

Mining Social Media for Barriers to Opioid Recovery with LLMs

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Abstract

Opioid abuse and addiction remain a major public health challenge in the US. At a broad level, barriers to recovery often take the form of individual, social, and structural issues. However, it is crucial to know the specific barriers patients face to help design better treatment interventions and healthcare policies. Researchers typically discover barriers through focus groups and surveys. While scientists can exercise better control over these strategies, such methods are both expensive and time consuming, needing repeated studies across time as new barriers emerge. We believe, this traditional approach can be complemented by automatically mining social media to determine high-level trends in both well-known and emerging barriers. In this paper, we report on such an effort by mining messages from the *r/OpiatesRecovery* subreddit to extract, classify, and examine barriers to opioid recovery, with special attention to the COVID-19 pandemic’s impact. Our methods involve multi-stage prompting to arrive at barriers from each post and map them to existing barriers or identify new ones. The new barriers are refined into coherent categories using embedding-based similarity measures and hierarchical clustering. Temporal analysis shows that some stigma-related barriers declined (relative to pre-pandemic), whereas systemic obstacles—such as treatment discontinuity and exclusionary practices—rose significantly during the pandemic. Our method is general enough to be applied to barrier extraction for other substance abuse scenarios (e.g., alcohol or stimulants).

1 Introduction

The opioid epidemic in the United States has persisted for over two decades, with opioid-related fatalities surging despite concerted public health interventions (National Institute on Drug Abuse, 2024). Individuals struggling to recover from opioid abuse or addiction often encounter powerful

personal, social, and structural barriers such as traumatic life events, shame, or limited access to treatments that severely hinder the recovery process (Smith et al., 2021). As substance abuse is a multifaceted disease involving physiological, behavioral, and psychosocial factors, barriers to recovery are not always simple or obvious and may vary across different groups of people. However, it is critical to discover and document these barriers to tailor treatments and targeted interventions. This has been typically explored through qualitative methods like focus groups, surveys, and in-depth interviews. While these approaches yield valuable insights, they are also labor-intensive, rely on self-reported experiences in *controlled* settings, and cannot easily capture the evolution of new recovery challenges (without repeating studies).

Meanwhile, online communities have emerged as vital platforms where individuals can share their challenges, successes, and strategies for overcoming addiction. Due to the perceived anonymity, users also tend to express more freely compared to disclosing to a provider during face-to-face interactions. One such community is the subreddit *r/OpiatesRecovery* with over 50,000 members who share their struggles, successes, and motivations (Reddit, 2024). This user-generated content provides a dynamic lens into the nuances of opioid recovery, offering spontaneous, evolving narratives that traditional methods may miss. Yet, given the sheer volume of data generated daily, identifying specific barriers can be daunting without automated support. Our effort addresses this gap by extracting and temporally analyzing barriers to recovery as expressed by members of *r/OpiatesRecovery*. By focusing on posts from 2018 to 2021, we aim to capture how these barriers *changed* during the COVID-19 pandemic relative to pre-pandemic times. Here changes include how well-known barriers became more or less prominent across time and the emergence of any new barriers.

Before we proceed, for the purposes of this study, we define a “barrier” as any personal (e.g., stress from a recent breakup), social (e.g. shame), or structural (e.g., limited access to treatment) circumstance of a patient’s life that impedes their recovery from opioid addiction. A barrier is often expressed as a phrase, a sentence, or a short blurb that succinctly expresses the specific circumstance. Different users can express the same barrier in different ways. Unlike for entities such as diseases, medications, or side effects, there are no established terminologies or canonical definitions of barriers to recovery from substance abuse. This complicates (a). aggregation of barrier expressions that essentially mean the same thing and (b). characterization of what constitutes a new barrier. As such, barrier analysis poses interesting challenges to NLP methods (which typically handle categories with clear semantic distinctions using ample supervision signal from training data.) We believe these kinds of tasks are not uncommon in healthcare, where so called coding “instruments” are typically used to conduct qualitative research that can be subsequently interpreted through a quantitative lens.

Large language models (LLMs), based on the transformer decoder component, offer a new affordance with regard to the challenge posed in the previous paragraph. We use the GPT-4 LLM (specifically, GPT-4-1106-preview) in a semi-automatic setup to extract barriers, map them to predefined barriers from prior literature, identify new barriers, and quantify temporal barrier prevalence variations. Our contributions are as follows:

- We conduct a literature review to curate barriers to opioid recovery focusing on papers that report on conventional approaches such as a focus-groups and surveys. We extract a set of 21 barriers from this purely manual process.
- We use a multi-stage prompting approach with GPT-4 to extract barrier expressions from r/OpiatesRecovery messages from 2018 to 2021. Using Open AI embeddings (specifically, text-embedding-3-large) of these expressions we map them to the 21 literature-derived barriers identified in the previous step, if there is *sufficient* semantic similarity.
- The remaining barrier expressions (unmapped from previous step) are consolidated into a new coherent set of *emerging barriers* through agglomerative hierarchical clustering of their Open AI embeddings.

- We examine normalized shifts in prevalence of both literature-derived and emerging barriers in the periods before and after the pandemic declaration (March 11, 2020) from the 2018–2021 r/OpiatesRecovery messages.

Our approach is general enough to be applied for other substances and we provide concrete findings on emerging barriers and temporal trends. The code corresponding to our full barrier extraction and clustering pipeline is available here: https://github.com/bionlproc/opioid_recovery_barriers

2 Related Work

1. Prior work on barriers: Identifying barriers to recovery from opioid abuse has been extensively studied through conventional approaches, revealing a range of challenges including social stigma, lack of support networks, limited access to treatment, and economic hardships. Comorbid mental health disorders (e.g., depression and anxiety) further complicate recovery, highlighting the need for integrated treatment approaches (Cernasev et al., 2021; Dickson-Gomez et al., 2024).

2. Social media, Reddit, and substance abuse efforts: Social media platforms, particularly Reddit, have become valuable resources for researching substance (ab)use and addiction (Pandrekar et al., 2018; Kavuluru et al., 2019; Tran and Kavuluru, 2020). Our team has recently participated in the shared task on identifying clinical and social impacts of non-medical drug use in Reddit posts (Obeidat et al., 2024). Subreddit r/OpiatesRecovery, with its active community, offers insights into personal struggles and coping strategies that traditional methods may miss (Lu et al., 2019; Boettcher, 2021). NLP techniques are used to identify themes in recovery narratives, analyze sentiment trends, and classify behavioral shifts in substance use discussions (Sarker et al., 2022; Yang et al., 2023; Lu et al., 2019).

Recent studies have explored NLP-driven approaches to analyzing opioid-related discussions on social media. Bremer et al. (2023) applied NLP techniques to detect Reddit posts discussing barriers to opioid use disorder (OUD) treatment. Their effort is the closest to ours in terms of the main themes explored; however, their focus is more on barriers to seeking medical treatment for OUD and relies on manual analysis following an initial NLP-driven post identification. Our study broader in

scope (general barriers to recovery process) and introduces a semi-automated approach that uses LLMs to extract, categorize, and track the evolution of opioid recovery barriers over time. Unlike previous studies that primarily used NLP techniques for retrieving relevant discussions, our methodology automates key components of the analysis. This enables large-scale analysis of recovery barriers with minimal manual intervention. Yang et al. (2024) focused on self-disclosures of opioid use on Reddit, developing a classification system to distinguish different phases of substance use, such as medical use, misuse, addiction, and recovery. Additionally, Nasrallah et al. (2020) introduced a social media text mining framework for opioid-related discussions, leveraging ontology-based keyword searches and topic modeling to detect broader trends in drug abuse discourse on Twitter.

3. *Opioid epidemic during the pandemic:* The COVID-19 pandemic intensified challenges for individuals struggling with opioid recovery by disrupting healthcare services and support systems. Studies show increased isolation, reduced access to treatment, and higher stress levels during the pandemic, leading to higher relapse rates (Mellis et al., 2021; Melamed et al., 2022). The shift to telehealth introduced technological barriers and reduced personal interactions, further complicating effective treatment (Oesterle et al., 2020).

Our effort is at the intersection of the above three themes. Traditional studies offer foundational knowledge, while mining social media with NLP methods helps capture fine-grained challenges. Additionally, examining the impact of COVID-19 adds a temporal dimension, illustrating how external crises can alter the recovery landscape.

3 Methodology

3.1 Data collection

Reddit data: Posts were collected from r/OpiatesRecovery using *Academic Torrents*, a platform for sharing large datasets (Watchful, 2023). The extraction covered posts made between January 1, 2018, and December 31, 2021, a timeframe selected to capture opioid recovery barriers both before and during the COVID-19 pandemic. Initially, 25,552 posts from 8,594 unique users were extracted. However, due to their minimal content, posts with fewer than 50 words were excluded, resulting in a final dataset of 14,735 posts from 7,202 unique users.

Literature derived barriers: To identify well-known barriers to opioid recovery, a literature search was conducted using Google Scholar with the keywords “opioid use,” “barriers,” and “recovery.” The primary sources include multiple systematic reviews (between 2013–2024 (Notley et al., 2013; Grella et al., 2020; Barnett et al., 2021; Cernasev et al., 2021; Choi et al., 2022; Farhoudian et al., 2022; Hutchison et al., 2023; Dickson-Gomez et al., 2024)), which provided comprehensive insights into individual, social, and structural impediments to sustained opioid use disorder treatment. A few additional studies were incorporated to ensure a broad representation of barriers. Identified barriers were reviewed, categorized, and consolidated to eliminate redundancy, resulting in a final list of 21 distinct literature-derived barriers (LDBs) by merging conceptually similar factors and coming up with corresponding brief blurbs capturing their essence; since this was done manually, these blurbs were used as canonical ways of describing the LDBs.

3.2 Barrier expression extraction

A first task in mining Reddit posts for barriers is to ensure first person disclosures that are not vague. Thus, the following guidelines were established:

- The user is discussing their own experiences and not those of others.
- The barrier is explicitly mentioned by the user or strongly indicated as causing or contributing to the risk of relapse.

To evaluate multiple LLM prompting strategies, we selected a set of 100 posts with careful consideration to capture a diverse sample. This selection included posts that adhered to the guidelines — containing explicit mentions of self-reported barriers — as well as posts that did not meet the guidelines. In addition, the sample was curated to include posts of varying lengths, ranging from short entries to longer, more detailed narratives, thereby ensuring that the prompts were tested against a broad spectrum of user inputs. These posts were manually annotated with gold standard barriers or a “no barriers found” label, as appropriate. The evaluation was conducted on a per-post basis, with precision and recall metrics calculated individually for each post. Subsequently, average precision and recall across all 100 posts were computed to assess overall performance. Here it is important to note that by “gold standard” we mean annotator crafted sen-

tences in English that capture the barrier without any reference terminology.

Multiple prompt-engineering strategies were compared to identify which would most reliably capture personal struggles and relapse triggers mentioned in *r/OpiatesRecovery*. Specifically, we tested zero-shot, in-context learning (ICL), and chain-of-thought (CoT) prompting using OpenAI’s GPT-4-1106-preview model. Although both CoT and ICL outperformed zero-shot prompting, they still missed some barriers and occasionally extracted irrelevant information or failed to consistently adhere to the established guidelines. Additionally, ICL required carefully selected examples and proved unsuitable for longer Reddit posts due to high token usage and associated costs. To address these limitations, we developed a multi-step pipeline that incorporates a verification mechanism to ensure adherence to guidelines and refine the output. This process consists of three consecutive prompts (details in Table 6 of Appendix):

1. *Initial extraction*: A straightforward CoT prompt was used to direct GPT-4 to extract barriers based on the same guidelines that were used for manual extraction from the random sample —namely that the user must be describing their own experiences, and any mentioned barrier must be explicitly linked to causing or contributing to relapse.
2. *Verification*: The second prompt combined the first prompt, the model’s initial response, and an additional verification query. This step double checks that each extracted barrier indeed matches the criteria of being a personal challenge mentioned by the user.
3. *Finalization*: A final prompt was used to filter out irrelevant explanations and generate a concise list of barriers. This step is expected to maintain sufficient descriptive detail for each barrier while removing duplicates.

3.3 Mapping extractions to LDBs

To measure the relative prevalence of literature-derived barriers (LDBs) in social media, it is important to map the extracted Reddit barriers to them. For this, we compared Reddit barriers against the 21 LDBs (Table 4 in Appendix A).

First, both the Reddit-extracted barriers and the 21 LDBs were transformed into high-dimensional embeddings using OpenAI’s

text-embedding-3-large model. Next, pairwise cosine similarity scores were calculated to assess how closely each Reddit-derived barrier aligned semantically with a known LDB. Barriers exceeding a predetermined cosine similarity threshold were mapped to the most similar LDB, while those with lower similarity scores (across all LDBs) were labeled as “new”. This threshold value was set following manual evaluations of mapping outcomes, ensuring that barriers were only associated with an LDB when their semantic similarity and contextual relevance were high.

3.4 Clustering of new barriers

Barriers that don’t map to any LDB are considered “new”, though they may have some overlap with them. The challenge is to make sense of what these new barriers are conveying, given they are simply a bunch of sentences and there is no semantic anchoring to them. Our high level strategy here is to employ a clustering approach that groups similar barriers and surfaces semantically coherent “emerging” barriers represented by each cluster. Before clustering, all barriers are vectorized using Open AI’s text-embedding-3-large model, which produces 3072-dimensional vectors (OpenAI, 2024).

3.4.1 Initial clustering of new barriers

Multiple clustering strategies were explored to group newly identified barriers, including k -means and agglomerative clustering with both Euclidean and cosine distances. k -means proved inadequate for effectively capturing the nuanced, overlapping nature of opioid-related barriers, while agglomerative clustering with Euclidean distance similarly struggled to partition the data cohesively. Consequently, we employed the AgglomerativeClustering algorithm from scikit-learn (Müllner, 2011) using cosine similarity, which treats each barrier as its own cluster and iteratively merges the most similar clusters until a predefined threshold is met. Because barriers are multifaceted and difficult to compartmentalize, hierarchical clustering offered the advantage of a dendrogram structure of clusters, accommodating an adaptive stopping criterion driven by the data. This approach consolidated repetitive or semantically related barriers into more coherent groups while providing flexibility in determining the optimal number of clusters.

3.4.2 Secondary clustering of new barriers

Due to the nuanced nature of barrier expressions, the initial clustering resulted in a large number of small closely related clusters, creating challenges for direct interpretation. To refine these results into more semantically distinct categories, a second round of clustering was conducted using key phrases as anchors that guide the clustering, inspired by [Viswanathan et al. \(2024\)](#). To this end, for each initial cluster, GPT-4 was prompted to generate two to three concise key phrases capturing the group’s core semantic themes. These key phrases were then leveraged to guide the secondary clustering, ensuring that similar clusters—those sharing conceptual or topical grounding—could be merged more effectively. The key phrase generation prompt also incorporated a classification step, separating genuine barrier clusters from non-barrier phrases (e.g., “Finalized list of barriers to recovery:” or “Identified barriers:”). Clusters identified as “not a barrier” were excluded from further analysis, ensuring the final dataset focused solely on substantial opioid-related challenges.

To enhance clustering accuracy in this refinement stage, two embeddings were combined: the barrier text embedding (weighted by α) and the key phrase embedding (weighted by $1 - \alpha$). Applying the linkage function from the `scipy.cluster.hierarchy` library ([Müllner, 2011](#)), a full hierarchical structure was then constructed, enabling dynamic exploration of relationships among clusters. Adjusting α allowed for a balanced influence between the original barrier content and the generated key phrases.

Getting to high quality clusters is still not enough because these clusters could still have dozens of barrier expressions with no overarching description what this cluster is expected to represent. At this stage, we used GPT-4 to produce descriptive labels for each refined cluster, resulting in a concise thematic summary. These descriptors aided in interpreting the diverse range of new opioid recovery challenges that had not previously been documented in the literature. We term these as “emerging” since they appear more specialized and do not have the higher prevalence of well known LDBs.

3.5 Temporal trends in barriers

The final part of this study examined how extracted barriers evolved over time, with the onset of the COVID-19 pandemic as the index date. Reddit data

was divided into two segments: (1). Pre-pandemic (January 1, 2018–March 11, 2020): before the WHO’s official declaration of COVID-19 as a pandemic. (2). Pandemic portion (March 12, 2020–December 31, 2021): After the global crisis was formally recognized. To examine shifts in opioid recovery challenges between the pre-pandemic and pandemic periods, we tracked the normalized frequency of each barrier in both segments. The idea was to examine which barriers remained stable and which either intensified or diminished during the pandemic. We applied this to both LDBs and emerging barriers.

4 Results

4.1 Literature-derived barrier curation

As discussed in Section 3.1, we did a review of scientific literature to identify barriers that were already identified using traditional means. Table 4 (in the Appendix) presents details of the 21 LDBs where the first column indicate the barrier ID. These barriers encompass a variety of psychological, social, and systemic challenges that individuals face during opioid recovery. Several well-known barriers are discussed in the literature including fear of dealing with anxiety and stigma, co-morbid physical health issues, housing instability, negative attitudes about treatment, fear of incarceration, and ineffective services and exclusionary attitudes. Our goal in curating this list was to see if we can demonstrate the emergence of new barriers that may not have already been well known.

4.2 Reddit barrier extraction

As discussed in Section 3.2, we evaluated multiple prompting strategies for barrier extraction using the curated set of 100 posts with results shown in Table 1. Notably, the chain-of-thought with verification (CoT + Verification) strategy demonstrated superior performance, achieving the highest precision (95.14%) and recall (94.24%) scores among all methods. This enhanced performance underscores the benefit of incorporating verification into the CoT framework.

Following the evaluation, CoT with verification prompting strategy was run on all posts. Out of the 14,735 posts analyzed, 9,618 posts ($\approx 65.3\%$) contained barriers that aligned with the extraction guidelines. That is, they explicitly discussed authors’ own recovery experiences and identified challenges contributing to relapse or hindering re-

Prompt strategy	Precision (%)	Recall (%)
Zero Shot	88.91	88.41
CoT	92.32	90.52
ICL	89.01	88.21
CoT + Verification	95.14	94.24

Table 1: Precision and recall for different prompting strategies averaged over 100 posts.

covery. From all qualifying posts, a total of 29,641 potential barriers were identified.

4.3 Classification of barriers — LDB or new

The classification process mapped 17,603 extracted Reddit barriers (59.3% of the total) to LDBs, confirming a strong alignment between user-generated content and established research. In contrast, 12,038 barriers (40.7%) were deemed novel, potentially highlighting emerging challenges, particularly during the COVID-19 pandemic. The classification threshold was set to 0.55, based on manual evaluation to ensure that mapped barriers exhibited sufficient semantic similarity to LDBs, while allowing room for identifying distinct, novel expressions of recovery challenges.

4.4 Clustering of new barriers

The clustering quality was assessed using the silhouette score, a metric that quantifies how similar an object is to its own cluster relative to other clusters (Pavlopoulos et al., 2024). In simple terms, it measures the cohesion within clusters and the separation between clusters, with values ranges from -1 to 1 (higher values indicating better-defined and more coherent clusters).

Clustering method	Sil. score	# clusters
<i>k</i> -means	0.028	1,310
Agglomerative (Euclidean)	0.037	962
Agglomerative (cosine)	0.071	1,369
+ Secondary clustering	0.181	354

Table 2: Performance of clustering methods for new barriers (Sil. score is the silhouette score achieved)

Among the clustering methods evaluated, agglomerative clustering with cosine similarity achieved the highest silhouette score of 0.071, compared to scores of 0.028 for *k*-means and 0.037 for agglomerative clustering using Euclidean distance. Although the score may initially seem low, it is not necessarily a definitive indicator of poor clus-

tering quality. Given the high dimensionality of the embeddings, achieving high scores is challenging due to the “curse of dimensionality,” where cosine distances between points become less distinguishable. Recent research on text clustering with LLM embeddings further shows that silhouette scores can be misleading when working with high-dimensional text representations (Petukhova et al., 2024). Moreover, the inherent complexity and semantic nuances of barrier texts further contribute to lower absolute silhouette values. Based on the results summarized in Table 2, agglomerative clustering with cosine similarity was picked for clustering the new barriers.

The secondary clustering process (from Section 3.4.2) substantially reduced the number of barrier clusters from 1,369 to 354 by incorporating key phrases generated via GPT-4. By optimizing the balance between barrier descriptions and key phrase themes (with a barrier text embedding weight of $\alpha = 0.3$ and a key phrase embedding weight of $(1 - \alpha)$), it consolidated similar clusters while maintaining semantic coherence; this resulted in a much better silhouette score (last row of Table 2). Additionally, clusters containing fewer than 10 elements were merged into a single cluster, as these small clusters likely represent barriers experienced by few individuals and would unnecessarily muddle the analysis. This refinement resulted in 185 final clusters, whose descriptors were generated with GPT-4 to provide a concise summary of the barriers they represent. Some illustrative examples are presented in Table 5 of the Appendix. This process enhanced both the manageability and interpretability of the thematic structure underlying new barriers.

Notable emerging barriers include (1). Kratom, a popular plant derived substance that is generally used to handle opioid cravings, was reported as also causing stomach issues and hence this alternative’s side effects disrupted the recovery for those who relied on it. (2). Isolation due to work-from-home requirements during the pandemic lead to lack of social engagement depriving individuals of essential support networks. (3). Disruption of group support sessions where peers motivate and help each other cope with opioid dependence emerged as a pandemic era barrier that highlights how public health crises indirectly affect substance use recovery.

4.5 Temporal shifts in barrier prevalence

Table 3: Temporal shifts in LDB prevalence in Reddit data with counts of posts containing a barrier in the pre-covid data and covid data along with absolute count difference and percentage change normalized by total posts in each period

ID	# Pre-covid	# Covid	# Diff	% Change
0	609	527	-82	-11.06%
1	1,820	1,708	-112	-3.55%
2	189	152	-37	-17.34%
3	187	199	12	9.37%
4	12	20	8	71.29%
5	212	221	9	7.14%
6	568	509	-59	-7.90%
7	47	36	-11	-21.28%
8	380	321	-59	-13.18%
9	168	116	-52	-29.04%
10	520	462	-58	-8.69%
11	347	329	-18	-2.56%
12	491	479	-12	-0.26%
13	139	143	4	5.73%
14	197	121	-76	-36.87%
15	10	18	8	84.997%
16	9	20	11	128.39%
17	162	129	-33	-18.16%
18	186	170	-16	-6.06%
19	200	190	-10	-2.36%
20	2,469	2,811	342	17.01%

4.5.1 Temporal shifts of LDBs

Table 3 summarizes the temporal changes in the matched barriers with the first column corresponding to the ID field of Table 4. We emphasize all shifts discussed in this section are relative to the pre-pandemic period (before March 11, 2020). The analysis revealed nontrivial decreases in prevalence of certain LDBs. Notably, *identity difficulties* (ID 14) experienced the biggest decline of 36.87%. *Secrecy or fear about the past in new interpersonal relationships* (ID 9) declined by 29.04%. *Overreliance on other patients or treatment staff* (ID 7) decreased by 21.28%. *Fear of stigma* (ID 2) dropped by 17.34%, suggesting a potential reduction in internalized shame and an increased willingness to seek treatment. Conversely, certain barriers exhibited notable increases. The biggest increase was seen in the *lack of connection between emergency care and professional medical treatment* (ID

16), which soared by 128.39%, pointing to gaps in care continuity. Similarly, the *poor staff attitudes and training deficiencies* (ID 15) rose by 84.997%, pointing to potentially overwhelmed healthcare personnel and hurried onboarding of new staff without sufficient training, during the pandemic. Additionally, *unsuitable or ineffective services, along with exclusionary attitudes, policies, and programs* (ID 4), surged by 71.29%, indicating difficulties in accessing apt supportive treatment services. (Since the total absolute counts for IDs 4, 15, and 16 are each around thirty, the percent increases ought to be treated with a grain of salt.)

4.5.2 Temporal shifts of emerging barriers

After the WHO pandemic declaration, our results show that the prevalence of several emerging barriers rose substantially. Particularly, those related to *pandemic-induced isolation* and *reduced professional support*, soared over 500% and were closely tied to heightened anxiety, depression, and increased relapse vulnerability. Others, increasing by more than 300% dealt with the *loss of critical recovery resources*, including the closure of support groups and cancellations of outpatient treatments, which destabilized individuals' established sobriety-supportive routines. A modest uptick of 30% was seen in *serious sleep-related struggles*, such as insomnia and reliance on potentially addictive sleep aids, each contributing to a greater risk of relapse. These shifts highlight how the pandemic environment magnified existing vulnerabilities across multiple facets of recovery.

In contrast, some categories of novel challenges saw notable declines. One set of barriers, previously rooted in *resistance toward traditional 12-step or group-based treatment models*, dropped by over 60%, suggesting a diminished emphasis on philosophical or logistical objections to these support systems. Another emerging barrier involved a complex interplay of psychological, environmental, and social triggers complicating recovery. Exposure to drug-related content in media, music, and social interactions, as well as environmental cues such as specific locations or objects linked to past use can evoke powerful emotional responses and conditioned urges to relapse. Individuals face both subtle cues, like nostalgic music and overt triggers, such as drug paraphernalia or messages from dealers, create a constant battle against cravings and the risk of relapse. Discussions around this decreased by 45.28%, suggesting that while the

challenge remains, it became less prominent in recovery narratives during the pandemic. Although these declines do not necessarily indicate that the issues were resolved, they do suggest a shift in the relative prominence of longstanding emotional, behavioral, and logistical hurdles to recovery. In other words, certain difficulties, while still present, became less frequently discussed.

5 Discussion

By harnessing opioid consumer posts on r/OpiatesRecovery, our findings show how emerging challenges such as disrupted treatment pathways and heightened isolation may aggravate well-known barriers like stigma, financial hardship, and limited healthcare access. In doing so, our approach addresses a gap in the literature, where the complexity and rapid evolution of barriers may often go underreported. Case in point, the high proportion of newly identified barrier expressions emphasizes the importance of mining social media data to complement and extend established knowledge. While this study confirms many classic themes in opioid recovery such as stigma and mental health comorbidities, it also highlights how online forums can shed light on previously unrecognized or insufficiently explored obstacles. The classification (LDB vs new) and clustering of new barriers, even if challenged by the inherent nuance and overlap in user narratives, offers a more agile perspective on how recovery challenges change over time. In the wake of the pandemic, the intensification of systemic barriers from strained healthcare systems to diminished access to essential services emerged as a powerful illustration of why adaptive solutions are critical.

Temporal comparisons before and after the WHO pandemic declaration underscore COVID-19's impact on recovery trajectories. Personal/social barriers, such as stigma and identity conflicts, appeared to ease—possibly reflecting the supportive role of online communities—while systemic obstacles like limited access to treatment, financial pressures, and housing insecurities intensified, reflecting the strain on healthcare resources during the pandemic. Additionally, emerging challenges such as increased isolation, disrupted treatment pathways, and sleep disturbances illustrate the multifaceted struggles faced by individuals in recovery. The persistence of entrenched relapse cycles and insufficient social support underscores

the necessity for flexible, integrative strategies that address both immediate and structural issues.

Some of the new barriers indicated by Redditors have a grounding in COVID-19 literature. For instance, among the emergent challenges, altered sleep patterns have been noted as a barrier. Recent research by [Donzella et al. \(2022\)](#) found that COVID-19 infection significantly disrupted sleep patterns, with infected individuals experiencing longer sleep durations and increased trouble sleeping compared to non-infected individuals. This finding suggests that the sleep disturbances observed in our analysis may reflect both a general pandemic-related phenomenon and a specific consequence of COVID-19 infection.

To conclude, our effort is a proof of concept to conduct qualitative research aided by LLMs, with human steering. With appropriate recalibration to account for domain-specific language and contexts, the same method can be applied to other substance use disorders, such as alcohol or stimulant abuse, to uncover relevant barriers within other parallel online communities. Future work will address better streamlining of all the steps in the pipeline (LDB curation, barrier extraction, matching, and clustering) with recent advances. For example the “Deep Research” versions of Google Gemini and Open AI o3 models could reduce most of the manual work done in LDB curation. Dynamic topic models ([Zhang and Lauw, 2022](#)) applied to GPT-4 barrier extractions can also help with clustering by considering topic distribution as an additional feature during the clustering process.

6 Limitations

Despite promising insights, our work also exposes limitations of applying recent advances in NLP to consumer text analysis. Although a multi-step verification process improved classification precision and recall, subtle linguistic nuances and context-dependent barriers may still be misclassified or overlooked. Our approach needs careful human intervention at multiple steps in the pipeline and is not fully automated. For example, there was a need to at least generate a few human annotations of barriers from messages to assess different prompting strategies. Next, prompt engineering also needs major human inputs to instruct LLMs to generate barrier expressions that are not too short but also not too long and meandering. Checking different prompt outputs against human annotations (needed

to create Table 1) is also manual because unlike traditional classification methods where ground truth class labels can be simply matched against model predictions, here one needs to check if GPT-4 extracted barriers “capture” the essence of what human annotators generated. Next, the appropriate cosine similarity threshold to match GPT-4 extractions to LDBs is also manually determined based on observations on a few samples. During clustering of new barriers, which in our opinion was the hardest part of this project, choosing a strategy along with any hyper-parameters (e.g., α in Section 3.4.2) also needs to be done by manually examining the quality of the clusters — to make sure they are thematically coherent but are not overly specific resulting in singleton clusters. While LLMs proved to be powerful in generative aspects of this project, they still need nontrivial steering effort by humans.

Self-reported data from Reddit carry intrinsic caveats, including possible exaggeration, underreporting, or skewed user demographics. The relatively low silhouette score in clustering, for instance, partly reflects the difficulty of discretely segmenting highly interrelated challenges (e.g., mental health issues intertwined with social isolation and financial strain). Nonetheless, the hybrid process of validation, merging quantitative metrics with careful prompt engineering, provides reassurance that the majority of extracted barriers are meaningful, although not without room for further refinement.

Acknowledgement

This work is supported by the U.S. NIH National Institute on Drug Abuse through grant R01DA057686. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

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A Appendix

Table 4: List of manually curated literature-derived barriers

lit_barrier id	Barrier	Description
0	Low self-confidence and negative self-perception	A deeply ingrained negative self-image can significantly increase the risk of relapse by fostering feelings of worthlessness, making it difficult to build healthy relationships, and deterring individuals from seeking help. This negative self-perception also contributes to poor self-care and reinforces internalized stigma, making the recovery process more challenging.
1	Fear of dealing with emotions and anxiety	Opioids often mask underlying emotional issues and boost self-esteem, creating a fear of confronting raw emotions without the crutch of drugs. This fear makes it difficult for individuals to manage overwhelming feelings of anxiety, worry, and stress, which can hinder the recovery process and increase vulnerability to relapse.
2	Fear of stigma	Stigma related to aging, past drug use, mental health issues, poverty, and methadone treatment profoundly affects self-identity and recovery. The internalization of these stigmas can lead to shame, social withdrawal, and a reluctance to seek or continue treatment, further complicating the recovery journey.
3	Negative attitudes or beliefs about treatment	Stigmatizing beliefs about medication-assisted treatment (MAT) and the uncertainties surrounding treatment options can prevent individuals from seeking help. Misinformation, fear of judgment, and negative perceptions of treatment can lead to resistance or disengagement from the recovery process.
4	Unsuitable/ineffective services and exclusionary attitudes, policies, and programs	Inadequate or rigid treatment services, particularly for those with co-occurring mental health conditions, fail to meet the specific needs of individuals. Exclusionary policies, such as restrictive program hours, lack of language services, and daily attendance requirements, further alienate those seeking help, limiting their access to effective treatment.
5	Housing instability and homelessness	A lack of stable housing creates an unpredictable and stressful environment that disrupts recovery efforts. Without a secure place to live, access to treatment is often compromised, and the constant exposure to triggers increases the risk of relapse.
6	Difficulties with establishing a non-drug-using network of friends and lack of social capital or support	Building new, supportive social networks that do not involve drug use is a significant challenge. The absence of compassionate and understanding relationships, particularly with family members, can lead to isolation and a lack of the social support necessary for successful recovery.
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lit_barrier id	Barrier	Description
7	Over-reliance on other patients or treatment staff in treatment facilities	In treatment centers, individuals may become overly dependent on other patients and staff, creating a sense of being caught between two worlds. This reliance can hinder the development of personal autonomy and coping skills essential for long-term recovery.
8	Influence of habits of spouse/partner/family members/peers to drugs	The drug use habits of close family members, partners, or friends can increase the availability and temptation of drugs, making it harder for individuals to maintain sobriety. This close proximity to drug use can be a significant trigger for relapse.
9	Secrecy or fear about the past in new interpersonal relations	The inability to share past experiences with new acquaintances can lead to feelings of isolation and exile from mainstream society. This secrecy can create barriers to forming genuine, supportive relationships, which are crucial for recovery.
10	Fear of incarceration	For some individuals, particularly women who fear losing custody of their children, the threat of incarceration is a significant barrier. The criminalization of drug use, fear of police harassment, and the risk of arrest discourage seeking help, leading to untreated addiction and increased relapse risk.
11	Co-morbid mental and physical health issues	The presence of additional addictions or physical and mental health conditions, such as anxiety, depression, self-loathing, childhood trauma, or physical illnesses, complicates the recovery process. These co-occurring issues require specialized treatment, and when unaddressed, they can significantly hinder recovery.
12	Expensive costs and financial problems	The high costs of treatment, particularly for those without insurance, can prevent individuals from accessing necessary care. Financial barriers, including the inability to afford medication and out-of-pocket costs, are significant obstacles to sustained recovery.
13	Issues in accessing treatment	Accessing treatment is particularly challenging for individuals from culturally and linguistically diverse communities or those in rural areas. Geographical barriers, lack of transportation, and limited availability of medication-assisted treatment (MAT) create significant obstacles to regular and consistent treatment.
14	Identity difficulties	Some individuals struggle with the identity transformation required by treatment programs, resisting the label of “patient” and finding it difficult to construct a new identity free from drug use. This identity conflict can create resistance to treatment and complicate the recovery process.

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lit_barrier id	Barrier	Description
15	Staff attitudes and training deficiencies	Judgmental attitudes from treatment providers and staff who lack empathy and understanding can create an unwelcoming environment for patients. When staff view clients as psychologically impaired or needing long-term maintenance without offering hope for recovery, it can discourage individuals from engaging fully in treatment.
16	Lack of connection between emergency care and professional medical treatment	A disconnect between emergency care services and ongoing professional medical treatment can lead to gaps in care. This lack of continuity can result in missed opportunities for intervention and support, increasing the risk of relapse.
17	Lack of adherence to treatment protocol	Managing multiple appointments and responsibilities, especially for mothers, can be overwhelming and lead to non-adherence to treatment protocols. The stress of balancing treatment with daily life can make it difficult to stay committed to recovery.
18	Misuse of prescribed medications	Some individuals misuse their prescribed medications by taking higher doses than recommended or combining them with illicit substances. This misuse can undermine the effectiveness of treatment and increase the risk of relapse.
19	Belief that treatment was unnecessary	Some individuals prefer to withdraw from opioids alone, without assistance, believing that treatment is unnecessary. This belief can lead to unsuccessful attempts at recovery and a higher likelihood of relapse.
20	Fear of withdrawal symptoms	The physical and psychological symptoms of withdrawal, such as nausea, vomiting, diarrhea, muscle aches, sweating, chills, fever, anxiety, depression, and intense cravings, can be overwhelming. The fear of experiencing these symptoms often discourages individuals from seeking help or continuing with treatment, increasing the risk of relapse.

Table 5: Examples of descriptors for emerging barrier extractions with GPT-4

GPT-4 generated cluster descriptor	Some example barriers in the cluster
<p>The primary themes and challenges in opioid use disorder recovery, as highlighted by the list of barriers, revolve around the adverse reactions to and ineffectiveness of various alternative treatments and medications, including Kratom, benzodiazepines, clonidine, and suboxone. Users face significant obstacles such as physical side effects (nausea, vomiting, stomach issues, and severe sweating), psychological effects (increased anxiety, depression, and suicidal ideation), and specific health concerns (restless leg syndrome, sexual dysfunction, and dental health issues). These are compounded by the medications' unpleasant taste and physical discomfort upon ingestion, leading to non-adherence and relapse. The fear of losing access to necessary medications due to honesty about relapse, as well as the potential for medications to mask or exacerbate other health issues, creates a complex environment where individuals struggle to find tolerable and effective treatment options to manage withdrawal symptoms and support their recovery journey.</p>	<ul style="list-style-type: none"> - Adverse physical reactions to Kratom: The user experiences stomach issues when using Kratom, which could discourage its use and negatively impact their detoxification and recovery process. - Intense cravings triggered by Benadryl: The user has experienced strong cravings for substances following the administration of Benadryl through an IV. - Concerns about the side effects of current anxiety medication (hydroxyzine), such as sleepiness, which may interfere with daily activities and thus pose a barrier to the recovery process.
<p>Individuals in recovery from opioid use disorder are encountering significant barriers due to the ineffectiveness of both prescription and over-the-counter sleep aids, including melatonin, Zopiclone, and Ambien, as well as alternative methods like homeopathic remedies, kava root, and relaxation techniques. This pervasive lack of effective sleep solutions exacerbates insomnia, which not only impedes their recovery process but also poses a risk of relapse as they struggle to manage sleep disturbances without resorting to opioids. The reluctance of healthcare providers to prescribe certain hypnotics, coupled with the side effects and diminishing returns of available medications, underscores the urgent need for a comprehensive and effective treatment plan to address the critical role of sleep in the recovery journey.</p>	<ul style="list-style-type: none"> - The person is restricted to using only over-the-counter sleeping aids, as they are unable to utilize prescription sleep medications or benzodiazepines to address their sleep disturbances. - Ineffectiveness of homeopathic remedies: The individual has attempted numerous homeopathic remedies to address their sleep issues, but none have been successful. The lack of an effective solution for their sleep disturbances is an additional barrier to their recovery from opioid use disorder. - Limited access to hypnotics, due to the general practitioner's reluctance to prescribe them, is a source of frustration for the user and is seen as a barrier to overcoming insomnia and aiding their recovery.

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GPT-4 generated cluster descriptor	Some example barriers in the cluster
<p>The overarching challenge in opioid use disorder recovery, as reflected by the experiences described, is a pervasive lack of adequate and empathetic medical support across various healthcare settings. Patients frequently encounter barriers such as healthcare professionals prioritizing financial interests over patient care, insufficient understanding and coordination between pain and addiction clinics, and a general sense of isolation due to the healthcare system's failure to provide comprehensive and compassionate support. This lack of support extends to GPs who often dismiss patient concerns, inadequately address mental health needs, and fail to establish trust or offer practical assistance in creating and following effective recovery plans. The resulting environment is one where patients feel unheard, misunderstood, and inadequately treated, which severely undermines their confidence in the healthcare system and impedes their journey towards recovery. Additionally, systemic issues like misinformation, inadequate facilities, and cultural barriers further exacerbate the struggle for individuals seeking help for opioid use disorder, especially in regions with less developed psychiatric support systems.</p>	<ul style="list-style-type: none"> - A lack of proper support and understanding within the healthcare system presented a barrier, as evidenced by the user being passed between the pain clinic and addiction clinic without receiving appropriate care. - Lack of medical support: The user feels that doctors do not take their concerns seriously, indicating a lack of accessible supportive medical care that is essential for managing recovery symptoms. - A history of inadequate support and assistance from hospitals and specialists, resulting in a diminished trust in the healthcare system, as the user has not received answers or help despite multiple consultations.
<p>The primary themes and challenges in opioid use disorder recovery, as reflected by the barriers listed, revolve around the inadequacy of pain management solutions and the limited access to both pharmacological and non-pharmacological alternatives. Individuals struggling with chronic pain find non-opioid medications such as NSAIDs, over-the-counter pain relievers, and alternative therapies like CBD oil or marijuana to be ineffective, leading to a heightened risk of relapse into opioid use for pain relief. Compounding this issue is the reluctance or inability of medical professionals to explore new pain management methods, often leaving patients with unmanaged pain and a sense of desperation. This situation is exacerbated by the lack of access to specialized pain management services, particularly in the context of COVID-19, which has disrupted healthcare delivery and limited options for those seeking to manage pain without opioids. The collective impact of these barriers underscores the need for comprehensive, effective, and accessible pain management strategies as a critical component of opioid use disorder recovery.</p>	<ul style="list-style-type: none"> - The inability to use NSAIDs due to medical contraindications, which restricts the user's alternatives for non-opioid pain relief and presents a challenge in reducing opioid use. - The closure of the Pain Management clinic due to Covid-19 has resulted in the inability to find a new doctor, disrupting the user's medication regimen. - Difficulty in finding a new doctor who can provide non-narcotic pain management solutions, following the dismissal of the previous pain management doctor.

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GPT-4 generated cluster descriptor	Some example barriers in the cluster
<p>The primary themes and challenges in opioid use disorder recovery, as highlighted by the list provided, revolve around the profound impact of social isolation, disruptions to daily routines, and the exacerbating effects of the COVID-19 pandemic. Individuals face a multifaceted struggle where isolation—whether due to weather, unconventional wake-up times, work-from-home structures, or quarantine measures—significantly hampers their ability to connect with support networks and engage in recovery activities. The pandemic has intensified feelings of loneliness, anxiety, and depression, triggering memories of past substance use and increasing the risk of relapse. The lack of professional support and reduced engagement in positive activities further contribute to a sense of hopelessness and loss of purpose. Environmental factors, such as the dark times of lockdowns, and personal factors, such as bipolar disorder and the desire for self-isolation, compound the psychological distress. This complex interplay of isolation, mental health challenges, and pandemic-related constraints creates a formidable barrier to recovery, underscoring the need for robust, adaptive support systems that can reach individuals even in the most isolating circumstances.</p>	<ul style="list-style-type: none"> - Quarantine situation: Users are experiencing isolation and a lack of support due to being stuck in quarantine, which poses a significant challenge to recovery. - Increased isolation and lack of productive activities because of COVID-19 restrictions, leading to intensified cravings, as described by the user who was laid off and forced to stay at home without engaging in meaningful activities. - Work-from-home isolation: The user’s job does not involve much interaction with others, exacerbating their feelings of isolation and potentially depriving them of much-needed social support during recovery.
<p>The COVID-19 pandemic has significantly disrupted the recovery process for individuals with opioid use disorder by imposing barriers that undermine their support systems and daily routines. Emotional distress has been exacerbated by the inability to attend support group meetings and therapy sessions, including AA and NA meetings, which are crucial for mutual support and maintaining sobriety. Lockdown measures have further restricted access to coping activities such as going to the gym, engaging in hobbies, and attending outpatient treatment, all of which are essential components of a structured recovery plan. The loss of these routines and support mechanisms has led to increased isolation, mental hardship, and a heightened risk of relapse, highlighting the profound impact that external factors and disruptions to daily structure can have on the journey to recovery.</p>	<ul style="list-style-type: none"> - The closure of the center where group sessions are held due to the coronavirus pandemic is a barrier because it disrupts the structured recovery support necessary for maintaining sobriety. - The temporary shutdown of support meetings and therapy appointments, including physiotherapy, acupuncture, and cupping, poses a barrier as these services help manage painful side effects from methadone and are integral to the user’s recovery support system. - Loss of access to the gym due to lockdown: The gym served as a critical support system for the user during their withdrawal period, and the inability to attend the gym because of lockdown measures is directly associated with their relapse.

Table 6: The three stage barrier extraction prompts

Prompt type	Prompt
Initial prompt	<p>“You are given a Reddit post. Your task is to extract barriers to recovery from opioid use disorder as explicitly mentioned by the user. Strictly adhere to the following guidelines when extracting the barriers:</p> <ul style="list-style-type: none"> • The user is talking about their own experience and not someone else’s. • The barrier is explicitly mentioned by the user or has strong indications as causing them to relapse or contributing to the risk of relapse. Discard barriers that do not adhere to the above guidelines. • If no barriers are found, mention “No barriers found”. Only use the details provided by the user in the post, without relying on previous knowledge on the subject or making assumptions. • Provide reasons for the selection of the items. • Finally, provide the items as a numbered list as follows: <p>Identified barriers: <barrier 1> <barrier 2> ... Post: {post}”</p>
Verification prompt	<p>“Verify that the user explicitly mentions or has strong indications of the identified items as causing or contributing to relapse or shows strong indications of presenting challenges in maintaining recovery. The user must be talking about their own recovery.”</p>
Finalization prompt	<p>“You are given information about potential barriers to recovery as mentioned by Reddit users in their posts, along with a verified list of barriers. Your task is to extract the finalized list of barriers from the provided text. Ensure each barrier is represented as a numbered list using clear and meaningful sentences that accurately capture the context and details without shortening them excessively. The barriers should be concise yet detailed enough for someone reviewing them later to fully understand what each barrier entails. If no barriers are found, return “No barriers found.”</p> <p>Info on barriers to recovery: {verified_list_of_barriers} List of barriers to recovery:”</p>