2 percentage points. This increment was smaller than the overall model fit and should be interpreted as a conditional refinement rather than the main source of explained variation. Statistical significance indicates that the fitted coefficient was distinguishable from zero under the conventional OLS assumptions in this generated sample. It does not establish that the interaction is large enough to guide clinical decisions.

At low literacy (eHEALS = 15.40), the conditional health anxiety association was $B = 0.465$, $SE = 0.054$, 95% CI [0.358, 0.572], $p < .001$.

At mean literacy (eHEALS = 23.78), the conditional health anxiety association was $B = 0.352$, $SE = 0.041$, 95% CI [0.272, 0.433], $p < .001$.

At high literacy (eHEALS = 32.15), the conditional health anxiety association was $B = 0.240$, $SE = 0.056$, 95% CI [0.130, 0.349], $p < .001$.

The health anxiety slope was approximately 48.5% smaller at high than at low literacy, using the unrounded slope estimates. Both slopes remained positive and their confidence intervals excluded zero. Thus, the observed-score model represented attenuation over the examined range. It did not demonstrate complete protection or identify a literacy threshold at which the association disappeared. No such threshold analysis was performed.

The integrated indirect association was $B = 0.176$, bootstrap $SE = 0.026$, 95% CI [0.127, 0.230]. The model did not specify moderation of the indirect pathway. H1 to H4 matched the expected directions and indirect association; H5 matched the negative interaction. These are within-simulation outcomes partly determined by the generating assumptions, not independent confirmation of the substantive hypotheses.

Table 4
Integrated Model Coefficients and Conditional Associations

Term	<i>B</i>	<i>SE</i>	95% CI	<i>p</i>
Intercept	22.622	1.666	[19.348, 25.895]	< .001
Health anxiety centered	0.352	0.041	[0.272, 0.433]	< .001
Intolerance of uncertainty	0.369	0.045	[0.280, 0.459]	< .001
Literacy centered	-0.221	0.059	[-0.337, -0.105]	< .001
Health anxiety by literacy	-0.013	0.004	[-0.022, -0.005]	.002
Low literacy direct slope	0.465	0.054	[0.358, 0.572]	< .001
Mean literacy direct slope	0.352	0.041	[0.272, 0.433]	< .001
High literacy direct slope	0.240	0.056	[0.130, 0.349]	< .001
<i>Note.</i> $N = 450$. B = unstandardized coefficient; SE = standard error; CI = confidence interval. Health anxiety and literacy were mean-centered. Conditional slopes are evaluated at literacy scores of 15.40 (low), 23.78 (mean), and 32.15 (high), corresponding to the mean and ± 1 SD. $R^2 = .416$; adjusted $R^2 = .411$.				

Discussion

Main findings

This revision replaces the earlier illustrative numbers with estimates calculated from a new, reproducibly generated CSV. Health anxiety and cyberchondria were positively related ($r = 0.547$), intolerance of uncertainty accounted for an indirect association, and the direct association was weaker at higher literacy scores. The full model explained 41.6% of artificial outcome variance. The principal contribution is a transparent computational demonstration of how these models can be estimated and reported. It is not an empirical study of cyberchondria in adults.

The distinction between recovering an assumed relationship and discovering a relationship is central. The generator included positive health anxiety and uncertainty coefficients, a negative literacy coefficient, and a negative interaction. Consequently, a significant indirect effect and interaction are compatible with the data-generating assumptions and do not provide independent evidence for their clinical validity. The results depend on the specified coefficients, measurement noise, response

thresholds, and random draws. A different generator could produce a weaker relationship, a null association, or a reversed association. The observed significance should therefore be described as an outcome of this simulation rather than hypothesis confirmation in a population.

Hypothesis outcomes

H1 was statistically supported within the synthetic dataset: health anxiety and cyberchondria were positively correlated, $r = .547$, $p < .001$. H2 was supported within the simulation, with a positive anxiety and uncertainty correlation of $.528$, $p < .001$. H3 was supported within the simulation, with a positive uncertainty and cyberchondria correlation of $.540$, $p < .001$. These directions fit the imposed structure and resemble the theoretical expectations motivated by prior research. They do not independently confirm those hypotheses in adults.

H4 was statistically supported within the simulation because its indirect estimate was positive and the percentile bootstrap interval excluded zero, $B = 0.177$, 95% CI $[0.127, 0.231]$. The direct anxiety coefficient also remained positive. This outcome describes an indirect association alongside a remaining direct association. It should not be called evidence that uncertainty is a causal mediator in people. The concern identified by Maxwell and Cole (2007) applies even to observational human data, and the present simulation additionally assumes the direction of the pathway.

H5 was statistically supported within the simulation: the interaction coefficient was $B = -0.0134$, $p = .002$. Its negative sign was the predicted direction, not a rejected or adverse hypothesis. Holding the other model terms constant, an increase in literacy reduced the fitted positive anxiety slope. The three conditional slopes remained positive, so the result represents attenuation and does not mean that higher literacy reversed the association or eliminated it.

No hypothesis was statistically rejected in this single generated dataset. Accordingly, there is no unsupported hypothesis for which a post hoc explanation should be invented. The appropriate rationale concerns the negative H5 coefficient and the limits of interpreting it. A positive interaction or an interval including zero would have failed to match H5 in that generated realization, but neither occurred. Such outcomes could still arise under other seeds, weaker effects, more measurement noise, or alternative assumptions, which were not systematically evaluated here.

Health anxiety and intolerance of uncertainty

The simulated positive health anxiety association resembles the direction reported in reviews of cyberchondria (McMullan et al., 2019; Schenkel et al., 2021). Those reviews provide the empirical basis for the proposed conceptual model; the present generated records do not strengthen that evidence. In a real study, repeated searching might function as reassurance seeking, and exposure to alarming or inconsistent information might reinforce concern. Neither search behavior nor its function was observed

here. CSS-range scores stand in for a construct and do not represent recorded searches or clinical diagnoses.

The indirect association through intolerance of uncertainty illustrates a statistical decomposition of shared variation. Prior studies have identified uncertainty-related cognition as relevant to health anxiety following online searching and to cyberchondria dimensions (Fergus, 2013, 2015). In the current artificial model, the ordering from health anxiety to uncertainty was explicitly imposed. It therefore cannot decide whether uncertainty precedes anxiety in real life, whether searching increases both, or whether another vulnerability explains their relationship. Even an empirical cross-sectional indirect effect would require caution because alternative temporal orderings could fit related covariance patterns.

The retained direct health anxiety coefficient indicates that the fitted indirect pathway did not account for all of the synthetic relationship. This reflects both the direct term in the generator and attenuation arising from artificial item measurement. It does not identify additional psychological mechanisms. Emotion regulation, metacognitive beliefs, anxiety sensitivity, and reassurance tendencies remain plausible empirical candidates, but they were not measured or simulated in this dataset. Blachnio et al. (2023) provide relevant empirical context for emotional functioning; their findings should not be treated as replicated by this demonstration.

Interpreting the hypotheses together gives a more balanced account than treating each p value as a separate discovery. The positive anxiety association provides the overall fitted pattern, the uncertainty terms partition part of that association, and the literacy product permits its remaining slope to differ across literacy levels. These pieces answer different statistical questions. None identifies a unique clinical process by itself, and their combination remains constrained by the original equations. The coherent conclusion is that the supplied workflow estimates the proposed structure transparently, not that the structure has been established as a treatment model.

Digital health literacy

The negative interaction means that the fitted health anxiety slope declined as artificial literacy increased. All three reported slopes remained positive. This demonstrates attenuation within the imposed model, rather than elimination of the association. A negative interaction on this scale is also not equivalent to proof that literacy training protects people from cyberchondria. The simulation did not assign an intervention, model learning, measure objective information appraisal, or observe symptom change.

The mathematical rationale for the negative coefficient is direct. The generating equation includes a negative health anxiety by literacy term. After item noise and discretization, the fitted observed-score model retained this direction. The possible substantive rationale is more tentative: a person who evaluates sources carefully may interpret a threatening search result with more context or recognize when additional checking offers little useful information. That explanation is compatible with the concept of literacy, but it was not observed or tested in the artificial records.

The modest incremental variance explained also matters. The interaction added approximately 1.2 percentage points, whereas the integrated model explained 41.6% overall. This indicates that the conditional pattern was a refinement of broader associations in this dataset. A statistically detectable interaction should therefore not dominate the interpretation or be described as the principal cause of cyberchondria. Evidence of practical importance would require independently measured outcomes and a prespecified criterion for meaningful change.

Perceived literacy and objective skill need to be distinguished. The original eHEALS concerns self-reported competence (Norman & Skinner, 2006), whereas this dataset uses artificial codes within its scoring range. Confident users may differ from skilled users, and searching competence could increase access to both reassuring and threatening material. Empirical variation in literacy associations therefore remains important. Fang and Mushtaque (2024) and Zhang et al. (2026) provide context for moderation and heterogeneous associations. The present outcome cannot resolve such heterogeneity because a single negative interaction was specified in advance.

What the method shows

Using item-level artificial responses enables exact scoring checks and calculation of reliability coefficients. It also exposes an important limit: high alpha is expected when items share a latent generating variable. The coefficients here cannot establish instrument reliability in a new culture, language, clinical group, or age range. Response discretization and bounded total scores also mean that latent coefficients and observed-score regression estimates differ. Reporting the observed CSV analyses rather than the latent parameters keeps the numerical results traceable to the supplied records.

The bootstrap intervals quantify variation obtained by resampling one generated dataset. They are not Monte Carlo confidence intervals across independently generated studies and do not assess interval coverage. One dataset is insufficient to determine whether a mediation or moderation method is biased or well calibrated across generating conditions. A methodological extension would repeat the complete generation and fitting process across many independent datasets, vary effect sizes and measurement noise, and evaluate bias, coverage, and false-positive rates under both nonzero and null interaction conditions.

For this reason, reproducibility and robustness should be treated separately. Re-running the supplied script reproduces the same records and statistics because the seeds are fixed. That establishes computational reproducibility. Robustness would require examining how estimates change across seeds, alternative response thresholds, smaller and larger sample sizes, different measurement error, and null or reversed interaction assumptions. Those evaluations were not undertaken, and the present results should not be presented as stable across untested conditions.

The numerical differences from the earlier draft further show why results need to follow the actual dataset. A model can retain the same conceptual structure while producing different correlations, reliability coefficients, and explained variance. The present integrated explained variance is 41.6%, and

the discussion has been revised around that value. The change is not a contradiction between empirical samples because neither version represented recruited participants. It is a consequence of replacing illustrative numbers with a new specified synthetic realization.

Future research

The model offers a specification that can guide empirical investigation, provided its assumptions are tested independently. A longitudinal study could examine whether earlier health anxiety is associated with subsequent searching after accounting for prior cyberchondria and whether uncertainty-related cognition helps explain change. Objective search indicators and performance-based literacy tasks could complement questionnaires. Sampling and covariate choices should reflect the intended population, and power calculations should focus on the interaction rather than only the main associations.

A useful empirical study would also define what successful protection means. A smaller cross-sectional association is not sufficient. Investigators could assess whether an intervention improves objective appraisal, reduces distress during a search, shortens repetitive checking, or improves decisions about appropriate care. These outcomes are related but distinct. Any trial should specify its primary outcome before collecting data and distinguish reduced unnecessary checking from reduced access to useful information.

Longitudinal assessment could clarify whether the same person searches more during periods of heightened worry or whether stable differences between people account for most of the relationship. Repeated observations would also allow examination of feedback, such as whether distress after a search predicts another search. Such questions cannot be answered by a single row per artificial record. The present design therefore provides a statistical starting point rather than a model of moment-to-moment behavior.

Clinical recommendations cannot be derived from this simulation. It identifies no treatment benefit, screening threshold, risk group, or causal intervention target. The theoretical possibility of combining uncertainty-focused psychological approaches with digital information appraisal training remains a question for adequately designed human studies. Any intervention study would require its own ethics review, consent procedures, and preregistered outcome definitions.

Limitations

Every record is artificial. The generator assumes a particular structure, homogenous effects, independent descriptor variables, complete responses, and no recruitment or response bias. It includes no confounding, longitudinal feedback, clustering, site differences, cultural effects, or variation in item functioning. Age and other descriptors were generated independently and therefore cannot support meaningful subgroup conclusions. A single fixed-seed dataset also does not demonstrate robustness to random generation. Conventional OLS inference was used despite bounded score construction, and no

multiplicity adjustment or robust covariance estimator was applied. Finally, the original substantive introduction and references remain theoretical background rather than evidence generated by this study.

The limitations establish the appropriate concluding claim. The fitted model recovered a positive anxiety association, an indirect uncertainty pathway, and a negative literacy interaction in the generated scores. These findings are internally coherent with the supplied CSV and transparent assumptions. They support the use of the manuscript as a reproducible demonstration of analysis and reporting. They do not support statements that uncertainty has been proven to mediate anxiety in adults or that digital literacy has been shown to prevent cyberchondria. The next decisive step is independent empirical testing, complemented by repeated simulations that examine when the statistical method succeeds or fails.

Conclusion

This study developed and analysed a reproducible dataset of 450 artificial records to demonstrate how health anxiety, intolerance of uncertainty, digital health literacy, and cyberchondria can be represented in an integrated statistical model. The dataset contains item-level responses, checked total scores, and explicitly identified synthetic records. The manuscript reports estimates computed from that exported file rather than retaining numerical claims from an earlier draft. This alignment between data, code, tables, and interpretation is the central methodological contribution.

All five expectations matched the patterns observed in the synthetic scores. Health anxiety was positively associated with cyberchondria and uncertainty; uncertainty was positively associated with cyberchondria; the indirect association through uncertainty had a bootstrap interval excluding zero; and the literacy interaction was negative. The integrated model explained 41.6% of artificial outcome variance. The negative interaction reflected a smaller positive health anxiety slope at higher literacy, not a reversed association or complete protection. None of the hypotheses was rejected in this single realization, but their status is limited to the specified simulation.

The conclusions must follow from the origin of the data. Positive direct and indirect terms and a negative interaction were built into the latent generating equation. Detecting related patterns after artificial measurement demonstrates recovery under those assumptions. It does not demonstrate that adults experience the same psychological pathway, that uncertainty precedes cyberchondria, or that literacy training prevents distress. Prior research supplies the conceptual context, including evidence for anxiety-related searching, uncertainty vulnerabilities, and possible reciprocal processes. The generated results cannot add independent empirical confirmation to that literature.

The next methodological step is repeated simulation across different assumptions, including null and reversed interactions, varying measurement quality, and alternative sample sizes. The next substantive step is independent research with appropriate consent and ethical review, temporal measurement, objective indicators of searching and literacy, and explicit consideration of competing mechanisms. These approaches answer different questions and should be reported separately. The present

manuscript offers a transparent starting point for both, while its final claim remains a demonstrated analytical workflow rather than an established clinical explanation of cyberchondria.

Declarations

Permission to publish

Not applicable. The manuscript contains no identifiable personal information about any individual.

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Author Contribution

A.F. is the sole author of this manuscript and was responsible for the conceptualization, methodology, analysis, interpretation of results, drafting of the manuscript, and critical revision of the final text. A.F. reviewed and approved the final manuscript.

Data availability

The datasets generated during and/or analysed during the current study are available in the Zenodo repository, <https://doi.org/10.5281/zenodo.23111558>. All records are synthetic.

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