Identifying Advice-Seekers for Buprenorphine-Naloxone Use on Reddit via Social Network Characteristics and Medication Use Stage

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Abstract:

Online communities can provide social support for those recovering from opioid use disorder. However, advice-seekers on these platforms risk exposure to uncurated medical advice, potentially harming their health or recovery efforts. To identify advice-seekers on an online platform for buprenorphine-naloxone use, we combined text annotation, social network analysis, and statistical modeling. We collected 5,258 posts and their comments from Reddit between 2014 and 2019. Among 202 posts which met our inclusion criteria, we annotated each post to determine which were advice-seeking (n=137) and not advice-seeking (n=65). We also annotated each posting user’s medication use stage and quantified their connectedness using social network analysis. In order to analyze the relationship between advice-seeking with a user’s social connectivity and medication use stage, we constructed four models which varied in explanatory variables. The stepwise model (containing “total degree” (P=0.002), “using: inducting/tapering” (P<0.001), and “using: other” (P=0.01) as significant explanatory variables) outperformed all other models. We found that users with fewer connections and who are currently using buprenorphine-naloxone are more likely to seek advice than users who are well-connected and no longer using the medication, respectively. Hence, clinicians should be especially attentive (e.g., through frequent follow-up) to patients who are inducting or tapering buprenorphine-naloxone or signal limited social support. Moreover, advice-seeking behavior is most accurately predicted using a combination of network characteristics and buprenorphine-naloxone use status, rather than either factor alone. These findings provide insights for the clinical care of people who use buprenorphine-naloxone and the nature of online medical advice-seeking overall.

Conflict of Interest: The authors declare no conflict of interest.

Introduction

Many people recovering from opioid use disorder (OUD) face institutional barriers to recovery, including insufficient access to OUD treatment due to lack of health insurance and/or resources (e.g., transportation or time). For several reasons (e.g., poor treatment by healthcare professionals in prior care-seeking experiences), mistrust of medical professionals is common among those recovering from OUD [1, 2]. In addition, the stigma around OUD may cause providers to discriminate against those seeking medical treatment, potentially increasing mistrust between medical professionals and people who use opioids (PWUO) [3, 4]. Thus, even those who seek treatment may turn to online communities and social media platforms for the treatment advice and social support that they don’t find from their medical professionals.

Social media platforms such as Twitter, Facebook, and Reddit have fostered communities that provide solidarity and support for people dealing with a multitude of issues such as eating disorder recovery [5], suicidal ideation
[6], chronic illnesses, and OUD [7]. In these communities, users can receive emotional support, information, and companionship while, in some cases, preserving anonymity. For PWUO, in particular, the anonymity of online forums, such as Reddit, has the potential to reduce stigma and social exclusion and can be an important factor for seeking support online [8, 9]. While these communities can provide much-needed support for those recovering from OUD, there is also an abundance of medical advice from non-clinicians (e.g., unverified OUD treatment alternatives [10]). Given the potential benefits and risks of seeking support for OUD online, it is important to identify and characterize which people recovering from OUD are likely to seek advice online. Identifying common characteristics among advice-seekers on these online platforms can also aid clinicians in proactively anticipating and addressing the needs of such PWUO.

Despite the importance of characterizing advice-seekers on online recovery platforms, there is currently limited research on this topic. Research has analyzed these platforms to predict PWUO’s transition to OUD [11], discover alternative treatments for opioid use recovery [10], and determine the prevalence of polydrug use [12]. Other work focuses on the social aspect of OUD recovery such as the social connectedness of online communities. For instance, similar to in-person support groups such as Alcoholics Anonymous and Narcotics Anonymous (AA/NA) [13], community engagement and cohesiveness in an online addiction recovery group is driven by its core of long-standing members [14]. Similarly, in another study using an online health forum for OUD recovery, people on one online health forum for OUD recovery were most engaged with the platform when they were “withdrawing” or “using” [15]. Despite the growing research in this space, little investigation has been done to better understand the connection between how a user’s advice-seeking behavior on an online platform is related to their online social connectedness and OUD buprenorphine-naloxone use stage.

To address this research gap, we identify the characteristics of PWUO who use online platforms for seeking medical advice for OUD recovery. Specifically, we analyze user and social network attributes of a community on Reddit with a focus on discussions related to Suboxone® (i.e., a brand name for buprenorphine-naloxone, and the most commonly discussed brand on Reddit), an effective medication used to support remission from, and prevent relapse to, OUD [16]. We combine text annotation, social network analysis, and statistical analysis to quantify the relationship between advice-seeking, buprenorphine-naloxone use stage, and social connectedness within this niche online community. Our study intends to improve the understanding of those who are most likely to seek OUD buprenorphine-related advice from online platforms.

**Materials and Methods**

**Data Description**

Our data consisted of posts and comments collected from the “r/suboxone” subreddit, i.e., sub-community of Reddit described as “a community for all things buprenorphine.” A labeled snapshot of the r/suboxone homepage and an example post and its comments are shown in Figure S1. We collected data from r/suboxone spanning February 4, 2014 (the inception of this subreddit) to December 31, 2019, excluding content created after January 1, 2020, to mitigate the potential effects of the COVID-19 pandemic on Reddit users’ posting behavior. We used the pushshift.io API [17] to collect URLs from all posts in this time period and used RedditExtractor [18] library in R to extract relevant data (see Table S1) and subsequent comments from each post.

**Exclusion Criteria and Data Sampling**

To extract the most relevant posts for our analysis, we first excluded all empty and deleted posts since no text can be extracted from them, and network characteristics cannot be computed for users with deleted accounts. We then excluded all posts made by authors without one prior post, since users with no prior post-activity would have no connections to other users, resulting in an empty social network. Finally, because we were interested in medical advice-seeking, we narrowed our study sample to posts mentioning specific doctor/provider-related or Suboxone-related keywords (see Table S2), and the comments associated with these posts.
Annotating Advice-seeking Posts and Suboxone Use Stage

With the final study sample, each post was annotated as advice-seeking or non-advice-seeking, in addition to the posting user’s Suboxone use stage. Three bachelor’s level research assistants [MG, EM, JR] and one Ph.D. student [RD] with backgrounds in medical informatics (all supervised by a substance use services researcher with expertise in qualitative coding and analysis [ES]) each annotated an initial 10 posts and collaboratively defined the criteria for the advice-seeking and Suboxone use stage criteria. A post was designated as “advice-seeking” if the user asked a specific question in their post about addiction, Suboxone, or doctor-related issues. For annotating the Suboxone use stage, three categories were considered: using Suboxone, used to be on Suboxone, and cannot discern. A user was annotated as “using Suboxone” if the content of their post indicated they were actively using Suboxone. Users who were identified as “using Suboxone” were further classified as “inducing,” “tapering,” or “other.” The inducting and tapering stages are critical points in the medication for opioid use disorder (MOUD) treatment process [19]. For people who use Suboxone, the inducting and tapering stages are well-known to be critical points in the MOUD treatment process [19]. A user was annotated as “inducting” if they had just begun or were about to begin Suboxone treatment, “tapering” if they were decreasing their dosage of Suboxone with the intention to stop taking Suboxone, and “other” if they were neither inducing nor tapering. For simplicity, we combined inducting and tapering into a single “inducting or tapering” category since both categories comprise transition stages. Users were annotated as “used to be on Suboxone” if they mentioned past use of Suboxone but have since stopped the treatment, or “cannot discern” if they did not give enough details to discern their Suboxone use stage. Uncertainties regarding annotations for specific posts were discussed and deliberated. All annotations were completed in Microsoft Excel.

Measuring Social Connectedness

To characterize social connectedness, we constructed a social network graph for each sampled post based on a timeframe defined by the posting user’s first post or comment on r/suboxone and ended on the date at which they made the sampled post. All posts and comments made outside of this time period were not considered.

To construct each post-defined social network graph, we modeled nodes as unique users and edges as relations between two users. We added a directed edge, i.e., a relation, from user A to user B if either: (1) user A created a post and user B commented on that post, or (2) user A commented on a post and user B replied to that comment. The weight of each edge is equal to the number of relations between the two users on r/suboxone. We illustrate this process in Figure S2.

For each posting user, we computed their life span, total degree, eigencentrality, closeness, authority score, and hub score based on the user’s network at the time they made their post. A user’s lifespan is the total number of days between their first post or comment on r/suboxone and the date at which they authored the sampled post. A user’s total degree is the total number of relations to and from that user. Eigencentrality measures how influential a node is within the network [20]. For example, a user who is connected to many “important” users (i.e., other users with high eigencentrality) will have a relatively high eigencentrality. Closeness is equal to the inverse of the average length of the shortest paths to/from all the other vertices in the graph [21]. In other words, a user who is “close” to all other users in the social network (e.g., through direct connections with all other users or having direct connections with users who have many direct connections to all other users) would have a high closeness score. Finally, a user’s authority score and hub score represent two related centrality measures [22]. In this context, users with high authority scores will tend to receive comments from other users who frequently reply to others’ posts. Likewise, the users who tend to reply to others’ posts will have high hub scores.

Statistical Analysis

We computed the total number of posts and the mean and standard deviation (SD) for all network characteristics and the number and proportions of posts by Suboxone use stage. We then divided our data into advice-seeking and not advice-seeking posts and repeated this analysis. Differences between advice-seeking posts and not advice-seeking posts were analyzed using the Mann-Whitney U test for all numerical study variables and the Pearson’s Chi-squared test for the Suboxone use stage variables. To determine which specific Suboxone use
stage categories were driving significant differences across the entire group, we also conducted a post-hoc Chi-squared analysis on expected residuals [23] using the Benjamini-Hochberg p-value correction for multiple comparisons [24].

To quantify the relationship between advice-seeking (vs. not advice-seeking) with a user’s social connectivity and Suboxone use stage, we constructed four Generalized Linear Models (GLMs) with logit link functions. In each model, the dependent variable is given by a binary variable representing whether a post is advice-seeking or not. The independent variables include the posting user’s network characteristics and Suboxone use stage, the latter being re-coded as a series of binary variables using one-hot encoding with “used to be on Suboxone” as the reference category.

The stepwise model aimed to identify a parsimonious set of independent variables through statistical variable selection (i.e., using forward-backward selection). We compared the stepwise model to three additional models: the full model, Suboxone use model, and network model. The full model contained all network characteristics and the Suboxone use stage variables. The Suboxone use model and network model contained only the Suboxone use stage and network characteristics variables, respectively. To aid our inference of modeling coefficients, we computed the variable inflation factor to assess the multicollinearity of modeling variables for each model. We then applied leave-one-out cross-validation to evaluate each model using Area Under the Receiving Operator Characteristic Curve (AUROC), Akaike Information Criterion (AIC), and F1 score. Altogether, these measures provide a holistic picture of each model’s predictive performance.

Results

Data Characteristics
The final study sample contained 202 posts (see Figure 1). Table 1 summarizes these data with respect to our study variables. Within these posts, 137 (67.8%) were advice-seeking. Examples of posts annotated as advice-seeking and not advice-seeking are shown in Table S3.

Figure 1: Application of exclusion criteria to raw data for obtaining the study sample
Among posting users, those who made advice-seeking posts had a significantly different total degree (P=0.004), eigencentrality (P=0.003), authority score (P=0.014), and hub score (P=0.007) than users who did not make advice-seeking posts. Additionally, the proportion of users in each Suboxone use stage was significantly different between users who authored advice-seeking posts and those who did not (P<0.001). Notably, there was a significantly greater proportion of advice-seeking users vs. not advice-seeking users who were inducting or tapering (n=57, 41.6% vs. n=14, 21.5%; P=0.02) and a significantly lesser proportion of users who used to be on Suboxone (n=6, 4.4% vs. n=14, 21.5%; P=0.001). Examples of posts in each Suboxone use stage are shown in Table S4.

Table 1: Description of data with respect to post characteristics, network characteristics, and Suboxone use stage

<table>
<thead>
<tr>
<th>Variable</th>
<th>Full Study Sample</th>
<th>Advice-seeking</th>
<th>Not Advice-seeking</th>
<th>P-value1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of posts2</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>202 (137)</td>
<td>214 (222.9)</td>
<td>65 (572.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length of post (words)</td>
<td>297 (390.7)</td>
<td>472 (572.8)</td>
<td>196 (390.7)</td>
<td></td>
</tr>
<tr>
<td>Comments per post</td>
<td>12.9 (14.1)</td>
<td>11.7 (11.7)</td>
<td>15.3 (17.9)</td>
<td>0.529</td>
</tr>
<tr>
<td>Network characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total degree</td>
<td>44.5 (54.5)</td>
<td>33.9 (32.1)</td>
<td>66.6 (80.0)</td>
<td>0.004</td>
</tr>
<tr>
<td>Closeness2</td>
<td>0.0 (1.0)</td>
<td>-0.1 (0.7)</td>
<td>0.1 (1.4)</td>
<td>0.904</td>
</tr>
<tr>
<td>Eigencentrality</td>
<td>0.2 (0.2)</td>
<td>0.1 (0.1)</td>
<td>0.2 (0.2)</td>
<td>0.003</td>
</tr>
<tr>
<td>Lifespan (days)4</td>
<td>178.8 (289.5)</td>
<td>159.7 (247.6)</td>
<td>219.1 (361.1)</td>
<td>0.848</td>
</tr>
<tr>
<td>Authority score</td>
<td>0.2 (0.2)</td>
<td>0.1 (0.1)</td>
<td>0.2 (0.2)</td>
<td>0.014</td>
</tr>
<tr>
<td>Hub score</td>
<td>0.1 (0.1)</td>
<td>0.1 (0.1)</td>
<td>0.2 (0.2)</td>
<td>0.007</td>
</tr>
<tr>
<td>Suboxone use stage</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.0015</td>
</tr>
<tr>
<td>Using Suboxone:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>inducting/tapering</td>
<td>71 (35.1)</td>
<td>57 (41.6)</td>
<td>14 (21.5)</td>
<td>0.02</td>
</tr>
<tr>
<td>Using Suboxone: other</td>
<td>102 (50.5)</td>
<td>70 (51.1)</td>
<td>32 (49.2)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Used to be on Suboxone</td>
<td>20 (9.9)</td>
<td>6 (4.4)</td>
<td>14 (21.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>Cannot discern</td>
<td>9 (4.5)</td>
<td>4 (2.9)</td>
<td>5 (7.7)</td>
<td>0.33</td>
</tr>
</tbody>
</table>

1P-values compare difference across advice-seeking and not advice-seeking posts; 2Total number of posts exclude repeat posts by the same author; 3Normalized values presented due to scale of variable; 4Denotes lifespan of posting user; 5P-value computed using Pearson’s Chi-square test to compare distribution across Suboxone use stage categories for advice-seeking and not advice-seeking.

Figure 2 illustrates examples of advice-seeking and not advice-seeking posts, along with the posting user’s social network graph, post characteristics, network characteristics, and Suboxone use stage. These examples were selected to be close to the mean total degree in each category.

(A) Advice-seeking

Post title: “Need Support”

“Ok guys I purposely skipped my Sub doc appointment today. my reason, I am tired of taking this medicine and going to piss in a cup every month. Tired of looking like a junkie at the pharmacy. I am done!!! Now here’s the thing, I do have 75 / 8 mg subs to taper down to zero!!! I am guessing that should be plenty. I just need help from you guys, you guys who understand me. Please help me taper with a plan. I have no idea the best way to do it. If anyone has time, I would be really greatful [sic]. thanks and I will keep this thread open and write down my progress.”

Characteristics:

Suboxone use stage: Using Suboxone: Tapering
Total degree: 48
Closeness: -0.24
Eigencentrality: 0.11
Lifespan: 287 days
Authority score: 0.11
Hub score: 0.06
Post title: “Subutex”
“I finally got my dr to prescribe subutex instead of suboxon and I must say I don’t feel that gross anxiety feeling like suboxon gave me. Much more of a clean feeling I guess. Hope it lasts”

Suboxone use stage: Using Suboxone: Other

Total degree: 85
Closeness: -0.23
Eigencentrality: 0.32
Lifespan: 88
Authority score: 0.28
Hub score: 0.19

Figure 2: Illustration of (A) advice-seeking and (B) not advice-seeking posts with posting user’s network. Posting user shown as a red node, all other users are shown as blue nodes, edges indicate the relation between users.

1Normalized value computed by subtracting the sample mean and dividing by the sample standard deviation

Regression Modeling
Our GLMs are described in Table 2. In the stepwise model, “total degree,” “closeness,” and the Suboxone use stage variables were selected by the variable selection procedure, with “total degree” (P=0.002), “using Suboxone: inducting/tapering” (P<0.001), and “using Suboxone: other” (P=0.002) being significantly different from 0 (i.e., strongly associated with advice-seeking). These three variables had variance inflation factors (VIF) ranging from 1.04-1.08, indicating low multicollinearity, and none of the variables that were removed by the stepwise variable selection procedure were significant in any of the other GLMs. Additionally, all variables that were significant in the stepwise model were significant in at least one other GLM. Notably, VIFs in all other models were low-moderate (i.e., VIF≤5) except for eigencentrality (VIF=10.94-11.26) and authority score (VIF=9.53-9.69) within the full and network models. Nevertheless, these variables had coefficient estimates close to 0 and were not significant in either model.

Whether each variable increased/decreased the likelihood of being an advice-seeker (i.e., whether the coefficient was positive/negative) was consistent across all models. Among variables with coefficients significantly different from 0, “total degree” had a negative coefficient, indicating that posting users with more connections were less likely to be advice-seeking. Likewise, the coefficients for “using Suboxone: inducting/tapering” and “using Suboxone: other” were positive, indicating that posting users who were identified as using Suboxone were more likely to be advice-seeking than users who were identified as formerly using Suboxone.

With regard to performance measures, the stepwise model outperformed all other models with the greatest AUROC (0.66 vs. 0.52-0.61), least AIC (231.86 vs. 239.19-246.85), and greatest F1 score (0.47 vs. 0.30-0.44).

Table 2: Model coefficients and performance measures for each model predicting the likelihood of advice-seeking

<table>
<thead>
<tr>
<th>Model</th>
<th>Full</th>
<th>Network</th>
<th>Suboxone Use</th>
<th>Stepwise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coefficient (95% CI)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.86 (-2.07, 0.24)</td>
<td>0.67* (0.08, 1.25)</td>
<td>-0.85 (-1.89, 0.07)</td>
<td>-0.69 (-1.76, 0.28)</td>
</tr>
<tr>
<td>Total degree</td>
<td>-0.82 (-1.70, -0.01)</td>
<td>-0.81* (-1.65, -0.06)</td>
<td>-0.63** (-1.07, -0.25)</td>
<td></td>
</tr>
<tr>
<td>Closeness</td>
<td>-0.33 (-0.83, 0.04)</td>
<td>-0.30 (-0.74, 0.05)</td>
<td>-0.31 (-0.69, -0.01)</td>
<td></td>
</tr>
<tr>
<td>Eigencentrality</td>
<td>0.00' (-1.18, 1.20)</td>
<td>-0.02' (-1.20, 1.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifespan</td>
<td>0.00 (0.00, 0.00)</td>
<td>0.00 (0.00, 0.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authority score</td>
<td>-0.05' (-1.15, 1.07)</td>
<td>-0.02' (-1.13, 1.09)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In this research, we assessed the relationship between advice-seeking behavior, social connectedness, and buprenorphine-naloxone (Suboxone®) use stage in Reddit. While previous studies using Reddit data have individually analyzed social roles and connectedness of subreddits [9], advice seeking among users with OUD [25], and posts regarding induction and tapering [26], our study is the first to connect the three topics and to do so by combining social network analysis, text annotation, and statistical modeling.

Our analysis focused on advice-seekers in r/suboxone. Suboxone (and buprenorphine and/or buprenorphine-naloxone, more broadly) is an effective treatment for OUD [16, 19, 27]. Nevertheless, there remain many limitations to Suboxone treatment (e.g., insufficient training of medical professionals and stigma) that erode trust between PWUO and their providers [28, 29]. These limitations may lead PWUO to seek treatment advice online, as evidenced by the subreddit we analyzed. Our analysis provides some insight into the characteristics of advice-seekers on Reddit, potentially identifying PWUO who may not be receiving sufficient medical advice or support from their prescribing clinician.

In our best-performing model (i.e., stepwise), we found that advice-seeking behavior had significant associations with a user’s total degree (i.e., number of connections with other users) and Suboxone use stage. In particular, our results suggest that users with few connections on r/suboxone as well as those who are using Suboxone are more likely to seek advice online than users who have more connections and no longer using Suboxone. Regarding advice-seeking among Suboxone users, our descriptive analysis proved a significantly higher proportion of advice-seekers who were inducting or tapering compared to non-advice-seekers. This result may suggest that PWUO who are inducting or tapering, i.e., in a transition stage, may be more likely to seek advice online than Suboxone users who are not in a transition stage. To this end, previous research has connected social network characteristics with advice-seeking in addiction recovery homes and found that the number of advice-seeking relationships was positively correlated with high levels of stress [30]. While we did not explicitly study stress, previous literature has reported increased stress levels among patients who are initiating or tapering with buprenorphine, partly due to intense withdrawal symptoms [31, 32]. Thus, stress may play a key role in the positive relationship between being in a transition stage and advice-seeking—future research should investigate this assumption especially in social media platforms. In stressful circumstances, people who are seeking advice might feel more comfortable doing so from their peers, rather than their providers, especially if they remain ambivalent about quitting and are concerned about judgment from their providers [33, 34].

While we found no link between lifespan (i.e., the length of time a user has been active on r/suboxone) and advice-seeking behavior, we did find a relationship between Suboxone use stage and advice-seeking behavior. In this way, our results suggest similar dynamics to those in AA/NA, where new members are encouraged to seek advice and support from more experienced sponsors [13]. In the context of an anonymous online forum,

<table>
<thead>
<tr>
<th>Model</th>
<th>Full</th>
<th>Network</th>
<th>Suboxone Use</th>
<th>Stepwise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hub score</td>
<td>1.69 (-2.77, 6.39)</td>
<td>1.18 (-3.19, 5.80)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using Suboxone: inducting/tapering2</td>
<td>2.10*** (0.96, 3.34)</td>
<td>2.25*** (1.17, 3.44)</td>
<td>2.08*** (0.94, 3.31)</td>
<td></td>
</tr>
<tr>
<td>Using Suboxone: other2</td>
<td>1.41* (0.33, 2.59)</td>
<td>1.63** (0.63, 2.74)</td>
<td>1.42* (0.35, 2.57)</td>
<td></td>
</tr>
<tr>
<td>Cannot discern2</td>
<td>1.02 (-0.83, 2.92)</td>
<td>0.62 (-1.04, 2.28)</td>
<td>1.09 (-0.67, 2.90)</td>
<td></td>
</tr>
</tbody>
</table>

Performance measures3

| | AUROC | AIC | F1 | |
| | | | | |
| AUROC | 0.61 | 0.54 | 0.52 | 0.66† |
| AIC | 239.19 | 246.85 | 241.02 | 231.86† |
| F1 | 0.44 | 0.30 | 0.40 | 0.47† |

1Significance: *<0.05**<0.01, ***P<0.001; 2Suboxone use stage variable binarized using one-hot encoding with “Used to be on Suboxone” as the reference category; 3AUROC: Area under the receiver operating characteristic curve; AIC: Akaike Information Criterion; †best-performing model; ‡variance inflation factor>5.
inducting onto Suboxone (a subset of our analyzed group) is a better corollary to the AA/NA “newcomer” than lifespan per se.

From a clinical perspective, our findings suggest the need for prescribing clinicians to pay special attention (e.g., by providing more frequent follow-up and being especially accessible) to PWUO who are inducting or tapering and who have a limited support network. The importance of having a strong support network for maximizing the likelihood of recovery is well-established [19, 35]. However, how to anticipate and address the potential needs of PWUO in the inducting or tapering stage remains challenging for clinicians; mention of these transition stages is typically restricted to recommendations to help clinicians determine dosing levels or identify when it is appropriate to begin inducting or tapering with buprenorphine [19, 36, 37]. As clinical best practices and public health interventions for OUD treatment continue to evolve, it will be critical to understand why PWUO in transition stages turn to online platforms, what specific advice they are seeking, and whether some or all of their needs could be better addressed by providers.

Beyond the clinic, quickly and accurately identifying advice-seeking users can help online platforms automate the delivery of medically sound informational resources (e.g., via chatbots [38]) for people recovering from OUD. Since our stepwise model achieved greater predictive accuracy than the network and Suboxone use models, these results suggest that the combination of network characteristics and Suboxone use stage are better indicators of advice-seeking behavior than either of those factors individually. Notably, the network model attempted to include a more comprehensive description of each user’s network compared to the stepwise model. However, none of the additional variables beyond total degree were significant and the network model had far worse predictive performance than the stepwise model. These findings indicate the importance of focusing on the right measures of social connectedness when attempting to identify advice-seekers on online platforms. Fortunately, the total degree is relatively simple to compute. Hence, if Suboxone use stage can be classified with relatively high accuracy (e.g., using natural language processing methods), then our stepwise model can provide a starting place for identifying users who might benefit from targeted medically-sound advice on online platforms. Research into whether users of online platforms would welcome such advice is warranted.

Our findings may also be connected with the use of online platforms for other health areas. Online information seeking, especially for chronic diseases, weight loss, and mental health issues, is commonplace [5-7]. Across many health areas and online platforms, drivers for seeking health information online include gaining social support [39, 40] and receiving tailored advice from online users with similar experiences [41, 42]. While an analysis of the contents of our post data was beyond the scope of this research, it is plausible that advice-seekers on r/suboxone were also hoping to gain social support or receive individualized treatment advice.

This research is not without its limitations. First, this study focuses only on advice-seeking on r/suboxone. Future research can consider additional social roles, including users who give advice or social support, on additional opioid-related subreddits such as r/opiates. Second, our study focused on the characteristics of advice-seeking users and not the characteristics of the posts themselves. Additional insights can be drawn from analyzing the content of the posts to highlight patterns of advice-seeking posts and facilitate the automated identification of advice-seekers. This analysis could even be extended to evaluate the quality of advice shared on these online platforms. Third, our work leveraged manual annotations of users’ posts to determine respective Suboxone use stages. Future research may explore algorithmic techniques to classify such users, which in tandem with the model presented here would streamline the identification of advice-seeking users and facilitate analysis of topics for which advice is often sought. Finally, our study is limited to data ending on December 31, 2019. The onset of COVID-19 has brought many challenges to PWUO, which could have changed the nature of their online activity and interactions. Thus, future analyses can investigate how online social roles may have changed since the pandemic started in the United States.

Despite these limitations, this research: (1) demonstrates a method to classify advice-seeking users based on their network characteristics and buprenorphine-naloxone use stage; (2) sheds light on the characteristics of advice-seekers on an online platform for OUD recovery; and (3) provides insights for the clinical management of PWUO who are recovering from OUD as well as the nature of online medical advice-seeking. Given the
vulnerability of PWUO, it is imperative that future research continues to explore the needs of this population and how they can be met.

References:
**Online Supplementary Document for**

**Identifying Advice-Seekers for Buprenorphine-Naloxone Use on Reddit via Social Network Characteristics and Medication Use Stage**

Figure S1: Illustration and anatomy of (A) the r/suboxone homepage and (B) a post and its comments.

(A) The r/suboxone homepage

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**Figure S1:** Illustration and anatomy of (A) the r/suboxone homepage and (B) a post and its comments.
(B) Example post and comments

IF I was unemployed I'd be sober by now

Work is the only reason I haven't quit subutex yet. I can't have enough time off and my job is tough and non-stop, and I have a huge amount of responsibility. I can barely even taper because whenever I lower the dose it takes about 5 days to adjust and each step down feels harder the lower my daily dose is.

I booked 10 days off, each day just sat around, diazepam, smoked some weed, watched TV and was relatively easily getting through it but it is just such a drawn out affair. Had to go back to work so boom I was back on the subs. What a waste of time. Enabled me to move to a lower dose though, I'm on 0.5mg daily now and slowly getting lower with volumetric dosing.

I don't even want heroin, I have no opiate cravings, and I didn't when I was in withdrawal. I'm absolutely ready to quit but I just don't have enough fucking time.

But if you weren't working, eventually you would get bored, and thats a huge trigger. I had 5 years unemployed, just taking care of my son, you think I tapered? No, I should have but I had to make it through it.

First off, you are sober. Don't ever think you're not. And second, be VERY careful using benzos to help get off. You do not want to trade habits. Benzos withdrawal will make you wish for Suboxone withdrawal ten times over.
Figure S2: Illustration of social network graph construction

Edge weights represent the number of relations between two users. For example, $w_{BA}=3$ could mean that user B has commented on user A’s post and has replied twice to replies by user A.

Relations BA and CA are created when users B and C comment on user A’s post.

Relation BC created when user B comments on a post by user C in a separate r/suboxone thread.
Table S1: Features and descriptions of data collected from r\suboxone

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>Relates each comment or post to their reply comments.</td>
</tr>
<tr>
<td>Post_date</td>
<td>Shows the dates each post created</td>
</tr>
<tr>
<td>Comm_date</td>
<td>Shows the dates each comment created</td>
</tr>
<tr>
<td>Num_comments</td>
<td>Number of comments for each post-replied comment</td>
</tr>
<tr>
<td>Author</td>
<td>The author of each post</td>
</tr>
<tr>
<td>User</td>
<td>The author of each comment</td>
</tr>
<tr>
<td>Comment</td>
<td>The texts for each comment</td>
</tr>
<tr>
<td>Post_text</td>
<td>The texts for each post</td>
</tr>
<tr>
<td>Title</td>
<td>The post title</td>
</tr>
<tr>
<td>Lifespan*</td>
<td>Number of days between first post or comment and the current post or comment for each user</td>
</tr>
</tbody>
</table>

*Denotes a feature that was computed using collected data.

Table S2: Doctor- and Suboxone-related keywords used to select posts for study.

<table>
<thead>
<tr>
<th>Doctor-related keywords</th>
<th>&quot;doc&quot;, &quot;docs&quot;, &quot;doctor&quot;, &quot;doctors&quot;, &quot;dr&quot;, &quot;drs&quot;, &quot;gp&quot;, &quot;general practitioner&quot;, &quot;physician&quot;, &quot;physicians&quot;, &quot;primary care provider&quot;</th>
</tr>
</thead>
</table>

Keyword lists were compiled by manually inspecting a list of all words appearing in the corpus to identify misspellings and abbreviations. Two doctor-related words were excluded due to possible multiple meanings: namely, "pcp" (Phencyclidine, or Angel Dust), was not included as an abbreviation for “primary care provider”, and "DOC" (all caps, drug of choice) was not included as an abbreviation for “doctor.” Care was taken to ignore the drug brand “Dr. Reddy” when searching for a doctor-related keyword.
**Table S3: Examples of advice-seeking and not advice-seeking posts**

<table>
<thead>
<tr>
<th>Example 1</th>
<th>Example 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advice Seeking</strong></td>
<td><strong>Advice Seeking</strong></td>
</tr>
<tr>
<td>I just got the lab results back from some blood work I had done this past Monday because I told my doctor that I had basically no sex drive and that I always feel tired and lazy. I found out that my T level was at 150 when the average person has a testosterone level of between 300 and 800 I believe. I'm getting ready to find an endocrinologist and have all of my paperwork sent over there so that I can get started on the T injections for the time being to get my numbers up, but I have to run this by my Suboxone doctor first and foremost. Right now I am on 16mg of testosterone and I've been on Suboxone for a year and a half. I've had some of the symptoms of low sex drive since before I started taking Suboxone but don't have a base line to compare it with, so we don't know for sure if the Suboxone is what is causing the low T count - but most of us who in an ORT (opioid replacement therapy) group know that painkillers, especially long-acting ones, can lower your T count quite a bit in some people. I'm afraid that my doctor is going to want me to come down from 16mg of Suboxone daily and get me on a lower dose and I'm not prepared for that yet. I want to be on 16mg for at least until the end of summer and when it starts cooling off start stepping down. This is mainly because I sweat profusely even when it's not all that hot outside and find myself changing undershirts at least once a day because of the sweat even after using prescription antiperspirant to help with the sweats. When it gets cooler I will be more willing to start stepping down to 12mg and see how I handle that dosage. Does anyone think that my Suboxone doctor will want to lower my dosage levels, and will it matter that I'm receiving a schedule 3 substance from another doctor while I'm on Suboxone (another schedule 3 drug)? If my Sub doctor has to prescribe the testosterone I don't have a problem with that since all of my controlled substances would be scripted by the same doctor, but right now I'm afraid that if I have to start on weekly injections of T that he will want to lower my dosage to help with my T levels and I don't think I'm ready to step down for another 3-4 months or so at the least. If anybody out there is receiving Suboxone as well as some form of testosterone I would really love to hear from you and your experience regarding taking both substances together. Thanks for any input you might have regarding this situation.</td>
<td>Can anyone tell me their about experience tapering off of subs? I'm on 8mg a day and have been for a long time but I really really want to be off of them. The nalaxone makes me feel like shit all the time and I get cold sweats. I want to start tapering after my next appointment with my doctor but I'm really scared</td>
</tr>
</tbody>
</table>
Non-Advice Seeking

I have taken my last dose of sub today so here we go! Wish me luck fam. I'm really nervous and anxious but that is to be expected. I have been on subs for 3 months and 27 days. Started at 12mg a day and just jumped from .5mg a day. I wanted to taper lower but lacked the self control it took, I would cheat on days sometimes taking 2-4 but for the most part over the last month I've taken 0.5 to 1mg a day. I'm really worried what this is going to bring but I'm hoping that all I am doing is building it up in my head. Before subs I had a 30-60 mg oral oxy habit, not crazy but enough to cause bad withdrawals. I'm really ready to be done with all the dependent chemicals. I have gabapentin but I'm not sure I will use that. Also have low dose benzos for if and when I can't sleep, I'm sure that will come. I am completely out of subs and I'm not going back to the sub doctor. I'm also not going back to oxy. I'm ready for a normal life and I've put in the work to put myself in a position to be clean. Just scared of what's to come the next couple of weeks but I know it will pass. I am hoping that since I haven't been on subs long that it won't be unbearable.

Thanks for listening >>

I feel like Dr.'s who prescribe buprenorphine don't have enough of an education on opioid addiction. Just because the only true education is from experience. They can't know what we know if they've never been there. They don't know how strong buprenorphine is, and will have a hard time prescribing accurate & appropriate doses to patients. They also don't know how an addict's mind works and the lack of self discipline & self control addicts have in relation to opioids. They can't comprehend that their patients might have a hard time following their prescribed dosage. They don't understand the conundrum of prescribing the same class of addictive substance to treat a patient for their addiction to a similar substance. Akin to using fire to put out a fire. Which does exist as controlled burning of flammable fauna to take away the fuel source for an approaching fire. Which is a good analogy for how Suboxone should be used. The problem is that it's hard to do a controlled burn when you a Dr. are handing the tool to do so to someone with a lack of control in the first place.

Not saying that makes any of them bad doctors. Far from it. It's just that a short class or two that Dr.'s have to take to prescribe buprenorphine is so far from being enough info to really understand how complex addiction is. The very first day I took Suboxone, I was given a full 8mg strip and was told to keep it under my tongue for 5 min. Then the Dr. Would observe me for 10 min. 10 minutes is not enough time for buprenorphine to fully kick in. I had also been 2 weeks into withdrawal, and I had no idea how strong buprenorphine is. My tolerance was nil, and when it finally kicked in half an hour later I went from feeling like dog shit to superman. Cut to 2 hours later, I started to get nauseous. I ended up puking 10 times that day. 8mg was way too much. Now that I'm experienced with Suboxone, I would have been just fine on 2mg strips. But I didn't ask my Dr. to put me on a lower dosage, or even tell him that I puked 10 times the first day. Why because I'm an addict, and I'll take more than less.
### Table S4: Examples of posts annotated by Suboxone use stage

#### Example 1
**Using Suboxone: inducting**
Additional question about starting subs tomorrow. I know I need do be in withdrawal and can’t take benzos while on subs but can I take an ativan tonight for sleep since I won’t be on oxys?

Update: at dr and the sub is currently dissolving. I really like the dr and he is NOT pushing a high dose. Wants me to take smallest possible to feel ok.

#### Example 2
Hey, I start Suboxone on Monday because I just literally spend all day racking up lines of Oxy’s and sniffing them, its all through a recovery program and stuff so its all good, I just wondered, I have no intention of abusing any drug or even drinking booze anymore, just taking my sub and getting on with my life, will my health improve from stopping the oxy and moving onto subs? Like will my lungs stop hurting and my arms stop aching, will I stop waking up feeling like shit from wrecking my sinuses and all that bad stuff? Sorry if this sounds really naive to you guys but this is the first time I’ve ever asked for help for a problem and I now once I have this under control with the sub I won’t be tempted to take anything else, I really into fitness and powerlifting outside of being a bit of a wreck head. So I’m hoping I can take it, get a bath get dressed and go to the gym get on with my life and feel better? Anyway just a bit of a rant as I’m a bit anxious about seeing the doctor on Monday and about what will happen and stuff nobody knows about my addiction but the recovery people, not even my folks who I live with.

#### Example 1
**Using Suboxone: tapering**
My new doctor wants me off subs within 2 months. I’ve been on them about 2 years. I just moved to another state and I think that’s a great idea. However, it’s the way he wants to do it. He wants to taper me down from 8mg to .25 in two months. Then put me back on oxycodeone for one month and taper from that. He says the withdrawal from the oxy should be easier than coming off bupe. Isn’t this idea sort of crazy? Giving me opiates again? He also seems to think if I take testosterone while I’m withdrawing from the percocets it will make it milder because it will give me energy. Has anyone heard of this? It just sounds bat shit crazy to me.

#### Example 2
I made this account to make a post almost a week ago about how I couldn’t stop taking Suboxone, even though it was causing issues in my relationship. I also mentioned that I was having stomach issues and was passing a concerning amount of blood when I went to the restroom.

I went to the doctor (not Suboxone doctor) to get checked out and to hopefully get some clonidine and something non-narcotic to help me sleep while tapering off. My doctor told me that I had ulcerative colitis in my stomach and an infection in my colon from the blood work results.

He asked me if I was still taking the Suboxone, I assume after he looked at my recent prescriptions. I confirmed that I was, but that I was trying to taper off currently and that I would not be going back to get another script. He said, point blank, Get off the Suboxone as quickly as you can. I believe your issues stem from taking this medication and its effect on the digestive system. I was taken back a bit, leaving with a script for just antibiotics and an appointment for a month later, but I reflected on it when I was alone.

I’ve been going to NA recently, and I’ve been trying to connect with my higher power. I’ve been praying and meditating, anything I could to find what these people keep talking about. I’ve literally been down on my knees begging for some sort of sign to help me move on from this for good. I don’t want to take opiates anymore. I’ve been putting some form of opiate into my body for the last 8 years. I’ve wondered for a while how this is affecting my brain and my body, as its a long-term thing at this point, and I am afraid of doing irreversible damage to myself.

#### Example 1
**Using Suboxone: other**
So I went to the doc and was honest and everything worked out for the better... But now it feels like I’m wasting my subs. As soon as I put them in, my mouth fills with saliva and drowns the subs in spit. I just let the spit sit there, only swallowing when it becomes too much and making sure not to swallow the film. My question is, are the subs still gonna work properly? Seems like no one has a solution to this problem.

#### Example 2
I’ve been going to my Suboxone clinic for 4 weeks now. The doctor there said they could also be my primary care physician and has already written me a new script for one of my previous meds, Seroquel. I’ve been diagnosed with ADHD a long time ago and was taking Adderall/Vyvanse/Ritalin for a few years, but had stopped taking it a while back. Does anyone have any experience getting a script for Adderall from their clinic doc? At least with mine, I know he is a licensed Psychiatrist. Obviously, I know Adderall can be addictive and it could be a bad look trying to ask the doc about it, so just trying to get some advice before I pop the question. Thanks =O
So I posted a lot of reports during my jump from 0.5mg. I was on 8mg for about 2.5 years and over the course of 6-8 months I tapered down to 0.5mg. This is what I used for the jump.

1mg Clonazepam - 2x a day (Morning and Night)
0.1mg Clonidine - 2-3x a day
300mg Lyrica - 2x a day
Immodium (Lopermaid)

If you go back through my posts you will see I had a fairly easy time. The helper meds took almost all symptoms away and all I experienced was fatigue. I only took the meds for 2.5 weeks except the Lyrica I ended up taking for almost 6 weeks. My pharmacy and doctor screwed up and refilled it twice before I put a stop to it. It's very addictive and was tough to speak up about it so be careful with it!

So the update, I wanted to start by saying I think Suboxone is a great way to get off opiates. It helped me immensely. HOWEVER, now that I'm off it I see that it was definitely effecting my life negatively and probably should have been stopped sooner then being on it 2.5 years. It's not like I feel completely different now, but I definately feel better. I feel like I'm less in a fog, that I'm more aware of my life and my decisions. I've already managed to lose 10lbs and have been sticking to. Ketogenic Diet that I wasn't ever able to do while on Suboxone. I have way less mood swings and especially don't get very low moods at night anymore. I was waking up every couple hours while on Suboxone and that has now completely dissapeared. Its taken until about 1.5 weeks ago but I can even fall asleep right away and then don't wake up until the morning. I don't have this anxiety about worrying about withdrawal anymore. I just generally feel better. Oh, and I know this doesn't make sense. But I was a chronic relapser while on Suboxone. Only ever going 2-4 months without having a couple days of using opiates. I'm now at 6 months without a relapse and I haven't even been getting cravings anymore. Not sure what else to report but feel free to ask me anything. I was also able to stop taking the Proton Pump Inhibitor from horrible gas and bloating I would get while on Suboxone. That's completely been resolved.

Well today is day 42. I am doing it regardless of how hard it seems to be. Still feel like I am moving slow and lots of muscles ache. Stomach is still a little messed up and the bathroom is a lot better. Could use a title advise as to when energy and happiness returns. I am hearing 60 to 90 days. I can dance that. My problem is that no one except my pharmacist even knows that I was on these for 3 years and decided to stop them. I live my wife and 2 daughters who are fully grown adults. I am over the hard part but need this to get a little better soon. Any advice on this will be helpful. I was a opiate addict for years until all doctors cut me off. Went to sub clinic and off and running what an a hole I was. I am in my 60s so this was not fun at the 2mg jump after doing 16 or a little less for 3 years. I will make this work because I know together we are stronger then Suboxone. Thanks in advance
Why does it say Do not cut, chew or swallow on the front of the (name brand) Suboxone strips? Don’t many people cut the film into smaller doses, and doctors recommend that?  Maybe i’m using “irony” wrong? That’s the thing to do though, isn’t it?

Aaanyway, I was just clicking on sites and such, and I find it.... funny, that a good number of sub docs in my area are actually in boutique practices where they do pain management and physical therapy, ya know, the kinda practices with little water falls and they also sell you special herbs that will “detox” your body? No, not that kind of detox. Like purge your intestine of harmful.... whatevers....

Big deal? Lots of docs with sub waivers treat pain patients. But no. They do not treat people who have become dependent upon their pain medication. And they don’t treat “regular” addicts. They just use the subs as an alternative pain med, which sort of reflects our current panic about addiction.

Get to the point!

Okay, so, what’s funny --- these people (the doctors) all spent at least a day of their time in class and got registered with the DEA and waited 45 days to get a new number, had to order new prescription pads (those things add up!) blah blah.....

You don’t need a waiver to prescribe Suboxone for pain. You only need a waiver to prescribe it for addiction.

Of course, if the poor patient doesn’t want to spend 3 hours at the pharmacy while the pharmacist and doc exchange voicemails and just wants to get their freaking prescription, it sure helps to have that “X”. I just thought it was....

Well I guess my life is pretty uneventful. Naw, but I do just like this health policy and following changes in drug laws and all. Gave me a kick, thought I’d share it with my online buddies. Don’t throw stones.