CalmBrowse: A Just-in-Time Browser Extension to Mitigate Cyberchondria Using Large Language Models

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ABSTRACT

Cyberchondria, defined as the excessive or repeated searching for health information online, often resulting in increased health anxiety, has become a significant digital health concern. This behavior is strongly associated with heightened psychological distress, unnecessary medical consultations and procedures, and overall deterioration in mental and physical well-being. Existing evidence-based therapies like Cognitive Behavioral Therapy (CBT) and mindfulness are effective but typically require scheduled sessions, lacking availability at the critical "moment of need" when anxiety is triggered by online content. We present *CalmBrowse*, a novel, lightweight, and privacy-preserving browser extension designed for Chrome and Edge. CalmBrowse actively detects when a user is viewing health-related web pages likely to trigger cyberchondria and non-intrusively injects two evidence-based micro-interventions directly into the Browse experience: (i) a cognitive-behavioral reframe delivered as context-aware information, and (ii) a brief 60-second guided breathing exercise prompt. The system architecture relies on carefully orchestrated, client-side calls to a large-language model (LLM) to dynamically analyze page content and generate contextually relevant, third-person feedback designed to gently challenge catastrophic thinking and provide perspective. Crucially, all potentially personally identifiable data, including the page content itself, remains on the client and is not transmitted externally beyond the anonymized, truncated text sent to the LLM API. Within a compressed one-week development sprint, we successfully implemented a fully functional prototype, conducted qualitative prompt engineering iterations to refine the LLM's output, and compiled a robust corpus of peer-reviewed psychological and clinical studies to ground the intervention design in established therapeutic principles. While severe time constraints inherent to the project timeline precluded a formal controlled user study or clinical evaluation, this paper thoroughly details our technical engineering approach, the safety guard-rails implemented to ensure responsible deployment, and the research-backed rationale informing the intervention strategy. CalmBrowse lays foundational groundwork for future rigorous empirical evaluation of just-in-time, LLM-powered psychological interventions delivered directly within the digital environments where anxiety is often amplified.

KEYWORDS

Cyberchondria, Health Anxiety, Browser Extension, Large Language Models, Cognitive Behavior Therapy, Mindfulness, Digital Health Interventions, Just-in-Time Adaptive Interventions

ACM Reference Format:
Joshua Fonseca Rivera. 2025. CalmBrowse: A Just-in-Time Browser Extension to Mitigate Cyberchondria Using Large Language Models. In . ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn

1 INTRODUCTION

Access to online health information has become ubiquitous, with recent estimates indicating that the vast majority of adults now utilize the internet to research symptoms, conditions, and treatments [2]. While empowering for many, for a significant minority, estimated at 30–40% of the population engaging in health searches, this behavior can escalate into a maladaptive pattern known as *cyberchondria*. Cyberchondria is characterized by excessive, repeated, and often compulsive online symptom checking that, paradoxically, amplifies rather than alleviates health anxiety, frequently leading to increased distress and unnecessary healthcare utilization [1, 2]. This phenomenon represents a critical challenge at the intersection of digital behavior and mental health.

Established evidence-based interventions, such as Cognitive Behavioral Therapy (CBT) and mindfulness-based approaches, have demonstrated efficacy in reducing health anxiety [3, 4]. However, these therapeutic modalities are traditionally delivered in structured, scheduled formats (e.g., therapy sessions, courses), which are often not readily available at the precise "moment of need", that is, when an individual is actively engaged in online health searching and their anxiety is peaking. This temporal mismatch between the onset of distress and the availability of support presents a significant barrier to effective intervention for cyberchondria.

We therefore pose the research question: **Can we effectively and safely deliver personalized, just-in-time psychological support directly within the web browser environment, without compromising user privacy by capturing sensitive personal health data or impeding access to information itself?** To explore this timely question, we designed and engineered **CalmBrowse**, an open-source browser extension. CalmBrowse is conceived as a non-blocking, low-friction intervention system that surfaces concise, LLM-generated psychological perspective and a brief calming exercise whenever a user navigates to a symptom-focused article on common health websites such as WebMD, Mayo Clinic,

Conference'17, July 2017, Washington, DC, USA

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM
https://doi.org/10.1145/nnnnnnn.nnnnnnn

Healthline, and others. Our aim is to provide immediate, contextually relevant support precisely when and where the problematic behavior occurs.

2 RELATED WORK

Our intervention design is grounded in established research on cyberchondria and evidence-based psychological treatment approaches.

2.1 Evidence on Cyberchondria

Extensive meta-analytic work consistently links excessive health-related internet searching to a cascade of negative outcomes, including increased health anxiety, heightened distress, and problematic medical service utilization [2]. A foundational study by Doherty-Torstrick *et al.* provided empirical evidence showing that individuals with pre-existing elevated illness anxiety reported feeling significantly *worse* (i.e., more anxious) after engaging in symptom searches online compared to individuals with lower baseline anxiety levels [1]. This highlights a key mechanism: for vulnerable individuals, online health information can become a trigger for catastrophic misinterpretation and escalating worry, rather than a source of helpful knowledge.

2.2 Intervention Strategies

CalmBrowse integrates elements from well-validated psychological interventions, adapted for a brief, just-in-time delivery format.

Cognitive Behavioral Techniques. Internet-delivered CBT (ICBT) has demonstrated robust effectiveness in reducing cyberchondria severity, with meta-analyses reporting large effect sizes (e.g., Hedges $g \approx 1.1$ compared to control groups) [3]. Core components of successful CBT for health anxiety include:

- *Cognitive Reframing:* Identifying and challenging catastrophic thoughts (e.g., interpreting a mild symptom as a sign of a severe disease) and replacing them with more balanced, realistic perspectives.
- *Exposure with Response Prevention (ERP):* Gradually exposing individuals to anxiety triggers (like symptom descriptions) while preventing their usual coping responses (like excessive checking or reassurance seeking). While full ERP is complex to implement in a micro-intervention, introducing alternative responses like mindful breathing and probabilistic information can be a form of response disruption.

Our LLM-generated reframe aims to embody principles of cognitive restructuring by offering alternative, non-catastrophic interpretations and contextualizing the information presented on the page.

Mindfulness and Breathwork. Mindfulness-based interventions, such as Mindfulness-Based Cognitive Therapy (MBCT), have shown promise in reducing health anxiety and clinical hypochondriasis rates, demonstrating sustained benefits over time [4]. A key element of mindfulness is paying attention to the present moment without judgment, which can help individuals detach from anxious thought spirals. Simple physiological techniques, such as slow, controlled breathing exercises, have been consistently shown in randomized trials to reliably lower anxiety across populations by regulating the autonomic nervous system [5]. The inclusion of a guided breathing prompt in CalmBrowse provides users with an immediate, physiological tool to manage acute anxiety triggered by the content they are viewing.

The combination of cognitive reframing, and a physiological calming technique, delivered precisely when the user is engaged with potentially anxiety-provoking content, forms the core therapeutic mechanism of CalmBrowse.

3 METHODOLOGY

The technical architecture of CalmBrowse is designed for efficiency, privacy, and responsiveness, operating primarily client-side within the user's browser. All computational logic, content extraction, and UI rendering occur locally within the browser extension's sandboxed environment, with the sole external communication being a single HTTPS request to a configured LLM provider API (tested with Gemini 2.5 and Llama-3 8B via AwanLLM, a platform providing API access to open models).

3.1 Content Extraction

Upon detecting that the user has navigated to a URL matching a predefined list of trusted health information domains (e.g., '*webmd.com/*', '*mayoclinic.org/*', '*healthline.com/*'), a content script is injected into the page. This script's primary task is to robustly extract the main article text while avoiding boilerplate, advertisements, or navigation elements. We employ a hybrid approach: first, utilizing domain-specific CSS selectors for known website structures to target article paragraphs accurately; second, providing a fallback mechanism using a generic visible-text walker traversing the DOM tree. To manage the potential token limits imposed by LLM APIs and focus the model on the most relevant information, the extracted text is intelligently truncated. This involves including the first 1 kB (typically containing the introduction and main subject), the middle 1 kB, and the last 1 kB (often containing summaries or conclusions), supplemented by up to five additional paragraphs identified as being rich in medical keywords using a simple heuristic keyword density analysis. This strategy aims to capture the essence of the article while staying within processing constraints.

3.2 Prompt Engineering

The core of CalmBrowse's intelligence lies in its interaction with the LLM, guided by carefully engineered prompts. A strict `system` prompt is used to establish the LLM's persona and constraints, explicitly forbidding it from making diagnoses, requiring the use of third-person wording (e.g., "For *a person* experiencing these symptoms..."), enforcing the consistent denominator rule for prevalence statistics, and appending a clear disclaimer stating that the information is not medical advice. Following the system prompt, a concise `user` prompt is constructed containing the truncated page text and clear instructions for the LLM to extract and format specific pieces of information as JSON: `mainCondition` (the primary health issue discussed), `reframe` (a brief, balanced cognitive perspective), and `calmingSuggestion` (a brief prompt for a calming activity). The extension anticipates a JSON response and includes error handling; if the LLM fails to return valid JSON or provides a problematic response (e.g., violating safety rules), it falls back to a pre-defined,

canned message prompting the user to perform a simple breathing exercise, ensuring the user still receives a calming intervention.

3.3 UI Layer

The intervention is presented to the user via a non-modal, non-blocking user interface element: a Shadow-DOM panel. Using the Shadow DOM encapsulates the panel's CSS and structure, preventing conflicts with the host page's styling. The panel slides in from the side of the viewport, occupying a fixed width (e.g., 350 px), and is overlaid atop the page content with a semi-transparent backdrop that subtly dims the background page without obscuring it entirely. This design choice ensures the user can still see the original content while the intervention is displayed. The panel is easily dismissible by the user at any time via a prominent close button. The panel dynamically populates with the information extracted from the LLM's JSON response. Additionally, the UI includes a curated list of trusted, high-authority links (e.g., to the National Institutes of Health (NIH), Centers for Disease Control and Prevention (CDC), Mayo Clinic's main health pages) to gently encourage users to seek further evidence-based information from reliable sources, reinforcing healthy information-seeking behavior.

3.4 Safety Guard-Rails

Given the sensitive nature of health information and anxiety, implementing robust safety guard-rails was important. These are implemented client-side within the browser extension:

- **Privacy by Design:** The system is architected such that *only* the de-identified, truncated page text is transmitted to the LLM API. No user identifiers, Browse history, cookies, IP addresses (the request originates from the client), or direct user input are ever captured or sent externally. This minimizes privacy risks inherent in handling health-related content.
- **Content Filtering:** After receiving the LLM response, the system performs post-processing checks. Responses containing prohibited phrases or patterns, particularly any language that could be interpreted as direct, second-person reassurance (e.g., "*you probably don't have this condition*" or "*don't worry, it's likely benign*"), trigger an immediate rejection of the LLM output. In such cases, the UI falls back to displaying the safe, canned breathing-exercise message. This prevents the LLM from offering potentially inaccurate or inappropriate personal medical opinions.

These guard-rails are essential for mitigating the risks associated with using generative AI in a health context and ensuring the intervention remains safe and non-diagnostic.

4 RESULTS

Despite the highly compressed one-week development timeline, we achieved several key implementation outcomes demonstrating the feasibility and initial robustness of the CalmBrowse prototype.

Prototype Completeness. We successfully implemented a fully functional end-to-end prototype of the CalmBrowse extension. This included the core pipeline components: health URL detection, dynamic content extraction from diverse page structures, intelligent text truncation and sampling, secure API communication with two distinct LLM back-ends (Gemini 2.5 and Llama-3 8B via AwanLLM), structured prompt formulation, JSON response parsing, safety guard-rail checks, and the dynamic injection and population of the Shadow-DOM UI panel. The extension successfully deployed and ran within Chromium-based browsers (tested primarily on Chrome version 123) on a standard development machine (M1 MacBook). The median latency from page load detection to the appearance of the populated intervention panel was measured to be under 5 seconds in local testing, which is well within acceptable limits for a just-in-time intervention.

Prompt Robustness. A critical part of the development was iterative prompt engineering. To assess the robustness of the finalized prompt structure and system instructions, we performed manual tests. This involved navigating to randomly selected articles related to various health conditions, with a particular focus on cancer-related pages known for their potential to trigger significant anxiety. For each page, we observed the LLM's generated JSON output. We specifically evaluated whether the responses consistently adhered to the required consistent denominator rule for prevalence statistics and, importantly, whether they successfully avoided the disallowed second-person reassurance language. Across these tests, the LLM responses consistently did not include the prohibited reassurance phrases, indicating a good level of prompt control over the LLM's output style for these critical safety requirements.

Qualitative Inspection. To gain an initial understanding of the *quality* and *tone* of the generated cognitive reframes and suggestions, we independently rated twelve generated panels based on a subset of the 50 manual tests. Each panel's language was assessed for qualities such as "calming," "non-patronising," "clear," and alignment with general principles of CBT-consistent phrasing, particularly regarding balanced perspectives rather than definitive statements. All twelve independently rated panels were judged as having language that was "calming" and "non-patronising," aligning well with the intended therapeutic style and established guidelines for effective cognitive restructuring techniques in CBT [6]. While this was not a formal user evaluation, this qualitative check provided initial confidence in the tone and style of the LLM-generated content.

5 LIMITATIONS AND FUTURE WORK

Due to the severe time constraints of the project's one-week timebox, we were unable to conduct any form of controlled user study or clinical evaluation to empirically measure the intervention's impact on user anxiety or behavior.

Building upon this foundational prototype, next steps for future work could include:

(1) **IRB-Approved Pilot User Study:** Conducting a formal, IRB-approved pilot study with a target population of individuals who self-report or are screened for elevated health anxiety. This study would ideally employ a controlled design (e.g., comparing CalmBrowse users to a control group) and utilize validated psychological instruments, such as the State-Trait Anxiety Inventory (STAI-S) state-anxiety subscale, administered pre- and post-exposure to anxiety-triggering content

with or without the intervention. Objective behavioral measures (e.g., time spent on health sites, number of distinct searches) could also be explored.

(2) **Personalized Prevalence Tailoring:** Enhancing the LLM prompt and processing pipeline to automatically tailor the presented prevalence statistics based on demographic information (e.g., age, sex) that could potentially be inferred or provided by the user with explicit consent (while maintaining strict privacy). This could improve the relevance and impact of the probabilistic reframe.

(3) **Integration of Graded Exposure Elements:** Exploring the feasibility of integrating elements of exposure with response prevention. This could involve dynamic features such as an "image soften" slider that gradually blurs potentially graphic or anxiety-provoking images on the page, allowing users to control their exposure level while practicing response prevention (e.g., resisting the urge to close the page or seek reassurance). This would require careful design to ensure it remains non-blocking and user-controlled.

(4) **Extending Intervention Modalities:** Investigating the potential to integrate other evidence-based micro-interventions, such as brief guided mindfulness exercises, progressive muscle relaxation prompts, or thought challenging prompts presented interactively.

(5) **Cross-Browser and Platform Compatibility:** Expanding support beyond Chromium browsers to include Firefox and potentially exploring desktop application or mobile browser integrations.

These planned steps represent critical pathways for moving CalmBrowse from a functional prototype to an empirically validated digital health intervention.

6 CONCLUSION

In this paper, we presented CalmBrowse, a novel browser extension prototype that demonstrates the technical feasibility of leveraging modern Large Language Models to deliver just-in-time, evidence-based psychological micro-interventions specifically targeting cyberchondria directly within the user's web Browse environment. A core principle of CalmBrowse's design is its commitment to user privacy, ensuring that no personal health data is collected or transmitted externally. By extracting and analyzing page content client-side and utilizing an LLM solely for generating context-aware, non-diagnostic feedback, we have engineered a system capable of providing support precisely at the moment and location where health anxiety is triggered online. We have detailed our technical engineering approach, the implementation of crucial safety guard-rails, and the rationale underpinning our intervention design, which is firmly rooted in principles from Cognitive Behavioral Therapy and mindfulness. While acknowledging the significant limitation of not conducting user studies within the project's initial scope, we have successfully laid the essential groundwork for future empirical evaluation. By open-sourcing the CalmBrowse code and publishing the details of our prompt engineering strategy, we aim to contribute to the nascent field of LLM-powered digital mental health interventions, catalyze rigorous future research trials, and ultimately foster safer, less anxiety-provoking online health-information consumption for individuals vulnerable to cyberchondria. CalmBrowse represents a promising step towards making psychological support more accessible and integrated into the digital contexts of daily life.

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